Progress Report-10
Economics Program

Fertilizer Consumption and Growth in Semi-Arid Tropical India A District-Level Analysis

Dayanatha Jha and Rakesh Sarin

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh, India 502 324

FERTILIZER CONSUMPTION AND GROWTH IN SEMI-ARID TROPICAL INDIA : A DISTRICT-LEVEL ANALYSIS

Dayanatha Jha and Rakesh Sarin†

Studies on fertilizer use in Indian agriculture have focused mainly on the high fertilizer consuming irrigated crops and regions that have provided the main base for past growth in fertilizer consumption [2,3,4,5]. There is no study relating exclusively to the position in the semi-arid tropical (SAT) parts of the country. An all-India analysis based on district-level data for the sixties by Desai and Singh [6] showed that in the low rainfall zones, fertilizer use was high and growing in the irrigated districts, while the unirrigated districts had poor and stagnant consumption levels. Exceptions to this were districts where unirrigated commercial crops like cotton, groundnut, tobacco, chillies, etc., were important. These studies hypothesized that the highly irrigated areas would eventually reach their agronomic potential and subsequently cease to generate future growth in fertilizer use and crop production.

This paper examines these issues with special reference to the SAT areas of the country on the basis of the latest available data. The specific questions addressed are: (1) How much fertilizer is actually used in the irrigated and unirrigated areas of SAT India? (2) Is fertilizer use uniformly spread over districts? (3) What has been the pattern of growth in fertilizer consumption over the last decade or so (1969-70 to 1978-79)? (4) Do the data for the seventies provide any indication of slackening demand for fertilizers in the irrigated areas?

† Economics Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), ICRISAT Patancheru Post Office, Andhra Pradesh 502 324, India. The authors are grateful to Drs. James G. Ryan, Matthias von Oppen, and Hans P. Binswanger for their comments and suggestions. This paper forms the first part of a larger project on Fertilizer Use in Semi-Arid Tropical India.

DATA AND PROCEDURE

This analysis is based on district level data. The Indian SAT is spread over 10 states: Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Tamilnadu, Uttar Pradesh, Punjab, Haryana, Rajasthan and Gujarat. The districts in these states were classified on the basis of normal annual rainfall[1] and 192 of these receiving between 500 mm to 1500 mm normal annual rainfall, were identified as semi-arid districts. These were further grouped into irrigated and unirrigated categories depending upon whether the irrigated area was more than or less than 25% respectively.

Data on fertilizer consumption in these districts were taken from various issues of *Fertilizer Statistics*, an annual publication of the Fertilizer Association of India, New Delhi. Current fertilizer consumption estimates were worked out by taking the average consumption of nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) in each of these districts during 1977-78 and 1978-79,[2] and were expressed in kilograms per hectare of cropped area. Districtwise acreage data were available only for the early seventies and we used the average of the last three years to arrive at the cropped area for each district. These were used to calculate the per hectare consumption levels. The analysis of growth in fertilizer use was beset with problems because the past (pre-1970) trend in fertilizer consumption was vitiated during early and mid-seventies [3,6]. It was not possible to use any regression-based trend analysis. Instead, we considered the consumption levels in the initial period (average of 1969-70 and 1970-71) and the current period (average of 1977-78 and 1978-79) and interpreted the increment (or change)

[1] See [1] for details of this classification.

[2] The use of oxide units was prefered because districtwise consumption data were available consistently in these units. The term fertilizer has been used in its nutrient connotation.

expressed in annual terms as the linear growth rate. This assumes that the vitiating influences of the mid-seventies have now played themselves out and fertilizer consumption has come back to the previous trend line. Desai [3] has argued that this is probably the case and attributes bulk of the post-1975 growth in fertilizer consumption to recovery in trend after poor growth in 1972-73 and 1973-74 and a sharp decline in 1974-75. This assumption needs to be borne in mind while studying the growth pattern.

Two other limitations need to be mentioned. The classification of districts as irrigated or unirrigated is based on the latest available data on irrigated area in different districts. In most cases, these pertain to the early seventies. It is quite likely that several of the unirrigated districts (as classified here) have now moved to the other category. Secondly, it is well known that the post-price hike recovery in consumption of phosphatic fertilizers did not start before 1976-77. This might have led to some under-estimations, particularly in the analysis of levels of consumption.

The next two sections give the status of fertilizer consumption in terms of nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) in the SAT districts.[3] The growth pattern is analyzed in the following section and the concluding section contains a summary of results and their implications.

FERTILIZER CONSUMPTION IN SAT DISTRICTS

Table 1 shows the average level of fertilizer (nutrient) consumption in kilograms per hectare of gross cropped area for the SAT as a whole and for the irrigated and unirrigated zones. The average consumption levels in the SAT districts are somewhat higher than the corresponding national averages but figures for irrigated and unirrigated zones

[3] Henceforth, in the text and in the tables we shall use N, P, K for these three nutrients, respectively.

