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PERFORMANCE AND PROSPECTS OF CROP PRODUCTION IN INDIA

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Introduction

1 Viewed against the perspective of the experience of the pre-independence period, as well as the record of most other countries in a comparable phase of development, the performance of India agriculture since 1950 can hardly be considered insignificant. Crop production, which is by far the biggest component of agricultural output, has risen at an average annual rate of some 2.6 percent during the last 25 years[1/] compared to less than half a percent per annum during the first half of the 20th century[2/]. More importantly, in sharp contrast with the pre-independence era when the level of agricultural technique and productivity remained more or less stagnant, there have been substantial and sustained improvements in cultivation practice - improvement which are reflected proximately in the use of such inputs as water, fertiliser, better seeds and plant protection chemicals, and ultimately in the steady increase in per hectare yields of practically all important crops.

1/ Estimated by fitting the function log y=a+bt to the revised indices of agricultural production as published in GCI, Estimates of Area, and Production of Principal crops in India 1973-74 (mimeo)

2/ Estimated on the basis of three year average output centred around 1900/1 and 1950/51. The output estimates are from M.Mukherji, "A Note on the Long Term Growth of National Income in India, 1900/1 to 1952/3" in Indian Conference on Research in National Income, Papers on National Income and Allied Topics Vol.II (London 1960).

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2 On the international level, very few countries of comparable size and diversity have recorded sustained secular growth rates of this magnitude: The average annual growth rate of agricultural production between 1880 and 1960 has been estimated at no more than 1.5 percent in the USA and 1.9 percent in Japan; the average annual rate in UK was barely 1 percent[3/]. In more contemporary experience barring countries like Thailand, Mexico and Malaysia which are either relatively small and/or had large reserves of uncultivated land, growth rates in agriculture exceeding 3 percent a year are quite rare. And in China, which in size and diversity of natural conditions is closer to India than any other country, available evidence suggeststhat the rate of growth in the last two decades may not have been higher than in India.

3 Nevertheless, there is widespread dissatisfaction at the performance of Indian agriculture. Unlike the USA and Japan in the 19th century, India has the advantage of an accumulation of scientific knowledge for increasing productivity of land manifold. And since the gap between present and potential productivity in India is much greater than in countries like China, which had already achieved a very high level of intensity on land use and cultivation practices, it should be possible to step up the growth rate to much higher levels than recorded in Mainland China, Taiwan or Korea. Indeed, the Indian planners thought that, given the

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[3/] BruceF.Johnston and Peter Kilby, Agriculture and Structural Transformation (OUP, London, 1975) p.19?.

extemely low level of crop yields and the existence of a proven body of technical know-how for increasing yields, it should be possible to achieve considerably higher rates of agricultural growth-typically 4 percent or more per annum than those recorded by other countries in the past.

4 That these expectations have been and the actual record has consistently fallen short of target is the major reason for dissatisfaction. The concern has been further heightened by the apparent slowing down of agricultural growth during the last decade which, in the context of an acceleration in population growth, has resulted in a near stagnation of agricultural output per capita and in turn severely constrained the growth of the rest of the economy. Thus, as against the target of 4-4.5 percent a year, the trend rate of growth in crop production has been only 2.6 percent a year since 1950-51. The average annual growth rate between 1950-51/1954-55 and 1960-61/1964-65 was over 3 percent in the aggregate, and 1 percent per capita. In the subsequent decade, ending 1970-71/1974-75, the overall growth of crop output was around 2.1 percent.[1/] With population growing 2.4 percent a year, this meant a slight reduction in per capita crop output in the latter period.

5 The purpose of this paper is to examine the causes for the

1/ On the basis of a trend line ($\log Y = a+bt$) fitted to the time series of agricultural production index, the average annual growth rates work out to 3.4% during 1949-1961, and 2.4% during 1961-1973.

non fulfillment of targets and to assess the possibilities of, and constraints on, increasing agricultural production in the next decade or so. The arguments in the paper are based on a comparison of targets and achievements of food grain output for the country as a whole. In a situation marked by vast variations in such natural factors like soil, climate and water availability, as well as institutional conditions, the value of analysis for the country as a whole may rightly be doubted, the more so when the analysis relates only to a portion of the agricultural output. While more detailed and disaggregated analyses should be made, it is believed that the conclusions of the present exercise are sufficiently well grounded to merit serious consideration.

II

An Analysis of Performance 1961-1973

6 In trying to understand the reasons for actual growth falling persistently short of targets, a major problem arises from the rather loose manner in which the plans deal with the relation between targets and programmes. Typically the five year plans indicate (a) the targetted levels of production in the aggregate and for principal crops; (b) the targetted levels of use for major inputs; and (c) the set of policies and institutional framework to ensure that farmers do get the inputs and make effective use of them. However the Plans do not give targets/projections for some key inputs (the most notable example being total cropped area); more frequently over-all targets are given (as in the case of irrigation and fertilisers) but their crop-wise allocation is not indicated;

and, except in the case of foodgrains, the quantitative relations between inputs and output are seldom articulated. Even in the case of foodgrains this exercise is far from satisfactory. Such "looseness" in planning may be unavoidable, perhaps even justified, because of inadequate data on yield responses to different inputs and, more importantly, because the factors determining the farmer's rate of absorption of inputs as well as their allocation between crops are very complex and inadequately understood. All the same, it makes a meaningful analysis of deviations of actual performance from targets more difficult.

