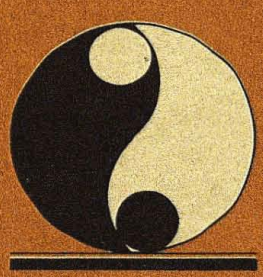
Journal of Indian School of Political Economy

Vol. VI No. 4

October-December 1994



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Editorial communications should, however, continue to be sent to the Editor, Journal of Indian School of Political Economy, 'Arthabodh', 968/21-22, Senapati Bapat Road, Pune 411 053.

JOURNAL
OF INDIAN SCHOOL
OF POLITICAL ECONOMY

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Vol. VI | October-December 1994 | No. 4

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BACK ISSUES AVAILABLE IN HARD BOUND VOLUMES

Vol. No.	Number of pages	Price (Rs.)
Vol. I-II (1989 and 1990) combined	1,000	500
Vol. III (1991)	800	500
Vol. IV (1992)	800	500
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IMPACT OF IRRIGATION ON PRODUCTIVITY OF LAND

A. Vaidyanathan, Asha Krishnakumar, A. Rajagopal, and D. Varatharajan

That irrigation makes a significant difference to productivity of land is obvious enough. There is ample evidence that yield of particular crops per unit area is invariably higher under irrigated than under rainfed cultivation; crop patterns on irrigated land are very different from those on unirrigated land; and irrigated land is generally used more intensively through the year than unirrigated land. Expansion and improvement of irrigation is therefore considered to be the crucial, 'leading' input for raising agricultural productivity especially in countries like India where the scope for expansion of cultivation is practically exhausted. It is also generally known that the extent of the difference on these accounts taken individually and collectively is not uniform across space or over time; that it depends on the source of irrigation, the way water is managed, on the quality of seed varieties and level of fertiliser use; and that both the benefits of irrigation and its costs also vary.

I
REVIEW OF PAST WORK

There have been several attempts to assess the magnitude of irrigation impact on productivity, the variation therein and causes thereof. These can be broadly divided into two categories. One relying on multiple regression analysis to estimate the extent to which variations in production per unit of area across space and time are attributable to variations in the extent, and in some cases, quality of irrigation [Abbie *et. al.*, 1982; Dhawan, 1988; Mahendra Dev, 1989; Ranade, 1980; Rao, 1971; Vaidyanathan, 1980; and Vaidyanathan and Mukherjee, 1989]. The second seeking to directly estimate the differences in the average total output per unit irrigated and unirrigated area from available data, on land use, irrigated and rainfed area by crops and crop yields in specific projects and in different regions [For a summary of these studies see Dhawan, 1988 and Vaidyanathan, 1987].

Regression Analysis

A number of studies have used the multiple regression technique to assess irrigation impact. Abbie *et. al.* estimated a linear regression of *total agricultural* income across major states in 1977-78 on rainfall, irrigated and unirrigated crop areas. Dhawan used the same technique (with fertilisers and time as additional explanatory variables) to estimate output per ha of irrigated area from time series data (1966-67 to 1978-79) for selected states in the Indo-Gangetic plain, south India and the Deccan plateau. Rao examined the relation between rate of agricultural growth and the increase in the irrigation during the 1950s across a cross section of states. Ranade was concerned with spatial variations in per hectare output and its relation to rainfall, irrigation ratio, fertiliser use per ha and crop pattern. For this purpose, districts were grouped into 56 regions and the relation tested for three different points of time.

The regressions in general confirm that the average output per irrigated hectare is higher than that of unirrigated areas and that the differences in irrigation ratio are a significant factor in accounting for variations in output per unit area to both across space and time. The regressions on cross-section data do much better than time series and in the latter case where the dependent variable is aggregate output rather than per hectare output.

However, there are a number of problems both in specifying the function relating output to inputs and estimating it. The Abbie model, for instance, implicitly assumes that production of irrigated

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This is the consolidated report on the study of productivity impact of irrigation conducted by the Madras Institute of Development Studies, as part of a larger project on Costs and Productivity of Irrigation sponsored by the Planning Commission, Government of India. A. Vaidyanathan had the overall responsibility for the study. The work on regression analysis of district cross section data (section 2) was largely done by Asha Krishnakumar; that on time series analysis of district level data (section 3) by D. Varatharajan. The section on direct estimates of productivity of irrigated and unirrigated areas at the state level and analysis based on that (section 4) is primarily the work of A. Rajagopal. Both Asha Krishnakumar and A. Rajagopal have contributed to the work on district level estimates for Tamil Nadu reported in Section 5. The integrated report has been written by A. Vaidyanathan based on the reports on different components of the study.

We gratefully acknowledge the unstinting and efficient help of Mrs. P.S. Syamala in typing several drafts and carrying out several corrections and modifications. We would also like to acknowledge our debt to B.D. Dhawan, S. Janakarajan and S. Mahendra Dev for useful discussions at various stages of the study and for their comments on some of the earlier drafts.

and unirrigated lands is the same across states/regions - which is obviously difficult to reconcile with vast inter-regional differences in agro-climatic conditions. Dhawan's formulation for analysing time series data on the other hand is based on the equally questionable assumptions that unirrigated yield is solely a function of rainfall and that all fertilisers are used on irrigated lands. (Interestingly, Dhawan does not hesitate to use an essentially similar formulation as that of Abbie to estimate productivity of rainfed land and different categories of irrigated land from cross section data). The Ranade formulation has the advantage of focusing directly on overall productivity per unit area, but cannot capture the effect of irrigation on crop patterns, or of the level and efficiency of fertiliser use. In so far these indirect effects are important the regression would understate the impact of irrigation. Rao's assumption that agricultural productivity growth is a function of growth in irrigation ratio ignores the fact that some elements of bio-chemical technology are changing independently of irrigation and that such changes (e.g., HYV) affect both old and newly irrigated areas.

In all cases, there is also the problem of deciding which inputs to include and specifying the precise functional form of the relation to be estimated. Most of the studies referred to above focus on the rainfall, irrigation and fertilisers as the key inputs. Some studies use specifications which include human and animal labour, mechanical power, indices of inequality, tenancy, etc., among the explanatory variables [see e.g., Mukhopadhyaya, 1976]. The former is however to be preferred in as much as it focuses clearly on the bio-chemical determinants of land productivity and keep out other factors which have more to do with determining the state of advance in biochemical technology and its diffusion, how much of the basic bio-chemical inputs are used, how the operations involved in their application and management are organised, and which forms of motive power are used in cultivation [see Vaidyanathan, 1978 on this issue]. But the bio-chemical inputs include not only water and fertilisers, but the seed varieties used, efficacy of pest and disease control measures and the quality of irrigation. The care with which cultivation is done - and this is a function more of the intensity, timeliness and proper management of non-bio-chemical inputs - can also affect yields.

Lack of data precludes all these inputs from being considered; but their omission makes the estimates subject to 'excluded variable bias'. Moreover convenience of estimation usually dictates assuming that the input-output relations are linear. But it is well known that there are non-linearities such as diminishing marginal product as the level of a particular input rises, and synergy between inputs (e.g., irrigation-fertilisers-HYV). And in time series estimation attempts to capture the effect of excluded variables by including 'time' as a catch all factor gets into problem of multicollinearity.

These complexities figure prominently in the literature on analysing the sources of growth and fluctuations in agricultural productivity [Cummings and Ray, 1969; Mukhopadhyaya, 1986; Rao *et. al.*, 1989; Ray, 1977; Vaidyanathan, 1980; Vaidyanathan and Mukherjee, 1980]. Data limitations, the multicollinearity problem and difficulties of capturing the complex inter-relations between the various inputs and their yield impact are daunting. The best that can be done is to explore the relation between overall crop output per unit area and the level of rainfall, extent (and quality) of irrigation and fertiliser use.

Direct Estimates

Estimates of the productivity per unit irrigated and unirrigated land derived directly from data relating to area and yields of various crops are sought to be extended and refined. The ideal would be to compare actual output per hectare of cropped and cultivated area irrigated by specific irrigation projects over a period of years before and after the introduction of irrigation. A less satisfactory alternative is to compare the productivity in the command of particular systems with that of unirrigated areas in the vicinity. These have the advantage of controlling for climate and soil and also permitting comparisons between different types of systems (canal, tanks, canal+well, well) in a given area. But we have very few 'before and after' studies [e.g., Gadgil,

1948]. Studies of the 'with and without' type are also rare [For a review see Dhawan, 1988; Vaidyanathan, 1987].

The other way is to use the available estimates of irrigated and unirrigated areas under various crops and their respective yields. These data collected and published by the Ministry of Agriculture, are available over a period of time, at the state level and at least for some states by districts. Dhawan [1988] and Vaidyanathan [1987] used these data for estimating the levels of productivity on irrigated and unirrigated areas, as well as the trends therein, for the major states. The assumptions and estimation procedures used by them however differ in important respects.

Both classified crops into predominantly irrigated and predominantly unirrigated; the total area under the former (latter) was assumed to be wholly irrigated (wholly rainfed) and the average overall yield of the crop taken as a reasonable approximation of irrigated (rainfed) yields. However, in order to get aggregate output, Dhawan used a concept of foodgrain energy equivalents (FEES) based on calorie content of different crops. All foodgrains are assumed to have the same caloric value per unit. Calorie value of groundnut was taken at 120 per cent of foodgrains, cane gur at 110 per cent and potatoes and bananas 25 per cent. Crops like cotton and jute which have little significance as source of calorie are assumed to produce the same calorie per ha as foodgrains and groundnut.

The crops were grouped into five broad categories. The difference between the estimated irrigated and unirrigated yield in each category (in terms of FEES) was weighted by its share in the irrigated crop pattern to get a measure of the increased productivity on irrigated land. The effect of differences in crop patterns are not taken into account. On the other hand, adjustments are made for differences between kharif, rabi and perennials in terms of 'output foregone from irrigated crop areas by not raising alternative dry crop' [For details see Dhawan, 1988, Ch. 3, especially Pp. 74-82].

Vaidyanathan [1987] estimated the value of output per ha of irrigated and unirrigated areas on the basis of the average prices obtained by the producer in the market. Crops which are grown predominantly under irrigated (rainfed) conditions are taken as wholly irrigated (rainfed). In other cases, the ratio of estimated yield under irrigated and that obtained under unirrigated conditions, taken along the official estimates of crop-wise average yields and irrigated-unirrigated area distribution, were used to derive irrigated and unirrigated yields of each crop. The aggregate value of output (of the selected crops) per unit of irrigated area and per unit of unirrigated area is then derived on the basis of average product prices of each crop as estimated by the CSO for computing national income. The difference between irrigated and unirrigated productivity thus obtained reflects the effects of differences both in yields of particular crops and in the crop patterns in these two categories of land.

Both studies give estimates of irrigated and unirrigated productivity across states at a point in time and their respective behaviour over time. Dhawan reports interstate variations in unirrigated yield to be positively correlated and irrigated yields as well as the difference between irrigated and rainfed yields to be negatively correlated to rainfall. But the statistical significance of the relation is not indicated. Adding fertiliser as an additional explanatory variable (assuming that all fertilisers are used on irrigated land), 65 to 70 per cent of the variation in irrigated yield and irrigated - unirrigated differential is explained. Dhawan also fitted linear trends to the state level series of irrigated and unirrigated yields essentially to assess the role of irrigation in stabilising output. There is no discussion on the relative behaviour of irrigated and rainfed yields or their variation across states. Apart from the fact that linear trend is not appropriate in all cases, the estimates reported in the book do not indicate the statistical significance of the coefficients. Vaidyanathan found that in most states and in most districts in Tamil Nadu, irrigated yield shows a significant rising trend, while unirrigated yields were either stagnant or reducing in a majority of instances.

II
OBJECTIVES AND SCOPE OF THE PRESENT STUDY

Regression Analysis

This study seeks to refine and extend the analysis using both the above approaches. The multiple regression approach is applied at a more disaggregated level (namely districts) than in earlier studies which relate to the country as a whole or to states. An attempt is also made to see if the interactions between level of rainfall and irrigation, and yield response to irrigation can be captured by partitioning the districts into 'homogeneous' categories. The possibilities of estimating these relations from district level time series are also explored at some length.

Like earlier studies of irrigation impact, yield differences across space and time are viewed primarily as a function of rainfall, irrigation and fertilisers. Together they capture the essential elements of the agro-climatic environment and the biochemical technology affecting yields. Why the levels of irrigation and fertiliser use are what they are, and how effectively they are used, depends on numerous other factors (including relative prices, progress in biochemical technology, incidence and terms of tenancy, infrastructure and the like) which can be studied separately. Since crop pattern is a function of soil moisture conditions (defined by rainfall and irrigation), there is no need to include the former as a separate variable especially when we are interested in assessing irrigation impact on productivity. Including crop pattern as a distinct variable will understate the impact of irrigation. This is evident from Mahendra Dev's regression results which show that the coefficient for irrigation is much lower when crop pattern figures among the explanatory variables than when it is excluded [Mahendra Dev, 1989].

For these reasons, it seems appropriate to view yields as a function of rainfall (R), the irrigation ratio (I) and fertiliser use per hectare (F). For purposes of this study, we postulate average crop yield to be a linear additive function of rainfall, irrigation ratio and fertiliser use per ha.

$$Y_t = a + bR_t + cI_t + dF_t + u \qquad (1)$$

This functional form - which is chosen partly for lack of data on other inputs and partly for convenience in estimation - implies that the yield response to each input is proportional to its level and independent of the level of other inputs and their impact on yield. These assumptions are obviously open to question. However it may be possible to take care of the non-linearities and synergistic relations between inputs, when the relations are estimated at the level of districts. Given the large number of districts (over 200 in this exercise) for which the above relation can be estimated, we can classify them into groups homogeneous in respect of conditions of agriculture. Since the soil moisture regime is known to be critical for fertiliser use and its effectiveness, as well as for the performance of HYVs, we use rainfall and the level of irrigation as the basis for stratifying districts into homogeneous groups. Unless fertiliser use is strictly complementary to rainfall/irrigation, comparison of the magnitude of yield impact of each one of these inputs under different agro-climatic conditions will enable us to judge whether the response to irrigation is systematically related to rainfall and whether response to fertilisers varies systematically with respect to rainfall and irrigation.

Direct Estimates

Estimates of the value of production per ha of the irrigated and rainfed areas are based on official data on land use, irrigation, crop patterns and yield. Productivity is measured in terms of market value of output per unit area. This a simpler measure, more comprehensive and also economically more meaningful. The general approach is the same as used in Vaidyanathan [1987] except that the state level estimates cover a larger number of crops (23 as against 12 in the above mentioned paper). The district level estimates for Tamil Nadu cover a somewhat longer period, 1970-1983. Variations in the absolute and relative magnitudes of the difference between irrigated and rainfed productivity across states both at a point of time and in their behaviour over time are highlighted. And an attempt is made to explore some tentative explanations for these differences.

The study of Tamil Nadu districts covers somewhat wider ground in attempting to explore the impact of irrigation on cropping intensity and crop patterns as well as on the absolute and relative yield levels of irrigated and unirrigated areas.

We planned to use the cost of cultivation surveys which collect detailed plot-wise information for a sample of farms and provide a potentially rich source for comparing differences in productivity of plots without irrigation and those served by different sources of irrigation, as well as their relative behaviour during the last twenty years. But access to the original schedules unfortunately remains a serious impediment to such an exercise.

SCHEME OF THE REPORT

The details of the cross-section regression analysis and the results are summarised in section III and those relating to the district level time series regressions in section IV; Section V presents the estimates of irrigated and unirrigated productivity and their relative trends at the state level; and section VI the results of the district level analysis for Tamil Nadu. The concluding section summaries the main findings and their limitations and outlines the directions of further work.

III
CROSS SECTION REGRESSIONS

Scope and Method

The exercise is based on Bhalla-Tyagi estimates of the gross area sown and value of output for 19 major crops along with data on gross irrigated area and fertilisers for three points of time namely 1962-65, 1970-73, and 1980-83 made by Bhalla and Tyagi [1989]. The data cover 281 districts spread over 16 major states. However, non-availability of rainfall data (normal and actual) for some districts made it necessary to restrict the study to 216 districts covering 10 states. The 19 crop estimates are based on data relating to actual output in each district; Bhalla-Tyagi also give estimates for another 22 crops. But the district estimates are based on the state average yield for each crop in this group applied to the area sown to each of these crops reported in district level statistics. We have confined analysis to 19 crops, on the assumption that the overall irrigation ratio and fertiliser use/ha (which cover a larger number of crops) give a reasonable approximation of the relative irrigation ratio and fertiliser use in respect of the 19 major crops. We are grateful to Mahendra Dev for making this data available. The excluded states are Assam, Bihar, Kerala, Jammu and Kashmir, Orissa and West Bengal. We have grouped the districts into three rainfall zones, namely, districts with normal annual rainfall below 750 mm; those with rainfall between 750 and 1,050 mm; and those with more than 1,050 mm rainfall. Within each rainfall zone we further distinguish between districts where the irrigation ratio is below average and those where it is above average. In principle a further classification in each rainfall - irrigation ratio category by level of fertiliser use is possible. But we have not done this for two reasons: first because it would reduce the number of observations available in each stratum; second, and far more important, the nutrients used per hectare of gross cropped area - which is the only information available - is not as easy to interpret as rainfall or irrigation ratio. The average nutrient used per ha of area is influenced by differences in the extent of fertiliser use between irrigated and rainfed land, the crop patterns on these two categories of land and of course the irrigation ratio itself. All these are highly variable across districts, and regions with very different rainfall irrigation ratios could have the same average nutrient per ha of gross cropped area. Later in the paper an alternative grouping based on rainfall, irrigation and growth of yields is used to highlight the importance of efficiency of fertiliser use.

Table 1 gives the mean values of rainfall, irrigation ratio and overall fertiliser use per ha of area in the six rainfall zones - irrigation categories. This shows that output per ha in the high irrigation tract is higher than in below-average-irrigation districts; that in each irrigation category the output/ha rises as we move from low to high rainfall zones. It turns out that in all the rai fall zones, districts with above-average irrigation ratio have somewhat higher mean rainfall than those with low irrigation ratios; the high

irrigation districts in all rainfall zones have several times higher mean levels of both irrigation ratio and fertiliser use; and across rainfall zones the mean irrigation ratio as well as mean fertiliser use in each irrigation category do not differ much in the early sixties but widen progressively in the subsequent periods. Nevertheless, the sharp differentiation in respect of irrigation and fertiliser use between the two irrigation strata in each rainfall zone, combined with a broad similarity in each irrigation stratum across rainfall zones, facilitates comparisons of the impact of irrigation and fertiliser response across rainfall regimes as well as response to rainfall and fertiliser across irrigation regimes.

TABLE 1. MEAN VALUES OF SELECTED CHARACTERISTICS FOR DISTRICTS IN EACH RAINFALL - IRRIGATION CATEGORY CLASSIFIED BY NORMAL RAINFALL AND 1962-65 IRRIGATION RATIO

Zone	1962-65				1970-73				1980-83			
	Output per ha	Fertilisers[1]	Irrigation Ratio[2]	Rainfall[3]	Output per ha	Fertilisers[1]	Irrigation Ratio[2]	Rainfall[3]	Output per ha	Fertilisers[1]	Irrigation Ratio[2]	Rainfall[3]
LR LI	409	1.9	7.1	572	507	9.5	10.6	504	664	20.8	20.1	562
LR HI	826	5.3	38.5	625	1,154	26.8	49.6	575	1487	63.3	57.1	599
MR LI	564	1.7	7.3	892	608	10.0	10.3	817	780	23.3	17.5	905
MR HI	890	5.3	34.7	910	1,055	24.6	40.4	868	1,377	61.8	48.5	941
HR LI	758	1.7	5.4	1,515	797	10.9	9.5	1,464	1,004	25.5	14.1	1,502
HR HI	1,080	6.0	38.2	1,354	1,268	28.9	41.6	1,299	1,513	58.0	46.1	1,409

1. Kg of nutrients/ha (N,P,K); 2. Irrigation ratio is the ratio of gross irrigated area under all crops to the total gross cropped area (GCA). We have taken the total area under 41 crops as a close approximation of GCA. Estimates of fertiliser use per ha are also computed from the data on total nutrients consumed and the total area under 41 specified crops for each district; 3. mm;
LR = Low Rainfall (< 750 mm);
MR = Medium Rainfall (750 mm - 1,050 mm);
HR = High Rainfall (>1,050 mm);
LI = Below Average Irrigation Ratio;
HI = Above Average Irrigation Ratio.

We therefore estimate the relation (1) on cross-section data for districts in each rainfall irrigation stratum at particular points in time.

SPATIAL DIFFERENCES IN YIELDS AND IRRIGATION

Differences in R, I and F explain, in most cases, upwards of 60 per cent of yield differences between districts (Table 2). The proportion of variance explained is higher in the high irrigation category in all rainfall zones during 1962-65 and 1970-73, and in the low rainfall zone during 1980-83. There is no consistent pattern in variation of R^2 across rainfall-irrigation categories in 1962-65 or 1970-73; but in 1980-83 the proportion of variance accounted by the selected input variables increases progressively from the low to the high rainfall zone in the low irrigation category, the converse tendency being manifest in the high irrigation category. In the low rainfall zone and in the high irrigation districts of the high rainfall zone, the proportion of variance explained by the selected variables is considerably higher in 1962-65 than in the subsequent two periods; while in the medium rainfall zone and low irrigation districts of high rainfall zone the opposite is true.

Somewhat surprisingly - and contrary to findings of Ranade, and Mahendra Dev - variations in rainfall do not show up as a significant factor accounting for yield variations in several strata. In the low rainfall zone the coefficient is positive and significant only in three out of six cases (two in 1960s and one in 1980-83); all but one of the coefficients for rainfall in the medium rainfall zone are non-significant; in the high rainfall zone, the coefficient is positive and significant at all three points of time in the low irrigation category, but only in one year in the high irrigation category.

The coefficient values are unstable with no perceptible trend over time. It is possible that the number of observatories at the district level being small, estimates for individual districts may be much noisier than for the groups of districts or at the state level.

The coefficients for fertilisers are all positive, almost all of them being statistically significant. Fertilisers and moisture availability are believed to have a synergistic relation to yield. This would lead one to expect the fertiliser response to be higher in better irrigated areas within a given rainfall regime and at a given level of fertiliser use; and given the level of irrigation, when rainfall is more abundant. Our regressions show that in six out of seven cases where coefficients for both irrigation categories are significant, the value of the fertiliser coefficient in the below - average irrigation category is higher than in the above - average category. This does not necessarily mean that the synergy hypothesis is invalidated in as much as districts with above-average-irrigation, use much more fertilisers and therefore may be affected by diminishing returns.

TABLE 2. ESTIMATED COEFFICIENTS OF MULTIPLE REGRESSION OF OUTPUT PER HECTARE ON RAINFALL, IRRIGATION AND FERTILISERS

Zones	1960-65				1970-73				1980-83			
	R	I	F	R^2	R	I	F	R^2	R	I	F	R^2
LR LI	0.355*	18.75*	31.00*	0.76	C.159	21.10*	11.8*	0.70	0.77*	3.15*	10.60*	0.68
	(0.115)	(4.60)	(7.16)		(0.261)	(6.07)	(3.34)		(0.27)	(2.29)	(2.18)	
LR HI	0.814*	10.43*	31.20*	0.95	0.121	6.92*	14.5*	0.88	0.254	5.38	11.61*	0.90
	(0.134)	(1.11)	(2.34)		(0.303)	(2.76)	(2.70)		(0.341)	(3.31)	(1.70)	
MR LI	0.073*	10.58*	52.99*	0.52	0.152	15.87*	12.40*	0.64	-0.020	12.70*	7.50*	0.75
	(0.139)	(3.45)	(10.35)		(0.166)	(3.40)	(3.36)		(0.158)	(2.72)	(1.89)	
MR HI	0.034	8.20*	24.96*	0.56	0.189	10.60*	15.53*	0.73	-0.709*	7.48*	8.87*	0.65
	(0.250)	(2.56)	(7.39)		(0.230)	(2.57)	(3.05)		(0.230)	(3.05)	(1.81)	
HR LI	0.298*	9.55	49.27*	0.68	0.211*	-1.90	21.16*	0.67	0.357*	3.21	12.10*	0.85
	(0.0460)	(7.18)	(14.89)		(0.060)	(4.72)	(4.95)		(0.050)	(3.39)	(1.74)	
HR HI	0.161	2.57	64.05*	0.82	0.99*	22.57*	8.60	0.76	0.330	22.30	2.80	0.46
	(0.127)	(4.24)	(15.75)		(0.327)	(7.17)	(6.76)		(0.470)	(15.0)	(5.70)	

Figures in brackets relate to standard error of coefficients.
Statistically significant coefficients are marked with asterisk (*).

On the other hand the fact that the coefficients for comparable irrigation categories (between which there is not much difference in mean levels of fertiliser use) are generally higher in the high rainfall zones than in the low rainfall zones is indicative of synergy. Taking all the zones and years together, it is also seen (see Figures 1 (a) and (b)) that though the fertiliser coefficient tends to fall as the level of fertiliser use increases in both low and high irrigation districts, the coefficients in the high irrigation districts are generally higher and show a much more gradual decline with reference to the level of fertiliser use than in the low irrigation districts.

The other notable feature is that coefficients for fertilisers have fallen progressively and steeply in all the six strata, the decline between 1960s and 1980s mostly ranging from 50 to 85 per cent. The HRHI regime is an extreme case where the reduction is much steeper (from +66 in 1960s to practically zero in the 1980s). This general decline in the yield impact of fertilisers (keeping rainfall and irrigation constant) cannot be attributed wholly or even primarily to diminishing returns, in as much as the decline is seen at very different levels of fertiliser use, and there is no relation between the extent of decline and the level of application per ha across the strata. Given that fertiliser is an imported and capital intensive input, and that productivity under field conditions seems to be much less than obtained in demonstrations, the reasons for this phenomenon need closer investigation. But this is outside the purview of the present exercise.

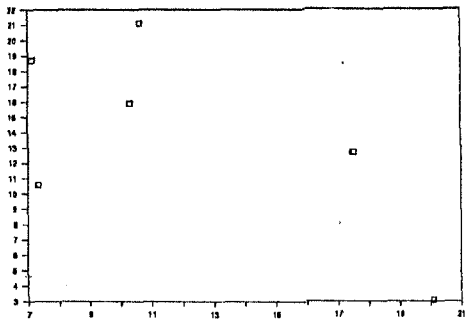

Figure 1(a) (Low Irrigation)

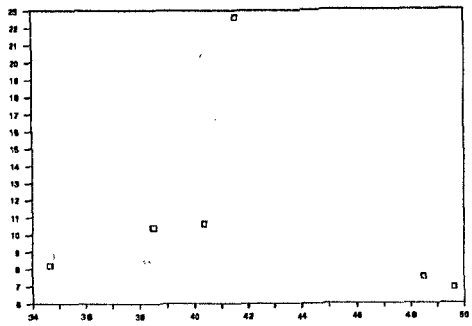

Figure 1(b) (High Irrigation)

Extent of irrigation and Yield response to irrigation $\overline{X}$ % of GCA irrigated $\overline{Y}$ value of regression coefficient for irrigation

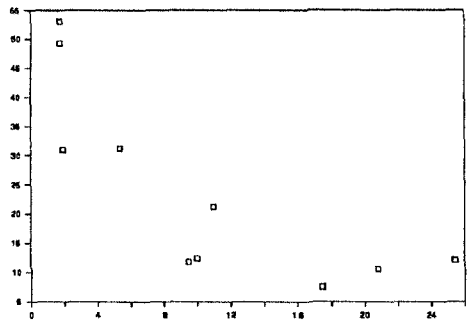

Figure 2(a) (Low Irrigation)

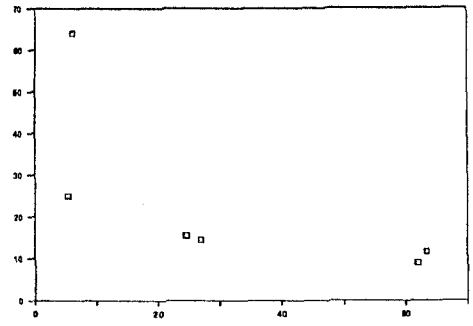

Figure 2(b) (High Irrigation)

Level of fertiliser use per ha and yield response to fertiliser $\overline{X}$ Nutrients per ha (kg) $\overline{Y}$ value of regression coefficient for fertiliser per ha

The coefficients for *irrigation*, which give a measure of the impact of irrigation on output per hectare of cropped area, *given rainfall and fertiliser use*, are positive and statistically significant in four out of six cases in the low rainfall regime; in all six cases of the medium rainfall regime; but in only one case in the high rainfall regime. Though one would expect the impact under conditions of abundant rainfall to be relatively low, it is somewhat surprising that irrigation seems to have no significant impact on output per ha in high rainfall zone.