Table 1. Average level of fertilizer consumption in kilograms per hectare of gross cropped area : 1977-79

Fertilizer	Irrigated SAT (78 distts)	Unirrigated SAT (114 distts)	Total SAT (192 distts)	All-India
Nitrogen (N)	40.0 (6.8)	11.6 (4.8)	21.5	18.9
Phosphorus (P)	11.6 (2.0)	4.5 (1.9)	7.0	5.9
Potash (K)	5.9 (1.0)	2.4 (1.0)	3.6	3.2
(N+P+K)	57.5	18.5	32.1	28.0

Figures in parentheses indicate consumption ratio of N and P in relation to K.

reveal the wide variability which prevails within the SAT. The average level of consumption of N+P+K in the irrigated SAT districts is more than three times as high as in the unirrigated districts. In terms of individual nutrients, the gap is more pronounced for nitrogen consumption. As such, the table shows that the average consumption ratio of N, P, and K is less heavily biased towards nitrogen in the unirrigated SAT districts.

The table demonstrates the importance of irrigated districts as major consumers of chemical fertilizers in SAT India. The pattern is more clearly brought out by Table 2 which provides information on the proportion of aggregate fertilizer consumption accounted for by the irrigated and unirrigated SAT zones at two points of time -- 1969-70 to 1970-71 and 1977-78 to 1978-79.

The total SAT column in Table 2 shows the overwhelming importance of SAT areas in fertilizer consumption in the country. The SAT districts which cover nearly two-thirds of the total cropped area of the country, currently account for 72% of the national consumption of total plant nutrients. The proportion is higher for phosphatic fertilizers.

Table 2. Contribution of irrigated and unirrigated SAT zones to aggregate fertilizer consumption : 1977-79 and 1969-71

Particulars	Period	Irrigated SAT	Unirrigated SAT	Total SAT
1. Number of districts		78	114	192
2. Percent of all-India cropped area		23	42	65
Percent of SAT cropped area		35	65	na
3. Percent of all-India consumption:				
Nitrogen (N)	1977-79	47	26	73
	1969-71	51	24	75
Phosphorus (P)	1977-79	43	32	75
	1969-71	47	31	78
Potash (K)	1977-79	40	30	70
	1969-71	43	26	69
Total fertilizer (N+P+K)	1977-79	45	27	72
	1969-71	49	26	75
4. Percent of total SAT consumption:				
Nitrogen (N)	1977-79	65	35	na
	1969-71	68	32	
Phosphorus (P)	1977-79	58	42	na
	1969-71	61	39	
Potash (K)	1977-79	57	43	na
	1969-71	62	38	
Total fertilizer (N+P+K)	1977-79	62	38	na
	1969-71	66	34	

[na] Not applicable

The irrigated SAT districts, which account for only 23% of the national and about 35% of the SAT gross cropped acreage, use 45% of the national and 62% of total SAT consumption of fertilizers (N+P+K). On the other hand, the unirrigated SAT districts covering 42% of the national and 65% of the SAT cropped acreage, account for a bare 27% of the aggregate and 38% of the total SAT consumption of fertilizers. The proportions are somewhat higher for phosphatic and potassic fertilizers.

Corresponding figures for 1969-71 show that the share of SAT areas in national consumption of fertilizer (N+P+K) has come down from 75% to 72% in 1977-79, implying a marginal improvement in the share of non-SAT areas. The share of irrigated SAT areas in total SAT consumption of all the three nutrients was higher in 1969-71 as compared to 1977-79. This implies a relative improvement in fertilizer consumption in the unirrigated SAT areas. Both the tables show the poor status of fertilizer consumption in unirrigated SAT areas. These results follow directly from the extremely low fertilization levels observed for most of the unirrigated crops [12].

VARIATION IN LEVEL OF FERTILIZER CONSUMPTION IN SAT DISTRICTS

The pattern of concentration in fertilizer consumption in SAT districts is presented in Table 3. Part A of this table shows the distribution of districts in terms of level of consumption of total nutrients (N+P+K) per hectare of gross cropped area. It shows wide variability across districts. Nearly 42% of the total fertilizer consumed in the 192 SAT districts is accounted for by 35 districts in the above 60 kg class. On the other extreme, 49 districts consume less than 10 kg per hectare and account for only 4.7% of the total fertilizer consumed. Figures for irrigated and unirrigated districts bring out the disparities more clearly. In 32 out of 78 districts in the irrigated category, the average consumption level exceeds

Table 3. Distribution of SAT districts in different fertilizer (N+P+K) consumption level classes, 1977-79

Consumption range (kg/ha of gross area or '000 tonnes)	Irrigated SAT			Unirrigated SAT			Total SAT	
	No. of dis-tricts	% total SAT consumption	% irrig. SAT consumption	No. of dis-tricts	% total SAT consumption	% unirrig. SAT consumption	No. of dis-tricts	% total SAT consumption
(A) Total plant nutrients (N+P+K) per ha of cropped area in kg.								
> 60	32	38.6	62.2	3	3.1	8.2	35	41.7
41 - 60	21	14.3	23.0	9	7.3	19.3	30	21.6
21 - 40	20	8.5	13.6	30	15.6	41.5	50	24.1
11 - 20	4	0.7	1.1	24	7.2	18.9	28	7.9
5 - 10	nil	na	na	26	3.5	9.2	26	3.5
< 5	1	0.1	0.1	22	1.1	2.9	23	1.2
Total	78	62.2	100.0	114	37.8	100.0	192	100.0
(B) Total plant nutrients (N+P+K) per district in '000 tonnes								
> 60	4	9.0	14.5	nil	na	na	4	9.0
41 - 60	15	20.6	33.2	2	2.5	6.6	17	23.1
31 - 40	8	8.0	12.8	7	6.9	18.3	15	14.9
21 - 30	19	13.2	21.4	14	9.5	24.8	33	22.7
11 - 20	22	9.5	15.2	28	11.8	31.3	50	21.3
5 - 10	7	1.5	2.4	23	4.5	12.1	30	6.0
< 5	3	0.4	0.5	40	2.6	6.9	43	3.0
Total	78	62.2	100.0	114	37.8	100.0	192	100.0