Sources of Production Growth: An Analytical Framework

7 We have nevertheless attempted such an exercise for foodgrains, which after all comprise the bulk of the country's crop production. In the absence of any systematic calculations of the contributions of different input elements to the targetted production in the plan documents, we have in effect tried to reconstruct the picture on the basis of (a) the targetted and the actual levels of use of selected key inputs; (b) available data on the proportion of different inputs applied to foodgrains; and (c) coefficients of yield response to each selected input estimated from various surveys. The procedure used and the basis for assumptions under (b) and (c) are detailed below.

8 The additional production potential for foodgrains is the sum of additions to production due to (a) expansion of area under foodgrains evaluated at the average yield per unit of area in the [illegible] base year, (b) increase in irrigated area under foodgrains; (c) the

shifts in the allocation of area from low-yielding type of grains (like millets) to those (like rice and wheat) which give a higher yield per unit area; and (d) increase in fertilizer application. These elements can be symbolically expressed as under:

$P_a = (A_t - A_o)Y_o$ where P_a denotes increased output due to area expansion; A_t represents total area under foodgrains in year t and Y_o the average per hectare yield of food grains in the base year.

$P_i = (I_t - I_o)Y_i$ where P_i denotes increased output due to irrigation; I_t represents irrigated area under food grains in year 't'; and Y_i stand for the absolute difference between per hectare yields of irrigated and un-irrigated foodgrains, notionally in the absence of any change in other inputs.

$P_c = (c_{jt}Y_{jo} - c_{jo} y_{jo})A_t$, where P_c represents the effect of changes in the proportion of area allocated to different food grains; Cjt represents the proportion of total area under food grains in year 't' allocated to grain 'j'; and A_t is the total area under foodgrains in year 't'.

$P_f = (F_{tn} - F_{on})\alpha + (F_{tp} - F_{op})\beta$ where p_f stands for additional production attributable to fertilisers; F_{tn} for nitrogeneous fertilisers (in term of N), and

F_{tp} for P_2O_5, applied to food grains in year 't', α and β are incremental response of foodgrains yield per unit of N and P_2O_5 respectively.

$P = P_a + P_1 + P_c + P_f$ (P= total increase in foodgrains production potential)

9 This framework, in effect, carries the arithmetical decomposition of output growth into area, crop pattern and yield effects[1/] a step further in trying to quantify the contribution of irrigation and fertiliser to yields. The exclusion of several other known yield-improving factors (like soil conservation, improved seeds, plant protection etc) as well as the apparently oversimplified concept of input-output relations implied by the additive model are the principal drawbacks of this scheme.

10 The effect of inputs other than land, water and fertilisers have not been included in the calculation essentially for want of reliable data on response coefficients and on the extent of increase in the quantum of these inputs. There is information to suggest that the yield increases due to varietal change, plant protection and better cultivation practices could be quite.

1/ See, B.S. Minhas and A. Vaidyanathan, "Growth of Crop output in India 1951-54 to 1958-61" Journal of the Indian Society of Agricultural Statistics vol XVII No.2, 1965.

significant[1]. However to the extent that these inputs are used in conjunction with water and fertilisers, it is essential to have composite yardsticks which net out the inter-action between the effects of different elements of the input package. In the absence of such information, it seemed prudent not to make any allowance for the contribution of such inputs on the basis of partial coefficients. Since the use of these inputs (including farmyard manure) has grown as fast, and in some cases much faster, than water or fertilisers, the estimates of additional production from the latter alone errs on the conservative side.

11 Some analysts[2] have tried to capture the impact of factors other than irrigation and fertilisers by computing the contribution of intensification of labour at the going wage rate (assumed to be equivalent to marginal product of labour). It seems impossible to get an accurate measure of labour input because of the lack of comparable time series of even the number of workers employed in agriculture, not to speak of the mandays of labour used in crop production. Secondly, except in a few operations like weeding, intensification of labour input does not by itself

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1/ For instance, the shift from local varieties of wheat to a high yielding variety like sonora by itself is believed to increase yield per hectare by one tonne. See B.S. Minhas and T.N. Srinivasan New Agricultural Production Strategy: Some Policy Issues", in Pramit Chaudhuri (ed) Readings in Indian Agricultural Development (1972). Similarly, the adoption of Japanese method of rice cultivation is estimated to increase productivity by 485 kg/ha, with fertiliser at recommended levels. See J.G.Pause, T.P. Abraham and C.R. Leelavathi Yardsticks of Additional Production of certain Food grains, Commercial and oil seed crops (New Delhi 1964)

2/ John W.Mellor et.al. Estimates of Foodgrain Production and Marketing From Input Estimates, India 1949/50 to 1973-74 and Prospects to 1983/84 (Cornell University, 1975, mimeo) increase productivity; it is more often a reflection of increased intensity of input use and in particular water, fertilisers, manures and plant protection. It seems more meaningful, therefore, to directly relate production to these basic inputs. Of course, to the extent one cannot account for all these basic inputs, there is something to be said for using changes in labour input as a proxy but so long as some of them figure in the calculation their effect on labour use has to be netted out. A third problem is that change in labour input may be affected by substitution between human, animal and mechanical power. The use of human labour alone can be justified if there was strict complementarity between different sources of power. That this is evidently not so, is shown by the disparate rates of change of human, animal and mechanical power input.

12 The lack of reliable data on the behaviour of labour and capital inputs makes the more conventional type of production function analysis of agricultural growth difficult. On the other hand, attempts to explain growth by statistical regression of output on area, irrigation and fertilisers have not been successful either in terms of R^2 or in terms of the commonsense interpretation of the coefficients. Perhaps this reflects the difficulty of specifying appropriate functional relations between output and the selected inputs. But pending a satisfactory solution to this problem, we have to make do with cruder ways of quantifying input/output relations.