For comparable irrigation categories, during 1962-65, the strength and/or magnitude of the coefficient for irrigation is relatively high in low rainfall zones and falls progressively as we move to medium and high rainfall zones. This conforms to the expectation that irrigation is likely to make a greater impact in low rainfall areas. But in the later periods, the pattern of variation is not clear. During 1970-73, in the low irrigation category, the coefficient is highest in the low rainfall zone and the least in the high rainfall zone; the opposite trend is noticed in the high irrigation category. In 1980-83, the irrigation coefficients are significant only in the medium rainfall zone.

The behaviour of the irrigation coefficients as between the three points of time covered by this study also shows a mixed pattern. In one case (LRHI) its value falls progressively over the

period; in LRLI, MRLI and MRHI the coefficient in 1970-73 is higher than in 1962-65 but falls or becomes non-significant in 1980-83. In the high rainfall zones, no trend is discerned as most coefficients are non-significant. Plotting the irrigation coefficients (wherever they are significant) against the irrigation ratio over the years (Figures 2 (a) and (b)), it would seem that yield responses to irrigation *per se* tend to be clustered at relatively higher levels in the low irrigation districts than in the high irrigation tracts.

SPREAD OF IRRIGATION AND CHANGES IN PRODUCTIVITY

From Table 1 it is apparent that while productivity has increased in all categories, the increase is much greater, both in absolute and relative terms, in the high-irrigation districts. There are also significant differences in the extent of change in irrigation and fertiliser use. In general the gap between low and high irrigation tracts has narrowed in respect of irrigation and fertiliser even as the yield gaps have widened. Given the differences both in respect of the level of yields and of changes in yields across rainfall-irrigation categories, it is of some interest to see whether there are also significant differences between these zones in the impact of changes in input factors on yield changes.

The estimated coefficients of multiple regression relating changes in yields with changes in the three input variables in different rainfall-irrigation ratio groups are presented in Table 3. The strata being defined with reference to normal rainfall and base year irrigation ratios, the districts falling each rainfall-irrigation category are unchanged over time. Irrigation and fertiliser use have grown appreciably in all zones but at different rates. Therefore, the estimated coefficients of increase in yield with respect to increments in irrigation are of special interest.

TABLE 3. RESULTS OF REGRESSIONS BASED ON INCREMENT OF PER HA YIELD AND RELATED VARIABLES

	1962-65 to 1970-73				1970-73 to 1980-83				
Zones	R	I	F	$\bar{R}^2$	R	I	F	$\bar{R}^2$	N
LR LI	0.509*	22.68*	0.72	0.345	0.186	0.129	7.08*	0.257	35
	(0.240)	(7.81)	(3.49)		(0.21)	(1.65)	(2.32)		
HI	0.039	13.19*	4.57*	0.810	0.150	13.70*	7.15*	0.717	28
	(0.223)	(2.78)	(1.54)		(0.27)	(5.1)	(1.22)		
MR LI	0.063	11.89*	3.27	0.370	0.061	7.59*	2.74	0.295	49
	(0.880)	(3.65)	(2.64)		(0.09)	(3.43)	(1.76)		
HI	0.200	12.09*	14.00*	0.720	-0.165	23.26*	3.81*	0.770	41
	(0.161)	(2.29)	(2.80)		(0.20)	(3.05)	(1.82)		
HR LI	-0.002	9.98*	-4.15	0.313	0.225	5.06	7.17*	0.560	43
	(0.050)	(2.70)	(2.27)		(0.13)	(4.41)	(1.67)		
HI	-0.179	-11.80	11.00*	0.480	0.169	19.96	4.62	0.047	19
	(0.218)	(7.50)	(3.56)		(0.31)	(12.74)	(3.00)		

Figures in bracket give standard error of coefficients.
Statistically significant coefficients are marked with asterisk (*).

The proportion of variance in the increments to output per hectare explained by the changes in R, I and F is in most cases much lower in the low irrigation districts than in the high irrigation groups; the difference being more marked in the period from 1970-73 to 1980-83 than in the previous decade. The proportion of variance explained in the latter period is the same or lower than between 1960-63 and 1970-73 in four cases and about the same or higher in the other two categories.

Changes in rainfall do not seem to bear any significant relation to changes in productivity in any of the categories during either period. Between 1962-65 and 1970-73, differences in increments to fertiliser use had no significant impact on the increments in output per hectare in the low irrigation category districts. But they had a significant positive effect in the high irrigation categories of all rainfall zones. This was despite the fact that high irrigation districts invariably had much larger increases in level of fertiliser use than

the low irrigation districts. This could be a reflection of synergy between fertiliser and irrigation leading to a significant upward shift in the fertiliser - yield response curves under irrigation. The incremental response coefficient of fertiliser is also seen to be relatively low in the LRHI compared to medium and high rainfall regions.

During the seventies, when irrigation had become more widespread even in low irrigation districts, the fertiliser coefficients are seen to be stronger and/or higher compared to the sixties. In the high irrigation districts, which had higher initial levels and a larger increment of fertiliser use, the incremental response coefficients of the 1970s for the medium and high rainfall zone are substantially lower/weaker than in the 1960s. In the low rainfall zone, however, the coefficient in the 1970s shows a marked increase. This may be due to the fact that this category includes most of the 'green revolution' districts (Punjab, Haryana, West Uttar Pradesh) where the high yielding varieties covering a higher proportion of crop are introduced and the quality of the irrigation showed the greatest improvement. The environment in medium and high rainfall zones is not as conducive to HYVs, which in any case were not available for all crops. Overall, the coefficients of incremental yield with reference to increments in average fertiliser use show no particular pattern.

As for the productivity impact of the spread of irrigation-- confining comparisons only to those cases where the coefficients are significant in both periods -- the following points emerge from Table 3: (i) Between 1962/65 and 1970/73, the spread of irrigation made a significant impact on yield in all cases except the high irrigation districts of high rainfall zone. The estimated yield response to incremental irrigation is (a) higher in the low irrigation category than in the high irrigation district of each rainfall zone; and (b) inversely related to rainfall in each irrigation category. The incremental effect of changes in the extent of irrigation in LRLI is about 90 per cent more than MRLI and 130 per cent more than HRLI. The difference in the high irrigation category as between low and medium rainfall zones is not as marked, while the impact in HRHI is negative, though statistically non-significant. (ii) In the seventies, the pattern is quite different. The coefficients, though positive, are non-significant in LRLI and in both irrigation categories of high rainfall districts. In the medium rainfall zone, the only case where coefficients are significant in both irrigation categories, the response to incremental irrigation, as in the 1960s, is higher in the high irrigation districts than in the low irrigation category. And (iii) the value of the irrigation coefficient in the seventies is higher than in the 1960s in the high irrigation categories and lower in the case of low irrigation tracts.

COMPARISONS ACROSS RAINFALL-YIELD GROWTH STRATA

An alternative stratification would be to group districts in each rainfall zone according to the direction and magnitude of change in per hectare output in the two periods. Three categories of districts are distinguished: (a) those which have experienced a decline in per ha output; (b) those which have recorded an increase in per ha output higher than the average for districts reporting an increase in per ha output; and (c) those where the increase is lower than average (Table 4).

In both periods, in the low and medium rainfall zones, districts where productivity is declining have on the average significantly lower productivity, less irrigation and also lower fertiliser use compared to the districts where productivity has grown. Among the latter again, the districts with higher than average growth have higher productivity, substantially higher level of irrigation and (in the 1970s) higher levels of fertiliser use compared to those with below-average growth of productivity. This characteristic is also shared by above-average growth districts in the high rainfall zone but districts reporting a decline in yields had higher mean yields, higher fertiliser use, and at least in the 1960s higher irrigation ratio than the slow growth districts.

The results of the multiple regressions (summarised in Table 5) show that when districts are classified in terms of growth performance, the equation does much better in both periods in terms of the proportion of variance in yield changes 'explained' by the changes in selected inputs. Thus during the first period, $\bar{R}^2$ exceeds 0.6 in five out of nine cases in the growth based stratification compared to two out of six in the irrigation based categorisation. The comparable proportions in the 1970s being eight out of nine and three out of six, respectively.

TABLE 4. MEAN VALUE OF PRODUCTIVITY AND INPUTS IN DIFFERENT CATEGORIES OF DISTRICTS

Rainfall Zone	Growth Category	Mean Value in 1962-65				Mean Value in 1970-73			
		Output/ha	RF	%IA	F	Output/ha	RF	%IA	F
L	Decline	460	593	11.2	1.87	358	463	12.5	9.4
	Below average	627	617	19.1	4.29	795	589	25.0	16.8
	Above average	619	574	27.1	3.24	1,050	466	43.1	23.0
M	Decline	614	886	13.0	3.35	363	771	7.5	9.3
	Below average	723	925	21.0	3.40	753	843	23.0	15.2
	Above average	779	873	24.0	3.10	1,087	853	33.4	22.3
H	Decline	918	1,556	15.2	3.22	843	1,570	11.3	14.6
	Below average	730	1,440	10.0	1.59	806	1,342	16.1	13.1
	Above average	962	1,427	22.2	4.56	1,208	1,474	28.2	22.8

Note: The classification into below average and above average districts is made with reference to average percentage increases in per hectare yields among districts reporting a rise in yields for each rainfall zone and period separately.

TABLE 5. ESTIMATED COEFFICIENTS OF MULTIPLE REGRESSION OF CHANGES IN PRODUCTIVITY IN CHANGES IN SELECTED INPUTS

Rainfall Zone	Growth Category	1960s					1970s				
		N	RF	%IA	F	$\bar{R}^2$	N	RF	%IA	F	$\bar{R}^2$
Low	Decline	11	0.186	-22.96*	-3.97	0.52	10	0.43	2.17	15.31	0.61
			(0.99)	(2.59)	(0.92)			(0.72)	(0.64)	(1.65)	
	below average growth	26	-0.009	9.52*	4.01*	0.70	36	0.123	11.19*	9.35*	0.87
			(0.07)	(3.43)	(3.54)			(0.48)	(4.81)	(7.12)	
	above average growth	26	0.072	7.59*	6.14*	0.84	17	0.216	8.53*	12.84*	0.96
			(0.36)	(3.03)	(4.40)			(0.60)	(2.26)	(3.28)	
Medium	Decline	22	-0.146	19.6*	1.58	0.75	7	1.17	16.78*	-7.96	0.73
			(1.43)	(8.7)	(0.52)			(1.39)	(2.62)	(1.13)	
	below average growth	42	-0.021	1.33	3.95*	0.28	59	0.014	6.32*	9.72*	0.74
			(0.41)	(0.84)	(3.90)			(0.09)	(3.21)	(5.66)	
	above average growth	26	0.222	7.02*	12.04*	0.68	24	-0.235	7.46*	9.85*	0.78
			(1.16)	(2.70)	(4.88)			(1.06)	(2.55)	(4.00)	
High	decline	16	0.243*	5.44*	-4.86	0.70	9	0.603*	19.87*	-0.452	0.85
			(3.85)	(1.86)	(4.03)			(3.95)	(2.28)	(0.08)	
	below average growth	25	-0.008	-2.12	2.32*	0.30	33	0.205*	4.20	14.66*	0.80
			(0.38)	(1.58)	(3.07)			(2.8)	(1.53)	(6.04)	
	above average growth	21	-0.067	-7.44*	8.71*	0.57	20	0.362*	12.68*	11.78*	0.60
			(0.77)	(2.85)	(5.21)			(2.45)	(2.55)	(2.16)	

* Statistically significant.
Note: Figures in brackets relate to 'T' values of estimated coefficients.

In general, changes in rainfall, irrigation and fertilisers account for a higher proportion of variance in yield changes during the 1970s than during the 1960s. In the low rainfall zone, in both periods, the proportion of variance explained is least in the declining districts and highest in the above-average growth districts. This is also the case in the 1970s in the medium rainfall zone. But in the high rainfall zone changes in selected inputs seem to be far more important in explaining the yield changes in the districts where it is declining than in the districts where it is increasing at a relatively fast rate.

In the low rainfall zone, in both periods, the productivity effect of irrigation changes is higher and that of changes in fertiliser lower in the below-average-growth districts than in the above average group. Higher productivity of incremental fertilisers seem to be the main reason for higher productivity growth. In this zone, in both categories of districts, yield impact of both incremental irrigation and incremental fertiliser is higher in the 1970s.

In the medium rainfall zone, by contrast, productivity impact of changes in irrigation and in fertiliser use in the above average growth districts is higher than in the below-average group in both periods. The difference in the second period is however considerably less than in the first. The yield impact of changes in irrigation is higher in the 1970s than in the 1960s in both groups of districts reporting a rise in yields. But in the case of fertilisers the impact of incremental use in the 1970s is higher than during the 1960s in the below-average growth category, the reverse being the case in the above-average growth districts.

The high rainfall zone presents a very different picture. Somewhat surprisingly, unlike in the low and medium rainfall zone changes in rainfall turns out to be a significant factor affecting yields in the high rainfall tract especially in the 1970s. Among the districts reporting a fall in productivity, changes in rainfall are a significant factor in both periods and have a much higher effect on yield changes than in the growing districts. During the 1960s difference between below-average and above average yield improvement was entirely on account of differences in the response to fertilisers. In the second period, the yield impact of incremental irrigation and fertiliser use are higher than in the 1960s wherever the coefficients are significant. Altogether the impact of changes in rainfall, irrigation and fertilisers on the magnitude and direction of yield changes seem to be more complex in the high rainfall zone than in the other rainfall zones.

Some Limitations

Several caveats have to be borne in mind while interpreting these results. In the first place the output per ha relates to only 19 crops. While they, on the average, account for 85 per cent of area and output of 41 crops at the national level, their share in area and output of 41 crops varies from as little as 35 per cent in some states to as much as 95 per cent in a few. The variability in this respect at district level is much greater.

Apart from the fact that the 41 crops figuring in the Bhalla-Tyagi exercise are not exhaustive - they do not include, for example, fruits and vegetables - the ratio of area under 19 crops to 41 crops is not a reliable indicator of the ratio of the respective values especially at the district level. More detailed work to collect district level data for all the crops is needed to get a better approximation to the value of output per gross cropped hectare. We also need to allow, as far as possible, for quality differences in respect of the same crop (e.g., cotton) grown rainfed and with irrigation.

Output per ha of gross cropped area is not an adequate measure of land productivity. The more appropriate index would be output per ha of cultivated land (or net sown area). It has the merit of capturing the effect of irrigation on cropping intensity, output per ha of net sown area and avoiding biases arising out of neglect of differences in the duration of various crops. Because of partial crop coverage and the fact that extent of this varies as between regions, it is not possible to make a proper correction in this exercise. All one can say is that the procedure used in this paper understates the impact of irrigation in as much as irrigated lands tend to have substantially higher cropping intensity than rainfed areas.

The relations are estimated for irrigated and

unirrigated areas taken together. The response functions, including the nature and extent of interactions among inputs, are not the same on irrigated and unirrigated lands. Thus the estimated fertiliser use per hectare represents an average which conceals wide variations in the extent and intensity of fertiliser use on irrigated and rainfed areas, on different crops, and on different varieties of a given crop. The yield response to fertilisers differing as it does between soil-moisture regimes, crops and crop varieties, the 'average' coefficient is difficult to interpret. One could get a better idea if yield and fertiliser data were available for irrigated and rainfed areas separately and differences in quality of irrigation were taken into account.

The following set of equations takes care of some of these points.

$$y = y_i\, a + y_u\,(1 - a) \quad \ldots (2)$$
$$y_i = f_i\,(R, Rd\ Fi\ Q) \quad \ldots (3)$$
$$y_u = f\,(R, R_d\, F_u) \quad \ldots (4)$$

Where y = output per ha overall.
a = Proportion of irrigated to total crop area.
y_i = output per ha of irrigated area.
y_u = output per ha of unirrigated area.
R = total rainfall.
R_d = the proportion of rainfall occurring in the main monsoon season of the region.
F_i = fertiliser used per ha.
F_u = fertiliser use per hectare of irrigated area of unirrigated area.
Q = an index of irrigation quality. Equation (3) and (4) imply that while changes in irrigation and rainfed yields are both influenced by soil moisture and fertiliser use, the nature and magnitude of impact are different. But estimating this set of equations requires more information than usually available.

The regression coefficient for irrigation is supposed to give a measure of the difference which irrigation alone makes to productivity, given rainfall and level of fertiliser use. But in so far as the level of irrigation influences the fertiliser response curve and, therefore, the level of fertiliser use as well as its productivity, the coefficients do not fully reflect the direct and indirect effects of irrigation on yield. They also do not allow for the influence of differences in quality of irrigation.

These limitations cannot be overcome with the Bhalla-Tyagi data set. The ICRISAT data set, which provides a continuous time series of relevant variables (including net sown area and sources of irrigation) for 164 districts, offers scope to assess the cropping intensity, crop pattern and per hectare yield effects. We have estimated the time series yield functions for each of the districts and then compared the value of the coefficients for groups of districts classified by level of rainfall, level and dominant source of irrigation. This exercise is discussed below. Beyond that, we have to take recourse to direct estimates of output on irrigated and unirrigated lands, preferably at the farm level, to get at a closer approximation to the overall impact of irrigation on land productivity. The results of these exercises are reported thereafter.

TIME SERIES ANALYSIS FOR SELECTED DISTRICTS

Data Sources and Limitations

District level data on cultivated and cropped area (irrigated and unirrigated), and output of major crops and the total quantity of fertilizers used over the period have been compiled by ICRISAT for seven states for the period 1956-57 to 1978-79. The crop coverage is not similar for all the seven states. The crop-wise data for Maharashtra, Gujarat and Rajasthan cover 16 major crops while for the remaining four states, namely Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu, the data relate to 23 crops. The crops for which area and output figures are available, on an average, account for about 77 per cent of total cultivated area in the case of the districts belonging to the first group of states and 85 per cent for the second group of districts.

Though the crop coverage of available statistics is incomplete, the value of output per ha computed from them can be taken as a reasonably good approximation of the productivity of all crops, on the assumption that the productivity of excluded crops is more or less the same or bears a constant relation to that of crops for which data are available. This is a tenable assumption if the

nature and extent of crops covered do not vary across districts at any point in time or over time in a given district. This unfortunately is not the case. In order to mitigate the problem, the analysis is limited to 110 districts where the selected crops cover more than 80 per cent of the total crop area. The actual crop coverage among them ranges between 81 per cent and 99 per cent with average of 90 per cent. There is still the problem that the extent of coverage in each district may not, and typically does not, remain the same throughout the period of study. This aspect and its implications are discussed a little later.

The district level yield data are also subject to errors partly because they are not strictly based, in all cases, on actual crop-cutting. Even if based on crop-cutting, the magnitude of error would be more than that of the state level estimate. Differences in the organisation and procedures for collection of data in respect of area across states are recognised but not accounted here. Some major changes in this regard have occurred in the states like Tamil Nadu and Andhra Pradesh following abolition of the Patwari system. The use of national average prices across all the districts and years has the marked disadvantage of not allowing for differences in quality/prices of the same crop across space and also for systematic changes in the quality mix of particular crops in a given district over time.

The Estimating Function

The considerations involved in specifying the estimating function have already been discussed in the previous section. For purposes of cross section analysis we postulated yield to be a linear, additive function of rainfall, irrigation and fertiliser use. Typically, though not always, irrigation and fertiliser use are rising over time, the inclusion of both in the regression raises the problem of multicollinearity. Other variables (especially HYV, quality of irrigation, gradually improving mastery over new techniques as a result of learning from experience) which affect the overall yields in a given district for a given level of input and fertiliser use, are also systematic functions of time. Because of this, the option of using 'time' as a catch-all for excluded inputs and learning effects is precluded. The possibility of getting around the problem of estimating the potential yields due to increased irrigation and fertiliser use, and testing for the existence of trend in the residual has been explored by Vaidyanathan and Mukherjee [1989]. But whether this really is a valid way out remains debatable. While the correlation between irrigation and fertilisers is not always high (and in a few cases may even be non-significant), we have for the present chosen to simplify the estimating equation further by making yield a linear function of only rainfall and irrigation.

$$y = f(R, I) \qquad (5)$$

Where y is the value of output per ha of cropped area, R is Rainfall in mm and I is the irrigation ratio.

The estimated regression coefficient for I from this equation, unlike (1), will not measure the effect of irrigation *per se*, but of irrigation and inputs which are strictly complementary to it. To the extent that other inputs and the quality of their management are not systematically correlated to irrigation, the specification suffers also from the excluded variable bias.

While the estimating equation $y = f(R, I)$ may not be able to directly capture the effect of other inputs fully, the existence of synergy between water and nutrients can be judged by comparing the value of coefficients across districts with different soil-moisture regimes. Synergy implies that faster spread of irrigation will go with faster growth of fertilisers and higher yield response to fertilisers reflected in a higher coefficient for irrigation in the above equation. This is the rationale for dividing the districts into strata which are relatively homogeneous in respect of rainfall and irrigation. We adopt the same stratification for time series analysis as used in the previous section.

TABLE 6. DISTRICTS CATEGORISATION BASED ON IRRIGATION SPREAD

Rainfall	Irrigation Ratio		Total Districts
	Low[1]	High[2]	
Low < 750 mm	15	10	25
Medium 750-1050 mm	34	21	55
High > 1050 mm	20	10	30

1. Below average. 2. Above average.

Table 6 gives the distribution of the selected districts among the six strata. In principle each rainfall - irrigation category can be further classified in terms of irrigation quality. But the number of districts in the sample does not allow this. Therefore in order to assess the effect of irrigation quality, districts have been reclassified by rainfall and irrigation quality. The latter has many dimensions, e.g., the relative importance of surface and ground water; as well as different sources of surface water (e.g., diversion works vs storages, large storages vs tanks); the extent of conjunctive use of ground with surface water and the quality of management. But given the lack of information on these attributes and the limited number of observations available, we have chosen the proportion of net irrigated area served by wells as the index of quality with comparisons being further restricted to districts at extreme ends of the spectrum of variation in this ratio. Specifically those districts where this ratio is below 25 per cent are categorised as low quality and those where it is above 75 per cent as high quality. The distribution of selected districts in different strata is given in Table 7.

TABLE 7. DISTRICTS CATEGORISATION BASED ON RAINFALL IRRIGATION QUALITY

Rainfall	Irrigation Quality		Total Districts*
	Low	High	
Low	4	11	25
Medium	10	20	55
High	18	3	30

* Total districts do not reflect the row total.

Problems of Changing Coverage

We have already indicated that all crops are not covered by the available area and yield estimates. The input variables however relate to all crops. Therefore in estimating the impact of irrigation, we have to assume that per ha output of the crops covered by the data are a reasonably good approximation of the per ha output of all crops and remain so throughout the time span covered by the study. Limiting the analysis only to districts in which the crop-wise data account for at least 80 per cent of their respective gross crop area takes care of this problem to some degree. But if the area under the selected crops as a proportion of total crop area (CA) changes systematically over time, the results of the analysis need to be interpreted with caution. A significant rising (falling) trend in CA is likely to strengthen (weaken) the estimated relation between I and Y and also bias the coefficient upward (downward). Such bias will not exist if CA has no trend.

The extent of variability in the input variables is also of some importance for our purpose. Variability can take the form of wide fluctuations around a near constant mean, or significant changes in the mean or both. Rainfall belongs to the first category and variability is high. In the case of irrigation (and fertiliser use) the systematic trend element is much more important than fluctuations. However, where the trend element in irrigation is negligible, the estimated regression may show a weak or non-significant relation between it and per hectare output. In such cases the regression does not tell us much about the true relation between the input and yields.

In order to allow for these considerations, we have categorised districts on the basis of trends in the proportion of gross cropped area under the selected crops (CA) and the irrigation ratio (IR) (see Table 8). Each cell refers to different scenario and has got different implication for bias in the estimated irrigation impact. The first row, for example, refers to districts which have significant positive trend in irrigation ratio and should bring out the impact of irrigation. The ideal combination would be one where there is positive trend in irrigation coverage (IR) and no significant trend in the proportion of total crop area under the selected crops (CA); cell a_{13} represents such a situation. Districts belonging to cell a_{11} would overestimate irrigation impact in as much as the regression coefficient for irrigation ratio will capture the effect of the rise in CA. By the same token, regressions based on observations in cell a_{12} are apt to understate irrigation impact because, despite positive trend in IR, the significant negative trend in CA nullifies the effect. Rows 2 and 3 refer to the situations where the irrigation ratio is either declining or remains unchanged. The estimated regressions for these districts will not be a reliable basis to assess irrigation impact.

TABLE 8.

IR \ CA* Trend \ Trend	Positive	Negative	Not Significant	Row Total
Positive	a_{11}	a_{12}	a_{13}	R_1
Negative	a_{21}	a_{22}	a_{23}	R_2
Not Significant	a_{31}	a_{32}	a_{33}	R_3
Column Total	c_1	c_2	c_3	

* CA is the proportion of area under the selected crops.

A large majority (89 out of 110) of selected districts have reported a significant positive trend in the irrigation ratio (Table 9); 17 districts show no significant change in irrigation ratio whereas four districts have registered a decline. Most districts registering a non-significant change in the irrigation ratio are from the high irrigation stratum and those recording a significant trend rise in irrigation ratio are relatively more frequent among districts with relatively low level of irrigation to begin with. By contrast, a relatively high proportion of districts show systematic trends in CA. In 40 of them, where CA is rising, the coefficient for irrigation is apt to be biased upward; in 28, where CA is falling, the bias would be to underestimate the irrigation coefficient. There are only 42 cases where CA is more or less constant during the period under study and the estimated irrigation coefficient will not be biased. The districts where the irrigation coverage has significantly increased are almost equally distributed among the three categories of CA trend. That is, the development of irrigation is not associated with any systematic shift either in favour of or against the included crops. Districts with a rising trend in CA are concentrated in those with rising irrigation ratios.

TABLE 9. TRENDS IN IR AND CA - DIFFERENT CATEGORIES OF DISTRICTS

Rainfall	Irrigation Coverage	IR Trend	CA Trend	Positive	Negative	Not Significant	Row Total
Low	Low	Positive		8 (53)	1 (7)	5 (33)	14 (93)
		Negative		-	-	-	-
		NS		-	-	1 (7)	1 (7)
	High	Positive		1 (10)	2 (20)	2 (20)	5 (50)
		Negative		-	-	-	-
		NS		3 (30)	-	2 (20)	5 (50)
Medium	Low	Positive		11 (32)	10 (29)	13 (38)	34 (100)
		Negative		-	-	-	-
		NS		-	-	-	-
	High	Positive		4 (19)	4 (19)	4 (19)	12 (57)
		Negative		-	-	1 (5)	1 (5)
		NS		4 (19)	1 (5)	3 (14)	8 (38)
High	Low	Positive		2 (10)	8 (40)	8 (40)	18 (90)
		Negative		1 (5)	-	-	1 (5)
		NS		-	-	1 (5)	1 (5)
	High	Positive		4 (40)	1 (10)	1 (10)	6 (60)
		Negative		-	1 (10)	1 (10)	2 (20)
		NS		2 (20)	-	-	2 (20)
		Column Total		40	28	42	110

* Figures in the parentheses are percentages in the respective category.