[na] Not applicable

60 kg per hectare and these account for 38.6% of the total fertilizer consumed in the SAT; in only one the fertilizer consumption is less than 10 kg per hectare. On the other hand, only three unirrigated districts have consumption levels exceeding 60 kg per hectare and in as many as 48, the level is less than 10 kg. Thus, while nearly 68% of the irrigated districts consume more than 40 kg, over 89% of the unirrigated districts have consumption levels below 40 kg per hectare. This pattern holds for individual plant nutrients also (Appendix I).

In order to facilitate comparison with other data sources, part B of the table shows the distribution in terms of fertilizer consumption per district. Aggregate statistics for the country as a whole[4] indicate that nearly 12% of the total number of districts in the country have consumption levels exceeding 30,000 tonnes of total fertilizers (N+P+K) and these account for over 42% of the national consumption. On the other extreme, 45% of the districts consume less than 5,000 tonnes and their share in the national consumption is barely 8%. Data for all SAT districts presented in Table 3 reveal similar inter-district variability. The concentration, however, is less sharp in total SAT as compared to the country as a whole -- the proportion of districts in the lowest class (less than 5,000) tonnes is significantly smaller at 22%, and that in the above 30,000 tonnes class is higher (35%).

Figures for irrigated and unirrigated SAT districts reinforce the conclusions drawn earlier. Most of the high fertilizer consuming districts belong to the irrigated category and the unirrigated districts reveal poor consumption levels. Thus, while the distribution of all SAT districts conveys a more favorable impression as compared to the country as a whole, it is so because of a blending of two

[4] *Fertilizer Statistics 1978-79*, Fertilizer Association of India, New Delhi, 1979, Table 6.09 (b), pp. I-127.

contrasting distributions -- the irrigated districts showing high fertilizer consumption and the unirrigated ones having low consumption levels. One should also note that the use of district level data may not fully reveal the dominance of irrigation, because even in the so called unirrigated districts, fertilizer use may be concentrated on the small proportion of irrigated areas possessed by farmers. This does not show up in district level data. Despite the apparent tendency of clustering, it would be incorrect to infer that inter-district variations within each category are nonexistent. For example, within the unirrigated SAT there are 12 districts where the consumption level exceeds 40 kg per hectare and these account for 27.5% of the consumption in unirrigated SAT; a slightly higher share is claimed by 72 districts consuming less than 20 kg per hectare. Thus, even within the unirrigated category, fertilizer consumption varies significantly and concentration tendencies persist.

Fig 1 shows that the low fertilizer using districts are concentrated in the states of Madhya Pradesh, Maharashtra, Rajasthan, and Gujarat. As expected, the high fertilizer consuming districts are concentrated in the coastal areas of Andhra Pradesh and Tamilnadu and the irrigated North Indian plains. The map also shows that fertilizer consumption is relatively lower in the irrigated districts of southern Uttar Pradesh, Madhya Pradesh, and Rajasthan.

In 1978-79, fertilizer consumption exceeded 40,000 tonnes in 26 districts.[5] Table 3 which shows the average position over the last two years, indicates that 21 districts in the SAT belonged to this category -- 19 of which were irrigated. Data presented in this section thus clearly show that the irrigated SAT districts lead the country in terms of fertilizer consumption. Unirrigated areas in the SAT, on the other hand, consume very low quantities of fertilizers. These account