Data and Assumptions

13 The figures of area under foodgrains (total and by individual grains) are actuals based on official statistics, and represent three year averages centred around 1950-51, 1960-61 and 1973-74. Data on actual irrigated area for these three years, in the aggregate and by individual foodgrains, are also available from published official sources. The target for irrigated area is derived by cumulating the targets for (a) major and medium projects and (b) the net additions on account of minor schemes for the Third Plan, 1966-69 and the Fourth Plan period. The irrigated area under foodgrains which would have been realised, if the irrigation programmes had been implemented as planned, is estimated by applying the observed proportion of irrigated area under foodgrains to the targetted increase in total gross irrigated area. The additional output per hectare due to irrigation alone is assumed to be 500 kg. Figures for targetted and actual total consumption of fertilizers are taken from the plan documents. For purposes of this exercise we have considered only nitrogenous and phosphatic fertilizers. Potassic fertilisers were excluded largely for lack of sufficient data on response coefficients. However more recent data [1/] show that the response to potassium is significant and large. Its omission, therefore, introduces another conservative bias in the estimates of potential production.

[1/] See K.S.Parikh, T.N.Srinivasan, et.al. Optimum Requirement of Fertilizers for the Fifth Plan Period (Indian Statistical Institute, New Delhi, 1974).

14 The average responses of foodgrains yield (in tonnes) per tonne of N and P_2O_5 represent conventional yardsticks estimated from simple fertiliser trials on farmers field conducted in the late fifties[1]. These trials were designed by "experimental techniques which are both scientific and simple enough to be adopted on cultivator fields without interfering with normal cultivation programmes and technique". Moreover the trials were designed so that "randomness in the selection of field was obtained to the maximum extent possible". The treatments were superimposed on the normal practices of farmers[2]. One can therefore assume with some confidence that the response coefficients obtained from these trials give a reliable measure of additional yield per unit of nutrient by itself, i.e., keeping other factors constant. Similar trials on HYV[3] as well as sample surveys of farmers[4] suggest that compared to local varieties (a) the yield of HYVs even without any fertiliser is significantly higher; (b) the optimal dose of fertilisers is much higher for HYV; and (c) the average response percent of nutrient at the recommended dosage is also significantly higher in the case of HYV. Despite strong evidence of superior fertiliser responsiveness of new varieties, which have spread rapidly since the mid sixties, we have chosen to be cautious by using the responses appropriate for traditional varieties.

1/ For a systematic analysis of the data and estimated response functions see V.G. Pause, T.P. Abraham and C.R. Leelavathi Yardstics of Additional Production of Certain Foodgrains, Commerical and Oilseed Crops op.cit.

2/ ibid

3/ See K.S. Parikh, and T.N. Srinivasan, op.cit.

4/ I.A.R.S. Sample Surveys for Assessment as High yielding varieties Programme Annual Report 1973-74; vol.I-Results of Yield Estimation Surveys (Mimeo), New Delhi, 1976

15. There are no reliable nation-wide data regarding the quantum of fertilisers applied to different crops. Surveys of some fifteen IADP districts show that in 1967/68 (a) the proportion of fertiliser used on foodgrains crops was greater than the proportion of area sown to foodgrains; (b) that the two proportions were positively associated and (c) the proportion of nutrients applied to foodgrains was generally higher than in 1962-63[1/]. For the for the country as a whole Desai estimated that in 1969-70, 73 percent of total nitrogeneous fertilisers was used for foodgrains[2/] and roughly the same proportion as being likely in the mid-seventies[3/]. The present calculations are based on the assumption that 75 percent of both N and P_2O_5 are applied to foodgrains. No attempt is made to further allocate this between irrigated and unirrigated areas or between different foodgrains. The latter refinements would, in principle, help take into account the water-fertilizer interaction. But since in practice, the bulk of fertilizers are applied to irrigated lands (and that too to wheat and rice) not much is lost by omitting them. The problem presented by interaction between water and fertilisers on the one hand and other inputs on the other is avoided by not taking any credit for the latters' contribution. In effect this means assuming that the other inputs are being used at levels which ensure that the marginal productivity of water and fertilisers will not be below the postulated levels. Since the latter are in any case conservative, the above

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1/ Ministry of Food, Agriculture, Community Development and Cooperation. Expert Committee on Assessment and Evaluation Modernising India's Agriculture; Fourth Report on the Intensive Agricultural District Programme 1960-1968 Volume I (New Delhi 1970)

2/ This estimate is referred to in John W Mellor et.al. op.cit.

3/ Gunvant M. Desai, Growth of Fertiliser use in Indian Agriculture Past Trends and Future Demand (Cornell University, Ithaca, 1970) assumption is perhaps not unrealistic.

16. The assumption that yield responses to N and P_2O_5 are additive, is again based on solid empirical grounds. Analysis of the earlier simple fertiliser trial data showed that, at the levels of fertiliser use recommended for traditional varieties, there is no significant interaction between the yield response to N and P_2O_5[1]. More recent data show that this is true even for high yielding varieties at much higher fertiliser dosages[2]. The foregoing arguments would suggest that, on balance, the estimates of productive potential derived here would tend be conservative.