RESULTS

Our interest is in seeing whether the strength and magnitude of yield impact of irrigation differs systematically across the various strata. For this purpose we focus on the statistical significance of the overall regressions and more especially that of the irrigation coefficient: the proportion of variance in per ha output explained by the regression, the mean value and frequency distribution of the coefficients for rainfall and irrigation. Our a priori expectations may be summarised thus:

(1) The lower the rainfall, the lower the average output per hectare and the greater the variability under rainfed conditions. This leads us to expect the yield impact of irrigation, under similar irrigation regimes, to be inversely related to rainfall.
(2) In so far as irrigated yields are more stable than yields under rainfed conditions, the regressions should do better under high irrigation conditions than under low irrigation conditions.
(3) Rainfall is likely to have a stronger and larger impact on yields in low rainfall regions than in high rainfall areas under conditions of limited irrigation; where irrigation is well developed, the yield impact of rainfall would be less pronounced.
(4) The impact of irrigation is likely to be greater in areas where ground water is a more prominent source of irrigation.
(5) The irrigation coefficient is unlikely to be significant in cases where the irrigation ratio shows a declining trend or no trend at all.
(6) There is no reason to suppose that the level of irrigation development *per se* would affect the yield response to increase in irrigation. Since the irrigation coefficients are likely to have an upward (downward) bias in districts where the proportion to total crop area covered by selected crops is rising (falling), valid comparisons to test the above hypotheses must be restricted to districts where the proportion of crop area covered shows no trend.

Significance of the Regression

When we talk of the performance of the regression, significance and strength provide two different dimensions. 'Significance' refers to the existence of a statistically significant relation between the dependent and the independent variables. The 't' ratio is a standard indicator for this purpose. The 'strength' of the regression refers to its explanatory power, i.e., the proportion of variance in the dependent variable explained by the independent variables measured in terms of R^2 or $\overline{R}^2$.

TABLE 10. SIGNIFICANCE OF THE REGRESSION-PERCENTAGE DISTRIBUTION OF THE DISTRICTS

Stratum	Number of Districts	Average		Per cent of districts where			
		Rainfall (mm)	Irrigation (per cent)	R alone significant	I alone significant	Both	
						significant	insignificant
	1	2	3	4	5	6	7
LRLI	15	597.1	10.05	20	13.5	53	13.5
LRHI	10	644.2	30.30	10	30	20	40
MRLI	34	891.2	6.56	9	33	29	29
MRHI	21	873.8	31.00	14.5	33	38	14.5
HRLI	20	1,218.8	5.70	45	20	25	10
HRHI	10	1,207.5	52.80	Nil	50	30	20

Variations in the significance of the regression across the rainfall-irrigation ratio strata are summarised in Table 10. The estimated regression is taken to be 'significant' if the coefficient of at least one of the explanatory variables is found to be statistically significant. On this criterion, the regression is significant in about 79 per cent of the districts, the proportion ranging from about 60 per cent in LRHI to 90 per cent in HRLI. The proportion of significant regressions is higher in the low irrigation districts in the 'low' and 'high' rainfall category; but in the medium rainfall category a larger proportion of regressions in the high irrigation group is significant.

Rainfall turns out to have a significant effect on yields in half of the districts and irrigation in about 60 per cent cases. In roughly a third of the districts both are significant. Rainfall is significant in a much higher proportion of cases in the low irrigation strata compared to the high irrigation category in the low and high rainfall group; but not in the medium rainfall category. The proportion of cases, where the regression coefficient for I is significant, is relatively high in the high irrigation stratum of medium and high rainfall zones. The opposite pattern is observed in the low rainfall zone. The proportion of significant regression coefficients for I is the highest in HRHI.

The performance of I, in terms of the proportion of cases where the coefficient for this variable is significant, shows a systematic pattern across rainfall-irrigation strata. In the case of high irrigation districts it increases as one moves from the low rainfall to the high rainfall stratum. But in the low irrigation category, the opposite tendency is in evidence, the proportion of cases with a significant irrigation coefficient being higher in low rainfall districts compared to medium and high rainfall tracts.

Strength of Regression

As already mentioned, in about 21 per cent of the districts the regression is not significant. In more than 30 per cent of the districts where the regression is significant, the $\bar{R}^2$ is as low as 0.2 (Table 11). At the other extreme $\bar{R}^2$ exceeds 0.4 in 20 per cent of the districts, the proportion being somewhat higher in the low than in the high irrigation category. That changes in rainfall and irrigation do so poorly in 'explaining' the changes in productivity is quite contrary to our expectation.

To some degree the problem may be with the equation and the way it is estimated. For instance in regressions where only one of the included variables is significant, the insignificant variable(s) contribute negatively to the overall $\bar{R}^2$. In so far as the extent of complementarity between irrigation and fertiliser use is not as strong or universal as assumed, the exclusion of fertilisers may account for lower $\bar{R}^2$. Moreover, the estimating equation in effect postulates that the incremental output attributable to irrigation and complementary inputs is constant. It therefore does not capture increase in productivity of these inputs due to new seeds, improved irrigation quality, and learning effects.

Part, perhaps a good part, of the reason for the poor performance of the regression could be that district level data on inputs and yields are much noisier than state level estimates. No standardised procedure for estimating district level crop yields is followed in all states. A great deal of judgment is involved and it is impossible to ensure that the basis for such judgement remains uniform in each district. While little can be done about this, we can examine the extent to which absence of any trend in irrigation and/or biases in crop coverage may affect the estimated relation. For this purpose we look at the significance and strength of the regression in districts classified according to the existence of trends in I or CA. This is set out in Table 11.

As expected a higher proportion of districts with a significant trend in the irrigation ratio have significant coefficients for irrigation than those where the irrigation ratio is more or less stagnant; but the proportion of cases with R^2 exceeding 0.4 is not. Among districts with a rising trend in I, the proportion of cases, where the regression coefficients for I and R are significant, is higher in the sub-set where both I and CA are rising compared

to the subset where only I rises. The contrast between districts where CA is rising and where CA is constant is much more marked among districts with no significant trend in I.

TABLE 11. FREQUENCY DISTRIBUTION OF $\bar{R}^2$

(Per cent)

Stratum	Insignificant	Per cent of districts where $\bar{R}^2$ value is			
		<0.20	Between 0.2 & 0.4	Between 0.4 & 0.6	Above 0.6
LRLI	13.5	34.6	19.9	19.9	12.1
LRHI	40.0	10.0	30.0	10.0	10.0
MRLI	29.0	35.5	20.6	12.1	2.8
MRHI	14.5	37.6	23.9	9.4	14.6
HRLI	10.0	45.0	35.1	9.9	-
HRHI	20.0	40.0	20.0	20.0	-

Magnitude of Impact

Among the 55 districts where the coefficient attached to the rainfall is significant, the simple average of value of the coefficient is around 0.4. That is, for every mm variation in rainfall, output per ha changes in the same direction by Rs 0.4 (Table 12). The mean value of the coefficient is highest in the low rainfall zone (0.79) and lowest in the high rainfall zone (0.32). In the medium category the coefficient average is 0.4. However it needs noting that in seven out of the twenty-four districts in the medium rainfall group the coefficient is negative, which clearly depresses the mean value for the medium rainfall category. The effect is particularly pronounced in the MRLI where seven out of thirteen districts have (somewhat surprisingly) significant negative coefficients for rainfall. These include Rajgarh, Sharajpur and Adilabad in Andhra Pradesh and Yeotmal and Wardha in Maharashtra. Allowing for this, it would seem to confirm the expectation that rainfall has a larger impact on yield in low irrigation areas; and that the coefficient tends to be higher under conditions of low rainfall compared to high rainfall regions at low levels of irrigation. In high irrigation districts there seems to be no systematic relation between rainfall and the value of the coefficient.

TABLE 12. EFFECT OF RAINFALL

Rainfall	Average impact of Rainfall	Irrigation	Number of districts where R is significant	Mean value of significant R coefficient
Low	0.79	Low	11 (73)*	0.83
		High	3 (30)	0.64
Medium	0.4	Low	13 (38)	0.10
		High	11 (52)	0.76
High	0.32	Low	14 (70)	0.37
		High	3 (30)	0.11

* Figures in the parentheses are percentages.

Table 13 presents the mean value of the significant coefficients for irrigation and their frequency distribution for different rainfall-irrigation strata. Several features are noteworthy. The mean value of the significant coefficients ranges from 42 (Rs 4,200 per ha) to 106 (Rs 10,600 per ha), being higher in low irrigation districts compared to the high irrigation category in all rainfall zones. On the average, and contrary to expectation, productivity impact of irrigation seems to be higher in high rainfall districts than in low and medium rainfall districts in the high irrigation category. No such consistent trend is noticed in the low irrigation category.

TABLE 13. EFFECT OF IRRIGATION - FREQUENCY DISTRIBUTION OF THE ESTIMATES (IRRIGATION STRATA)

Rainfall	Irrigation	Average Coeff. for Irrigation**	Number of districts where Coefficient of I is						
			<20	20-40	40-60	60-80	80-100	100-150	Above 150
Low	Low	98.4	-	4 (40)*	-	2 (20)	1 (10)	-	3 (30)
	High	42.5	1 (20)	1 (20)	2 (40)	1 (20)	-	-	-
Medium	Low	59.4	3 (13)	5 (23)	4 (18)	5 (23)	4 (18)	-	1 (5)
	High	42.3	5 (36)	2 (14)	5 (36)	-	1 (7)	1 (7)	-
High	Low	106.0	1 (11)	2 (22)	1 (11)	-	-	2 (22)	3 (34)
	High	74.1	-	1 (13.5)	1 (12.5)	3 (37.5)	2 (25)	1 (12.5)	-

Figures in the parentheses are percentages.
** Simple average of regression Coefficients for Irrigation (measured as per cent of GCA irrigated) which are statistically significant.

The interpretation of these coefficients is problematic for several reasons. They represent averages of only significant coefficients; the proportion of non-significant coefficients is high and, apparently, systematically variable across the strata. There is also a wide and erratic dispersion in the value of coefficients around the mean for each category. In the low irrigation districts, generally, a higher proportion of districts with significant coefficients have coefficients exceeding 80 (i.e., Rs 8,000 per ha) than that in the high irrigation regions; this proportion is exceptionally high in the LRLI (40 per cent of districts) and HRLI (56 per cent of cases). High mean value of irrigation coefficients in these categories is clearly due to a few districts having very high coefficients.

In so far as these are due to stagnation or decline of the irrigation ratio and/or significantly rising (or falling) trend in CA, we can filter out the biases by considering districts only with significant trend growth in the irrigation ratio with no significant trend in CA. (See Table 14). Comparison across districts with no significant trend in CA also broadly corroborates the finding that, except in the low rainfall zone, the coefficient for irrigation is higher in the high compared to the low irrigation category; that in the low irrigation category response increases as we move from the low to high rainfall regimes, while no such trend is noticeable in the high irrigation category.

The coefficients for districts with declining CA are invariably lower than for districts with no trend in CA. However, the coefficient for districts with a positive trend in CA are not in all cases higher than for those with no trend or a declining CA.

Considering cases only where I shows a significant rising trend and CA shows no significant trend, the addition of one hectare to irrigated area raises average output per ha in the low irrigation districts by Rs 5,650 in LRLI; Rs 11,500 in the HRLI; and in the high irrigation group from Rs 4,500 in MR to Rs 6,200 in HR.

TABLE 14. AVERAGE IMPACT OF IRRIGATION IN DIFFERENT CATEGORIES OF DISTRICTS

Rainfall	Irrigation Coverage	CA Trend	Impact of Irrigation*
Low	Low	Positive	129.41
		Negative	38.78
		Not significant	56.59
	High	Positive	41.82
		Negative	34.93
		Not significant	59.48
Medium	Low	Positive	19.00
		Negative	52.75
		Not significant	103.84
	High	Positive	26.09
		Negative	35.04
		Not significant	45.15
High	Low	Positive	155.15
		Negative	93.03
		Not significant	115.85
	High	Positive	83.91
		Negative	65.30
		Not significant	61.97

* Value of the Coefficient for Irrigation ratio. Represents the increase in value of output per ha associated with an increase of one percentage point in the irrigation ratio.

Impact of Irrigation Quality

As for impact of irrigation quality, the results (see Table 15) show that the significance of I and the proportion of districts where I is significant is relatively higher in districts with less than 25 per cent of NIA under well, compared to those where wells are the dominant sources. In both cases, the proportion of districts with significant regression coefficient of I falls progressively from low to high rainfall regions.

In terms of impact, there is no clear relation between irrigation quality and productivity (Table 16). In low rainfall category, irrigation ratio in the high quality group is more or less the same as in districts with low proportion of well irrigation and the coefficient for irrigation in the former is nearly thrice as that in the latter. But in the case of medium and high rainfall districts, the coefficient in high quality districts is lower than in low quality tracts. In both cases the overall irrigation ratio is much higher in the low quality districts compared to the districts with wells as the dominant source. While this may not by itself account for the lack of clear pattern, it is clearly necessary to control for level of irrigation in assessing the effect of quality and also to use more complex indices of quality.

TABLE 15. IRRIGATION QUALITY AND THE SIGNIFICANCE OF I

Rainfall	Quality of Irrigation	Number of districts where I is significant
Low	Low	4 (100)*
	High	6 (56)
Medium	Low	7 (70)
	High	9 (45)
High	Low	11 (61)
	High	1 (33)

* Figures in the parentheses are percentages.

TABLE 16. IRRIGATION QUALITY AND THE IMPACT OF IRRIGATION

Rainfall	Quality of Irrigation	Coefficient of I	Coefficient of R	Irrigation coverage (per cent)	Average annual rainfall (mm)
Low	Low	46.3	0.49	14.1	675
	High	99.3	0.60	13.2	585
Medium	Low	59.9	0.02	25.4	956
	High	54.5	-0.21	5.4	935
High	Low	78.7	0.06	37.5	1,222
	High	-32.6	-0.11	6.0	1,079

IV
DIRECT ESTIMATES OF IRRIGATION IMPACT: A STATE-WISE ANALYSIS

Sources of Data and Methodology

The basic source of data for this part of the study is *Estimates of Area and Production of Principal Crops in India* published annually by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.. These volumes provide information on overall land use, irrigation and cropping intensity as well as the total area sown, output and average yields of some 50 specific crops for the country as a whole and for individual states. These 50 crops account for about 90 per cent of the gross cropped area.

In addition, these volumes also provide data on irrigated area and yield for some crops. Estimates of area sown and per hectare yields under irrigated and unirrigated conditions based on crop-cutting surveys are given for 13 major crops, viz., rice, jowar, bajra, maize, ragi, wheat, barley, gram, groundnut, rapeseed and mustard, cotton, sugarcane, and tobacco. In respect of other crops, irrigated - unirrigated break down of neither area nor yield are available. However, some of them are known to be predominantly, if not exclusively, rainfed (e.g., small millets, pulses and some oil seeds) and a few (e.g., chillies, banana) predominantly irrigated. In such cases, the total area and production are assumed to be wholly unirrigated or irrigated as the case may be. This procedure has been followed in respect of 10 crops. Crops which have been assumed to be wholly irrigated are jute, chilies, banana and potato. On the other hand, small millets, tur, sesamum, linseed, castor and safflower are assumed to be wholly unirrigated. Thus our estimate of productivity of irrigated and rainfed crops covers 23 crops, accounting for about 85 per cent of the country's total crop area.

Before discussing the estimates, some words of caution are in order: In the first place one must bear in mind that the crop- cutting surveys are designed to give overall yield estimates with a relatively low margin of error; the estimates for irrigated crops - especially where the proportion of area under the crop which benefits from irrigation is small - are subject to a considerable margin of error. Precise estimates of the relative margins of error in the estimates of irrigated and unirrigated yields of different crops are however not available.

Estimates of area are not available for all years, crops and states. The details of the years, crops and the states affected by this problem are given in Table 17. It is also noticed that for some crops and in some states, the same figures of area have been repeated for more than one year; and in a few cases for several years. This problem occurs mostly in respect of crops for which separate estimates of irrigated and unirrigated areas are not available. All of them are minor crops accounting for a relatively small proportion of area. For the purpose of this exercise, those crops for which the same figure is reported for the entire period have been excluded from the estimates of output and output per unit area. Crops for which the repetition is only occasional have been included in our estimates by interpolating values for the missing years. In respect of crops for which yield estimates are published separately for irrigated and unirrigated areas, there are gaps in the estimates

for some states for a few years. In such cases we have interpolated yield from the figures available for the nearest earlier and subsequent years for estimating the values of missing years. The details of the years, crops and states for which interpolation has been done are given in Table 18.

TABLE 17. DETAILS REGARDING REPETITION OF DATA ON AREA

State	Crops	Years of Repetition
Andhra Pradesh	Potato	76-77, 79-80, 81-82, 82-83
	Linseed	77-78, 78-79
	Ginger	75-76 to 83-84
Bihar	Sesamum	81-82, 82-83
	Onion	81-82, 82-83
	Chillies	81-82, 82-83
	Linseed	81-82, 82-83
	Tur	81-82, 82-83
Gujarat	Onion	81-82, 82-83
	Banana	72-73, 73-74, 81-82, 82-83
	Castor	77-78, 78-79
	Small millets	74-75, 76-77
Haryana	Sesamum	74-75, 75-76
	Potato	71-72, 72-73, 76-77, 77-78
	Linseed	70-71, 71-72, 72-73, 81-82, 82-83
Madhya Pradesh	Safflower	70-71, 71-72, 74-75, 75-76
	Ginger	70-71 to 82-83
Maharashtra	Potato	77-78, 78-79, 79-80, 80-81
Orissa	Banana	70-71, 71-72, 72-73, 80-81, 81-82
Punjab	Linseed	70-71 TO 77-78
Uttar Pradesh	Onion	81-82, 82-83
	Banana	70-71, 71-72, 72-73, 80-81, 81-82
	Chillies	71-72, 72-73
West Bengal	Sesamum	75-76, 76-77, 78-79, 79-80

TABLE 18. DETAILS ON CROPS, YEARS AND STATES FOR WHICH INTERPOLATION HAS BEEN DONE FOR YIELD ESTIMATES OF IRRIGATED AND UNIRRIGATED CROPS

State	Crops	Years
Bihar	Rice, Maize	78-79 (Rice only), 81-82, 82-83
Andhra Pradesh	Rice, Jowar	72-73
Kamataka	Rice, Jowar, Bajra Ragi	73-74
Orissa	Rice, Groundnut, Rapeseed and Mustard	80-81, 82-83
West Bengal	Rice, Maize, Jute	72-73, 76-77

Productivity Estimates

For each year, the value of output of each of the 23 crops under irrigated and unirrigated conditions is worked out as follows:

(a) In respect of the 13 major crops, outputs are calculated on the basis of the estimates of area and yield available separately for irrigated and unirrigated areas.
(b) The remaining 10 crops, for which separate estimates for irrigated and unirrigated area are not available, have been, as already noted, assumed to be either wholly irrigated or wholly unirrigated, depending upon the nature of the crops.
(c) The productivity of irrigated and unirrigated areas is measured in terms of total value of output per hectare of cropped area under each of these categories. For this purpose the average unit values of the selected crops used in national accounts estimates (for 1986-87) have been adopted (Table 19).

TABLE 19. PRICE PER QUINTAL OF DIFFERENT CROPS, ALL INDIA, 1986-87

Crops	Unit Price (Rs)
Rice	269
Wheat	184
Small millets	145
Ragi	165
Bajra	174
Groundnut (pods)	552
Banana	157
Sugarcane (gur)	280
Potato	126
Mustard	630

(d) The sum of the values of output of irrigated and rainfed crops divided by the sum of the gross (and net) areas gives value productivity per unit of gross (and net) area under these two categories.

THE RESULTS

The productivity estimates have been made for each year from 1970-71 to 1983-84 (See Table 20 for output per hectare of Gross Area and Table 21 Net Area). These estimates are used as the basis for assessing (a) the magnitude of difference (absolute and relative) in the productivity per unit of irrigated and unirrigated area, their regional variations and the reasons therefor; and (b) the relative performance of productivity on irrigated and unirrigated areas both in terms of trends and of the degree of stability. For the purpose of (a) we use five year averages for 1979-80 to 1983-84. The assessment of trend and fluctuations raises some questions as to the basis for measuring growth and fluctuations.

Productivity of Irrigated and Rainfed Areas

During 1979-83, one hectare of irrigated crop area in the 13 states covered by this study produced on an average output worth Rs 4,900 (at 1986-87 prices), the level ranging from a low of around Rs 3,000 in Bihar to Rs 7,400 in Maharashtra (Table 22). In general, irrigated areas are relatively more productive in the south Indian states of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu and relatively less in the east Indian states of Bihar, Orissa and Madhya Pradesh.

An irrigated hectare produced on the average about Rs 2,900 (or 150 per cent) more than an unirrigated hectare; the difference ranging from Rs 715 (or 30 per cent more than unirrigated yields) in Bihar to Rs 5,800 (about 360 per cent) higher than rainfed yields in Maharashtra. Again the differential between irrigated and unirrigated yields, both in absolute and relative terms, is the lowest in the eastern states and highest in southern states mentioned above.

Differences between output per unit of irrigated and unirrigated crop area reflect differences in crop pattern and individual crop yields. Since irrigation also affects the intensity of cropping (i.e., the number of crops raised on a given piece of land in a year) and since individual crops are of widely different duration, a better comparison would be output per unit of irrigated and unirrigated land. Estimates of the latter based on the assumption that gross irrigated (unirrigated) crop area is equal to the gross cropped area on irrigated (rainfed) land are given in Table 23.

TABLE 20. OUTPUT PER HECTARE OF GROSS IRRIGATED AREA IN MAJOR STATES FOR THE PERIOD 1970-71 TO 83-84
(value in Rs per ha at 1986-87 prices)

Year	Gujarat	Karnataka	Maharashtra	Madhya Pradesh	Orissa	West Bengal	Tamil Nadu	Uttar Pradesh	Andhra Pradesh	Punjab	Bihar	Rajasthan	Haryana
1970	7,723	4,324	6,680	3,344	2,653	3,870	5,022	2,896	4,523	4,426	3,194	3,598	3,722
1971	7,793	4,254	5,001	2,896	2,438	3,767	6,100	2,826	4,803	4,620	2,693	3,788	3,628
1972	3,123	4,696	10,774	2,395	3,131	5,858	6,422	2,785	4,937	4,323	2,457	3,420	3,323
1973	7,528	5,015	11,264	2,897	3,162	5,275	7,802	2,426	5,404	4,915	2,945	3,283	3,323
1974	5,364	5,241	6,814	2,787	2,851	5,363	6,731	2,737	5,377	4,426	3,027	3,440	3,119
1975	6,864	5,794	7,149	3,162	3,427	6,104	6,924	3,112	5,424	4,935	3,123	5,035	3,862
1976	6,423	5,782	6,579	2,585	3,284	5,349	6,868	3,075	5,114	5,101	3,481	3,769	4,171
1977	9,167	6,170	6,863	3,339	3,347	5,069	7,707	3,429	5,578	5,211	2,867	4,098	4,464
1978	8,073	6,972	7,354	2,800	3,360	5,397	7,477	3,754	6,104	5,914	2,780	4,250	4,918
1979	5,269	6,384	6,792	2,245	4,183	4,888	7,203	2,954	6,031	5,633	2,472	3,123	4,074
1980	5,732	7,029	7,561	3,429	3,709	5,568	6,960	3,852	6,431	5,581	3,410	3,250	4,616
1981	6,538	6,123	8,022	3,621	3,415	5,371	7,549	3,853	6,851	6,093	3,011	3,540	4,242
1982	6,642	6,225	7,563	3,559	3,966	4,901	5,377	4,311	7,416	6,575	3,039	3,696	4,663
1983	7,582	8,359	7,137	4,101	4,517	7,544	6,354	4,406	6,714	6,105	3,032	3,523	4,716

OUTPUT PER HECTARE OF GROSS UNIRRIGATED AREA IN MAJOR STATES FOR THE PERIOD 1970-71 TO 83-84
(value in Rs per ha at 1986-87 prices)

Year	Gujarat	Karnataka	Maharashtra	Madhya Pradesh	Orissa	West Bengal	Tamil Nadu	Uttar Pradesh	Andhra Pradesh	Punjab	Bihar	Rajasthan	Haryana
1970	3,728	2,384	1,394	1,624	2,042	2,386	2,455	2,211	1,541	2,900	2,067	1,470	1,967
1971	3,712	1,510	1,485	1,877	1,922	2,436	2,726	2,175	1,768	3,084	1,695	967	1,635
1972	1,205	1,308	1,261	1,455	1,939	4,048	2,535	2,288	1,844	2,287	1,612	830	1,465
1973	3,198	1,970	1,582	1,709	2,084	3,341	2,970	1,555	1,934	2,395	2,119	884	1,358
1974	2,004	2,265	1,802	1,689	1,712	3,461	1,976	1,777	2,227	2,790	2,022	858	1,089
1975	3,391	2,266	1,678	1,864	2,131	3,699	2,638	2,084	2,027	2,671	2,151	1,370	1,862
1976	3,179	2,088	1,704	1,357	1,621	3,084	2,471	2,200	1,677	2,684	2,318	1,352	1,840
1977	3,211	2,118	1,976	1,739	2,213	3,000	2,934	2,414	2,169	3,116	1,995	1,219	1,793
1978	3,450	2,796	1,896	1,611	2,407	2,826	3,000	2,489	1,915	2,846	2,333	1,358	2,138
1979	2,723	2,812	2,122	964	1,798	2,179	2,501	1,223	1,943	2,376	2,019	539	856
1980	2,340	2,343	1,480	1,706	2,178	3,716	1,851	2,473	2,177	2,827	2,441	862	1,526
1981	2,875	1,935	1,665	1,736	2,026	2,830	2,721	2,410	2,544	2,546	2,308	1,088	1,205
1982	2,424	1,980	1,444	1,675	2,321	2,399	2,172	2,662	2,295	2,596	2,231	1,133	1,261
1983	3,206	2,415	1,302	2,200	2,615	4,863	2,378	2,834	2,451	2,794	2,392	1,484	1,620

TABLE 21. OUTPUT PER HECTARE OF NET IRRIGATED AREA IN MAJOR STATES FOR[1] THE PERIOD 1970-71 TO 83-84
(value in Rs per ha at 1986-87 prices)