[5]*Fertilizer Statistics, 1978-79, op. cit.*

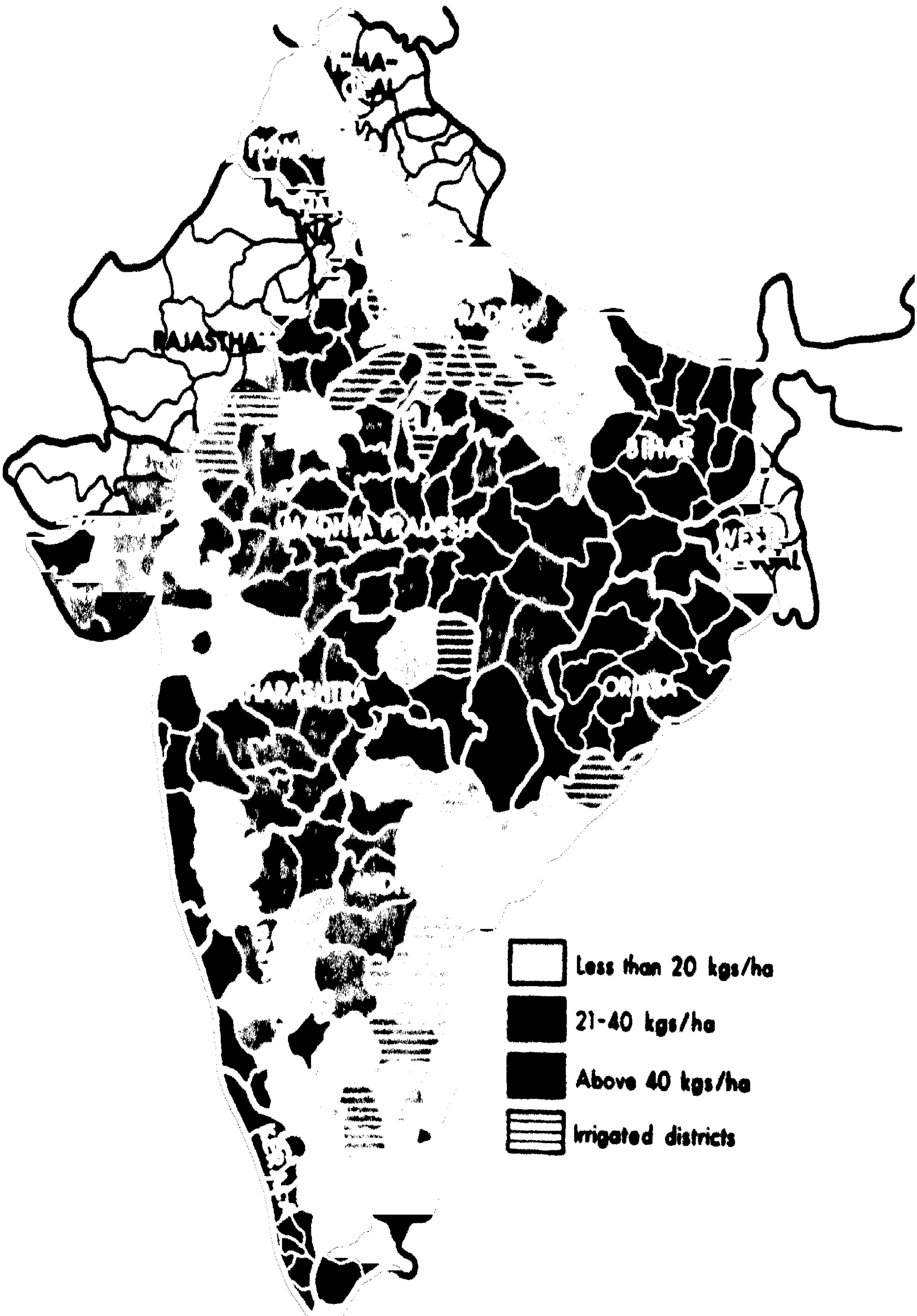

FIGURE 1. AVERAGE LEVEL OF FERTILIZER (N+P+K) CONSUMPTION IN KGS PER HECTARE OF GROSS CROPPED AREA IN SEMI-ARID TROPICAL INDIA, 1976-77

for over 42% of the gross cropped area of the country and about 65% of the Indian SAT.

GROWTH IN FERTILIZER USE IN SAT DISTRICTS

In a analysis by districts covering the decade of sixties [6], it was found that, by and large, the rainfed areas did not contribute significantly to growth in fertilizer consumption. Growth in fertilizer consumption in the country during the sixties was mainly due to diffusion of fertilizer use on (i) almost all crops grown under irrigated conditions, (ii) high-yielding varieties, particularly of wheat, and (iii) a few commercial crops grown under unirrigated conditions like cotton, groundnut, tobacco, etc. It was also found that growth was concentrated in a few districts of the country. In a recent resurvey based on data till 1977, Desai [3] observed that though there was some broadening of the districtwise base generating growth in fertilizer use, by and large, the same forces continued to be important even now. He cautioned that unless efforts were made to achieve rapid increase in fertilizer consumption on rainfed crops, the country might witness a slackening in the tempo of growth in fertilizer consumption.

(1) This section examines these hypotheses in context of SAT India with special reference to the seventies (till 1979). As explained earlier, annual increments in fertilizer consumption (N, P, and K) were worked out for each of the 192 SAT districts by considering the difference in consumption levels per hectare of cropped area, between 1970 (average of 1969-70 and 1970-71) and 1978 (average of 1977-78 and 1978-79). Table 4 shows the distribution of districts according to this annual rate of change in fertilizer consumption.

There is wide inter-district variation in annual increments in fertilizer consumption implying wide diversity in growth performance of SAT districts. The table also brings out the superior performance of irrigated SAT districts. In 83 districts, fertilizer (N+P+K) consumption

Table 4. Distribution of SAT districts according to rate of increase in fertilizer consumption per hectare (kg per annum) during 1970-78

Rate of increase per annum in kg per ha of cropped area	Nitrogen (N)			Phosphorus (P)			Potash (K)			(N+P+K)		
	Irrig. SAT	Unirrig. SAT	Total SAT	Irrig. SAT	Unirrig. SAT	Total SAT	Irrig. SAT	Unirrig. SAT	Total SAT	Irrig. SAT	Unirrig. SAT	Total SAT
< 0.10	2	12	14	6	39	45	19	65	84	2	7	9
0.11 - 0.50	1	45	46	35	54	89	45	39	84	1	33	34
0.51 - 1.00	10	24	34	22	14	36	9	6	15	3	25	28
1.01 - 2.00	24	23	47	9	6	15	4	3	7	14	24	38
2.01 - 3.00	19	8	27	4	1	5	1	1	2	19	14	33
3.01 - 4.00	12	1	13	1	nil	1	nil	nil	nil	14	6	20
4.01 - 5.00	6	1	7	1	nil	1	nil	nil	nil	13	3	16
> 5.00	4	nil	4	nil	nil	nil	nil	nil	nil	12	2	14
Total	78	114	192	78	114	192	78	114	192	78	114	192

grew at more than 2 kg per annum -- 58 of these were in the irrigated SAT. At the other extreme, the increment rate was less than one kg in 71 districts and 65 of these were unirrigated. This pattern holds for nitrogen, but for phosphatic and potassic fertilizers the irrigated districts also figure prominently in the low growth categories.