The Estimates:

17. Table-1 presents estimate of (a) the additions to potential foodgrains production between 1960-61 and 1973-74 which would have resulted if the targetted expansion of irrigated area and fertiliser use had been fulfilled; and (b) the additional potential corresponding to the actual increases in irrigated area and fertiliser application. The table also gives estimates of the apotential addition to production during the 1950's on the basis of the actual levels of area, irrigation and fertiliser use in 1950-51 and 1960-61.

Reasons for Non-fulfillment of Targets:

16.

18. Short falls in Input Programmes: It is clear from the above table that food production targets were not realised largely because the expansion in irrigation facilities and fertiliser use fell short of the levels projected by the Plans. If the projected levels of irrigated area and fertiliser consumption had been reached, the production potential for food grains at

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1/ See P[illegible]se, et.al. op.cit

2/ Parikh & Srinivasan, op.cit, Appendix 3

Table 1 - Estimated Increase in Food Grain Production Potential
All India, 1950 - 1973

Addition to	1950-51 to 1960-61 Input	Response	Output (mill tonnes)	1960-61 to 1973-74 Target Input	Response	Output (mill tonnes)	Actual Input	output (mill tonnes)
Area	19.7 (mill ha)	.54t/ha	10.6	6.5 (mill ha)	.69t/ha	4.5	6.5 (mill ha)	4.5
Shifts in area allocation			4.7			3.1		3.1
Irrigation	3.8 (mill ha)	.5t/ha	1.9	15.5 (mill ha)	.5t/ha	7.8	11.6 (mill ha)	5.8
Fertiliser (N)	160(000t)	10t/t	1.6	2240(000t)	10t/t	22.4	1190(000t)	11.9
P_2O_5	52(000t)	6t/t	.3	1000(000t)	6t/t	6.0	470(000t)	2.8
Total			19.1			43.8		28.1
			(24*)			(48-49)**		(20)*

*Refers to increase in actual output over the two periods calculated on the basis of 3 year averages.

**Difference between Fourth Plan target of 129 million tonnes for 1973-74 and actual output of around 80 million tonnes in 1960-61.

the end of the Fourth Plan would have been some 44 million tonnes more than the level of output (normalised for weather fluctuations) in 1960-61; and this would have been close to the targetted increase in production, namely 48-49 million tonnes. The additional potential corresponding to the actual growth of irrigation and fertiliser use over the same period was only 28 million tonnes, i.e., less than two thirds of the target.

19. Of the two input programmes, slippage in irrigation accounts for a relatively small proportion of the difference between targetted and actual increase in food production potential. Within the irrigation programme, the targets for minor works have been consistently fulfilled or even exceeded. The short-falls are exclusively in the major and medium projects, and reflect persistent defects in planning the latter category of projects. Inadequate preparatory investigations, change in scope and design of projects after approvals, and a tendency to spread available resources thinly over a large number of projects have delayed completion of projects. And lack of attention and resources for construction of field channels, land improvement and other investments beyond the government out lets have resulted in inordinate lags between the completion of projects and the full utilisation of the water made available by them. This aspect of irrigation planning has, however, been receiving greater attention of late and has resulted in a significant improvement in the utilisation rates.

20. The bulk of the shortfall in food production relative to targets arises from the fact that fertiliser consumption at the end of the Fourth Plan was barely 60 percent of the assumed levels. The reason for this large gap unfortunately have not received the

attention they deserve. In a study published in 1968,[1] Desai argued that targets of fertiliser consumption derived from "needs" (i.e. quantum required to produce a given amount of agricultural output) or from "recommended dosages" may prove to be unrealistic. He pointed out that, though a need based calculation (including allowance for the High Yielding Varieties), gave a potential demand for nitrogeous fertilisers in the range of 2.7 to 3.5 million tonnes, the actual level of consumption by 1973-74 was unlikely to reach anything like this magnitude for several reasons. Allowing for the fact that the recommended dosages may not be profitable under unirrigated conditions, and that the profitability of fertiliser use under irrigated conditions will depend on the quality of irrigation he estimated the probable actual demand in 1973-74 may be between 1.7 and 2 million tonnes of N, with the possibility of a slowing down in the rate of growth in demand as it approaches these levels. Given the inadequacies of underlying data, the reliance on informed judgement, rather than rigorous analytical procedures, and the fact that the effect of additional irrigation facilities were not taken into account in making the projections, the remarkable accuracy of the predictions would seem to be fortuitous. Nevertheless, Desai's study focussed on the possible divergence between response coefficients and optimal dosages estimated from field trials on the one hand and those obtained by farmers under conditions of mass-

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1/ Gunvant Desai, op.cit.

application on the other[1].

21. Fertiliser Response: That this divergence may be significant is also confirmed by our finding that on the basis of a yield response to fertilisers as shown by simple fertiliser trials, (a) the actual increase in production during 1960-61 to 1973-74 (computed from 3 year averages) is much less than the additions to potential; and (b) the difference between additional potential created and increases in actual output is much greater in the sixties compared to the fifties. Thus between 1950/51 and 1960/61 the estimated additions to production potential on account of the specified inputs was about 19 million tonnes compared to an actual increase of 24 million tonnes (based on three year averages); the comparable figures for 1960/61 to 1973/74 are 28 million tonnes and 20 million tonnes respectively[2]. The divergence is the more significant when we consider that the sixties were marked by a rapid spread of HYVs which are supposed to be much more responsive to fertilisers than the traditional or improved-local varieties, and that the practically all yield raising inputs, besides irrigation, have shown an accelerated increase during this period.