Year	Gujarat	Karnataka	Maharashtra	Madhya Pradesh	Orissa	Tamil Nadu	Uttar Pradesh	Andhra Pradesh	Punjab	Bihar	Rajasthan	Haryana
1970	8,416	5,153	7,816	3,441	3,604	6,607	3,355	5,744	6,503	3,993	4,140	5,418
1971	8,447	4,933	5,951	3,099	3,355	7,946	3,271	6,052	6,843	6,840	4,253	5,295
1972	3,542	5,429	12,390	2,484	4,302	8,379	3,252	5,974	6,470	5,995	4,041	5,046
1973	8,543	5,938	13,517	3,050	4,275	10,179	2,845	6,863	7,628	7,569	3,699	4,561
1974	6,051	6,159	8,177	2,900	3,920	8,374	3,228	7,098	6,634	3,663	4,085	4,551
1975	7,748	7,246	8,579	3,323	5,004	9,113	3,621	7,160	7,795	3,810	5,800	6,037
1976	7,271	6,975	8,026	2,674	4,330	8,846	3,626	6,188	8,116	4,351	4,299	6,259
1977	10,348	7,552	8,510	3,471	4,525	10,117	4,041	7,251	8,793	3,727	4,692	6,613
1978	9,156	8,501	9,266	2,919	4,642	9,939	4,465	7,874	9,982	3,475	5,061	7,643
1979	6,030	7,769	8,422	2,338	5,834	9,614	3,663	7,901	9,114	3,016	3,620	5,867
1980	6,679	8,656	9,754	3,607	5,223	8,921	4,634	8,039	9,540	4,194	3,603	7,158
1981	7,654	7,503	10,669	3,756	5,638	9,544	4,693	8,701	10,666	3,583	3,866	6,520
1982	7,751	7,507	10,664	3,677	4,312	6,514	5,288	9,492	11,389	4,375	4,695	7,042
1983	9,338	10,231	8,707	4,243	4,911	7,885	5,418	8,728	10,611	4,548	4,317	7,742

OUTPUT PER HECTARE OF NET UNIRRIGATED AREA IN MAJOR STATES FOR[2] THE PERIOD 1970-71 TO 83-84
(value in Rs per ha at 1986-87 prices)

Year	Gujarat	Karna-taka	Maha-rashtra	Madhya Pradesh	Orissa	Tamil Nadu	Uttar Pradesh	Andhra Pradesh	Punjab	Bihar	Rajas-than	Haryana
1970	4,021	2,489	2,239	1,832	2,411	2,727	3,254	1,845	3,572	1,621	1,608	2,638
1971	3,978	1,584	1,817	2,141	2,231	3,081	3,145	1,634	3,709	1,861	1,059	2,257
1972	1,275	1,372	1,735	1,644	2,339	2,902	3,330	1,396	3,040	1,935	884	2,064
1973	3,406	2,066	2,304	1,968	2,494	3,515	2,273	1,731	2,940	2,034	989	1,904
1974	2,142	2,383	2,199	1,882	2,093	2,086	2,579	2,419	3,478	2,358	953	1,406
1975	3,665	2,381	2,344	2,200	2,601	3,063	3,118	2,329	3,413	2,155	1,552	2,700
1976	3,627	2,194	2,492	1,542	1,956	2,787	3,237	2,405	3,321	1,965	1,512	2,573
1977	3,673	2,252	2,232	1,909	2,912	3,431	3,607	2,715	3,410	2,322	1,352	2,692
1978	3,737	2,956	2,554	1,884	3,253	3,433	3,977	2,783	3,496	2,042	1,517	3,137
1979	2,992	2,963	2,222	1,103	2,448	2,875	1,905	2,906	3,011	2,088	620	1,480
1980	2,583	2,465	2,664	1,975	3,118	2,107	4,203	2,075	3,432	2,346	986	1,614
1981	3,241	2,019	2,561	2,015	2,825	3,148	4,120	2,452	3,096	2,764	1,330	1,713
1982	2,718	2,089	2,452	1,992	3,539	2,385	4,562	1,525	591	2,461	1,303	2,305
1983	3,623	2,553	2,638	2,643	4,446	2,728	3,652	1,665	4,738	2,740	1,733	1,966

1. Value of output per ha GIA as in Table $4 \times \frac{GIA}{NIA}$ as reported in land use statistics.

2. Value of output per ha GUIA as in Table $4 \times \frac{GUIA}{NUTA}$ as reported in land use statistics.

TABLE 22. OUTPUT PER HECTARE OF GROSS IRRIGATED AND GROSS UNIRRIGATED AREAS
(AVERAGE FOR THE PERIOD 1979-80 TO 1983-84)

(in Rs)

State	Output per hectare of Gross Area		Difference	Ratio
	Irrigated	Unirrigated		
Gujarat	6,353	2,714	3,639	2.34
Kamataka	6,825	2,297	4,528	2.97
Maharashtra	7,415	1,603	5,812	4.63
Madhya Pradesh	3,391	1,656	1,735	2.05
Orissa	3,958	2,188	1,770	1.81
West Bengal	5,654	3,197	2,457	1.77
Tamil Nadu	6,689	2,325	4,364	2.88
Uttar Pradesh	3,875	2,320	1,555	1.67
Andhra Pradesh	6,689	2,282	4,407	2.93
Punjab	5,998	2,628	3,370	2.28
Bihar	2,993	2,278	715	1.31
Rajasthan	3,400	1,020	2,380	3.33
Haryana	4,500	1,293	3,107	3.48

On this basis, the productivity per unit of irrigated land and, much more importantly, the absolute as well as the relative difference between irrigated and unirrigated land is considerably higher than suggested by Table 22. In absolute terms a hectare of irrigated land yields between Rs 1,100 to Rs 7,300 more than a hectare of unirrigated land while in relative terms the former yields between 30 and 285 per cent more than the latter.

These figures however underestimate the difference in productivity of irrigated and unirrigated areas for the following reasons: in the first place, in so far as a part of the area under crops *assumed* to be wholly irrigated is in fact rainfed, the calculated yield of these crops will be lower than would be the case if yields on irrigated and rainfed components were estimated separately; by the same token the procedure would overstate the yield of rainfed area for crops which are assumed to be wholly rainfed. A second reason is that the entire area under irrigated crops is not covered by the estimates and these excluded crops (vegetables, condiments and spices, flowers) are often high value crops. Thirdly, irrigated land often grows superior quality of a given crop which commands a higher value in the market compared to the produce of unirrigated land. For instance, long staple cotton which fetches a much higher price per kg than ordinary varieties is mostly grown under irrigated conditions. In Tamil Nadu, irrigated groundnut is found to fetch a considerably higher price than unirrigated groundnut [Iyengar, 1991].

TABLE 23. OUTPUT PER HECTARE OF IRRIGATED AND UNIRRIGATED LANDS (AVERAGE FOR THE PERIOD 1979-80 TO 1983-84)
(in Rs)

State	Output per Hectare		Difference	Ratio
	Irrigated	Unirrigated		
Gujarat	7,490	3,031	4,459	2.47
Karnataka	8,333	2,418	5,915	1.40
Maharashtra	9,643	2,507	7,136	3.84
Madhya Pradesh	3,524	1,946	1,578	1.81
Orissa	5,184	3,275	1,909	1.58
Tamil Nadu	8,496	2,649	5,847	3.21
Uttar Pradesh	4,739	3,688	1,051	1.28
Andhra Pradesh	8,572	2,124	6,448	4.03
Punjab	10,264	2,974	7,290	3.45
Bihar	3,943	2,480	1,463	1.59
Rajasthan	4,020	1,194	2,826	3.37
Haryana	6,866	1,816	5,050	3.78

A further, and even larger, source of bias in our estimate of yield per hectare of irrigated and unirrigated land (as distinct from irrigated and unirrigated crop area) arises from the implicit assumption that the ratio of gross irrigated to net irrigated area and of gross unirrigated to net unirrigated area accurately reflect the cropping intensity of irrigated and unirrigated lands, respectively. This assumption is open to question.

A piece of unirrigated land, by definition, cannot grow any irrigated crop. But a piece of irrigated land could grow an irrigated crop in one season and a rainfed crop in another. In north Indian states, for instance, it is possible to raise a kharif crop wholly on the basis of south west monsoon rainfall while rabi crops (e.g., wheat) are widely grown under irrigated conditions. In so far as this happens, GIA/NIA is likely to understate, even as GUIA/NUIA will exaggerate, the intensity of cropping on irrigated and rainfed lands, respectively. Which implies that our procedure overestimates the productivity of unirrigated land and underestimates that of irrigated land as well as the difference between the two.

It will be noticed from Table 24 that in several states there is hardly any difference between GIA/NIA and GUIA/NUIA. In general, the two ratios are much closer to each other in northern states than in the south. In some cases (like Uttar Pradesh, Madhya Pradesh and Bihar) GUIA/NUIA is in fact higher than GIA/NIA. Because of this, the bias in the estimates of differential productivity of the two categories of land is also likely to be higher in these states. This is apt to vitiate comparisons of productivity differential between irrigated and unirrigated lands across states.

Factors Underlying Variations

The high variability across states in the level of per hectare output on irrigated and unirrigated areas as well as in the differentials between the two is noteworthy and calls for explanation. One would expect that unirrigated yields would tend to be higher in regions with relatively high rainfall and that irrigation would make a relatively smaller impact on cropping intensity, yields and crop patterns in regions with high rainfall compared to those with low and uncertain rainfall. The duration of the rainy season, the seasonal distribution of precipitation and its variability will also affect the outcome. The other factors which would affect productivity include the quality of irrigation in terms of duration and reliability of water supplies and the extent to which timing and quantum of irrigation can be adjusted to the actual need of crops in each season. In principle, these expectations can be empirically verified. But our attempts to do so failed to yield any definitive results.

TABLE 24. DETAILS OF CROPPING INTENSITY IN IRRIGATED LAND (GIA/NIA) AND UNIRRIGATED LAND (GUIA/NUIA) DURING 1979-80 TO 1983-84

State	1979-80		1980-81		1981-82		1982-83		1983-84	
	Irr	UnIrr	Irr	UnIrr	Irr	UnIrr	Irr	UnIrr	Irr	UnIrr
Gujarat	1.14	1.10	1.17	1.10	1.17	1.13	1.17	1.12	1.23	1.13
Karnataka	1.22	1.05	1.23	1.05	1.22	1.04	1.21	1.06	1.22	1.06
Maharashtra	1.24	1.07	1.29	1.08	1.33	1.09	1.41	1.07	1.22	1.12
Madhya Pradesh	1.04	1.14	1.05	1.16	1.04	1.16	1.03	1.19	1.03	1.20
Orissa	1.39	1.36	1.41	1.43	1.65	1.39	1.09	1.53	1.09	1.70
Tamil Nadu	1.33	1.15	1.28	1.14	1.26	1.16	1.21	1.10	1.24	1.29
Uttar Pradesh	1.24	1.56	1.20	1.70	1.22	1.71	1.23	1.71	1.23	1.75
Andhra Pradesh	1.31	1.10	1.25	1.09	1.27	1.11	1.28	1.10	1.30	1.10
Punjab	1.62	1.27	1.71	1.21	1.75	1.22	1.73	1.15	1.74	1.15
Bihar	1.22	1.37	1.23	1.40	1.19	1.47	1.44	1.06	1.50	1.28
Rajasthan	1.16	1.15	1.11	1.14	1.09	1.22	1.27	1.15	1.23	1.15
Haryana	1.44	1.73	1.55	1.06	1.54	1.42	1.51	1.83	1.64	1.21

Notes: Irr = Cropping intensity in irrigated land GIA/NIA
UnIrr = Cropping intensity in unirrigated land GUIA/NUIA

The level of yield per gross unirrigated hectare shows a significant positive association with average rainfall and a negative one with the proportion of rainfall accounted by the south west monsoon. This means that unirrigated yields tend to be higher in regions with relatively high rainfall and those with relatively more even seasonal distribution of it. However, neither rainfall characteristics nor the proportion of irrigated area under tanks or wells seem to be significant in accounting for inter-state variations in irrigated yields. Dhawan [1988] also reports that the inter-state variations in per ha output of unirrigated areas (in 1983-84) is positively correlated, and that of irrigated areas negatively correlated with rainfall. The significance of the correlation is not indicated.

Again neither the absolute nor the relative difference between irrigated and unirrigated yields shows any significant association with rainfall and its distribution or the quality of irrigation (judged by the proportion of area irrigated served by tanks, or by wells). Dhawan [1988] reports that differential between irrigated and unirrigated yields is negatively related to rainfall and positively to fertiliser use (assumed to be confined to irrigated areas). Dhawan uses linear multiple regression of output over unirrigated area and area irrigated by different sources to estimate the per ha yield of each category of land. The estimates in general show coefficient for rainfed areas to be lower than for irrigated areas, and for the coefficient for wells to be higher than for canals or tanks. For a particular state, the coefficients as well as the difference between them differ considerably from period to period. Dhawan also presents data about the productivity differences between areas irrigated by different sources in Andhra Pradesh based on a NCAER survey. While the superiority of wells comes out clearly in Andhra Pradesh, there seems to be no difference between sources in Uttar Pradesh [Dhawan, 1988, Pp. 117, 130]. A scrutiny of the scatters however suggests that there may be discontinuities. The states seem to fall into two distinct groups: one comprising Bihar, Haryana, Madhya Pradesh, Orissa, Rajasthan and Uttar Pradesh and the other including Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Punjab, Tamil Nadu and West Bengal. The former has consistently lower irrigated and unirrigated yields than the latter. Within each group high irrigated yields seem to be associated with high unirrigated yields; also the differential between irrigated and rainfed yields appears to be inversely correlated with the level of unirrigated yields.

These rather anaemic conclusions may, in some measure, reflect defects in (a) the productivity estimates which, as mentioned earlier, tend to

underestimate irrigated productivity and overstate rainfed productivity but not uniformly across regions; (b) estimates of average rainfall of states comprising large and heterogeneous tracts; and (c) the quality of data on source-wise irrigated area. Moreover, the relations between these factors (and the interactions among them) and yield may not be linear and additive which is an assumption implicit in the analysis. Some of these difficulties can be mitigated, but not wholly avoided, if the analyses could be done at a more disaggregated level- say districts. As far as the state level analysis is concerned, no definite relations were found.

TRENDS AND FLUCTUATIONS IN PRODUCTIVITY

The time pattern of output and yield changes being varied, it is both inappropriate and misleading to estimate trends or measure the degree of instability (which has to be with reference to the trend) on the basis of a single, uniform function for all the series. [For a discussion of this see *Indian Journal of Agricultural Economics* (IJAE), 1980]. In order to avoid this, we have fitted the following three functions to each of the series:

i) $y = a+bt$ implying a constant, absolute change in y per unit of time and a declining growth rate over time.
ii) $\log y = a+bt$ implying a constant growth rate.
iii) $\log y = a+bt+ct^2$ which tests for steady acceleration or deceleration of growth.

The function which best fits each series (on the basis of significance) is taken as the basis for assessing the direction and magnitude of the trend as well as the extent of instability. Where none of the above functions give a statistically significant fit, we infer that there is no trend. The degree of instability in such cases is estimated as the arithmetic mean of the percentage deviation of each year's actual value from the mean for the entire period. As an alternative procedure, we have used the mean of the percentage deviation of actuals from five-year moving averages for each year as a measure of instability. This procedure in effect allows for systematic changes in yield over time (including cycles) of a much wider range than covered by the three functional forms used for statistical trend fitting.

In all but five states productivity per hectare of irrigated crop area shows a statistically significant rising trend best approximated by semi-log (constant growth) function in seven states (Karnataka, Orissa, West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab and Haryana) with the growth rates ranging from 2.3 to 4.2 per cent per annum; an accelerating trend is seen in one (Madhya Pradesh). By contrast, in all but four states, the productivity per hectare of unirrigated crop area shows no significant trend at all; three states (Orissa, Andhra Pradesh, Bihar) show a trend rise (one of them, viz., Orissa, accelerating) and the fourth (Maharashtra) a decline (see Table 25). Dhawan [1988] reports that a linear regression of yield on rainfall and time showed that the time trend in irrigated yield is statistically significant for all states except Rajasthan. The trends in unirrigated yields are in most cases non-significant.

As already noted we have used two methods to measure the instability in yield: (i) mean of the percentage deviation of actual from trend value estimates from best fitting function or where no function fits from the mean of the series, and (ii) mean of the percentage deviation of actuals from five-year moving average. Except Maharashtra and Bihar the instability of unirrigated crops is greater than irrigated under both the methods of measurement (Table 26). When we consider the first method only, apart from the two states mentioned above, in Madhya Pradesh also irrigated yield is more unstable than unirrigated. The fact that sample survey estimates of irrigated yield for major crops are subject to larger margin of error would exaggerate the fluctuations in irrigated yields relative to that in unirrigated yields. To this extent our estimates of instability of irrigated yields have an upward bias which is statistical in nature. This bias only reinforces the conclusion that yields of rainfed crops are more unstable. The fact that in a majority of states irrigated yield is more stable than unirrigated is according to expectation and also in conformity with empirical findings of other studies. See, for example, Dhawan [1988, Ch. 7]. The instability in yields after eliminating trend is seen to be substantially lower under irrigated conditions than in rainfed cropping.

TABLE 25. TRENDS IN THE OUTPUT PER HECTARE OF GROSS IRRIGATED AND UNIRRIGATED AREAS IN MAJOR STATES FOR THE PERIOD 1970-71 TO 1983-84

State	Irrigated			Unirrigated		
	$\bar{R}^2$	b	c	$\bar{R}^2$	b	c
Gujarat	NS			NS		
Karnataka	0.82	0.042		NS		
Maharashtra	NS			0.68	-0.047	
Madhya Pradesh	0.38	0.018	0.006	NS		
Orissa	0.75	0.035		0.25	0.015	0.003
West Bengal	0.24	0.023		NS		
Tamil Nadu	NS			NS		
Uttar Pradesh	0.73	0.038		NS		
Andhra Pradesh	0.90	0.030		0.56	0.026	
Punjab	0.86	0.030		NS		
Bihar	NS			0.44	0.020	
Rajasthan	NS			NS		
Haryana	0.56	0.029		NS		

Note: NS = No significant trend.
In other cases results relate to the best fitting function which is generally Lny = a + bt, except Madhya Pradesh (irrigated) and Orissa (unirrigated) where the best fitting function is Lny + a + bt + ct^2.

TABLE 26. INSTABILITY IN IRRIGATED AND UNIRRIGATED YIELDS

State	Method I		Method II	
	Irrigated (%)	Unirrigated (%)	Irrigated (%)	Unirrigated (%)
Gujarat	20.50	24.88	17.79	15.95
Karnataka	5.25	16.18	3.72	12.76
Maharashtra	14.36	7.76	12.58	8.24
Madhya Pradesh	14.09	12.74	10.29	12.56
Orissa	6.59	10.18	7.42	9.59
West Bengal	11.55	19.36	6.66	12.40
Tamil Nadu	6.92	11.18	5.15	11.51
Uttar Pradesh	7.19	12.16	6.32	13.95
Andhra Pradesh	3.40	7.00	2.89	7.00
Punjab	4.15	7.53	3.74	8.05
Bihar	7.84	7.45	7.48	6.61
Rajasthan	9.05	25.22	10.47	17.50
Haryana	7.63	21.40	5.79	15.79

Notes: Method I: Mean of the percentage deviation of actual from trend values estimated from best fitting trend or, where no function fits, the mean of the series.
Method II: Mean of the percentage deviation of actuals from five-year moving average.

As for output per net irrigated and unirrigated land (Table 27), out of twelve states for which data is available, eight states (Karnataka, Madhya Pradesh, Orissa, Uttar Pradesh, Andhra Pradesh, Punjab, Bihar and Haryana) show a rising trend in the case of irrigated yield. Of these, two (Madhya Pradesh and Uttar Pradesh) experienced an acceleration and one (Orissa) deceleration in yield growth. The remaining four states (Tamil Nadu, Gujarat, Maharashtra and Rajasthan) show no trend. By contrast, in the case of unirrigated land eight states (Gujarat, Karnataka, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Punjab, Rajasthan and Haryana) show no trend in output per hectare. Four states (Maharashtra, Orissa, Uttar Pradesh and Bihar) show an increasing trend of which one (Orissa) is accelerating.

In three states, viz., Gujarat, Tamil Nadu and Rajasthan there is no significant trend in production per hectare of both irrigated and unirri-

gated lands, while both show a rising trend in three other states, namely, Orissa, Uttar Pradesh and Bihar. In five states (viz., Karnataka, Madhya Pradesh, Punjab, Andhra Pradesh and Haryana) while output per unit of irrigated land shows an increasing trend, there is either decline or no significant trend in unirrigated yields. Only in Maharashtra is the reverse of the case.

TABLE 27. TRENDS IN OUTPUT PER HECTARE OF NET IRRIGATED AND UNIRRIGATED AREAS IN MAJOR STATES FOR THE PERIOD 1970-71 TO 1983-84

State	Irrigated			Unirrigated		
	$\bar{R}^2$	b	c	$\bar{R}^2$	b	c
Gujarat	NS			NS		
Karnataka	0.81	0.058		0.24	0.024	
Maharashtra	NS			NS		
Madhya Pradesh	0.42	0.036	0.006	NS		
Orissa	NS			NS		
Tamil Nadu	NS			NS		
Uttar Pradesh	0.39	85.0		0.14	0.018	
Andhra Pradesh	0.73	0.04	0.004	0.50	0.22	0.40
Punjab	0.77	0.079		0.27	0.80	
Bihar	0.33	-0.085		0.48	-0.059	
Rajasthan	NS			NS		

Note:
1. NS = No significant trend. In other cases results relate to the best fitting function which is generally Lny = a+bt, except Madhya Pradesh (irrigated) and Andhra Pradesh (both irrigated and unirrigated) where the best fitting function is $y = a + bts$. In Madhya Pradesh, Orissa and Uttar Pradesh (all irrigated) and Orissa (unirrigated) the best fitting function is $Lny = a + bt + ct^2$.
2. Data on NIA/NUIA for West Bengal and Haryana are not available and hence excluded from the analysis.

Trends in Irrigated and Unirrigated Yield Differentials

That irrigated yields are rising in most cases even as unirrigated yields show no significant trends over time implies that the differentials between irrigated and unirrigated yields must be rising. This is indeed the case. In absolute terms, the differential in terms of outputs per hectare of gross cropped area is seen to be increasing in most cases, with the trend being statistically significant in eight states (Table 28). Much the same pattern is observed in the ratio of irrigated and unirrigated yields. The pace of widening is the greatest in Punjab and Haryana.

TABLE 28. TRENDS IN ABSOLUTE AND RELATIVE DIFFERENCES IN THE IRRIGATED AND UNIRRIGATED YIELDS PER UNIT OF GROSS AREA IN MAJOR STATES FOR THE PERIOD 1970-71 TO 1983-84

State	Absolute Difference			Ratio of Irrigated to Unirrigated Yield		
	$\bar{R}^2$	b	c	$\bar{R}^2$	b	c
Gujarat	NS			NS		
Karnataka	0.77	0.057		0.17	0.021	
Maharashtra	NS			NS		
Madhya Pradesh	0.55	0.037	0.007	0.25	0.015	
Orissa	0.53	0.074		0.22	0.020	
West Bengal	0.61	0.042		0.18	0.148	
Tamil Nadu	NS			NS		
Uttar Pradesh	0.81	0.083		0.23	0.021	
Andhra Pradesh	0.84	0.037		NS		
Punjab	0.78	0.067		0.60	0.032	
Bihar	0.21	(-)0.037		0.52	(-)0.016	
Rajasthan	NS			NS		
Haryana	0.87	0.056		0.47	0.044	

Note: NS = No significant trend. In other cases results relate the best fitting function which is generally Lny = a+bt, except Madhya Pradesh (irrigated) where the best fitting function is $Lny = a+bt+ct^2$.

There are a few states where the differential seems to be declining (largely because of stagnation or fall in irrigated yields) but except in Bihar these are not statistically significant trends. In Bihar, unlike in any other state, the irrigated-unirrigated yield differential shows a strong *declining* trend because the estimated yield per ha of irrigated crop area shows no significant trend while that of unirrigated area shows a statistically significant trend rise of around two per cent a year. Andhra Pradesh and Maharashtra, where the differential shows no significant trend, are also among the few states where the unirrigated yield shows a statistically significant rising trend; irrigated yields show no trend in Maharashtra, while they are rising in Andhra Pradesh, the rate of increase is not much higher than that of rainfed crops. In interpreting these trends, one must of course bear in mind that the estimates of irrigated yields are subject to a larger margin of sampling error as discussed earlier.

V
IMPACT OF IRRIGATION ON CROPPING INTENSITY, CROP PATTERNS AND PRODUCTIVITY IN TAMIL NADU

In the previous section we presented state level estimate of the productivity of irrigated and unirrigated areas as well as their relative movement over time with some attempt to see whether differentials in productivity between these categories of land bear any relation to rainfall, its seasonal distribution and irrigation quality. This section attempts a similar exercise using district level data for Tamil Nadu. It also seeks to explore the impact of irrigation on cropping intensity, crop patterns and the degree of diversification of crop husbandry. We begin with a discussion of crop intensity; this is followed by an analysis of irrigated and unirrigated crop patterns; the final section deals with output per unit area.

CROPPING INTENSITY

All recent explorations of the determinant of cropping intensity variations and trends [Ray, 1989; Dhawan, 1991 and Mahendra Dev, 1991] confirm the importance of irrigation in raising crop intensity. Mahendra Dev's study covers districts of Tamil Nadu. In Tamil Nadu, as in most parts of the country, unirrigated lands can only grow seasonal crops which take 120-150 days to mature on the basis of limited and uncertain moisture available from rainfall. Irrigation, in so far as it increases the quantum of water available to the crops, makes possible the cultivation of relatively water intensive seasonal crops particularly paddy. In so far as it also makes water available for a longer duration after the monsoon is over, irrigation permits cropping in the dry season as well. This could take the form of growing a different crop during the dry season, growing longer duration crops (like sugarcane) or crop varieties (as in the case of paddy). All of which mean that a piece of land with access to irrigation will grow crops for more months in a year than those which depend wholly on rainfall.

Regional Variations

During the quinquennium ending 1986, irrigated cropping intensity as conventionally measured (i.e., GIA/NIA) range from 1.04 in Ramanathapuram to 1.45 in South Arcot; and unirrigated intensity (GUIA/NUIA) from around 1 in Ramanathapuram to 3.4 in Thanjavur. In most districts irrigated cropping intensity is higher than on unirrigated areas. However, an extreme example of this is Thanjavur where GUIA/NUIA works out to 3.4, compared to GIA/NIA of 1.34. Clearly it is absurd to infer from this that rainfed land in Thanjavur is cropped three and half times a year. The fact is that a substantial part of the land classified as irrigated (NIA/NSA = 87 per cent) is cropped without any irrigation in one or two seasons. This is perhaps the reason that GUIA/NUIA is greater than GIA/NIA in Chingleput also. In general the conventional measure understates the differential in cropping intensities on the two classes of land. The more appropriate measure would be gross cropped area on irrigated land per unit of NIA (rather than GIA/NIA). This index would show the cropping intensity on irrigated land to be considerably higher, and that of unirrigated land lower, than the conventional estimates.

Determinants

One might expect the cropping intensities to be a function of the level of rainfall, its seasonal distribution and the extent and quality of irrigation. On unirrigated areas, rainfall and its seasonal distribution must be the dominant factors. The expectation is that the higher the rainfall and smaller its seasonal concentration, the higher will be the cropping intensity. On irrigated areas the quality of irrigation is an additional factor: well irrigation (presumed to be available for a longer period and more controllable) is of superior quality, while water supply from tanks is rather uncertain. One might therefore expect irrigated cropping intensity to be higher in areas with a relatively high proportion of irrigated land under wells; the greater dependence on tanks is likely to lower the irrigated cropping intensity.

We have tested these expectations against the pooled data for all the districts for four points of time (Table 29). The regressions show that, other things given, GIA/NIA tends to be higher when total rainfall is higher; when its seasonal concentration is less; and when a higher proportion of irrigated area is under wells. The first two associations are statistically significant but the third is not.

Unirrigated cropping intensity (GUIA/NUIA) also is strongly and positively associated with total rainfall and, somewhat surprisingly, also its seasonal concentration. If we include the irrigation ratio along with the level and seasonal concentration of rainfall among the explanatory variables, the coefficient for the latter becomes non-significant, irrigation emerging as a strong influence on unirrigated cropping intensity conventionally measured. Given the limitation of the conventional measure of irrigated and rainfed cropping intensity- the former being an underestimate and the latter an overestimate, with the extent of the bias varying across districts- these associations need to be interpreted with caution.