The irrigated districts have continued to perform well in terms of level (Table 3), as well as growth in consumption of nitrogenous fertilizers. The unirrigated districts, with some exceptions[6] present a dismal picture with over 50%, 81% and 91% of them having less than half kg per annum growth in nitrogen, phosphorus and potash consumption, respectively. It may also be noted that in the irrigated category, only two out of 78 districts had less than 0.1 kg growth in nitrogen consumption; for phosphatic and potassic fertilizers, the numbers were 6 and 19, respectively. This suggests that growth in nitrogen consumption has been more strongly associated with irrigation [9].

The rate of growth exceeded two kg for nitrogen and one kg for phosphorus in 10 and 7 unirrigated districts, respectively (Table 4). In almost all these districts crops like cotton, groundnut, tobacco, chillies, etc., were found to be important.[7] Thus, despite data inadequacies, the results broadly confirm the pattern observed by Desai and Singh [6] for the sixties.

(2) We have also evaluated the contention [3] that, by and large, the districtwise base sustaining growth in fertilizer consumption has remained quite narrow over time, by comparing the performance of high

[6] The rate of growth exceeded two kg per annum in only 10 districts for nitrogen and one kg per annum for phosphorus and potash in only 7 and 4 districts, respectively.

[7] The districts for nitrogen were: Kaira, Sabarkanta, Surat, Gandhinagar (Gujarat), Kolhapur, Jalgaon (Maharashtra), Bellary, Raichur (Karnataka), Khammam (Andhra) and Mirzapur (Uttar Pradesh). For phosphorus, the districts were: Sabarkanta, Rajkot, Junagarh, Bhavnagar (Gujarat), Hassan (Karnataka), Khammam (Andhra) and Kolhapur (Maharashtra).

growth districts[8] during the sixties and seventies (Appendix II). This comparison provides unmistakable evidence of a widening of the district level base supporting growth in fertilizer consumption. It shows that 44 irrigated and 26 unirrigated districts, had high growth in nitrogen consumption during seventies. In 25 of the irrigated and 5 of the unirrigated districts, growth was high during the sixties also. Similarly, in 29 irrigated and 21 unirrigated districts, growth in consumption of phosphatic fertilizers was high during the seventies; out of these in 14 irrigated and 8 unirrigated districts, growth in consumption was high during sixties also. This clearly shows that new districts have come up to the front particularly in the unirrigated SAT areas.

(3) Table 5 compares the distribution of SAT districts (in terms of rates of annual increment in tonnes per district per annum between the sixties and seventies (1970-78). The pattern for sixties is based on a reclassification of Desai and Singh [6] data. Comparable figures for the seventies[9] have been worked out by us. The purpose of this comparison is to test the hypothesis that growth in fertilizer use in irrigated areas would eventually decline [3,4,5,6].

The table reveals an overall improvement in the performance of total SAT during the seventies with respect to growth in nitrogen consumption. The percentage of districts with high to very high growth has risen from 22 to 37% and in the low to very low category it has fallen from 46 to 32%.

[8]The analysis for sixties [6] measured growth in terms of annual increment in fertilizer consumption per district (in tonnes per district rather than kg per ha). The same approach was used by us for the seventies also in order to allow comparison. It must also be mentioned that the performance of districts during the sixties was read from maps in [6]. There might be some minor errors in this because the maps are not very clear.

[9]Note that the definition of SAT is different in these two analyses. From Desai and Singh [6], Tables 4.7 and 4.8, 166 districts receiving between 500 to 1150 mm annual normal rainfall were considered as SAT districts. In the present study, the definition is different. The definition of irrigated district was kept the same. Comparison has been attempted in Table 5 by considering the percentage of districts falling in different categories.

Table 5. Distribution of SAT districts in different classes according to annual increment in fertilizer use in sixties (1960-68) and seventies (1970-78)

SAT category	Period	% of districts falling in different growth classes: Very high	High	Medium	Low	Very low	Total number of districts
	NITROGEN USE	> 1500t	751-1500t	301-750t	101-300t	< 100t	
Irrigated	Sixties*	14	23	33	18	11	70
	Seventies	28	28	36	5	3	78
Unirrigated	Sixties	1	9	31	26	32	96
	Seventies	4	18	28	25	24	114
Total SAT	Sixties	7	15	32	23	23	166
	Seventies	14	23	31	17	15	192
	PHOSPHORUS USE	> 500t	301-500t	101-300t	51-100t	< 50t	
Irrigated	Sixties	8	18	40	16	17	70
	Seventies	15	22	47	8	8	78
Unirrigated	Sixties	5	8	30	20	36	96
	Seventies	8	11	33	18	30	114
Total SAT	Sixties	7	13	34	18	28	166
	Seventies	11	15	39	14	21	192

*Figures for sixties pertain to 1960-68 and have been taken from [6].