22. While conclusions regarding the actual and potential field responses to fertilisers based on such crude and aggregate calculations cannot be definitive, they are suggestive enough to warrant

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1/ Besides these factors operating on the demand side, one should also consider the possibility of supply bottlenecks. While it is impossible to assert that the latter were not a significant factor throughout the period, the tendency for accumulation of fertilizer stocks in the late Sixties suggests that they were not a constraint at least in the latter part of the period.

2/ If we took a five year average, the additional output during 1960-1973 ([illegible] million tonnes) works out to higher than during 1951-1961 ([illegible].8 million tonnes). However the ratio of actual additions to potential additions to production during the sixties is still significantly higher than in the fifties and early [illegible].

much closer scrutiny. The profitability of fertiliser use, which is the major determinant of the farmers' willingness to apply recommended doses, depends on yield response and relative prices of food to fertilisers. There was a general improvement in the ratio of output to fertiliser prices during the sixties, which should have helped, in fact, to stimulate larger demand. Therefore, it is the magnitude of yield response which seems to be the critical factor. It is known that under rainfed conditions the response is generally lower, and that the optimal dose for any given relative prices of output and input is smaller compared to irrigated conditions. To the extent that the timing and quantum of moisture supply under rainfed conditions is highly uncertain, the yield response may also be highly variable, thereby increasing the risk. The combination of these factors is likely to inhibit the application of fertilisers to rainfed lands, their inhibiting effect being greater as one moves from relatively assured rainfall tracts to areas of low and uncertain rainfall. However, the number of farmers' field trials on unirrigated lands is far too small to assess the magnitude of these effects with precision.

23. In the case of irrigated areas, which in any case absorb the bulk of fertiliser, the quantum, timing and assurance of water supplies is highly variable and this can significantly affect the response coefficients. It is well known that the quality of water control and management over much of the irrigated area is far from satisfactory. But this is not by itself sufficient to explain why responses should be lower than shown by the fertiliser trials because the latter were reported to be conducted under existing conditions of water availability in irrigated tracts and, more importantly, because there has been a significant improvement in the

quality of irrigation reflected in the steady rise in the proportion of irrigated area served by groundwater.

24. Failure on the part of farmers to follow the recommendations regarding timing and mode of fertiliser application, the emergence of deficiencies in trace elements, and the higher basal requirements of nutrients for maintaining the yield level of the HYV's[1/] are some other technical factors which might have depressed fertiliser response. But far too little is known about these aspects of fertiliser use to permit any confident judgement of whether and how important they are as explanatory factors. Another possible explanation could be that the use of fertilisers is excessively concentrated in a particular areas or classes of land-holdings. But available data give no support to this hypothesis either: In fact, the use of fertilisers on foodgrain crops is quite widespread and, while there are considerable variations in the rate of application, the large majority of farmers use much less than the recommended doses.[2/]

1/ The base yield, without fertilisers, of HYV is much higher than for local varieties. The latter probably are adapted to the low fertility status of the soil and might be expected to sustain a certain level of yield indefinitely without fertilisers or manures. The higher basal yields of HYVs, to the extent they involve an annual rate of removal of nutrients higher than the rate of natural replenishment, would require a certain minimum application of nutrients in order to maintain the basal yields year after year. If this requirement is large, the apparent ratio of incremental yield to a given increment in fertiliser use may be less than suggested by the demonstration data for particular years.

2/ See, IARS, Sample Surveys for Assessment of High Yielding Varieties ...... op., cit. Note that, given the shape of the response curve, the average response per unit of nutrient at less-than-optimal dosages will be greater than at the optimal dosage. Of course there is considerable variation in response across regions. If crops and regions with a relatively low fertiliser response account for a disproportionate share (in relation to their share of crop area) in fertiliser consumption, this could depress the national average response. But this hardly seems likely. There are no data regarding responses in different land holding classes.

III

Prospect:

The Plan Perspective:

25. Though agricultural growth has consistently fallen short of targetted levels, and the rate of growth has recorded a fall in the sixties, the country's Plans continue to be based on the assumption that a 4-4.5 percent annual growth in agricultural production is feasible over the next 10-15 years. The revised version of the Fifth Plan[1/] Projects food-grain output to increase from around 105 million tones in 1973-74 to 125 million tonnes in 1978-79 and 160-170 million tonnes in 1988-89. The rate of non-foodgrain output is projected to rise from an estimated 3.9 percent a year in the fifth plan to nearly 5 percent per annum in the seventh plan period.

26. The strategy for longterm planning of the agricultural sector according to this document "centres round detailed assessment and exploitation of ground and surface water, intensification in application of new technologies in agriculture, extension machinery and programmes for supply of inputs, apart from attention to the special needs of problem areas and vulnerable segments of the society[2/]. True to past practice, the Plan does not give even rough estimates of the expected contributions of different input elements to output growth. However the document indicates the order of expected expansion in cropped and irrigated areas as well as in fertiliser use, from which rough estimates of potential production using the method outlined in the previous section can be attempted.

1/ Government of India, Planning Commission Fifth Five Year Plan 1974-1979 (New Delhi 1976), Chapter 2.