These limitations however do not apply to overall crop intensity (GCA/NSA) which is seen to be significantly influenced only by the irrigation ratio and the level of rainfall- the higher the irrigation ratio and the higher the rainfall, the higher tends to be the overall cropping intensity. The seasonal distribution of rainfall and the relative importance of irrigation sources turn out to be non-significant.

TABLE 29. RELATION BETWEEN CROPPING INTENSITY AND SELECTED AGRO-CLIMATIC VARIABLES, TAMIL NADU

	Independent variables					
	Total Rainfall	% Rainfall in NE monsoon	NIA/NSA	%NIA served by		
				wells	tanks	R^2
GIA/NIA	+0.00039*	-0.00869*		0.000368		0.406
	(0.00014)	(0.00257)		(0.00141)		
	+0.000369*	-0.00890*			-0.00009	0.405
	(0.000113)	(0.00242)			(0.00092)	
GUIA/NUIA	0.000897*	0.025238*				0.205
	(0.000446)	(0.00949)				
	-0.00010	0.000816	0.020928*			0.340
	(0.00054)	(0.12289)	(0.00739)			
GCA/NSA	0.029423*	-0.12839	0.321876*	0.00303	-0.009922	0.595
	(0.01002)	(0.210)	(0.13093)	(0.09444)	(0.06391)	

Figures in brackets refer to standard error of estimated coefficients.
* denotes coefficients which are statistically significant.

CROP PATTERN

Salient Features

In Tamil Nadu cereals other than paddy, oilseeds and pulses are the dominant unirrigated crops (Table 30). Together they account for 77 per cent of total unirrigated gross cropped area. This pattern holds in most districts, except Chingleput and Ramanathapuram where the cultivation of rainfed paddy is rather extensive and accounts for a substantial portion of unirrigated crop area. Cereals are a heterogeneous group, comprising several different crops whose relative importance varies from district to district. For instance, cholam is prominent in Coimbatore, Madurai and Salem; cumbu in South Arcot and Tirunelveli; and ragi in Salem. Pulses account for a relatively higher proportion of unirrigated crop area in Coimbatore, Salem, Tirunelveli and Madurai (all relatively low rainfall districts) while in Kanyakumari and Chingleput (both characterised by relatively high rainfall) it is negligible. The high incidence of unirrigated pulse cropping in Thanjavur seems to reflect the practice of growing this crop on residual moisture after the paddy is harvested. Oilseeds (groundnut) is the dominant rainfed crop in North Arcot, South Arcot and Chingleput; and prominent in Salem, Thanjavur and Tiruchirappalli. Cotton is a significant rainfed crop only in Tirunelveli and Ramanathapuram.

TABLE 30. CROP PATTERNS IN IRRIGATED AND UNIRRIGATED AREAS, 1978-79 TO 1982-83

(per cent)

		Paddy	Other Cereals	Pulses	Oilseeds	Cotton	Sugar cane	Condiments & Spices	Fruits & Vegetables	Tobacco	ONFC
Chingleput	UI	39.9	9.7	3.9	39.7	neg	0.5	0.2	4.1	0.0	2.0
	I	81.9	4.2	0.2	10.2	neg	1.2	0.8	1.1	0.0	0.3
Coimbatore	UI	0.5	52.3	20.1	17.9	0.8	0.1	0.4	0.1	0.0	7.8
	I	27.5	19.9	1.0	20.8	6.7	11.0	4.6	5.0	2.0	1.4
Kanyakumari	UI	0.0	0.0	2.4	29.0	neg	5.7	6.0	31.2	neg	25.6
	I	91.8	0.0	0.1	3.4	neg	0.0	0.1	4.5	neg	neg
Madurai	UI	0.1	47.4	14.5	16.7	6.3	0.1	1.6	6.8	neg	6.5
	I	52.8	11.6	0.6	9.3	9.9	3.9	2.4	8.3	0.6	0.7
North Arcot	UI	0.4	25.7	10.8	60.3	neg	0.1	0.3	2.0	neg	0.4
	I	67.6	6.2	0.1	12.3	0.3	10.5	0.7	2.0	neg	0.3
Ramanathapuram	UI	26.8	25.6	6.6	10.6	11.0	1.3	5.4	1.5	neg	11.2
	I	73.6	5.8	0.3	3.2	5.3	2.2	7.3	1.9	neg	0.4
South Arcot	UI	8.8	35.2	10.5	33.9	0.7	0.2	1.9	8.0	neg	0.7
	I	66.2	6.6	0.4	14.8	1.5	7.2	0.6	2.2	neg	0.5
Salem	UI	0.1	48.8	18.9	24.3	1.4	0.1	0.6	3.4	neg	2.3
	I	41.4	14.4	0.5	9.7	6.4	10.0	2.5	12.9	0.2	2.0
Thanjavur	UI	7.6	1.9	55.7	23.5	0.1	0.3	0.3	2.6	neg	7.9
	I	94.5	0.4	neg	2.0	0.3	1.3	0.2	1.0	0.1	0.1
Tiruchirappalli	UI	6.4	54.7	7.5	19.3	0.7	0.1	4.9	5.9	neg	0.6
	I	69.2	7.1	0.3	8.3	0.6	4.6	3.8	5.3	0.1	0.5
Tirunelveli	UI	0.2	29.9	14.3	5.6	20.5	4.0	7.6	0.8	neg	16.8
	I	62.6	8.4	0.9	4.1	7.8	0.6	8.0	6.6	0.1	0.9
Tamil Nadu	UI	6.0	38.1	15.9	23.3	3.9	0.7	2.5	4.0	neg	5.6
	I	66.4	7.8	0.4	9.3	3.3	5.1	2.6	4.1	neg	0.7

Note: ONFC stands for other non-food crops.
Source: Government of Tamil Nadu, *Season and Crop Reports:* various issues.

The irrigated crop pattern is dominated by paddy which accounts for nearly two-thirds of the gross irrigated area compared to a mere six per cent of gross unirrigated crop area. Correspondingly, other cereals, pulses and oilseeds figure much less prominently among irrigated crops. The proportion devoted to sugarcane is much higher on irrigated areas (5.1 per cent compared to 0.7 per cent on rainfed crop area) but its importance (in terms of area) is obviously small compared to paddy. There is not much difference between the two categories of land in the share of cotton, condiments and spices and fruits and vegetables.

At the district level also irrigated and unirrigated cropping follow a broadly similar pattern. However, there are important differences. Thus the dominance of paddy on irrigated areas is very marked in Chingleput, Kanyakumari and Thanjavur; by contrast, in Coimbatore and also in Salem and Madurai (all of which incidentally fall in the relatively low rainfall tracts of the state),

paddy is not as prominent among the irrigated crops. The irrigated crop patterns in Coimbatore and Salem are among the most diversified in the state, with sizable proportions of area devoted to oilseeds (mainly groundnut), sugarcane, cotton, condiments and spices, and fruits and vegetables. The share of all these crops in the irrigated crop pattern is higher, often much higher, compared to the unirrigated areas. In Madurai too, irrigated crop pattern is rather diversified though not of the same degree as in Coimbatore or Salem.

Changes Over Time

Looking at changes over time, the relative importance of paddy as well as other cereals in gross irrigated area has progressively declined since the early 1950s; while that of sugarcane, oilseeds, condiments and spices and fruits and vegetables have risen sharply. The rise in the share of sugarcane, a highly water intensive crop, is most marked in Coimbatore, Salem, South Arcot and North Arcot. Cotton has gained importance as an irrigated crop in some districts, notably Salem, Tirunelveli and Madurai. The fall in the share of paddy is noticeable mainly in Madurai, North and South Arcot, Chingleput and Tirunelveli. The share of cereals on a whole in unirrigated crop area has also fallen. The main gainer being pulses, and to a small extent fruits and vegetables. In some districts (Chingleput, North Arcot and Salem), oilseeds cultivation has become more widespread on unirrigated areas.

Irrigation and Crop Diversification

Irrigation not only changes the nature and composition of crops grown, but also leads to a higher degree of crop concentration. One index of crop concentration is the proportion of total cropped area accounted by the three largest crops. Taking the state as a whole, the three crops grown most extensively on irrigated areas (namely, paddy, oilseeds and cotton) account for a much higher proportion of gross irrigated area than the corresponding index for unirrigated areas. This is also true in practically all the districts.

An alternative and more comprehensive measure of concentration is the extent to which actual shares of the selected crop groups deviate from a situation of maximum diversification, i.e., when the total area is equally distributed among all the specified crops. This is reflected in the coefficient of variation of A_j / A (j = i.....n) with reference to the mean share of each crop when area is equally distributed $((A/n)/A) \times 100 = 100/n$. This index as well as that of spatial specialisation discussed subsequently was suggested by Asha Iyengar, [1991]. This again shows that irrigated crop patterns have a higher degree of crop concentration than unirrigated patterns (Table 31).

TABLE 31. DEGREE OF CROP CONCENTRATION IN IRRIGATED AND UNIRRIGATED AREAS, DISTRICTS OF TAMIL NADU

District	1951-55		1958-62		1968-72		1978-82	
	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
Coimbatore	97.8	98.0	117.4	115.4	107.4	134.3	98.1	155.0
Chingleput	297.3	157.8	302.5	172.8	292.3	175.8	291.8	181.1
Kanyakumari	NA	NA	292.9	163.3	339.0	173.4	328.1	170.0
Madurai	199.7	100.7	209.9	103.6	198.2	97.2	183.7	96.5
North Arcot	257.2	158.1	273.2	188.7	262.8	207.0	239.3	207.6
Ramanathapuram	233.8	108.2	247.9	87.0	269.5	84.1	260.0	91.3
South Arcot	259.2	120.5	275.8	113.3	258.7	121.4	234.4	114.2
Salem	149.1	98.8	183.7	96.4	180.0	103.2	145.1	105.7
Thanjavur	341.6	108.2	342.1	110.5	339.4	135.6	339.2	196.1
Tiruchirapalli	240.9	102.0	245.1	103.8	240.5	104.2	243.7	103.6
Tirunelveli	233.4	115.5	239.2	113.0	214.7	107.8	221.6	99.0

Inter-district Variations

District level data show considerable variation in the concentration indices in both categories of land. Overall, during 1978-79 to 1982-83, irrigated crop patterns were less diversified than on rainfed areas in all but one district. The exception is Coimbatore where the irrigated crop pattern is far more diversified than in any other district and also compared to rainfed crop patterns in the district.

Apart from Coimbatore, irrigated crop pattern is relatively more diversified in Salem and Madurai. All these districts have low rainfall and a relatively high degree of dependence on wells. Water intensive crops like paddy are relatively less important in these districts. The extent of diversification is relatively low in Thanjavur, Chingleput and Kanyakumari, all of which have relatively high rainfall and in two of them tanks are the dominant irrigation source. Upwards of 80 per cent of the irrigated area is devoted to paddy.

Unirrigated crop patterns are most diversified in Ramanathapuram, partly because cultivation of rainfed paddy is rather widespread. The degree of diversification is also quite high in Tirunelveli and Madurai. All these districts have relatively low rainfall; diversified cropping seems to reflect the strategy of farmers to reduce the risks associated with low and precarious rainfall. By contrast, districts with high rainfall have relatively much less diversified rainfed crop patterns.

The difference between the diversification indices is most marked in Ramanathapuram which combines a diversified rainfed crop pattern with a highly paddy-centric crop pattern on irrigated areas. It is relatively large in Tiruchirappalli and Tirunelveli, where irrigation is concentrated in river valleys and used mainly for paddy. At the other extreme are Coimbatore and Salem, both with extraordinarily diversified irrigation crop patterns, Salem having, in addition, a relatively diversified rainfed cropping.

Trends Over Time

On irrigated areas, seven out of the eleven districts show a tendency for increased diversification of irrigated cropping, mostly after 1958-62, the tendency being more marked in Coimbatore, Madurai and Salem, and rather weak in Chingleput and Tirunelveli. There is not much of a change in Thanjavur and Tiruchirappalli, while in Kanyakumari and Ramanathapuram irrigated cropping seems to have got more concentrated. In sharp contrast, rainfed cropping has tended to become less diversified in a majority of the districts (six out of eleven), the tendency being most marked in Thanjavur and Coimbatore. There is not much change in Madurai, Ramanathapuram, South Arcot and Tiruchirappalli. Tirunelveli is the only district where the cropping on unirrigated areas is getting more diversified.

The result is a narrowing down of the differences in the index of crop concentration between the two categories of land in a majority of districts (especially since 1958-62). In three districts (Ramanathapuram, Tiruchirappalli and Tirunelveli), where the diversification indices do not show any sustained trend, the differential also has not changed appreciably. Coimbatore is again the exception to this pattern - the irrigated crop pattern has become more and more diversified relative to that of unirrigated areas. The reason for this is beyond the scope of the present paper but merits closer study.

Underlying Factors

We explored the extent to which the degree of crop concentration on irrigated and unirrigated areas might be influenced by rainfall and irrigation characteristics (Table 32). Again using pooled data for the eleven districts in all four periods, the crop concentration index for irrigated areas is seen to increase with rainfall and its seasonal concentration, and to fall as the proportion of area irrigated by wells increases. All coefficients are significant and a major part of the variation in the diversification index is accounted for by these factors. On unirrigated areas total rainfall turns out to have a significant influence on cropping if we consider only rainfall characteristics; but once irrigation is also included as a possible explanatory variable the crop concentration is seen to be in strong positive association with the irrigation ratio and- not so strongly- inversely related to the seasonal concentration of rainfall.

TABLE 32. RELATION BETWEEN DEGREE OF CROP CONCENTRATION AND AGRO-CLIMATIC VARIABLES

	Total Rainfall	% RF in NE Monsoon	NIA/NSA	%NIA served by		R^2
				Wells	Tanks	
Irrigated areas	0.13719*	1.12982*		-1.18391*		0.796
	(0.03015)	(0.55395)		(0.30319)		
	0.23725*	2.10682*			0.70805*	0.669
	(0.03110)	(0.66296)			(0.25284)	
Unirrigated areas	0.8684*	-0.0715				0.295
	(0.02336)	(0.49633)				
	0.04	-1.2785**	1.02953*			0.370
	(0.03)	(0.65021)	(0.39106)			

Note: Figures in brackets refer to standard error of coefficient estimate.
* significant at 5 per cent.
** significant at 10 per cent.

Irrigation and Spatial Specialisation of Crops

The crop concentration index gives a measure of the extent of specialisation in crop patterns within a particular geographical area. The spread of irrigation may also affect the pattern of spatial specialisation in particular crops. The index relevant for this purpose is the coefficient of variation of

$$\left(A_{ij} / \sum_{j} A_{ij}\right) / \left(A_j / \sum_{j=1}^{n} A_j\right)$$

where A_{ij} is the area sown to crop i in the j^{th} region, the numerator measures the share of region j in the total area sown to crop i in all regions (j = 1.....n), and the denominator measures the total crop area in region j as a proportion of total crop area in all regions. The latter helps to normalise the index by netting out the effects of differences in size of each region and (in comparisons over time) of differential changes therein. The results are summarised in Table 33.

TABLE 33. INDEX OF SPATIAL SPECIALISATION OF CROPS

	Irrigated				Unirrigated			
	1951-55	1958-62	1968-72	1978-82	1951-55	1958-62	1968-72	1978-82
Paddy	79.3	75.6	66.1	75.7	199.9	199.3	210.6	222.1
Cholam	85.9	90.7	100.9	98.6	71.6	75.6	78.4	88.5
Cumbu	119.7	109.8	76.5	59.2	55.2	72.1	73.5	90.3
Ragi	48.3	52.0	51.0	67.8	148.7	128.7	134.4	154.6
Other Cereals	77.0	117.0	104.9	87.0	51.4	38.7	83.1	38.0
Pulses	150.3	89.4	120.4	76.7	131.4	98.6	94.9	107.4
Sugar Crops	76.3	78.4	73.0	76.7	146.6	155.6	138.0	158.6
Gingelly	73.7	57.6	69.1	101.3	88.5	68.3	73.7	81.3
Groundnut	94.3	64.7	53.7	51.0	77.8	81.0	90.8	134.1
Other Oilseeds	116.9	100.4	107.6	82.7	NA	NA	NA	NA
Cotton	150.7	115.7	120.6	96.0	134.1	135.3	150.1	169.2
Chillies	89.0	94.6	109.0	120.0	132.4	130.8	130.8	151.5
Turmeric	169.1	147.8	182.6	174.4	119.2	185.3	153.0	194.5
Tobacco	195.0	169.8	194.6	170.4	167.7	95.3	154.5	116.0
Other Food Crops	281.9	277.4	263.3	260.3	87.5	87.8	59.8	71.6
Other non-Food Crops	95.3	60.6	89.0	83.3	137.2	159.8	149.3	91.7

Differences Between Crops

Among irrigated crops the degree of specialisation across districts is the lowest in groundnut and highest in the group 'other food crops'. It is relatively low for cereal crops, sugar cane and pulses and high for chillies turmeric, tobacco and other 'minor' crops which evidently are more demanding in terms of environment. Among unirrigated crops, in a majority of cases, the degree of spatial specialisation is higher than among their irrigated counterparts. This is not surprising in as much as a wider range of crops can be grown under irrigation than under rainfed condition, and also because differences in soil-moisture regimes across regions are likely to be narrower on irrigated than on unirrigated lands. However agroclimatic conditions are still relevant; some crops do better, even with irrigation, under some type of soil/temperature/rainfall regime than under others. This accounts for the considerable variation in the spatial specialisation between crops.

Changes Over Time

Over time, the degree of spatial specialisation of a large majority of rainfed crops on unirrigated areas has risen (Table 34). This trend is particularly striking in the major rainfed crops of the state, namely, cholam, cumbu, groundnut and cotton. This contrasts with the tendency in the cultivation of majority of irrigated crops (including paddy, cumbu, pulses, groundnut and cotton) to become much more diffused spatially. However in a few crops (cholam, ragi, gingelly and chillies) irrigated cultivation is becoming more concentrated across space; and there is no change in the spatial concentration of sugarcane.

TABLE 34. DISTRICTS REPORTING CHANGES IN THE SHARE OF SELECTED CROPS IN IRRIGATED AND RAINFED AREA 1951-55 TO 1978-82

	Irrigated Area						Unirrigated Area					
	Paddy	Other Cereals	Pulses	S.Cane	Oilseeds	Cotton	Paddy	Other Cereals	Pulses	S.Cane	Oilseeds	Cotton
Increase	RP			CBE MDU NA RP SA SLM	CPT CBE MDU NA SA SLM TCY TLI	MDU SA SLM TLI	RP SA TCY	CBE	CBE MDU RP SA SLM TNJ TCY TLI		CPT NA SLM	
Decrease	CBE MDU SA SLM TLI	CPT CBE MDU NA RP SA SLM TCY TLI		CPT	CPT	TCY	CPT NA TNJ	CPT NA RP SA SLM TNJ TCY			TCY	CBE MDU RP TCY

Note: CBE - Coimbatore, CPT - Chingleput, MDU - Madurai, NA - North Arcot, RP - Ramnathpuram, SA - South Arcot, SLM - Salem, TCY - Tiruchirappalli, TLI - Tirunelveli, TNJ - Thanjavur.

Underlying Factors

Spatial specialisation on either category of land may change on account of broadly two sets of factors: (i) the development of transport leading to widening and integration of markets for farm produce; and (ii) shifts in comparative advantage due to differential changes in technology. The former, which has been a significant feature of the post-Independence period, may be expected to induce greater regional specialisation all around. In so far as technological progress, par-

ticularly in bio-chemical technology, has been largely confined to irrigated crops, the second factor is likely to have influenced regional specialisation in irrigated areas far more than on rainfed land. The general tendency towards greater regional specialisation among rainfed crops and greater specialisation of rainfed cropping in most districts is consistent with this. So is the fact that the pattern of change on irrigated areas is mixed. However, the growing importance of well irrigation, but at different rates, is likely to be an additional influence. Unravelling the relative roles of these factors and the extent to which growing regional specialisation on rainfed areas has helped to raise overall efficiency call for more detailed analysis.

OUTPUT PER UNIT AREA

Basis of Estimates

Estimates of the value of output per hectare of gross irrigated and unirrigated areas for the state as a whole and by districts are given in Table 35. The districts mentioned therein differ from those in earlier discussion because of bifurcation of some districts in the early 1980s. Pudukottai and Dharmapuri are newly created districts. These relate to the period 1982-83 to 1986-87 and outputs are valued on the state average farm harvest prices of 1986-87. They are based on the statistics of area, production and yield published in the *Season and Crop Reports* of the Government of Tamil Nadu. As in the case of state level estimates, the crops have been divided into two groups: (i) those for which estimates of area and yield are published separately for irrigated and unirrigated areas (cholam, cumbu, ragi, groundnut, cotton, sunflower and gingelly); (ii) those for which such separate estimates are not published but which are known to be predominantly irrigated (paddy, maize, chillies, banana, sugarcane, tobacco, potato, onion and turmeric) or rainfed (korra, varagu, samai, other cereals and all pulses). For the purpose of estimating value productivity, crops falling in the second group, the predominantly irrigated ones, are taken as part of irrigated agriculture and the predominantly rainfed crops as part of unirrigated agriculture.

TABLE 35. VALUE OF OUTPUT PER HECTARE OF IRRIGATED AND UNIRRIGATED AREA, TAMIL NADU AND DISTRICTS (AVERAGE FOR 1982-86)

(Rs at 1986-87 prices)

District	Output per ha of				Ratio of Irrigated to Rainfed Productivity		Rainfall mm	% NIA under Tanks	%NIA under Wells
	GIA	NIA	GUIA	NUIA	GROSS	NET			
Chingleput	6,701	9,498	2,973	1,872	2.25	5.07	1,259	49.4	47.4
South Arcot	9,582	13,785	2,327	2,288	4.12	6.02	1,102	24.4	50.9
North Arcot	8,098	10,862	2,805	2,883	2.89	3.77	964	30.7	66.0
Salem	9,823	10,551	2,609	2,809	3.76	3.76	826	4.2	81.1
Dharmapuri	9,689	10,695	2,004	2,101	4.83	5.09	747	20.4	56.1
Coimbatore	11,368	11,189	1,764	1,720	6.45	6.51	600	1.3	56.1
Tiruchirappalli	8,691	10,938	1,624	1,399	5.35	7.82	733	11.3	43.7
Pudukottai	5,780	6,735	3,090	2,420	1.87	2.78	778	80.7	11.7
Thanjavur	7,603	9,659	1,685	4,273	4.51	2.26	1,197	5.2	2.0
Madurai	7,476	8,090	1,977	1,728	3.78	4.66	741	18.7	54.5
Ramanathapuram	6,647	6,766	2,312	1,741	2.88	3.89	842	77.0	23.0
Tirunelveli	6,606	8,245	1,515	1,094	4.36	4.53	741	45.7	39.5
Tamil Nadu	8,175	9,965	2,109	2,003	3.88	4.98	952	21.8	39.0

Variations

On the average, a hectare of irrigated crop area in Tamil Nadu yielded output valued at Rs 8,175, nearly four times average for hectare of unirrigated crop area (Rs 2,110). The production per hectare of irrigated crops is the lowest in Pudukottai (Rs 5,780) and highest in Coimbatore (Rs 11,368). The comparable range for rainfed crops is Rs 1,515 (Tirunelveli) and Rs 3,090 (Pudukottai). The difference in output per gross hectare in absolute terms ranges from around Rs 2,700 in Pudukottai to Rs 9,600 in Coimbatore; and in relative terms (ratio of irrigated to unirrigated productivity) from 2.6 (Chingleput) to 7.75 (Coimbatore). These differentials are much wider than those obtained from state level estimates and suggest that comparisons across broad regions may tend to understate the impact of irrigation on productivity.

Outputs per unit of net irrigated and net unirrigated area are obtained by multiplying the outputs per hectare of gross irrigated and unirrigated areas by their respective cropping intensities measured by GIA/NIA and GUIA/NUIA. These estimates, for reasons already cited, tend to overstate the cropping intensity of rainfed land and understate that of irrigated land. Except in Chingleput and Thanjavur (where unirrigated crop intensities are higher than on irrigated areas) in all districts, the differential between output per hectare of irrigated and unirrigated land is more than the differential per unit of cropped area both in absolute and relative terms.

Underlying Factors

The inter district variations in output per ha of irrigated and rainfed crop areas as well as the differential between them are the result of several environmental and technological factors. A complete explanation is beyond the scope of the present study. However, it seems reasonable to expect that the output per ha of rainfed crops will be a function of rainfall and its seasonal distribution. In the case of irrigated areas, besides rainfall, the quality of irrigation is also relevant. The proportion of net irrigated area served by wells is taken as one index of quality - the higher this proportion the better the quality of irrigation. Tank irrigation is of relatively poor quality - the higher the proportion of irrigated area served by this source, the lower is likely to be the yield impact of irrigation.

The association between rainfall and output per hectare of unirrigated crop area is positive but not statistically significant; but the former's association with output per unit of net unirrigated area is strongly positive. Productivity per unit of irrigated crop area is negatively associated with rainfall and percentage of irrigated land served by tanks and positively with percentage of irrigated area under wells. However, only the coefficient for tanks is significant - suggesting that the greater the importance of tank as a source of irrigation, the less the overall productivity of irrigated areas. This pattern is also noticed, but to an even weaker degree, when we focus on variations in output per unit of net irrigated area (Table 36).

Rainfall and the proportion of irrigated land under tanks have a much stronger negative relation with the ratio of irrigated to unirrigated yield. Somewhat unexpectedly, the relative productivity differential seems to decline as the proportion of irrigated area under wells increases, but this association is statistically weak. The ratio of output per unit of net irrigated to that per unit of net unirrigated area has a significant negative relation to tank irrigation but not to rainfall or wells. This relation is however likely to be vitiated by the varying biases across districts involved in our procedure for estimating the productivity of irrigated and rainfed land.

Trends in Yield and Yield Differentials

Analysis of changes in per hectare yield from 1970-71 to 1985-86 suggests that in seven out of ten districts there has been a significant rising trend in irrigated yield; in three of them the yield increase shows acceleration. Unirrigated yields in most cases (eight out of ten) show no significant trend; in two, they have recorded a significant

decline (Table 37). There has thus been a progressive widening in the gap between irrigated and unirrigated yields, both in absolute and relative terms. This is in line with the pattern observed in our analysis of state level data in the earlier section and series to underline the growing dualism in Indian agriculture between an apparently stagnant rainfed agriculture and the reasonably dynamic, irrigated segment.

TABLE 36. RELATIONSHIP BETWEEN PRODUCTIVITY OF IRRIGATED AND RAINFED AREAS AND AGRO-CLIMATIC FACTORS IN TAMIL NADU

	Total Rainfall	% NIA Under Tanks	%NIA Under Wells	%RF in NE Monsoon	$\bar{R}^2$
Output/ha GIA	-1.4895	-380.1653*	22.0261		0.601
	(1.5932)	(12.8798)	(16.2191)		
NIA	2.15702	-71.12048	28.39789		0.621
	(3.43080)	(43.42707)	(60.08357)		
Output/ha GUIA	0.9573				0.445
	(0.7785)				
NUIA	3.2056*			-18.031	0.521
	(0.8930)			(20.8331)	0.704
Ratio of output	-3				
per ha GIA/GUIA	-2.9062*	-0.0405*	-0.0157		
	(1.0753)	(8.6935)	(0.0110)		
Ratio of output	-3			-3	
per ha NIA/NUIA	-1.7379	-0.0709*	-0.0494	-8.315	0.655
	(2.3959)	(0.2892)	(0.0508)	(0.0640)	

Figures in brackets refer to standard error of estimated coefficients.
* Significant at 5 per cent.
** Significant at 10 per cent (not used in this table).