It is also clear that this improvement has been brought about largely on account of the irrigated districts -- confirming what was mentioned earlier regarding irrigated areas continuing to provide the basis for growth in fertilizer (nitrogen) use. For unirrigated areas also, the percentage of districts in the high to very high category has improved from 10 to 22%, but the proportion of districts having low to very low growth recorded relatively modest decline from 58 to 49%. The same trend appears to hold with respect to phosphorus consumption also.

The above analysis suggests that irrigated districts continue to provide the main base for growth in consumption of both nitrogenous and phosphatic fertilizers. As compared to the sixties, a large number of such districts moved from low to high growth category in the seventies This has happened in some unirrigated districts also but nearly half of such districts continued to remain in the low growth categories during seventies also.

Table 5 does not provide any evidence regarding deceleration of growth in fertilizer consumption in the irrigated areas [6]. Appendix II, which shows the performance of high growth districts during sixties and seventies, is more revealing in this regard. If we consider change from high to low growth categories (between sixties and seventies) as a definite indication of slackening, we do not find any such district for nitrogen but in four districts (2 each in irrigated and unirrigated categories) this has happened with respect to consumption of phosphatic fertilizers.

The dominance of the irrigated districts is well brought out by the data in Table 6 showing the contribution of irrigated and unirrigated SAT districts to the total growth in fertilizer consumption between 1970 and 1978.

The table shows that the irrigated areas have accounted for most of the growth in aggregate fertilizer consumption in the SAT. This is so because nitrogen accounts for a major bulk of total fertilizers and

Table 6. Percentage contribution of irrigated and unirrigated SAT districts to growth in fertilizer consumption between 1970 and 1978.

Fertilizer	Percentage of total growth accounted for by:	
	Irrigated districts	Unirrigated districts
Total fertilizers (N+P+K)	59	41
Nitrogen	62	38
Phosphorus	55	44
Potash	53	47

and most (62%) of the growth in nitrogen consumption is accounted for by the irrigated districts. With respect to growth in consumption of phosphatic and potassic fertilizers, the unirrigated districts have contributed a relatively larger share to the post-1970 growth.

The analysis of growth in fertilizer consumption attempted above indicates that fertilizer consumption is growing in the SAT, and it is spreading to cover more areas. We do not observe any tendency towards slackening of growth in consumption of fertilizers in the irrigated SAT districts and the share of these areas in additional gains in fertilizer consumption in the SAT continues to be dominating. There has been some improvement in the growth performance of the unirrigated districts but this relative gain should be viewed in context of the fact that the absolute consumption of fertilizers (N+P+K) continues to be below 10 kg per hectare in over 42% of the unirrigated SAT districts (Table 3) and that fertilizer use has remained stagnant in 12, 39, and 65 districts, respectively, for nitrogen, phosphorus and potash, out of 114 unirrigated SAT districts (Table 4) over the period 1970-78. Moreover, the finding that most of the high fertilizer using districts in the unirrigated SAT have a sizeable area under unirrigated commercial crops suggests that the crop base of fertilizer consumption continues to be narrow and that the unirrigated food crops continue to be neglected in this regard. What seems to be happening in the unirrigated SAT is relatively rapid diffusion of fertilizer use on commercial crops. This is a welcome trend in itself but it does not alter the basically poor status of fertilizer use in these areas in terms of levels as well as growth.

SUMMARY AND CONCLUSIONS

This paper provides an overview of fertilizer consumption and growth in SAT India based on district level data. It was found that the 192 SAT districts accounted for nearly two-thirds of the gross cropped area of the country, and nearly 73%, 75% and 70% respectively, of the national consumption of nitrogenous (N), phosphatic (P_2O_5) and potassic (K_2O) fertilizers in 1977-79. Over 62% of the total fertilizers (N+P+K) used in the SAT districts was consumed in the 78 irrigated districts which claimed only 35% of the SAT cropped area. Thus fertilizer consumption in SAT India reflected a blending of two extreme situations -- the high-fertilizer using irrigated areas located in the plains of Northern India and coastal areas of Andhra Pradesh and Tamilnadu, and the low-fertilizer-using unirrigated districts spread over most of central and western India. The average level of fertilizer (N+P+K) consumption per hectare of cropped area was 57 kg in the irrigated and 18 kg in the unirrigated districts.

Considerable variation was noted in fertilizer consumption between districts even within irrigated and unirrigated categories. The average consumption of fertilizers (N+P+K) per hectare of gross cropped area exceeded 40 kg in 53 out of 78 irrigated districts, and was less than 10 kg in only one district. On the other hand, only 12 unirrigated districts (out of 114) had consumption levels exceeding 40 kg and in as many as 48, the level was less than 10 kg per hectare. These data clearly showed that the irrigated SAT districts lead the country in terms of fertilizer consumption; bulk of the unirrigated SAT, on the other hand, being characterized by very low consumption levels.

The irrigated SAT districts also showed better performance in terms of growth in total fertilizer consumption during the period 1970-78. The exceptional unirrigated districts which performed well were those in which unirrigated commercial crops like cotton, groundnut, tobacco, chillies, etc. were important. These trends were also observed by Desai and Singh [6] in their analysis for the sixties.