2/ ibid, p.8

27. Gross cropped area is expected to rise at the rate of around 0.6 percent per annum over the next 25 years, which is slighly more than the rate recorded in the sixties, but considerably below the rate experienced in the fifties. Much of this necessarily has to come from an intensification of cropping. Gross irrigated area is projected to grow by at least 4 percent a year and a more intensive growth (of unspecified dimensions) is postulated for subsequent plan periods. The consumption of fertilisers is projected to rise from 2.84 million nutrient tonnes in 1973-74 to 8 million tonnes by 1983-84. Assuming that the proportion of total cropped and irrigated areas allocated to foodgrains remains at the 1973-74 levels, that 75 percent of the nutrients are applied to foodgrains, and that yield response to different input are as assumed in Table 1, the projected growth of input supplied should generate an additional foodgrain potential of 47 million tonnes between 1973/4 and 1983/4 (Table 2). This would seem more than adequate to meet the targetted addition of 40 million tonnes over the same period implied in the plan[1]. However, this should not be taken as evidence that the input targets are over generous in relation to output objectives. One has to allow for [illegible], and [illegible] allow for the possibility that the proportion of inputs allocated to foodgrain crops may have to be progressively reduced if the much higher growth rate targets for non-foodgrain output is to be realised[2].

1/ Note that no allowance is made here for the additional foodgrain output on account of the shift from low yielding grains to rice and wheat which invariably accompanies the introduction of irrigation.

2/ The Parikh-Srinivasan study cited earlier suggested that the properly utilised, the output targets for 1978-79 could be reaslised with substantially smaller input of fertilisers then projected by the Plan. This is indicative of the scope for increasing the overall productivity of nutrients assuming that the responses derived from single fertiliser trials can be obtained under conditions of mass application. The latter assumption is precisely what the present paper argues to be doubtful.

Table 2 - Projected Growth of Foodgrain Production

Potential 1973/4 to 1983/4, All India

	1973-74		1983-84		Increase 1983/4 over 1973/74		
	Total	Foodgrain	Total	Foodgrain	Inputs	Response	Output (mill tons)
Area (mill ha)	162	128	172	133	8	0.84t/ha	6.7
Irrigation (mill ha)	42	34.	64	51.	17.[illegible]	0.50t/ha	8.5
Fertiliser N(mill tons)	1.83	1.37	5.6	4.2	2.83	10 t/t	28.3
P_2O_5 (,,)	.65	.49	1.5	1.13	.64	6 t/t	3.9
							47.2

Prospects for Growth: A Critical Assessment

28. The projected expansion of cropped area as well as that of fertiliser use are critically dependent on the expansion and improvement of irrigation: With the reserves of uncultivated land practically exhausted, more intensive cropping of land already under cultivation will have to be the principal source of additions to gross cropped area and this is, in turn, largely a function of the rate at which irrigation facilities can be extended and improved. Similarly, since irrigation greatly increases the capacity of plants to absorb nutrients, as well as the productivity per unit nutrient, the level of fertiliser use is also to an important degree determined by the extent of irrigation facilities available.

29. Targets of Irrigated Area: The expectations of the Fifth plan regarding the area to be brought under irrigation over the next 10 years implies additions to irrigated area at an annual rate of some 2.1 million hectares per annum, well below the rates likely to be realised in the current plan. However, these targets imply that practically all the

utilisable water potential be harnessed by 1990/1. This is however likely to present several major problems; First the estimates of ultimate potential are highly notional[1] and a great deal more work, by way of surveys and site investigation, will be needed to demarcate the precise locations and extent of groundwater, as also to generate properly investigated and engineered proposals for major and medium surface projects. Even with most determined and vigorous efforts to intensify these activities, the process will necessarily take time. To this have to be added the inevitable construction lags, which are apt to be quite long in the case of large surface projects. The concerned departments of government will no doubt claim that they have a large enough pipe-line of well-worked projects on the shelf, ready to be launched once the sanctions are given. But past experience is littered with far too many instances of bad planning and delayed implementation to permit these claims to be accepted without question. In the case of minor irrigation, apparently high rate of expansion can be achieved by multiplying pumpsets and tube-wells in known groundwater tracts. However, as has happened in some areas already, this can result in over-exploitation of resources leading to a depletion of the water supply over a period of time. While detailed surveys to locate promising new groundwater tracts are needed, the lack of such knowledge is not always the binding constraint. The eastern part of the Gangetic basin is known to have abundant sources; but the fact that, despite the big increase in availability of funds, these potentials have been meagerly utilised perhaps points to the

1/ The highly nebulous character of these estimated ultimate potential is underlined by the large unexplained upward revisions in the last 10 years. The Fourth Plan placed the ultimate potential at 82 million hectares. These estimates were substantially raised by several states in their responses to the Irrigation Commission questionnaire. The net result was to increasethe figure to 87 million ha. Within a year of the Irrigation Commission Report, however, the Planning Commission task forces on Surface and Groundwater revised the estimate to 107 million hectares. (See <u>Draft Fifth Five Year Plan 1969-74</u> p.105). Since no details of the basis for the latter are available, we have used the estimates derived from the Irrigation Commission Report.

social and institutional obstacles.

30. A second major problem arises from the highly unbalanced distribution of unexploited potential as between states in relation to the distribution of financial resources for undertaking new projects. Table 3 gives an idea of the existing irrigated area by states, additions to irrigation since 1961 and the additions required to fully exploit the estimated potential. Haryana, Punjab, and Tamil Nadu, which accounted for nearly 30 percent of the additions to irrigated area during the sixties, have harnessed practically all the utilisable water. The unexploited potentials are concentrated in A.P, Madhya Pradesh, Maharashtra, Mysore, Orissa, U.P and West Bengal. In order to exploit the potential in these states fully by the late eighties, the rate of annual additions to irrigated area during the period 1970-1985 would have to be 3-10 times the pace actually recorded during the sixties. To look at it another way, it will call for a major reallocations of the provisions for irrigation may be gauged from the fact that, many of the above states will have to contribute a much higher share of future expansion than they have in the sixties or are likely to in the Fifth plan. Whether this order of realignment of inter-state allocation of irrigation funds is at all possible under the existing arrangements for financing state plans is far from clear. The question has not even been posed so far. Moreover some of the states with apparently large unexploited potentials (notably A.P., Gujarat, Maharashtra, Madhya Pradesh and Mysore) are involved in disputes. Unless these are resolved, the prospect for