TABLE 37. TRENDS IN IRRIGATED AND UNIRRIGATED YIELD PER HECTARE OF CROPPED AREA, 1970-71 TO 1985-86

	Irrigated				Unirrigated			
	$\bar{R}^2$	Function	Value of b	Coefficient c	$\bar{R}^2$	Function	Value of b	Coefficient c
Coimbatore	NS				0.45	semi-log	-0.047	
Chingleput	0.24	semi-log	+0.017		NS			
Madurai	0.21	semi-log	+0.016		0.45	semi-log quadratic	-0.270	-0.0074
North Arcot	0.39	semi-log	+0.017		NS			
Ramnathpuram	NS				NS			
South Arcot	0.41	semi-log	+0.220		NS			
Salem	0.72	quadratic	+0.049	+0.0053	NS			
Thanjavur	0.56	quadratic	+0.020	+0.0029	NS			
Tiruchirappalli	0.57	quadratic	+0.012	+0.0061	NS			
Tirunelveli	0.30	semi-log	0.017		NS			

Note: NS- not significant.

VI
SUMMARY AND CONCLUSIONS

In this paper we have tried to (a) extend multiple regression analysis to assess irrigation impact at a disaggregated level using district level data; and (b) estimate of the overall value product per hectare of irrigated and unirrigated areas by state, and for the districts of Tamil Nadu, on the basis of official statistics of land use, crop area and yields.

Multiple Regression Analysis

The multiple regression analysis first estimates a linear, additive production function relating per ha output to rainfall, irrigation ratio and fertilisers

across districts, grouped by rainfall and irrigation development, at three points of time. It also estimates the relation between the increment in yield per ha across districts within each of the above groups and the corresponding increment in the three inputs between three points of time. The main points emerging from this exercise are as follows:

(i) differences in the irrigation ratio are a significant factor in accounting for inter-district variations in output per hectare among districts in the low and the medium rainfall zones, but not in the high rainfall tracts.

(ii) The extent of the influence is generally higher in the low than in the medium rainfall tracts; greater in low than high irrigation tracts. The influence of irrigation in accounting for spatial differences in yield has tended to decline over time in low rainfall tracts and to increase in the medium rainfall zones.

(iii) While there is no strict complementarity between irrigation and fertiliser use, the fact that the fertiliser coefficients are generally higher in high rainfall and in high irrigation regions supports the belief that yield response to fertilisers depends on the soil moisture regime.

(iv) In most cases changes in the extent of irrigation *per se* have significant bearing on changes in productivity especially among districts experiencing a decline in productivity and those recording a higher-than-average growth. The irrigation coefficient is much higher in districts experiencing decline in productivity than among those where productivity is rising. Within the latter group there is no relation between the yield increment due to an increase of one percentage point in the irrigation ratio and the extent of irrigation.

(v) Irrigation also affects yields via its influence on the level of fertiliser use and the yield response per unit of incremental nutrient. Regions with a high level of irrigation tend to use more fertilisers per ha, at any rate since the early 1970s and also show a higher yield response coefficient per unit of incremental fertilisers. Indeed this indirect impact of irrigation seems far more important in accounting for difference in growth of yields, than yield response to irrigation *per se*.

(vi) Other things given, one hectare of irrigation *per se* makes a difference to output per gross hectare (valued at 1967-69 prices) ranging between Rs 700 and Rs 2,100 in the low rainfall tracts and from Rs 750 to Rs 1,600 in the medium rainfall areas. At 1986-87 prices the direct contribution of irrigation as a factor accounting for spatial differences in output per hectare would be Rs 2,300-6,900 in the low and Rs 2,500-5,300 in the medium rainfall categories. This is a crude adjustment based on the wholesale price index of agricultural products, which has risen by 230 per cent between 1970-71 and 1986-87 (the value of the index in 1986-87, with 1970-71 = 100, being 330).

(vii) The yield response to *increments* in irrigation also shows a high degree of variability. Considering only the significant coefficients, and also ignoring the one case (low rainfall, declining districts in the first period) when the irrigation coefficient is significantly negative, the output per ha (at 1967-69 prices) is estimated to be higher by between Rs 630 and Rs 2,000 when the irrigation ratio increases by one percentage point. At 1986-87 prices, the comparable figures would be Rs 2,100 to Rs 6,600. This is similar to the range indicated by the regression estimates relating level of yield to those of inputs across districts at different points in time. However there is no consistent pattern across rainfall zones and growth categories.

We then attempted a similar exercise using time series data on output per ha, rainfall and irrigation for some 110 districts covering seven states and the period 1956-57 to 1978-79.

The aim was to estimate productivity of irrigation in each of the 110 districts covering seven states using time series data. A linear regression

function was specified and estimated with value product per hectare as dependent variable. The districts were grouped into several strata based on rainfall, irrigation coverage, and quality of irrigation. An attempt was also made to assess, and correct, two major sources of bias. This was done through another categorisation of districts based on trends in the irrigation ratio and in crop coverage of the districts.

The results do show that there is considerable difference in the impact of irrigation on output per ha, and that there may be systematic differences in response across rainfall, irrigation level and irrigation quality categories. However, one cannot draw robust inferences from the analysis. In a substantial proportion of cases (even if the limit assures to districts with a rising irrigation rate but constant crop coverage), the regression coefficient for irrigation is not significant and that in most cases irrigation and rainfall account for not even 40 per cent of the changes in yields. This could be due to the high level of noise and non-comparability of estimates over time, but it is also possible that the 'excluded variable' bias is a contributing factor. Fertilisers, changes in the quality of irrigation, and increased productivity of input due to new seeds are important factors. While lack of data and multicollinearity are severe limitations, perhaps the role of fertilisers and secular improvement in productivity inputs can be explored at least in districts experiencing relatively little change in irrigation ratio, and a low correlation between changes in irrigation and in fertiliser use.

Direct Estimation of Productivity Impact of Irrigation

The 'direct estimates' of the productivity of irrigated and unirrigated land relate to selected crops (23 in number) in the case of state level estimates (and 21 in the case of district level estimates for Tamil Nadu) which account for the bulk of crop area. They are derived from official statistics of crop-wise area and yield on certain assumptions: (a) In the case of crops for which separate figures of area and yield are not available, those predominantly irrigated (unirrigated) are taken as wholly irrigated (rainfed). (b) The outputs for state level estimates are valued at all India's average harvest prices of 1986-87 and in the case of Tamil Nadu the average farm harvest prices for the state in 1986-87 are used. (c) The ratio of gross to net irrigated area, and gross to net unirrigated area are taken as measures of cropping intensities respectively of irrigated and unirrigated land.

The state-level estimates show that during the quinquennium 1978-83, the average production per hectare of irrigated cropped area was Rs 4,900, which is Rs 2,900 more than that of a hectare of rainfed crop area. The difference between irrigated and unirrigated productivity ranged from Rs 715 (30 per cent of unirrigated yield) to Rs 5,800 (360 per cent of unirrigated yield). Comparing productivity per unit of irrigated and unirrigated land (i.e., adjusting for cropping intensity differences as indicated), the difference ranges from Rs 1,100 to Rs 7,300 per ha. These estimates are demonstrably biased, in that they underestimate productivity of irrigated land and overestimate that of unirrigated land. These differences do not seem to be systematically related to rainfall, its seasonal distribution or irrigation quality.

Productivity of irrigated area shows a significant rising trend in a majority of states covered (eight out of thirteen) while only four showed a significant trend in rainfed areas (one of them a declining trend). The differential between irrigated and rainfed yields have been rising practically in all the states. In a large majority of states, but not all - irrigated yields are more stable (i.e., fluctuations around the trend are smaller) than unirrigated yields.

District level estimates for Tamil Nadu corroborate the above findings. The range of variation in productivity of irrigated land as well as the irrigated -unirrigated area differences are much larger at the more disaggregated level. The output per ha of unirrigated area ranges from Rs 5,780 to Rs 11,400 and the difference between per ha output of irrigated and unirrigated area ranges from Rs 2,700 to Rs 9,600. In most districts unirrigated yields show no significant trend, while the opposite is the case for irrigated land.

Unlike in the state level data, spatial variations in per ha output of unirrigated land in Tamil Nadu

are found to bear a significant positive correlation with rainfall; productivity of irrigated land is negatively associated with rainfall (but not significantly), positively with the proportion of irrigated land served by wells (non significant) and negatively with the proportion of irrigated land served by tanks (significant). The differentials between irrigated and rainfed land (expressed on a ratio) are inversely associated (in a statistically significant way) with both rainfall and proportion of irrigated land under tanks.

Across Districts

Irrigated crop intensity (GIA/NIA) tend to rise as we move from districts with low rainfall to those with high rainfall; the higher the proportion of rainfall in the NE monsoon, the lower tends to be the irrigated crop intensity. Unirrigated crop intensity is positively correlated with rainfall and the proportion of precipitation occurring during the NE monsoon. But it also seems to be significantly correlated with the irrigation ratio. However the indices used to measure irrigated and unirrigated crop intensities being biased, in varying degrees in different districts, these associations need to be interpreted with caution. Overall crop intensity, which is free from such bias, is largely a function of total rainfall and the irrigation ratio.

Irrigated crop patterns are not only very different from unirrigated patterns, but also has diversified in most districts. Over time, irrigated crop patterns are showing signs of diversification while rainfed cropping is becoming less so.

Irrigated cropping tends to become more concentrated as we move from districts with low to high rainfall, and as the proportion of area under well irrigation increases. In unirrigated areas, total rainfall is a significant factor accounting for the extent of diversification; irrigation ratio also is positively associated with the extent of crop concentration in unirrigated land.

Spatial specialisation also varies a great deal along different irrigated and unirrigated crops. Among the former the cultivation of groundnut is most diffused across districts and that of 'other food crops' most concentrated. Among unirrigated crops, perhaps reflecting hetrogenity of soil moisture conditions under rainfed agriculture, the degree of spatial specialisation in most crops is also higher than under irrigation. Over time, the spatial specialisation of rainfed crop has increased, while the opposite tendency is noticed among irrigated crops.

Our studies suggest that the multiple regression approach to assessing productivity impact of irrigation does not do too well. There are serious problems of interpreting the coefficients partly because all crops are not covered and the extent of coverage by selected crops varies. Also all the relevant biochemical inputs and improvements in technique which may affect yield are not fully captured. Analysis of the relation between increments in yield and increment in inputs seems more meaningful and promising. That stratification by growth rate of yield gives better fits and more meaningful patterns than stratification by rainfall and irrigation is suggestive of the directions of further work.

The direct estimates, despite all the data limitations, involve fewer assumptions and give a more reliable plea of at least the overall difference in productivity between irrigated and rainfed areas. We know for certain that the procedure used underestimates irrigated productivity and overstates output per ha of unirrigated area. Refinements to extend crop coverage and take into account state/district specific prices rather than national/state averages, taking explicit account of differences and changes in quality of products are worth exploring. Also we need to analyse the role of fertilisers, public investments, nature and quality of irrigation, and the changes in incentive environment in accounting for differential performance across time and space.

These refinements can be done only to a limited extent from statistics of area, yield, and inputs compiled by the Ministry of Agriculture through the states. A more promising source of data which permits such analysis is the Cost of Cultivation Surveys which give plotwise details for a sample of farms of irrigation source, varieties used, fertilisers and the inputs by crop for a relatively long period, in fact since 1970. The data may not be amenable to time series analysis, but comparison of pooled data for different regions and irrigation types at a point of time and of changes

in these types between two or three points of time can throw a great deal of light not only on irrigation impact, but on the role of other input factors, and more generally, the dynamics of technological change in agriculture also.

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LABOUR WELFARE ADMINISTRATION IN INDIA
With Special Reference to Himachal Pradesh

Sewa Singh Chauhan

I. NATURE OF THE PRESENT STUDY

The objective of this study is to examine the problems of labour welfare in India in general and in the public and private sector industries of Himachal Pradesh in particular. In respect of the industrial units in Himachal Pradesh, the aspects examined are (i) role and adequacy of administration machinery; (ii) available welfare facilities; (iii) workers' participation in trade union activities; (iv) role of trade unions with respect to labour welfare; (v) problems of women workers as well as the welfare measures adopted for their betterment; and (vi) socio-economic conditions and characteristics of industrial working class in sample industrial units.

Sampling Procedure

Twelve large industrial units in Himachal Pradesh, each employing more than 200 workers, were selected for a general study. These were (1) Horticultural Produce Marketing and Processing Corporation (HPMC), (2) Himachal State Forest Corporation (HPSFC), (3) Cement Corporation of India (CCI), (4) Himachal Pradesh Agro Industries Corporation, (5) Himachal Worsted Mills, and (6) Himachal Fertilizers, all public sector units. The units selected from private sector were: (1) Associated Cement Companies (ACC), (2) Mohan Meakins, (3) Winsom Spinning Mills, (4) Sidhartha Spinning Mills, (5) Gabriel and Purelator Limited, and (6) Eicher Farm Tractors.

In order to study the problems of women workers, another six units selected were: (1) Electronics Corporation Television Unit (ECTV) at Solan, (2) Horticultural Produce Marketing and Processing Corporation (HPMC) units at Parwanoo and Jarol, (3) Cement Corporation of India (CCI) unit at Rajban, all in public sector. The units selected from the private sector were: (1) Khanna Watches at Parwanoo, (2) Gabriel and Purelator unit at Parwanoo, (3) United Diamonds unit at Parwanoo.

Sampling of the Respondents

In this study a sample was taken of 240 workers in case of general welfare of workers, 120 in case of specific problems of women workers, 80 trade union leaders (all office bearers) and 15 managerial personnel.

Method of Data Collection

The first hand information required was collected from workers with the help of pre-tested questionnaires. A separate questionnaire was prepared for collecting data on the problems of women workers.

The secondary data have been obtained from the Labour Bureau, Shimla; Department of Economics and Statistics, Himachal Pradesh, Shimla; Ministry of Labour and Employment, New Delhi; National Institute of Labour, New Delhi; State Labour Department, Himachal Pradesh, Shimla; Employers Federation of India, Bombay; Sri Ram Centre for Industrial Relations, New Delhi; Five Year Plans documents, Government of India, New Delhi; and related books, journals and reports as well as national newspapers.

Use of structural functional analysis was made in order to assess and analyse the adequacy of existing administrative structures at the state level concerned with labour administration.

Limitations of the Study

During the course of this empirical investigation the investigator had to encounter the following problems:

1. Non availability of the latest data with the Labour Bureau, Shimla;
2. Non co-operative attitude of management in many sample units;
3. Reluctance on the part of some workers to discuss their problems freely and frankly; and
4. The sample industrial units being scattered throughout the State making data collection time consuming and costly.

This article is a summary of the book *Labour Welfare Administration in India*, by Sewa Singh Chauhan, Kanishka Publishers Distributors, Delhi, 1993; Pp. xv+388, Price: Rs 450/-.
Summarised by B.P. Patankar, Nagpur.

II. GROWTH OF THE INDIAN WORKING CLASS AND THE EVOLUTION OF LABOUR WELFARE LEGISLATION AND ADMINISTRATION

(i) Origins of the Indian Working Class

The origins of the Indian working class have been somewhat different from those of its counterparts in the western industrial societies. In most of the western societies the origin of the industrial proletariat is traced to the town dwellers - the artisans and other social groups of the town economy. Migrants from the countryside were assimilated in the newly developed industrial centres and retained hardly any trace of their peasant stock.

The Indian industrial workers came from the villages. Those who joined the industrial centres were not independent farmers but socially and economically disabled groups, inured to exceedingly unfavourable economic and social circumstances. They migrated to cities in search of employment. They were 'pushed, not pulled to the city'. Plantation was the first capitalist industry to be started in India in the early part of the nineteenth century. In 1854, the foundations of the modern cotton textile industry and the jute industry were laid on sound footing. Initiation of modern industrialisation in India profoundly disturbed the traditionally stagnant Indian society. When plantations, mines and factories started making some progress in the sixties and seventies of the last century, the demand for workers was keenly felt. This was the beginning of the modern industrial wage earning class in India. It was composed of the most unfortunate class of the people, of people who ranked low in the social hierarchy of the village community. Looked down upon even in the mill towns as 'Jail Labour', this class created formidable problems of social and economic adjustment.

(ii) Size and Significance of the Industrial Working Force

Numerically, the class of industrial workers is 257.11 lakh which comprises hardly 3.75 per cent of the total working force in India. But concentrated as it is in the urban centres, it is the best organised and the most vocal class. Politically it is patronised by practically every major political party and, therefore, it compels prompt attention from the government and the employers as well.

(iii) Concept of Labour Welfare

The Committee of Experts on Welfare Facilities for Industrial Workers convened by International Labour Organisation (ILO) in 1963 included the following under the term labour welfare (Table 1).

TABLE 1. LABOUR WELFARE AS DEFINED BY ILO

Welfare within the establishment	Welfare outside the establishment
i. Latrines and Urinals	i. Maternity benefits
ii. Washing Bathing facilities	ii. Social insurance measures
iii. Creches	iii. Benevolent Funds
iv. Rest shelters and Canteen	iv. Medical facilities
v. Arrangements for drinking water	v. Educational facilities
vi. Health services including occupational safety	vi. Housing facilities
vii. Arrangements for prevention of fatigue	vii. Recreation Facilities
viii. Administrative arrangement within a plant to look after welfare	viii. Holiday homes and leave travel facilities
ix. Uniform and protective clothing	ix. Working co-operatives including consumers co-operatives. stores, fair price shops, co-operative and thrift societies
x. Shift allowance	x. Vocational Training for dependents of workers
	xi. Other programmes for the welfare of women, youth and children
	xii. Transport facilities

(iv) Labour Welfare in India in Retrospect

Earlier legislation in this country was mainly aimed at regulation of employment rather than at improving the working conditions of labour, e.g., the Breach of Contract Act 1859, and the Employer's and Women's (Disputes) Act 1860. A series of Acts between 1863 and 1901 were also enacted in respect of indenture labour for the plantation industry. The earlier factory legislation mainly regulated employment or working hours. This was the sum and substance of the Factory Act passed in 1881 amended subsequently in 1891 and 1911.

A real beginning in the field of labour welfare was initiated with the findings of the Industrial Commission in its report submitted in 1918. The Commission *inter alia* surveyed welfare provisions such as industrial housing, medical, health, sanitation and educational facilities to the industrial workers. It observed that efficiency of labour could be improved by the provision of adequate labour welfare facilities.

A Royal Commission on Labour, appointed in 1929, made comprehensive investigations of almost all the problems relating to labour in factories and plantations. Its recommendations laid down the framework for the extension and implementation of welfare measures in the country.

The Government of India Act, 1935 transferred certain subjects to the then provinces. Various committees were set up by the elected Provincial Governments to enquire into the working conditions of labour including the provision of housing facilities for them. These committees included the Bombay Textile Labour Enquiry Committee (1937), Kanpur Labour Enquiry Committee (1937), Central Province Textile Enquiry Committee (1938), and Bihar Labour Enquiry Committee (1938). The Committees conducted detailed investigations regarding the housing facilities available to industrial workers and made recommendations to the respective governments for improving the same.

A National Planning Committee was set up by the Congress Party in 1937, under the chairmanship of Shri Jawaharlal Nehru. Its Sub-Committee recommended 48 hours work per week, or 9 hours per day, and suggested raising the minimum age of employment of children to 15 years. It called for due attention to be paid to the housing problems of the workers, formulation of housing co-operative schemes, a special fund for maternity benefits and a system of contributory and compulsory insurance for industrial workers. A Tripartite Consultative Machinery was set up in India in 1942 for the discussion of the entire range of labour matters, including those of labour welfare. This machinery comprised the Indian labour conference and the standing labour committee. The consultations at these two forums eventually led to the setting up of a number of industrial committees on varied industries. The contribution of these Committees led to the enactment or amendment of legislation relating to factories, plantations, mines, etc. A Labour Investigations Committee was appointed in 1944. Popularly known as the Rege Committee, this Committee went into the details of working conditions including welfare measures available to the workers employed in 31 industries including mining and plantations as well as unorganised labour such as rickshaw pullers. The Committee covered almost all the subjects relating to labour welfare viz., housing, housing policy, rest and recreation, occupational diseases, relief in the case of old age and death, creches, canteens, medical aid, washing and bathing facilities, educational facilities and entertainment. The Committee recommended that labour welfare measures should be provided, not only in urban industrial centres, but also in other centres. It further highlighted the importance of administration and enforcement of the welfare measures.

The grand charter of labour, popularly known as the Declaration of Philadelphia, was laid down in May, 1944 by the member states of the ILO. In the same year, an Ordinance was issued by the Government of India to evolve a fund for financing the welfare of labour employed in the coal mining industry. The fund was to be built up from the contributions of workers, government grants and other sources like fines, rebate from contractors, profits of the canteens and yields from cinema shows, and dramatic performances,

etc. A total of 174 such funds for different establishments were in operation by the end of 1944-45.

(v) Labour Welfare During the Interim Government and after Independence

In 1946, immediately after the transfer of power to the interim Government of India, a five year programme for labour was drawn up, proposing the prescribing and enforcement of amenities like lighting, ventilation, safety, health and welfare of workers, improvement of conditions of work particularly in the unorganised sector, provision of adequate housing, health insurance and maternity benefits, provision of creches and canteens, and strengthening of the inspection staff and Inspectorate of mines.

In order to give practical shape to the policies drawn up by Indian leaders since 1937 and the policies incorporated in Articles 41, 42 and 43 of the Indian Constitution (Directive Principles of State Policy), various legislative measures were enacted or enforced, viz., Mica Mines Labour Welfare Fund Act, 1946; Coal Mines Labour Welfare Fund Act, 1947; Employees State Insurance Act, 1948; Factories Act, 1948; Dock Workers Act, 1948; Plantation Labour Act, 1951; Mines Act, 1952; Coal Mines Act, 1952; Employees Provident Fund Act, 1962; Merchant Shipping Act, 1958; Motor Transport Workers Act, 1961; Iron Ore Mines Labour Welfare Cess Act, 1961; Maternity Welfare Act, 1961; Beedi and Cigar Workers Act, 1956; Payment of Wages Act, 1936; Minimum Wages Act, 1948; Industrial Dispute Act, 1947; Worker's Compensation Act, 1923; Payment of Gratuity Act, 1972; Contract Labour Act, 1970; Employment of Children Act, 1938; The Bonded Labour System Act, 1976; etc.

(vi) First Five Year Plan

The First Five Year Plan laid emphasis on the development of welfare amenities, avoidance of disputes, and also constitution of joint committees of employers and workers. It recommended the establishment of a National Museum of Industrial Health, Safety and Welfare.

A Central Labour Institute, with regional offices was set up to conduct scientific studies on various aspects of industrial management with particular emphasis on human and safety aspects of industry. A subsidised housing scheme for industrial workers was evolved in September, 1952. Various social security measures and enactments were brought forth during the course of the First Plan. The Bombay Labour Welfare Fund Act, 1953, and the Assam Tea Plantations Fund Scheme, 1955, were passed during this plan period.

(vii) Second Five Year Plan

In the Second Five Year Plan, greater stress was laid on workers' participation in management by which a worker could realise that he was a part and parcel of the industrial apparatus that was to usher in a socialistic pattern of society.

Realising the success of the coal and mica mines welfare funds, the second plan suggested creation of a similar fund for the manganese industry. Adequate number of welfare centres were opened and training facilities were provided to the families of workers. Legislation to regulate working conditions in construction industry and transport services was also recommended.

The Second Five Year Plan also touched upon the problem of providing welfare measures to agricultural workers and discussed the measures necessary for women workers. During the Second Five Year Plan more workers were covered under welfare facilities. New enactments were carried out for seamen, motor transport workers, etc. A Dock Workers' (Safety, Health and Welfare) Scheme was drawn up in 1961. Various state governments also passed suitable legislation to provide better facilities for workers.

In December 1959, Government appointed a study team to examine wide ranging labour welfare activities and make recommendations on which labour welfare schemes in the Third Five Year Plan could be included. The study team categorised labour welfare amenities into three main groups, viz., (i) amenities and facilities that may be provided inside the undertakings; (ii) facilities to be provided outside the undertakings; and (iii) social security measures.

(viii) Third Five Year Plan

On the basis of the recommendations of the above study team, the Third Five Year Plan stressed the need for more effective implementation of statutory welfare measures. The Plan recommended that co-operative credit societies and consumers co-operative stores should be opened, so that trade unions would show greater interest in running them. Better living and working conditions were also recommended for agricultural workers.

Greater emphasis was laid on collective bargaining and on mutual agreements for improving industrial relations as well as workers' well being. For iron ore workers, the Iron Ore Labour Cess Act was passed in 1961. The Central Maternity Benefit Act, 1961 was passed to do away with disparities in maternity benefits in different states. The Subsidised Labour Housing Scheme was extended to plantation workers in 1966.

(ix) Fourth Five Year Plan

The Fourth Five Year Plan included the expansion of Employees State Insurance (ESI) facilities to provide hospitalisation to families of all insured workers, coverage of shops and commercial establishment in selected centres, as also of non-power factories employing 10 or more persons. A provision of Rs 37.11 crore was made for labour welfare programmes which indeed, was a notable feature.

(x) Fifth Five Year Plan (1974-79)

Removal of poverty and attainment of self reliance were the two major objectives of the Fifth Five Year Plan. A major thrust of policy was aimed for provision of employment opportunities to the weaker sections in general, and to agricultural labourers and small and marginal farmers in particular. The plan outlay during this plan period for labour welfare was Rs 57 crore. In order to improve the efficiency of Indian labour, the Ministry of Labour undertook schemes and programmes costing Rs 15.70 crore during the plan period.

(xi) Sixth Five Year Plan (1980-85)

A total outlay of Rs 167 crore was approved for programmes related to craftsmen, including training and labour welfare: Rs 82 crore for the Central sector and Rs 85 crore for States and Union Territories. Other major programmes included in this plan period were rehabilitation of bonded workers, revision of minimum wages in agriculture, modernisation and upgradation of the vocational training of women job seekers and rural people.

(xii) Seventh Five Year Plan (1985-90)

The thrust of the Seventh Plan was on the improvement of capacity utilisation, efficiency and productivity. Training of workers and craftsmen was given due consideration. Industrial safety, the role of employment exchanges, wage policy, etc., were looked into. An important provision was made for working and living conditions of organised labour both in rural and urban areas. Due attention was given to abolish bonded labour and to regulate employment of child and women workers in both organised and unorganised sectors. An outlay of Rs 334 crore was allocated for the plan period: Rs 95.44 crore for the Centre, Rs 219.75 crore for States and Rs 18.53 crore for Union Territories.

(xiii) Welfare Work by State Governments

Composite welfare activities through the institution of labour welfare centres were initiated by the Government of Bombay in 1937. The Governments of Uttar Pradesh and West Bengal followed the same pattern. Most of the State Governments and Union Territories Administrations run labour welfare centres as a part of labour welfare programmes, to cater to the medical, recreational and cultural needs of industrial workers.

(xiv) Welfare Work by Employers

A large number of employers, especially in large scale industrial establishments in the organised sector of industries, provided a variety of welfare amenities on a progressive scale even before the State thought of or initiated action in the matter. They have been providing facilities such as housing, education of workers' children, recreation, distress relief, grants for organising sports and dramatic performances, gratuity and other forms of retiral benefits. Certain organisations have set up their own hospitals, schools, etc.