Comparison of the growth performance of SAT districts between 1960-68 and 1970-78 revealed that the irrigated districts have continued to provide the base for growth in fertilizer consumption during the seventies also and there was no indication of a deceleration in growth. Our analysis does not support the contention that the spatial base sustaining growth in fertilizer consumption continues to be narrow. It clearly shows that new areas have come to the forefront, particularly in case of nitrogenous fertilizers in the unirrigated SAT. On the whole, the 78 irrigated districts accounted for 62% of the increase in nitrogen consumption in SAT India between 1970 and 1978; the share of these districts was somewhat lower for phosphorus (55%) and potash (53%) consumption.

This analysis has shown that fertilizer consumption has been growing even in the unirrigated areas. This, however, offers little consolation because: (a) this increase could be due to an increase in irrigation in these so called "unirrigated" districts; we do not have the latest districtwise data on irrigation to know the exact position,[10] (b) the cropwise base for growth in fertilizer consumption in unirrigated areas continues to be narrow and confined to a few commercial crops, and (c) the absolute level of consumption of fertilizers continues to be below 10 kg per hectare in nearly 42% of the unirrigated districts

[10]State level data on growth in irrigated area over this period suggest this as a strong possibility. One should also note that even in the unirrigated districts, bulk of fertilizers could be going to the irrigated crops grown on small areas.

and what is more, consumption levels have remained stagnant in 12, 39 and 65 districts (out of 114) for nitrogen, phosphorus, and potash respectively.

Review of past work and results of this analysis lead to the following hypotheses:

(1) Irrigated areas within SAT India continue to control growth in fertilizer consumption. Even as high irrigated areas reach their saturation level, ongoing irrigation development efforts would lead to diffusion of fertilizer use on hitherto unirrigated lands.

(2) Farmers in the highly unstable SAT setting adopt fertilizers only when returns are relatively assured (as on irrigated lands) and/or high enough (as for high-value commercial crops). Relatively lower valued foodgrain crops which do not respond significantly to fertilization and which occupy bulk of the unirrigated SAT cropped area, suffer on both these counts. Some dent on this barrier has been made by the high-yielding varieties of sorghum and pearl millet, but in these cases also irrigation seems to play the leading role [12].

The district level analysis does not permit testing of these hypotheses. It does, however, enable us to understand the magnitude of the problem. It has revealed two basic motivating forces -- irrigation and market incentives. It must be noted that over bulk of the Indian SAT, neither of these operate and one must look for a third catalyst -- technological change being the obvious choice.

It has been shown [8,10,11,15] that viable (improved) technological packages, including fertilizers as an essential ingredient are now available for most of the dryland crops and pilot efforts in these areas have yielded encouraging results [2,13]. Despite these facts and the imperative need [4,6,7,11] to concenrate on dryland agriculture, neither the government nor the fertilizer industry feel confident enough to launch any major extension or promotional program for increasing fertilizer use and its efficiency on dry crops.[11]

DJ:RS:sh
05221980

[11]Such a program, known as the Intensive Fertilizer Promotion Campaign, is currently operative in 75 districts having assured irrigation but low fertilizer consumption levels. The program was initiated in 1975 and has already shown impressive results [14].

REFERENCES

1. Bapna, S.L., D. Jha and N.S. Jodha, "Agroeconomic features of semi-arid tropical India." Presented at the *Workshop on Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture*, ICRISAT, Hyderabad 19-23 February 1979.

2. Chandrasekhar, Y., "Problems and prospects of fertilizer use in drylands : Karnataka's experience." Presented at the FAI Group Discussion on *Fertilizer Use in Drylands*, New Delhi, August 1979.

3. Desai, G.M., "A critical review of fertilizer consumption after 1974-75 and prospects of future growth," *Fertilizer News* 23(7), July 1978.

4. Desai, G.M., P.N. Chary and S.C. Badhopadhyay, *Dynamics of growth in fertilizer use at micro level*, CMA, Indian Institute of Management, Ahmedabad, 1973.

5. Desai, G.M., and J.W. Mellor, "Changing basis of demand for fertilizers," *Economic and Political Weekly* 4(39), *Review of Agriculture*, September 1969.

6. Desai, G.M., and G. Singh, *Growth of fertilizer use in districts of India : Performance and policy implications*, CMA, Indian Institute of Management, Ahmedabad, 1973.

7. Fertilizer News, "Editorial comment : Dryland areas not only thirsty but hungry too." *Fertilizer News* 22(9), September 1977.

8. Giri, G., and R. De, "Economics of fertilizer use under rainfed conditions," *Fertilizer News* 19(9), September 1974.

9. Jha, D., "Fertilizer use and its determinants : A review with special reference to semi-arid tropical India," (mimeo.), ICRISAT, Economics Program, September 1978.

10. Kemmler, G., "Questions of fertilizer use in rainfed agriculture of arid and semi-arid regions," *Fertilizer News* 20(7), July 1975.

11. Krishnamoorthy, Ch., "Recent advances in fertilizer use for drylands,' *Fertilizer News* 19(12), December 1974.

12. NCAER, *Interim report : Fertilizer demand survey*, National Council of Applied Economic Research, New Delhi, 1978.

13. Saolapurkar, V.K., "Problems and prospects of fertilizer use in dryland areas--industry experience." Presented at the FAI Group Discussion on *Fertilizer Use in Drylands*, New Delhi, August 1979.

14. Sohbati, G.K., "Role of fertilizer industry in fertilizer promotion," *Fertilizer News* 24(4), April 1979.

15. Venkateswarlu, J., and E.D. Spratt, "Some suggestions for increasing fertilizer efficiency in dryland farming," *Fertilizer News*, 22(12), December 1977.