Table:3 -- Irrigation potential and its Exploitation-India

10^6 ha

	Ultimate potential (mill ha) [1]	Area irrigated (mill ha) 1960-61 [2]	Area irrigated (mill ha) 1971-72 [3]	Addition 1960-1970 (mill ha)	%	Balance of potential (mill ha)	%
Andhrapradesh	8.7	3.5	3.8	0.3	2.8	4.9	10.2
Assam	2.2	.6	.6	-	-	1.6	3.3
Bihar	5.8	2.1	2.8	.7	6.5	3	6.3
Gujarat	2.6	.7	1.3	.6	5.6	1.4	2.9
J & K	.4	.3	.3	-	6	.1	.2
Kerala	1.5	.5	.5	.1	.9	[illegible]	1.9
Madhya Pradesh	8	.9	1.7	.8	7.5	6.3	13.2
Maharashtra	6.2	1.2	1.6	.4	3.7	4.6	9.6
Mysore	5.5	1.0	1.6	.6	5.6	3.9	[illegible]
Orissa	4	1.1	1.6	.5	4.7	2.4	5.0
Punjab & Haryana	6.9	3.9	6.6	2.7	25.2	.3	.6
Rajasthan	3.2	1.8	2.4	.6	5.6	.8	1.7
Tamil Nadu	3.4	3.3	3.5	.2	1.9	-	-
Uttar Pradesh	22.5	5.5	8.4	2.9	27.1	14.1	29.4
West Bengal	5.1	1.4	1.5	.4	3.7	3.6	7.5
All India		27.9	38.5	10.7			

Source: 1. Govt. of India, Ministry of Irrigation and Power, Report of the Irrigation Commissioner 1972 Volume-1. (New Delhi) p.218-219. The report gives two sets of figures; one as given the Fourth Plan (1969-74) and another as estimated by the states in response to the Commission's questionaire. The latter figures have been used wherever available. In other cases, figures the fourth plan estimates are adopted.

2. Govt. of India, Central Statistical Organisation, Statistical abstract of the Indian Union 1965. (New Delhi-1966)

3. Govt. of India, Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of area and production of Principal Crops in India 1973-74, (mimeo 1975)

harnessing these potentials within the next decade are dim indeed. For all these reasons the feasibility of irrigation targets assumed by the Fifth Plan is open to some doubt.

31. Quality of Irrigation: Along with quantitative expansion, a major effort to improve the quality of irrigation is essential. Optimum performance of new seed varieties, on which much of the hopes for large output expansion rests, is crucially dependent on assured, adequate, and timely supply of moisture in relation to plant-water requirements. This calls for a degree of sophistication in water control and management which cannot be attained without major changes in the design and operation of the irrigation systems.

32. The problems are in part of a physical (technological) character and arise from inadequate attention to construction and maintenance of field channels to carry water from government outlets to the individual plots; failure to provide adequate drainage facilities; excessive losses in conveyance of water from source to the field; wastage due to the neglect of levelling, bunding and other measures to properly prepare to land for irrigation, and excessive ragidity of irrigation schedules in major and medium surface irrigation projects. These deficiencies as well as the remedies are by now well known [1]. Many of the features needed to ensure speedy and efficient use of water (notably field channels, drainage and land preparation) are being implemented as part of the Command Area Development programmes intended to cover some 15 million hectares of cultivable command area

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[1] GOI, Planning Commission, Draft Fifth Five Year Plan, 1974-1979 (p. 110)

See also Chapter VII on Agricultural Development in the Report of the Irrigation Commission (1972).

under some 50 major projects.[1] But the plan gives no indication as to when this target is supposed to be realised. Information on the actual progress of these schemes is also rather scanty. It seems likely, moreover, that while many of the improvements can be incorporated in the design of new projects, they will be far more difficult to accompli[illegible]xisting projects (whose potential is already over 25 million hectares).

33. On the basis of past experience one should expect strong resistence to the implementation of other essential pre-requisites of efficient water use, namely consolidation of holdings and regulation cropping pattern. The successful examples of statutory consolidation programmes are largely confined to the Indo-Gangetic Plain perhaps because the differences in land quality in these tracts are much less than in other parts of the country. Whatever the reason, consolidation has not made much headway elsewhere and apparently does not command the necessary political support.

34. The regulation of cropping pattern, and more far reaching ideas of integrated planning of land and water resources development at the local level [2], involve far more complex questions of institutional reform. For instance take the relatively simpler problem of enforcing the crop pattern which will maximise social benefit per unit of water. Where land in the command area of an irrigated project is owned and operated by a large number of farmers each with fragmented holdings - and this is typically the case in all parts of the country - and individual farmer can, and often does, gain at the

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1/ GOI, [illegible] Five Year Plan [illegible] 1974, op.cit, p. [illegible]

2/ See B.S. Minhas 'Rural Poverty, Land Redistribution and Development Strategy' in P.K. Bardhan and T.N. Srinivasan (ed) Poverty and Income Distribution in India (Calcutta 1974). Also Planning Commission, Interim Report on Integrated Agricultural Development Projects in Canal Irrigated Areas by the Task Force on Integrated Rural Development, (1972).

expense of others by violating the socially desirable allocation of water in time and space. One manifestation of this is the tendency for the farms near the head of a canal system to grow crops which are more water intensive than desirable from social viewpoint and leaving the farmers at the tail end with little or no water. Even within the area commanded by a distributary, conflicts arise over who should get how much water and in what sequence. The relative power of different claimants is often the decisive factor in settling these conflicts. Not only does this result in an inequitable distribution of the benefits of irrigation between farmers in the command area, but could well lead to a reduction in the additional output per unit of water.