(xv) Welfare Work by Workers' Organisations

Though in a limited way, trade unions have also taken interest in welfare work for their members. Amongst the trade unions which undertake welfare activities, the Ahmedabad Textile Labour Organisation and the Mill Mazdoor Union at Indore need mention. The Textile Labour Organisation, Ahmedabad runs both day and night schools, maintains a residential boarding house for working class girls, study homes for boys, reading rooms and libraries, and runs gymnasia to impart physical education to children. It also organises games, competitions and imparts training in painting, embroidery, sewing, etc., to women workers. The union also runs Allopathic and Homeopathic dispensaries in different localities at Ahmedabad and maintains a maternity home. A workers' cooperative bank too functions for the benefit of workers.

The Mill Mazdoor Union, Indore runs labour welfare centres consisting of Bal Kanya and Mahila Mandirs; dance, music and social gatherings are also arranged.

(xvi) The General Picture

In spite of all these efforts, welfare work in India is still considerably below satisfaction. The plight of the working class cannot be said to have improved to an appreciable extent. Violations of labour laws in the industrial sector have been reported in the press columns. For instance during the year 1987, the then Union Minister for Labour personally visited some manufacturing units in Faridabad and Ghaziabad and found child labour below the age of 14 years working in these units. Bonded labour has been abolished by law but in various states like Uttar Pradesh, Bihar and Madhya Pradesh, bonded labour is still practised. During 1988, bonded labour was detected and reported by a social worker in Himachal Pradesh where workers from Bihar were forced to work as bonded labourers. Therefore, there is still much to be done to ensure the effective implementation of all enacted labour welfare laws and protect the rights of this important segment of the society.

(xvii) Himachal Pradesh

Himachal Pradesh, which is our universe for empirical investigation, is a state in the northern part of India. Being hilly, it is one of the least industrialised states. According to the 1981 Census, it has a population of 42,80,878, of which 93 per cent resided in the rural areas and were mainly engaged in agriculture. Obviously, agricultural labour constitutes a major section of the rural workers. According to the 1981 Census, agriculture in Himachal Pradesh employed 10.41 lakh workers, i.e., 70.76 per cent of the total of 14.71 lakh workers. Another type of labour force which exists in Himachal Pradesh, is the plantation labour on small tea estates in Kangra and Mandi districts. The tea shrubs in these plantations are very old. As a result, the number of plantation workers is declining.

The third category of labour in Himachal Pradesh is forest labour. Forests play a prominent role in the economy of Himachal Pradesh since they contribute about 25 per cent to the total revenue of the State. According to the 1971 Census, out of the total working force of 9.57 lakh workers about 17,486 persons were engaged in forestry and logging in the State. Presently, industries viz., Resin and Turpentine, Card Board, and furniture factories have provided jobs to more than a thousand workers. A very large number of the forest labour is ordinarily employed by the State for afforestation, protection of forest and for construction and maintenance of forest roads and buildings, in felling, logging, loading, unloading and transportation, etc. On a rough estimate about 12,000 casual and daily/paid workers were

employed by the State Forest Corporation. The total strength of unorganized workers in this State was 2,04,911 in 1981. There were 22 public sector undertakings in Himachal Pradesh during March, 1990. The State Government has been giving several incentives to entrepreneurs. The latest data pertaining to employment in the public and private sector factories and establishments by industry division, as in March 1986, is given in Table 2.

Table 3 portrays the employment position in the establishments by industry divisions (Public and Private Sectors).

TABLE 2. EMPLOYMENT IN WORKING FACTORIES IN PUBLIC AND PRIVATE SECTOR IN HIMACHAL PRADESH AS IN MARCH 1986

Sl. No.	Factories	Public Sector	Private Sector
1.	Mining	-	48
2.	Food and Food Products	310	350
3.	Tea Factory	-	251
4.	Distilleries	90	905
5.	Wool, Silk and other Textiles	167	1,200
6.	Wood Products	602	1,125
7.	Paper and Paper Products	304	015
8.	Resin and Turpentine	237	201
9.	Other Chemical Products	490	1,015
10.	Non Metallic Mineral Products	786	635
11.	Metal and Metal Products	11,047	1,102
12.	Machinery and Machine Parts	1,710	610
13.	Gun Manufacturing	-	77
14.	Other Manufacturing 9 Industries	1,885	37
15.	Electricity and Gas	693	-
16.	Education and Scientific Services	2,715	225
17.	Repair Services	2,837	1,087
	Total	13,873	9,183

Source: *Fact Book on Manpower*, 1988, Department of Planning, Government of Himachal Pradesh, Shimla, p. 52.

TABLE 3. EMPLOYMENT IN ESTABLISHMENTS BY INDUSTRY DIVISION (PUBLIC AND PRIVATE SECTORS) IN HIMACHAL PRADESH AS ON 31ST MARCH, 1987

Sl. No.	Industry Division and Code	No. of Workers Employed
1.	Agriculture, Hunting, Forestry and Fishing (O)	35,884
2.	Mining and Quarrying (1)	312
3.	Manufacturing (2 & 2)	17,622
4.	Electricity (4) Gas and Water	23,979
5.	Construction (5)	86,862
6.	Wholesale and Retail Sale Trade and Restaurants and Hotels (6)	1,776
7.	Transport, Storage and Communication (7)	13,480
8.	Financing, Insurance, Real Estates and Business Services (8)	7,418
9.	Community, Social and Personal Services (9)	98,976
		2,95,479

Source: *Fact Book on Manpower*, Planning Department, Government of Himachal Pradesh, 1988, pp. 53 to 56.

Trade unionism emerged in the State only after 1950. The important trade unions operating in the industrial sector are the All India Trade Union Congress (AITUC), the Indian National Trade Unions Congress (INTUC), Centre of Indian Trade Unions (CITU) and Bhartiya Mazdoor Sangh (BMS). The Government of Himachal Pradesh has implemented various central labour welfare legislations and also passed certain legislations of its own applicable to the workers of the organised sector, viz., (i) the Himachal Pradesh Shops and Commercial Establishment Act, 1969, (ii) the Himachal Pradesh Industrial Establishments (National and Festival Holidays and Casual

Leave and Sick Leave) Act, 1969, (iii) H.P.P.W.D. Contractors Labour Regulations, etc. However, the workers involved in the unorganised sector, especially women and child labour, are deprived of these welfare measures.

III. ORGANISATIONAL STRUCTURE AND PERFORMANCE EVALUATION OF ADMINISTRATIVE MACHINERY FOR LABOUR WELFARE ADMINISTRATION IN INDIA

(i) Administrative Organisation

Legislative powers in India are shared by the Union and State Governments. The Ministry of Labour at the Centre is responsible for laying down the labour policy for the whole of India and all labour matters relating to Central Government enterprises. The implementation of the labour policy for all other purposes is the responsibility of the State Governments subject to the control and directions of the Central Government. In the case of labour employed in railways, mines, oil fields, defence establishments, banking and insurance companies having branches in more than one state, and in major ports, the Central Government retains the responsibility in respect of labour relations. At the international level, the Union Ministry of Labour is the only competent authority.

(ii) The Central Machinery

Ministry of Labour:

The Ministry of Labour is assisted by various statutory organisations, *ad hoc* organisations and certain attached offices. (See Organisation Chart in Table 4).

TABLE 4. ORGANISATIONAL STRUCTURE OF MINISTRY OF LABOUR AND EMPLOYMENT

Ministry
Secretary

Attached offices 4 Nos.	Subordinate offices 22 Nos.	Autonomous organisations 7 Nos.
1. D.G. of Employment and Training, New Delhi.	1. D.G. Mines Safety, Dhanbad.	1. E.S.I. Corporation New Delhi.
2. The Chief Labour Commissioner (Central) New Delhi.	2. Office of Dy. Welfare Commissioner, Barbil.	2. Presidency Central Coal Mines Rescue Station Committee, Dhansar.
3. D.G. Factory Advice Service and Labour Institute, Bombay.	3. to 10 Offices of Welfare Commissioners at Bangalore, Jabbalpur, Bhubneshwar, Karma, Bhilwara, Kalichedu, Panaji, Allahabad.	3. Chairman National Council for Mines, Dhanbad.
4. Director Labour Bureau, Shimla/Chandigarh.	11. Office of the Accounts Officer Audit Cell, Delhi.	4. National Safety Council, Bombay.
	12 to 21 Central Government Industrial Tribunals-cum-Labour Courts at Bombay-1, Bombay-2, Dhanbad-1, Dhanbad-2, Dhanbad-3, Jabbalpur, Calcutta, Delhi, Chandigarh, Kanpur.	5. National Labour Institute, New Delhi.
	22. Office of the Chairman, Board of Arbitration (JGM), New Delhi.	6. Central Board for Workers' Education, Nagpur.
		7. Central Provident Fund Commissioner, New Delhi.

(iii) Performance Evaluation of the Central Machinery

(a) Industrial Relations

The data available, revealed that the Central Industrial Relations Machinery was functioning efficiently. More than 98 per cent cases were decided within one to twelve months. Some awards (92 out of 710 in the year 1988) could not however be implemented due to stay orders and wilful neglect of the management.

(b) Industrial Safety

The National Safety Council was set up in 1966. It has tackled the problem of high rate of industrial accidents and propagated safety throughout the country, through training courses, talks, poster services, periodicals, technical advice, films, National Safety Day campaign, National Safety Competitions, etc.

(c) Training Activities

(1) Training Activities Under D.G.E. and T.

The Director General of Employment and Training (D.G.E.T.) has been providing training to workers under two different schemes, viz., Craftsmen training scheme, under which 657 institutions had, in 1985, a capacity to train 2,15,000 trainees and training under the Apprentice Act 1961, under which 1,22,403 apprentices were undergoing training in 1987, in 14,323 establishments. There has been some setback to these training schemes.

(2) Training Activities Conducted by the Central Board for Workers Education (CBWE), Nagpur

This organisation has several regional centres for training education officers, workers' teachers, ULCs and FALCS.

(d) Employment Services

During the year 1988, there were 760 employment exchanges. 59.63 lakh vacancies were notified and 3.28 lakh candidates (5.5 per cent) were placed in different organizations. By the end of 1988, there were 30.05 million candidates on the live registers of employment exchanges throughout the country.

(e) Working of Social Security Legislations

(1) The Workmen's Compensation Act, 1923

In 1980, claims for 93,303 cases of injury were settled. In 1986, this figure came down to 24,990. This shows a declining trend in industrial accidents.

(2) The Maternity Benefit Act, 1968

From available statistics we have found that whereas the total number of women workers employed had almost doubled, the number of women workers claiming benefits had sharply declined from 41,913 in 1980 to 26,832 in 1987.

(3) The Employees Provident Fund Act, 1952

During 1989, the total number of classes of establishments covered was 173 and the total number of factories covered stood at 181,643. The total number of subscribers rose from 93.14 lakh in 1978 to 142.98 lakh in 1989.

(4) The Employees State Insurance Act, 1948

The activities under this Act have been as in Table 5.

(iv) (1) Administrative Machinery in States with Special Reference to Himachal Pradesh

The administrative machinery differs according to the nature of work performed by workers in different states. The existing administrative structure for labour welfare in Himachal Pradesh comprises (i) Department of Labour and Employment/Labour Commissioner/ Labour Officers, Inspectors, etc., (ii) Labour Court/Industrial Tribunal, and (iii) Boards and Committees (*ad hoc*). The Department of Labour and Employment is responsible for the implementation of the Central and State Acts given in Table 6.

TABLE 5. ACTIVITIES UNDER THE EMPLOYEES STATE INSURANCE ACT, 1948

	Particulars		Unit	1979	1985
I	*Payments made*		(Rs Lakh)		
	(a) Temporary Disablement			693.68*	1,354.00
	(b) Total Disablement			650.83*	2,282.00
	(c) Death			176.48*	914.00
II	*Hospital*		(Numbers)		
	(a) General	(i) General		9,480	16,613
		(ii) Annexe		282	343
		(iii) Others		...	2,721
	(b) Maternity	(i) General		1,126	1,946
		(ii) Annexe		285	...
		(iii) Others		1,505	284
	(c) Tuberculosis	(i) General		150	3,757
		(ii) Annexe		223	298
		(iii) Other		...	1,506
	(d) Hospital Beds			17,609	27,268
III	*Dispensaries*		(Number)		
	(a) Full Time			875	1,197
	(b) Part Time			49	39
	(c) Mobile			32	27
	(d) Employers' Utilisation			32	25
IV	*Beneficiaries of II and III*		(in Lakh)		
	(a) Hospitalised			3.49	3.19
	(b) Out-patients			457.00	365.49
	(c) Home-visits			2.55	2.42

* Refers to 1980

TABLE 6. LABOUR LAWS IN CENTRAL AND STATE SECTORS

Central Acts

The Industrial Disputes Act, 1947.
The Payment of Wages Act, 1936.
The Minimum Wages Act, 1948.
The Factories Act, 1948.
The Industrial Employment (Standing Order) Act, 1946.
The Workmen's Compensation Act, 1923.
The Working Journalists (Conditions of Service and Miscellaneous Provisions) Act, 1955.
The Motor Transport Workers Act, 1961.
The Maternity Benefit Act, 1961.
The Employees State Insurance Act, 1948.
The Employees Provident Fund and Family Pension Scheme, 1972.
The Trade Unions Act, 1926.
The Payment of Bonus Act, 1965.
The Payment of Gratuity Act, 1972.
The Plantations Labour Act, 1951.
The Contract Labour (Regulation and Abolition) Act, 1970.
The Equal Remuneration Act, 1976.
The Bonded Labour System (Abolition) Act, 1976.
The Sales Promotion Employees (Conditions of Service) Act, 1976.
The Indian Boiler's Act, 1923.
The Employment of Children Act, 1938.
The Inter State Migrant Labour Act, 1979.
The Personal Injuries (Compensation Insurance) Act, 1953.

State Acts and Rules

The Himachal Pradesh Shops and Commercial Establishments Act, 1969.
The Himachal Pradesh Industrial Establishment (National Festival Holidays and Casual Leave and Sick Leave) Act, 1968.
The HPPWD Contractors' Labour (Regulation and Abolition) Act, 1970.

(iv) (2) Performance Evaluation of State Machinery for Labour Welfare

The labour administration in Himachal Pradesh is not well equipped. Various positions have been lying vacant for the last so many years. Field staff has not been properly placed. Due to the large area of jurisdiction they can hardly supervise and inspect industrial establishments. Further, they have not been provided with assisting staff. Due to this reason workers were sore about the functioning of the Labour Administration. Workers who were interviewed, revealed that field functionaries had not even paid a single visit to industrial establishments under their jurisdiction. The Department took quite a long time to decide cases. Data maintained by the Department was not up-to-date and well arranged. The role played by this Department in employment side was good. The network of Employment Exchanges and information Centres have helped lakhs of unemployed persons in seeking suitable employment in different sectors. To act as a real custodian of labour force, the Department of Labour has to be equipped with trained staff and all vacant positions need to be filled without further delay.

IV. WORKING CONDITIONS AND SOCIO-ECONOMIC CONDITIONS OF WORKERS IN PUBLIC AND PRIVATE SECTOR UNITS IN HIMACHAL PRADESH

Industrial workers in India have faced certain unique problems like long hours of work, unhealthy surroundings, drudgery of factory work, rural attachment and uncongenial factory environment. In their social life, they fall an easy prey to various evils such as indebtedness, alcoholism, gambling and other vices which naturally demoralise them and sometimes completely ruin their family lives. For studying the working and socio-economic conditions of workers in Himachal Pradesh, a sample of 240 workers was taken from twelve sample industrial units. The result of the study is summarised below:

(i) Permanancy of Tenure

Out of 6,050 total workers in the sample units, there were 4,220 (69.75 per cent) permanent workers, 1,693 (28 per cent) casual workers and 137 (2.3 per cent) apprentice workers. The percentage of permanent workers was higher in private sector units. The private sector units had employed these apprentices and casual workers throughout the year. On the other hand the casual work force in public sector units had been engaged only during peak seasons, or as and when their services were required. It was revealed by the public sector management that it was not obligatory to engage casual workers again, but on the other hand, private sector management was under obligation to re-employ them because they were organized through trade unions and recruited through employment exchanges.

(ii) Child Labour

None of the sample units had employed child workers (below 14 years) and adolescents (15 to 17 years) in their establishment. It may be due to the fact that these units required only skilled workers, or that the nature of job was tough and risky.

(iii) Community-wise Distribution of Employment

Rajputs (Non-untouchables) have been dominating the employment trend in the sample industrial units. Out of 240 total workers interviewed, 131 workers (54.6 percent) were Rajputs. There were only 47 Scheduled Caste Workers (19.4 per cent). Backward Classes and Muslims had 23 workers each constituting 9.6 per cent of total workers, respectively. There were out of the total interviewed only 9 workers from Scheduled Tribes (ST) category which was 3.7 per cent of the total. Seven workers were from other categories. Thus ST people were not adequately represented.

Buddhist workers constituted 5.83 per cent of the total workers in the sample. They all belonged to Kinnaur District of Himachal Pradesh where Buddhist Tribes are found. Only eight and two workers respectively, from Sikh and Christian communities, were in employment. Four workers belonged to other religious backgrounds.

(iv) Employment to 'Sons-of-the Soil'

The industrial policy of Himachal Pradesh Government requires that 75 per cent employment in industries to be established in the State

should be from among bonafide Himachalis. But the present study indicates that out of 6,050 total workers in the sample industrial units, there were 3,197 bonafide Himachalis which constituted only 52.8 per cent. It was found that certain industrial units employed more than 50 per cent non-Himachalis. The managements reported that there was shortage of skilled workers in Himachal Pradesh. Therefore, they had to appoint workers from outside the State. They however, reported that more than 75 per cent of unskilled workers were from amongst the bonafide Himachalis.

The private sector management had preferred outside unskilled and semi-skilled workers due to the fact that such workers were ready to work at low rates of wages, and Himachali workers were also found not interested to work as casual labourers far away from their villages. Workers living in the interiors of Himachal Pradesh did not get timely information regarding job vacancies in different industrial units.

(v) Literacy

Literacy standard of workers in the sample units in Himachal Pradesh was found to be encouraging. Out of the total 240 sample workers, 208 were literate, but this varied from below primary to graduation and above. Only 32 workers out of the total studied, were found to be totally illiterate.

(vi) Employment of Leisure

Data collected revealed that the sample workers, especially those with family responsibilities, were generally over-burdened with their dual responsibility of family and employment. Out of the total, 58 workers were busy teaching their wards and in domestic affairs during their leisure time. 55 workers out of the total 240 sample industrial workers spent their leisure time in gambling and drinking. 68 workers were found spending their leisure time in reading newspapers, magazines, playing games and enjoying cinema, etc. There were 24 workers who were spending their leisure time in sleep and 35 workers used to go for a walk during their leisure-time. Average leisure time available per day to a sample industrial worker was found to vary between one and two hours.

(vii) Absenteeism

The incidence of absenteeism among the sample workers was found to be as under:

Below 2 days	174
2 days	39
3 to 4 days	22
4 to 6 days	5
above 6 days	-
Total	240

The reasons for being absent were given as sickness (179 workers), horticulture/agriculture seasonal work (33), socioreligious ceremonies (27) and others (3).

(viii) Awareness of Labour Welfare Legislation

Replies received from sample workers revealed that their awareness of labour welfare legislation was as follows:

Fully aware	153
Partially aware	33
Not aware	54
Total	240

(ix) Working Hours

The Factories Act, 1948 provides that no worker shall work for more than 48 hours in a week and nine hours per day (sec 54) with weekly holiday (sec 52 (i)) and half an hour rest (sec 55) after every five hours of work. The present study revealed that in the sample industries workers had to put in working hours as follows:

Hours	Workers
6	134
7	70
8-9	36
Total	240

36 workers out of 240 were working for more than 48 hours a week in violation of section 51 of the Act. Out of 240 workers 72 workers (30 per cent) were found doing overtime work. Out of those doing overtime work 57 workers reported that they had liked overtime work. Family liabilities and low wages had compelled them to accept overtime work. Majority of workers in both sectors (183 out of 240) did not like to work overtime.

(x) Working Conditions

The opinion of sample industrial workers regarding working conditions and work environment was as follows (Table 7):

(b) Provision of Safety Devices

The Factories Act, 1948, requires the provision of certain safety devices such as power-cutters, screens or goggles, breathing apparatus, protective clothing, etc. Only four sample industrial units had provided special clothing and power cutters to the workers during work. But this facility was not available to all workers in the respective units.

Four units had provided effective screens or goggles to those workers who really required such devices. Fire fighting devices were available in all sample units, except one. Eight units had provision of exhaust fans, reviving apparatus and breathing apparatus in their industrial units.

TABLE 7. WORK ENVIRONMENT

Particulars	Public Sector (N 120)		Private Sector (N 120)	
	Satisfactory	Not Satisfactory	Satisfactory	Not Satisfactory
1. Illumination	40	80	78	42
2. Ventilation	50	70	80	40
3. Temperature	70	50	70	50
4. Humidity	60	60	65	55
5. Dust	30	90	40	80
6. Smoke and Fumes	35	85	40	80
7. Cleanliness	25	95	70	50
8. Overcrowding	70	50	65	55
9. Machinery	40	80	90	30
10. Condition of work rooms	35	85	80	40
11. Surroundings	30	90	60	60

(c) Rate of Accidents

The rate of industrial accidents was found to be low in the sample units in Himachal Pradesh. Only 17.5 per cent of the total sample workers had faced fatal and non-fatal injuries during the course of their employment. Out of the injured, 74 per cent workers were given due compensation under the ESI Act, 1948 and the Workmen's Compensation Act, 1923. It was also revealed by the sample workers that the majority of units had not provided protective devices to meet accident like situations.

(xi) Economic Condition of Workers

The average monthly earnings of the sample industrial workers were in 1989 higher (Rs 1,104 per month) as compared to workers in other parts of the country (Rs 740 per month average) The number of dependents varied between 3 to 7 and the ratio of earners to total members varied between 20 to 40 per cent in these sample units. It was also found that industrial workers, despite their low wages, were interested in saving for their future. Savings range according to the study varied between Rs 200 and Rs 1,000 per month. Provident fund and banks were the principal mode of their savings.

(xii) Indebtedness

Indebtedness amongst the sample industrial workers was found as in Table 8. The reasons for indebtedness were given as social and religious obligations (43 cases), drinking and gambling (21 cases), largeness of family (16 cases), old family debts (14 cases) and others (11 cases).

TABLE 8. INDEBTEDNESS

No. of workers studied	No. of workers in debt	No. of Workers not in debt	Average Percentage	Average Range		
				Below Rs 1000/-	1000/- 3000/-	Above 3000/-
240	105 (43%)	135 (57%)	(47.75%)	40	34	31

V. PERFORMANCE EVALUATION OF LABOUR WELFARE MEASURES IN PUBLIC AND PRIVATE SECTOR UNITS IN HIMACHAL PRADESH

The present study conducted on 240 workers in the twelve sample units in Himachal Pradesh brings out the following position regarding the labour welfare measures laid down in the Factories Act, 1948.

(i) Cleanliness

Cleanliness in almost all sample units except Gabrial and Purelators was not satisfactory. There was accumulation of dirt and refuse on the floors, no provision of washing room with disinfectant, no periodical whitewashing of factory walls and very poor drainage system.

Out of the total 240 sample workers only 88 were satisfied with sanitation and cleanliness within and outside their units.

(ii) Drinking Water

In a majority of sample units, provision of drinking water was found adequate. In various units the supply of drinking water was not regular. Only two units were supplying cool water during the summer season, when mercury shoots up to over 40°C.

(iii) Latrines and Urinals

The provision of latrines and urinals in the sample industrial units was found to be very poor.

(iv) Medical Facilities

(a) By Employers

Though it is not mandatory on the part of employers to extend such facilities, 5 out of twelve units studied had arranged their own medical facilities. 4 of them were private sector units. Only one public sector unit, C.C.I. unit, had set up its own dispensary, In almost all the sample industrial units ambulance/vehicles were provided to the workers in cases of emergencies by the management. Medical reimbursement facilities were also available, but only to regular workers.

(b) Under ESI Scheme

The Employees State Insurance Act, 1948 provides five kinds of benefits to workers viz., maternity benefit, disablement benefit, dependents benefit, sickness benefit, and medical benefit. These benefits are available to casual workers also. Only 25 per cent of the workers questioned were satisfied with the behaviour of doctors, nurses and other staff. Workers also reported that medicines were not available in health centres run by the ESI Corporation. Only common medicines were supplied; no provision existed to investigate and treat occupational diseases; there was no arrangement of ambulance; etc. The ESI Corporation only reimbursed expenditure incurred on transportation in case of emergencies. There was delay in reimbursement of medical expenditure incurred by the workers.

(v) Safety Measures

It was revealed that only four sample units were providing special uniforms and six industrial units had provision of protective devices like goggles, electric cutters, screens and other

devices. Five units were found having arrangement of first-aid appliances/boxes. 5 out of the twelve units studied had made administrative arrangements in their units in regard to labour welfare. (2 units in public sector and 3 in private sector). In other units, personnel officers were reported to be handling this task.

(vi) Canteen Facility

Section 46(i) of the Factories Act, 1948 requires that in any specified factory wherein more than 250 workers are ordinarily employed, a canteen or canteens shall be provided and maintained by the occupier for the use of workers. A study was conducted of the twelve sample units i.e. six each in the public and private sectors. It revealed that canteen facilities existed in all the six private sector units and only in three public sector units. Standards of cleanliness, quality of food, hygiene, etc., differed from unit to unit. No suggestions from the workers were taken by the management to improve the functioning of these canteens. There was provision of credit sales by the canteens in very few units. Workers opined that credit sales by canteens should be a statutory provision.

(vii) Creches

Section 48 of the Factories Act, 1948 provides for the establishment of creches in factories employing 30 women workers. The study conducted in the sample industrial units revealed that there was not even a single creche in any industrial estate developed by Himachal Pradesh, where hundreds of factories have been set up in each estate. When women workers were interviewed in this regard, they revealed that after great difficulty they had got employment in such units and did not want to take any risk. Trade union leaders, too, were found unconcerned about it. They had never raised their voice in this regard. Managements of various industrial units were also interviewed and they assigned many reasons for not providing creche facilities to the women workers in their respective units. The reasons attributed were: small number of women workers, higher number of unmarried women workers, lack of finance, no co-operation among entrepreneurs and no demand from workers' side. When the Labour Inspector was questioned about this state of affairs, he replied that instructions had been given to those employers where more than 30 women workers were working. They were looking into the matter. This seems a ready answer with every government official.

(viii) Housing Facilities

Seven out of the twelve sample organisations/units have provided housing facilities to their workers. Private sector units have provided comparatively better housing facilities than public sector units. As a whole, the sample units provided housing to only 23.22 per cent of their workers.

Labour officials posted at Parwanoo reported that the State Government had formulated a plan to build a labour colony near Parwanoo where 500 workers would get accommodation in the near future. One trade union leader revealed that entrepreneurs from outside the State were hardly concerned about labour welfare because they had set up units just to get subsidized loans and other concessions.

(ix) Recreation Facilities

The importance of recreation in creating a healthy climate for industrial peace and progress has been emphasised by several study teams, committees and commissions. The lead in this field was given by progressive employers like the Tatas, Hindustan Lever Ltd., Aluminium Manufacturing Company, the Telco, the Mill Owners Association and most of the public sector undertakings such as H.S.L., Air India, BHEL, Heavy Engineering Corporation, I.T.I., Bharat Electronics, Heavy Engineering Corporation, I.T.I, Bharat Electronics, Bokaro Steel Ltd., U.C. and Indian Railways, in providing facilities and encouragement to the workers in games, sports and cultural activities. This has helped in the building up of sound employer-employee relations in industrial spheres. In Himachal Pradesh, some provision of recreational facilities existed in all the twelve sample units. The details are shown below (Table 9):

TABLE 9. RECREATIONAL FACILITIES

Type of facility	No. of Units in which facility provided (out of sample 12)
Leave travel Concession	10
Picnics and Tours	5
Cultural Programmes	4
Cinema shows	6
Sports and games	9
Library facilities	5
Television and Radio	6

In Himachal Pradesh the managements of the Industrial units bear the entire expenses incurred on such facilities. Trade unions assist in the management of such facilities. Trade unions in this State had not undertaken any welfare measures on their own.