Appendix I. Distribution of SAT districts in different consumption level classes for nitrogen, phosphorus and potassic fertilizers : 1977-79

Consumption range (kg/ha of cropped area)	Irrigated SAT			Unirrigated SAT			Total SAT	
	No. of districts	% total SAT consumption	% irrig. SAT consumption	No. of districts	% total SAT consumption	% unirrig. SAT consumption	No. of districts	% total SAT consumption
(A) NITROGEN (N)								
> 60	14	18.8	28.9	nil	na	na	14	18.8
40.1 - 60	24	24.9	38.4	2	2.3	6.6	26	27.2
20.1 - 40	29	18.4	28.3	21	12.6	36.1	50	30.1
10.1 - 20	8	2.5	3.8	29	11.4	32.5	37	13.9
5.1 - 10	2	0.3	0.5	28	6.3	18.0	30	6.6
2.1 - 5	1	0.1	0.1	24	2.1	5.9	25	2.2
< 2	nil	na	na	10	0.3	0.9	10	0.3
	78	65.0	100.0	114	35.0	100.0	192	100.0
(B) PHOSPHORUS (P)								
> 40	1	1.0	1.8	nil	na	na	1	1.0
20.1 - 40	7	12.4	21.9	2	3.7	8.6	9	16.1
10.1 - 20	31	27.8	47.4	9	9.0	23.0	40	36.8
5.1 - 10	29	14.1	24.9	26	15.5	35.7	55	29.6
2.1 - 5	9	2.2	3.9	41	11.0	25.3	50	13.2
< 2	1	0.1	0.1	36	3.2	7.4	37	3.3
	78	57.6	100.0	114	42.4	100.0	192	100.0
(C) POTASH (K)								
> 20	1	5.7	10.1	1	2.5	5.8	2	8.2
10.1 - 20	10	19.1	33.7	4	6.2	14.2	14	25.3
5.1 - 10	19	14.7	25.9	11	12.2	28.3	30	26.9
2.1 - 5	38	16.3	28.8	26	14.8	34.1	64	31.1
1.1 - 2	4	0.5	1.0	20	5.1	11.6	24	5.6
< 1	6	0.3	0.5	52	2.6	6.0	58	2.9
	78	56.6	100.0	114	43.4	100.0	192	100.0

na Not applicable

Appendix II. Relative performance of districts recording high* growth in fertilizer consumption in the sixties and seventies

SAT category	Growth in: 1970's	1960's	Name of the district
			NITROGEN
Unirrigated	H	H	Nasik, Dhulia, Jalgaon, Kurnool, Kaira
	H	M	Ahmadnagar, Satara, Sangli, Kolhapur, Mysore, Bellary, Belgaum, Raichur, Mahbubnagar, Nalgonda, Baroda, Mehsana, Surat, Rajkot
	H		Khammam, Allahabad, Mirzapur, Sabarkanta, Kheri, Bahraich, Hardoi
	M	H	Gonda, Buldhana
Irrigated	H	H	Guntur, Nizamabad, S. Arcot, N. Arcot, Coimbatore, Tiruchirapalli, Madurai, Moradabad, Rae-Barelly, Thanjavur, E. Godavari, W. Godavari, Mandya, Gurdaspur, Amritsar, Jullunder, Ludhiana, Patiala, Ambala, Kurukshetra, Muzaffarnagar, Meerut, Bulandshahr, Gorakhpur, Deoria
	H	M	Warangal, Karimnagar, Chingleput, Aligarh, Mainpuri, Budaun, Varanasi, Kapurthala, Saharanpur, Bijnor, Jaunpur
	H	L	Agra, Barelly, Shahjahanpur, Rampur, Ghazipur, Ballia, Shimoga, Karnal
	M	H	Cuddapah, Faizabad, Basti, Hoshiarpur, Krishna, Ropar
			PHOSPHORUS
Unirrigated	H	H	Dhulia, Jalgaon, Ahmadnagar, Kolhapur, Kurnool Junagarh, Rajkot, Amreli
	H	M	Chitradurg, Bellary, Dharwar Belgaum, Raichur, Mahbubnagar, Nalgonda, Surat Bhavnagar
	H	L	Mysore, Khammam, Sabarkanta, Hassan
	M	H	Nasik, Buldhana, Satara
	L	H	Poona, Sangli
Irrigated	H		Krishna, Guntur, Nizamabad, N. Arcot, Coimbatore, Thanjavur, E. Godavari, W. Godavari, Mandya, Amritsar, Kapurthala, Jullunder, Ludhiana, Gorakhpur
	H		Warangal, Karimnagar, Madurai, Aligarh, Etah, Farrukhabad, Varanasi, Shimoga, Gurdaspur, Hoshiarpur, Patiala, Karnal
	H	L	Agra, Mainpuri, Ghazipur
	M	H	Bulandshahr, Tiruchirapalli, Salem, S. Arcot, Chingleput, Muzaffarnagar, Deoria
		H	Basti, Meerut

*The growth categories were (in tonnes of annual increment in consumption):

	N	P
High (H)	>750	>300
Medium (M)	301-750	101-300
Low (L)	<300	<100

The position for sixties was read from maps 3.1 (p.33) and 3.2 (p.38) of Singh [6]. Since the maps were not very legible we expect some marginal error in growth categories for the sixties.

ICR