35. Unless farmers cooperate, or can be made to cooperate, in enforcing the crop patterns, as well as timing and quantum of water deliveries to individual plots necessary for achieving maximum production per unit water, it is difficult to ensure efficient use of irrigation. Clearly the formulation of regulations by the State is not by itself sufficient. Experience has amply shown that no state agency can really police compliance of regulation in this sphere, much less enforce compliance. This can be done only by local institutions governed by the farmers themselves which, in turn, is predicated on collective acceptance of the socially-desirable regime on all members of the community. The lack of such institutions is an extremely severe constraint on the extent to which the efficiency and productivity of India's irrigation systems can be improved.

36. A serious weakness of the Command Area and other similar programmes lies precisely in their tendency to view the organisational problem as one of strengthening the official machinery and to skirt around the problem of building effective local institutions. Unless

viable solutions are found to the latter --and there is hardly any sign of this happening -- major qualitative improvements in water use and management are unlikely. This has particularly serious implications for the level and efficiency of fertiliser use.

Fertiliser Use:

37. The critical importance of fertilisers to the attainment of targetted output can be judged from the estimate (See Table 2) that nearly three fourths of the expected addition to output during the next decade is contingent on the expansion of fertiliser use and on achieving yield response of at least the levels obtained in the simple fertiliser trials with traditional varieties. The targetted level of fertiliser use implies an increase in the average rate of application from around 14 kg. per hectare in 1973-74 to over 40 kg. per hectare in 1983/4. Since the potential for fertiliser application on rainfed land is limited, the bulk of the increase will have to be on irrigated lands. The projected increase in irrigated area will itself contribute significantly to an expansion of fertiliser use, but not enough to realise the plan targets. The latter require a sharp rise in the average rate of application per hectare of irrigated area to reach 100 kg. or more per hectare by 1983/84. To achieve this degree of intensification of fertiliser use within the next decade calls for an extra-ordinarily rapid improvement in the standards of farming techniques. A necessary condition is significant increase in the productivity of plant nutrients from the levels apparently realised in the nearest past. Unless the actual responses are brought closer to the levels demonstrated to be feasible by the Fertiliser Trials, the total absorption of fertilisers will be less, and the additional output will be more than proportionately smaller, than postulated by the Plan. We have noted in Section II that the

factors responsible for the apparent divergence between potential and actual fertiliser responses are quite complex and not sufficiently understood. Serious investigations to identify these factors and work out remedial action are urgently needed for all crops and for both irrigated and rainfed tracts. But since the bulk of fertilisers are, and will be, concentrated on irrigated land, the primary focus will have to be on the latter.

38. Prima facie, major improvements in the quality of irrigation systems seems to be one essential condition for increasing the productivity, and hence the profitability, of fertilisers. But, as mentioned earlier, the pace of such improvement is subject to severe constraints. There may also be other factors depressing fertiliser response below technically feasible levels. In the case of non-cereal crops, the absence of a varietal break-though and the relative paucity of fertiliser trials under field conditions pose additional problems. Finally, in so far as the efficient use of fertilisers involves a learning process on the part of the farmers, there is bound to be a considerable time lag before actual responses reach the technically feasible levels. For all these reasons, the prospects for increasing the productivity of fertilisers, and hence of achieving the targetted level of use, are quite doubtful. This in turn brings the feasibility of the crop output targets into serious questions.

39. Any attempt to judge what the realistic expectation of the additions to irrigated area, the rate of improvement in quality of irrigation and the growth of fertiliser use will be is necessarily hazardous. But it is significant to note that, even if projected increase in crop and irrigated areas under foodgrains as well as yield response to fertiliser are realised, the quantum of fertiliser needed to

sustain a mere 3 percent rate of increase in foodgrains output will be around 4.7 million tonnes compared to the 1973/74 level of 1.9 million tonnes, involving a significant intensification of fertiliser use on irrigated areas. Given the fact that there has hardly been any growth in fertiliser use for several years and the strong reasons for doubting the feasibility of the irrigated area targets or of rapid enough improvements in irrigation systems, one cannot confidently taken even this for granted.

Conclusion:

40. This is an admittedly pessimistic assessment of the prospects for accelerating agricultural growth, at any rate in the next decade. A degree of optimism may well have been justified a decade back: At that time, it seemed to most observers that given the abysmally low productivity and technological level of Indian agriculture, rapid growth should be relatively easy to achieve by a combination of massive investments in irrigation and fertilisers, supported by extension and credit. The advent of the HYVs in the mid-sixties lent greater confidence to this view. But faced with the fact that, after a decade of accelerated irrigation development, fertiliser use, and the rapid spread of HYVs, growth rates of production have not increased, and may have in fact fallen, compels a sober re-assessment. This is all the more important because, directly or indirectly, many of the problems of the Indian economy in recent years - whether it be inflation, stagnation of investment, or imbalances between production capacity and demand - are traceable to the poor performance of agriculture. To persist in planning based on a naive optimism of agricultural prospects in the face of such experience, can only further compound these problems.