(x) Transport Facilities

The International Labour Organisation in its recommendation No 21 of 1924 urged the member countries that, 'by means of a well conceived transport system and by affording special facilities in regard to fares and time tables, workers should be enabled to reduce to the minimum the time spent in travelling between their homes and their place of work and that employers and organisations should be extensively consulted by public transport undertakings as to the best means of securing such a system'. Out of the total twelve sample industrial units in Himachal Pradesh, four units had their own arrangement for transportation. All these units had extended certain other benefits like payment of conveyance allowance and had engaged H.R.T.C. buses for the purpose. Many units like, Mohan Meakin, C.C.I., A.C.C., Eicher Tractors and Gabriel and Purelators have encouraged workers to purchase their own vehicles, by giving loans at low rate of interest.

Seven units were not providing any type of transportation facility to their workers. Out of these seven units, five were in the public sector and two in the private sector. Trade union leaders reported that this issue had been discussed many times with the concerned managements but nothing positive could be achieved.

(xi) Educational Facilities

The need for imparting necessary education to workers had been emphasised by the Indian Industrial Commission (1918) and the Royal Commission on Labour in 1931. Educational facilities are also necessary for the children of industrial workers. None of the twelve sample industrial units in Himachal Pradesh had made arrangements for adult education for the workers and their dependents or made arrangement for family members to learn any vocation or craft. Only 2 units, both in the private sector, had put up schools for the education of workers' children. One unit, in the public sector, provided scholarships and transport facilities. All the 60 sample workers of these units were satisfied with these arrangements. Two units gave fee concessions, uniforms, etc.

(xii) Family Planning

It was found that only A.C.C. and C.C.I. units propagated family planning programmes. This was done through documentary pictures, pamphlets, posters and by arranging family planning programmes. C.C.I., units were found providing special leave for six days for undergoing sterilization and special leave for one day to the females undergoing IUCD insertions. There was provision for maternity leave also. Financial incentive of Rs 225/- was paid per case for vasectomy/tubectomy operations and Rs 10/- were paid per case for IUCD insertions which were reimbursed by the government to the entrepreneurs. In ACC units, cash prizes, in addition to all the above mentioned benefits, were given to the workers. Other public sector units were providing benefits like special increments

in case of those undergoing sterilization after two children. No such benefits existed in other private sector units.

(xiii) Workers' Attitude Towards Family Planning

240 sample industrial workers were questioned for ascertaining their attitude towards this programme. The attitude of 178 workers was found to be favourable towards family planning, 50 workers were not in favour, and 12 workers expressed ignorance of family planning measures.

VI. TRADE UNION MOVEMENT AND INDUSTRIAL DEMOCRACY IN ACTION

(i) The Growth of Trade Unions in India

The first two modern industrial units established in India were the cotton mill established in 1851 in Bombay and a jute mill in 1855 in Bengal. Thereafter the number of factories began to increase both in Bombay and Bengal. For the first time in 1875 factory workers united together for securing better working conditions in the factories. The first Factory Commission was appointed in Bombay in 1875 and the first Factories Act was also passed in 1875. Another Factories Commission was appointed in 1884. Mr. Lokhandey organised a conference of workers in Bombay and drew up a memorandum signed by some 5,300 workers to be presented to the Factory Commission. This was the beginning of the modern trade union movement in India. In 1890 the Bombay Mill Hands Association was formed under the Presidentship of Mr. Lokhandey. This was the first labour association in India. The movement could take permanent roots in the Indian soil only after the close of the First World War, when industrial unrest grew up as a result of grave economic crisis created by war. The rising cost of living prompted the workers to demand reasonable wages for which purpose they united to take resort to collective action. The Swaraj movement further intensified the labour movement. The success of the Russian Revolution of 1917 created a revolutionary wave of ideas, a new self respect and enlightenment, and a feeling of class consciousness among the labourers. The establishment of the ILO in 1919 gave recognition to the dignity of the working class and also provided an opportunity to send their delegation to the annual conference of this body.

It is estimated that between 2.5 and 5.0 lakh workers were organised into unions at this time. After 1919, Trade Unions spread to centres other than Madras, Ahmedabad and Bombay. During the quinquennium ending 1925, the number increased further. But during this period (1919-24) only 164 trade unions with a membership of 2.23 lakh were registered. The rest of the trade unions were not registered by their respective governments.

The influence of nationalist leaders on the labour movement added intensity, but it also tended to increase bitterness, and introduced in the minds of many employers a hostile bias against the movement.

By 1989 the number of registered trade unions had reportedly risen to 47,112 with a membership of almost 72 lakh. (These are only estimates, as a large number of trade unions do not comply with the requirement of sending annual returns to the Registrar of Trade Unions).

Among the political leaders who entered the trade union movement at this time were mostly national leaders such as Chittaranjan Dass, Moti Lal, Jawahar Lal Nehru, S.C. Bose, V.V. Giri, besides active communist leaders like Shripad Amrit Dange, S.S. Mirajkar, K.N. Joglekar, S.V. Ghate, D. Thengdi, R.S. Nimbalkar, Phillip Spratt, and S. Saklatwala.

From 1924 to 1934 the trade union arena was dominated by left wing leaders. There was a conflict between the leftist and the rightist trade union leaders. During this period there were three unions viz., the A.I.T.U.C., led by Royalists and militant nationalists, A.I.T.U.F., led by Congress nationalists and moderates, and the R.T.U.C. consisting of orthodox communists.

The Second World War, which broke out in September, 1939, created new constraints in the united trade union movement because a faction of the A.I.T.U.C. was of the opinion that it should support and participate in the anti fascist war and the other faction opposed it. Hence, again a rift

took place in 1941 which resulted in the creation of a new trade union i.e., Indian Federation of Labour (I.F.L.). The later years of the War witnessed an intense rivalry between the two trade unions (AITUC and IFL) for primacy in the field of leadership. By the end of the War, there were three principal political groups in the field, the communists dominating the AITUC, the Royalists having a hold on IFL, and the nationalist labour front.

When attempts to restructure the AITUC failed, those believing in the aims and objectives and ideals other than those of the AITUC, separated from the organisation and formed the Indian National Trade Union Congress (INTUC) in May, 1947. In 1941, a break-away group had formed a new trade union organisation called the Hind Majdoor Panchayat later on named as Hind Majdoor Sabha (H.M.S.). In 1949, a group of the dissatisfied left wing trade unionists formed the United Trade Unions Congress (U.T.U.C.). There was again a rift in the AITUC in 1970 when the communists divided themselves into two parts viz., CPI and CPM. The AITUC came under the control of CPI while CPM started a new central organisation- Centre of Indian Trade Union (CITU). The split in the Indian National Congress into two groups in 1972 also resulted in a change in the INTUC. The separated Congress group (old) formed a new union- National Labour Organisation (NLO). In 1977-78 the INTUC, AITUC and HMS came together to form a National Apex Body (NAB). It ceases to exist today.

(ii) Submission of Returns

Section 28 of the Trade Unions Act 1926 requires every registered trade union to submit returns to the Registrar of Trade Unions, providing full information relating to the total number of members, income, expenditure, etc. But less than 40 per cent registered trade unions had submitted their returns from 1974 to 1986. During 1984, only half of the States were seen having submitted their returns. Further, no data was available after 1986, because it took normally 3 to 4 years for the Labour Bureau to compile and publish the data. The 1990 documents had recorded data upto 1986. The state machinery was clearly not effectively administering and implementing the labour legislations.

(iii) Financial Position of Trade Unions

Trade unions suffered from financial weakness, as the average yearly income of the unions had been rather low and inadequate. Between 1960 and 1989 the average income of trade unions was Rs 2,511 and Rs 10,870, respectively. The total income of 6,825 trade unions during 1961 was Rs 171 lakh and during 1989 it was Rs 938 lakh for 8,742 trade unions submitting returns. This income cannot be considered to be sufficient for catering to the interests of a large membership. The total membership of reporting trade unions during 1961 and 1989 was 40.13 lakh and 71.8 lakh, respectively. The average income had been low not because of the poverty of the workers but because of other factors. The National Commission on Labour had observed that union organizers generally did not claim any amounts nor did workers feel like contributing more, because the services rendered by the various trade unions did not deserve a higher fee.

(iv) Empirical Study of Some Aspects of Trade Unionism in Himachal Pradesh

(a) Existence of Trade Unions in Sample Units.

Trade unions were found to be present in all the sample units. In a few units there were two trade unions; in a majority of the units there was a single trade union. It was generally found that employers recognised the union which was pro-management. Workers not satisfied with the working of a trade union formed a separate union.

(b) Affiliation of Trade Unions

Out of the total 16 trade unions in the sample units, six were affiliated to CITU and five to BMS. INTUC had its unions in three units, and AITUC in two units only. It was found that CITU was emerging as the sole representative of workers in the newly developed industrial estates in Himachal Pradesh. Out of the total 4,510 trade union

members, 2,060 (45.67 per cent) were members of CITU. Second place was accorded to BMS with 1,050 members (23.28 per cent) and INTUC had 610 members (15.4 per cent). The trade unions affiliated to AITUC, i.e., two unions, had 625 members.

(c) Extent of Membership

In all the industrial units there were in all 6,050 workers whereas only 74.5 per cent, i.e., 4,510 had joined trade unions. The reasons for not joining trade unions indicated by 240 sample workers interviewed, were (a) fear of victimization (22 workers, i.e., 9.1 per cent); (b) political interference (69, i.e., 28.7 per cent); (c) multiplicity of trade unions (23, i.e., 9.5 per cent); (d) no use in joining trade unions (78, i.e., 32.5 per cent); and (e) other reasons (48, i.e., 20 per cent).

Similarly, the reasons for joining trade unions were indicated by the 240 workers interviewed as (a) to get higher benefits (27 workers); (b) to safeguard against victimization (50); (c) for unity (60); (d) for help during strike (13); and (e) for welfare facilities (90 workers).

Regarding usefulness of trade unions, 80 workers opined that they were very useful, 77 that they were useful, 37 that they were moderately useful, 14 as slightly useful, and 32 as useless. The factors responsible for successful functioning of trade unions were, according to the 240 workers interviewed, (a) the unity among workers (123 workers), (b) justified demands (70), (c) capable union leaders (33), and others (14).

(d) Influences of Political Parties

One of the biggest problems of the country's trade unions is the influence of political parties. Trade unions, formed to safeguard and promote the social and economic interests of workers have tended to become tools of party politics. However, workers did not approve of political interference. Out of 240 workers interviewed in Himachal Pradesh, 183 did not favour such interferences. Opinion was elicited from 80 trade union leaders of the twelve sample units as to the role and involvement of political parties. 47 were of the opinion that such a role should be reduced. However 27 leaders revealed that political parties had helped them during negotiations with the management. There were also reports of help in adjudication and conciliation and of material help during industrial unrest.

(e) Trade Unions and Welfare Measures

Larger trade unions in big industrial towns in India provided various benefits and also undertook welfare measures for their members in the form of financial aid during industrial unrest, old age benefits, funeral benefits, sickness benefits and educational facilities. Certain trade unions had opened libraries and arranged sight seeing tours. But, during the present research investigation it was found that no welfare measures had been undertaken by the sample trade unions in Himachal Pradesh. Out of 80 trade union leaders interviewed, 52 leaders revealed that due to lack of finances and of outside financial support they could not provide welfare facilities to their members. 13 leaders attributed low membership as one of the causes. 10 trade union leaders attributed lack of cooperation among different trade unions as one of the possible reasons behind it.

(f) Facilities Available to Trade Unions

It is not mandatory for the management to provide infrastructural facilities to trade unions. But the present study reveals that almost all the recognised trade unions had been provided infrastructural facilities by the management. Even some unrecognized trade unions had been provided with such infrastructural facilities. However only 17 trade union leaders were satisfied with the facilities provided.

(g) Opinion of Trade Union Leaders Regarding Attitude of Management towards Trade Unions

It will be seen from Table 10 that out of the 80 trade union leaders studied, only 10 stated that the attitude of the management was cooperative. 45 stated that it was indifferent, while 25 stated that

it was of suspicion. Out of these 80 trade union leaders, 2 were post-graduates, 40 were graduates, 22 had technical education and 16 were matriculates or less. None were illiterate.

TABLE 10. ATTITUDE OF MANAGEMENT

Name of unit	Cooperative	Suspecious and Militant	Indifferent	Total
Public Sector				
1. H.P.M.C.	-	5	5	10
2. C.C.I.	5	5	-	10
3. H.P.S.F.C.	-	-	5	5
4. Agro. Ind. Corp.	-	-	3	5
5. Himalaya Fertilizer	-	5	5	5
6. Worsted Mills	-	-	5	5
Private Sector				
7. A.C.C.	-	5	6	10
8. Mohan Meakin	5	-	-	5
9. Gabrial & Purelators	-	-	5	10
10. Winsom Spg.	-	3	2	5
11. Sidhartha Spg.	-	-	5	5
12. Eicher Tractors	-	1	4	5
Total	10	25	45	80

(h) General

Trade unions in India suffer from a variety of problems such as politicization of trade unions, multiplicity of unions, intra-union rivalry, small size and low membership, financial debility, lack of welfare facilities, weak bargaining power, reliance on litigation and strikes, and dependence on outside leadership.

The growth of trade unions in India is quite satisfactory; but their role in creating harmonious industrial relations was not encouraging. During 1986 to 1989 in all 1,172.26 lakh mandays were lost due to 6,456 cases of strikes and agitations, etc.

The loss of production in 3,286 cases amounted to Rs 2,440 crore and the loss of wages in 3,731 cases amounted to Rs 256 crore. Information about losses in other cases is not available. Trade unions in India have not undertaken satisfactory welfare measures for the working class as those in other developed countries of the world. In Himachal Pradesh, there was total absence of these welfare measures by the trade unions. Too much political interference was found in the working of trade unions in this State. Inter union rivalry had also impeded the progress of trade unions and workers' interests in both the private as well as public sectors in Himachal Pradesh. Trade unions did not receive any outside financial assistance as was found in the case of central trade unions in different states.

To improve the working of trade unions, two measures should receive due attention. Firstly, the development of a sound trade union education which can create a body of competent, disciplined and full time trade union leaders, is required. Secondly, the unions have to play a vital role in improving the quality of life of the workers and as such they should evince greater interest in welfare programmes for the members such as education, health and family planning, recreational and cultural activities. They can also promote personal and environmental hygiene and promote a sense of thrift and savings. Such involvement in constructive activities would help the trade unions in furthering the interest of the members.

VII. PROBLEMS OF WOMEN WORKERS AND THEIR SOCIO-ECONOMIC CONDITIONS

(i) Equality

The right of women to public employment is recognised under the Constitution. Article 15(1) and 16(2) of the Constitution grant the right of equality in regard to employment opportunities to men and women.

(ii) Employment

Some interesting facts regarding the employment of women workers in India have emerged from the population census from 1901 to 1981. The percentage of female workers to total female population decreased from 32 per cent in 1901 to 12 per cent in 1961 and increased only marginally to 14 per cent in 1981.

(iii) Employment in Factories

Data on employment of women in factories was available from 1946 to 1985. It shows that until 1951, women workers constituted more than 11 per cent of the average daily employment in factories, that percentage gradually fell to 8.61 in 1972 but stabilised at 9.46 in 1984 and 9.44 in 1985.

(iv) Employment in Agriculture

Like other Asian countries where agriculture is the mainstay of the population, in India the largest avenue for women's employment is in agriculture. Census figures upto 1981 show that 70 per cent of the population earn livelihood from agriculture. Among the agricultural classes 18 per cent of the self supporting persons and 66 per cent earning dependents are women. 23 per cent of total female workers were engaged in cultivation and agricultural work during the 1901 Census. But in 1981, this percentage declined to 11.

(v) Employment in Mines and Quarries, etc.

Upto 1981, the number of women workers engaged in mines and quarries was 1,63,158 (0.73 per cent) out of 222,516,569 total workers engaged in this sector which is the lowest percentage as compared to other sectors of employment. Women workers engaged in manufacturing processing, servicing and repairs were 8.14 per cent out of 251,43,037 which is the third largest sector employing female workers in our country.

(vi) Other Sectors

In other industrial activities, viz., construction, trade and commerce, transport and communication and other minor services, only 10.27 per cent women workers were engaged. There were 46,15,409 women workers out of total 4,30,94,257 workers engaged in the said industrial activities.

(vii) General Pattern of Employment

Various labour legislations have imposed restrictions on the employment of women workers in men's jobs. For example, the Factories Act, 1948 imposes restriction on employment of women during night shifts, near machines in motion, near cotton openers, in certain chemical industries, etc. The Mines Act, 1952 imposes restrictions on employment of women workers in underground mines. From 1962 to 1987 there has been a continuous rise in the employment of women. This increase was constant in the public sector but private sector witnessed uneven growth during this period. Plantations offered the largest employment to women workers in India, the bulk being in tea plantations. In coffee plantations, the number of women workers which was 15,231 in 1961 went down to 6,148 in 1988. Women workers were replaced by men workers. On the other hand, employment of women had shown an increase in rubber and tea plantations. In rubber plantations, the percentage of women workers during 1967 was 26 which subsequently increased to 54.86 in 1988. In tea plantations it was 19.31 per cent in 1967 and rose to 45.37 per cent in 1988. During 1988, the number of women employed was highest in tea plantations (3.65 lakh) as compared to the other two sectors.

One very remarkable feature noticed in regard to employment of women in India, whether in agriculture, factories, or other sectors, is that in absolute number as well as relatively, women constitute a significant part of the labour force in the South rather than in the North.

(viii) Recruitment and Training

Recruitment of women workers for industrial

employment is mostly direct. The number of employers utilising the services of employment exchanges for this purpose is very small in the private sector. During 1968, there were 30.1 lakh workers registered with employment exchanges, out of which 5.58 lakh were women workers. Out of total registered women only 11 per cent were able to find jobs during that period. During 1987, there were total 302.41 lakh workers on the live registers of employment exchanges in the country, out of which 53.73 lakh were women workers. Only 45,300 (13.4 per cent of total) were recruited to different jobs.

There are many institutions in the country to impart training to male and female workers in engineering and non-engineering trades. 951 ITIs and other centres during 1989 imparted training to 4,232 female workers in the country. In addition, women were also being trained along with men at some other centres of the Directorate General of Training Employment and Settlement. Statistics revealed that the number of women workers trainees in engineering trades was much less than the number of male workers. During 1989, out of 150,685 trainees only 704 females were trained in engineering trades. But this gap does not exist in non engineering trades, in which, during 1961, out of total 1,703 trainees 499 were females and in 1981 out of 11,139 trainees there were 4,232 female trainees.

(ix) Awareness of Beneficial Legal Provisions

Awareness of workers, particularly of women workers in India, in regard to various labour legislations is very poor. Due to this reason, workers in India are exploited a lot. Employers do not like to educate the workers or even display on the notice boards the provisions for the welfare of workers. In Himachal Pradesh, taking the selected public and private sector industries together, 69.1 per cent were aware, 15 per cent of the total were partially aware and 37 were not at all aware of any beneficial legislation. The level of awareness was higher in private sector units due to the fact that educational level was higher in this sector.

(x) Working Conditions of Women Workers in Himachal Pradesh

Section 34(1) of the Factories Act, 1948 requires that no women should be employed in any factory to carry loads of more than 30 kg.The present study revealed that 17 sample women out of 120 women studied were supposed to carry weights up to 40 kg, and three women workers were supposed to carry more than 50 kg weight. One third of the women workers in the sample private sector industries were supposed to work during night shifts, whereas the Factories Act, 1948 prohibits the employment of women and children during night shifts.

(xi) Women Workers and Trade Unionism

Trade unionism among women workers in India has not made any appreciable progress. An ILO study entitled 'The Law and Women's Work' made the following observations in this regard. By custom and tradition a woman is responsible for the management of the home, in addition to her occupational task. There are a multitude of domestic tasks which she assumes like the care of the children and repair of clothing for the members of the family. The first consequence of this is that a working woman is inevitably overworked and would ruin her health, if certain measures of social protection are not taken. In the second place, her attention is to some extent distracted from the collective interests of the workers and in particular she shrinks from the extra efforts involved in taking an active part in the trade union movement. In addition, the fact of a woman's time being divided between her occupational work and her numerous domestic tasks reduces her occupational value and her ability to defend her interests as a worker.

It is seen from the annual returns under the Trade Union Act 1926, which only 50 per cent of the trade unions submit, that between 1971 and 1984, women workers constituted only between 7 per cent to 8.6 per cent of the total membership of trade unions. In Himachal Pradesh nearly half, i.e., 41.7 per cent of women did not participate in trade union activities. Out of 50 women who were not participating, 22 women workers attributed

financial liability behind non-participation, 13 workers did not participate as employment was of causal nature, five women were afraid of their employers; lack of knowledge (three women), ineffective leadership (four women workers) and trade unionism not effective (three women) are other factors contributing to their non-participation.

(xii) Welfare Coverage

A study was also conducted on welfare measures available to women workers in sample industrial units in Himachal Pradesh. For this purpose 120 women workers were selected and studied through structured questionnaire. It was found that out of 120 sample workers only 40 were provided with housing facilities. In certain bigger industrial areas in the country, women workers have been provided with certain educational benefits by their employers, by trade unions and by the respective State Governments. Study of the 120 workers in six selected units in Himachal Pradesh revealed that among the sample units there were no arrangements for adult education or vocational education. Workers in all the units studied revealed that there was provision for medical facilities. But when women workers were asked about the working of the ESI Hospital at Parwanoo, they revealed that there was no provision to investigate and treat occupational diseases, that the behaviour of the medical staff was not satisfactory, and that only the influential and the well known got medicine from ESI hospitals.

As regards family planning, of the 120 sample women workers studied in industrial units in Himachal Pradesh, only in one unit had the management arranged family planning camps and free contraceptives.

Section 48(1) of the Factories Act, 1948 provides that in industries where more than 30 women workers are employed, the management has to provide creche facilities to women workers. The present study, however, found that there was not even a single creche in the State of Himachal Pradesh.

(xiii) Summary

To conclude, we may say that an encouraging trend was going on in women's employment. But still, their share in total employment was not satisfactory. Women workers were not even conscious about their rights. Their participation in trade union activities needs to be encouraged so that they could have their say in collective bargaining. The Central and State Governments should take steps to educate women workers and to stop exploitation of this section of the society by enforcing labour legislations.

VIII. CONCLUSION AND RECOMMENDATIONS

Major Hypothesis Proved

The present research inquiry has proved our major hypothesis that public and private sectors units have not undertaken sufficient welfare measures for working class in Himachal Pradesh.

Sub Hypothesis

The study has proved that labour administration has failed in protecting the interests of working class in the organised sector in Himachal Pradesh. It has also proved that the workers are denied basic welfare and are not getting the benefits permissible under different labour legislations. The study has also proved that workers in the State have not been benefited by the promotion of industries. Also, the hypothesis that private sector units have not undertaken sufficient welfare measures for women workers has been proved.

Labour Administration

During the study, it was found that the State Labour Department was not properly managed. Various appointments required under the Factories Act, 1948 were found to be non existent. The positions of two zonal labour officers were lying vacant for over five years. Factory inspectors posted in the field areas were supposed to inspect vast areas and had not been provided with assisting staff. Only two inspectors had been appointed for the whole State.

Workers in the sampled industrial units were

highly critical about the functioning of the State Labour Department. It was revealed that in all the twelve sample units, factory inspectors had not paid even a single visit. Even for decisions on common matters, the State Labour Department had taken more than one year's time. The administrative machinery was not geared up with the increase in the number of industrial units, and of the work force, after attaining the statehood in 1971. The Labour Commissioner, besides looking after the general administration, combines in himself other functions, such as, Chief Inspector of Factories, Commissioner of Workmen's Compensation, and Registrar of Trade Unions. This shows the extent of burden on a single functionary, whereas in other states separate commissioners have been appointed for each field.

Tehsildars and District Employment Officers have been appointed as competent authorities (inspectors) under the Minimum Wages Act. These officials are already overburdened with their parent job and show no interest in this additional duty.

The mere setting up of a Labour Court/Industrial Tribunal should not be construed as compliance with the provisions of the Industrial Disputes Act, 1947. A single presiding officer appears to be unable to adjudicate the increasing volume of labour disputes expeditiously. Further, procedure of its functioning has also been reported to be lengthy and takes years for the disposal of disputes.

Interestingly, various *ad hoc* boards and committees have been set up by the State Government under the provisions of various Acts, but have remained only on paper. Data regarding the working class in Himachal Pradesh has been poorly maintained.

RECOMMENDATIONS

After conducting a thorough investigation of the problems of labour welfare in India in general and Himachal Pradesh in particular, the research makes the following recommendations.

Labour Administration

1. Administrative machinery at the central and state level should be strengthened by filling up all the vacant and required positions. There should be an adequate arrangement for maintenance of labour statistics.

2. With the growing industrial activities in Himachal Pradesh a separate Factories Inspectorate should be set up and should be under the administrative control of the Labour Department.

3. One more post of Joint Labour Commissioner should be created to reduce the burden of the Labour Commissioner. Instead of appointing Tehsildars and Employment Officers as competent authorities, i.e., as Inspectors under the Minimum Wages Act 1948, these duties should be assigned to Labour Welfare Officers. The State Government should create these positions for each district. There should be at least one Factories' Inspector in every industrial estate.

4. The State Government should create more positions of judges and other staff for the Industrial Tribunal and Labour Court and should regularly monitor the functioning of various Boards and *ad hoc* committees created under various labour legislations.

5. In the Head Office of the Labour Department, one computer should be installed immediately to maintain up-to-date data and other records.

6. Labour Bureau Shimla/Chandigarh should be adequately strengthened to enable publication of labour statistics.

7. The Union Ministry of Labour, State Department of Labour and other autonomous organizations should strictly implement the labour welfare legislations. Grievances of workers and employers should be redressed in time.

8. Limit of fine for violation of provisions of any Act by the employers should be minimum Rs 500 or six months' imprisonment and sometimes both.

Socio-economic Conditions

9. The State Government should prescribe and enforce a minimum 60 per cent quota in employment for bonafide residents of Himachal Pradesh.

10. Instead of setting up the industrial estates in border areas, the Himachal Pradesh Government should set up these estates in areas where local manpower could be benefited.

11. Before setting up any industrial estate, the State Government should impart technical training to the local people so as to ensure their induction into skilled jobs.

12. Back door entries in employment should be completely done away with. All appointments should be made through employment exchanges.

13. Workers and employers should be educated about environmental pollution. Employers causing water and air pollution should be punished severely. Before issuing licences to industrialists for setting up industrial units they should be directed to instal latest equipment for checking pollution.

14. To reduce the rate of industrial accidents, provision of protective devices should be made. Safety Officers should be appointed where necessary.

15. The State Government should ensure that provisions of the Minimum Wages Act, 1948 are implemented in letter and spirit. With the rise in prices, the minimum wages of industrial workers should be revised to ensure healthier and prosperous family life.

16. Workers should be educated about bad habits, viz., drinking and gambling, through audio-visual media.

Welfare Activities

17. There should be adequate facilities of health and medical care in the form of hospitals in every industrial estate. Private entrepreneurs should engage private medical practitioners on part time basis. Every industrial unit should maintain proper First Aid boxes and, to meet emergencies, provision of vehicle/ambulance should be there.

18. As a matter of encouragement, such employers as give better medical facilities, should be given considerable rebate in their contribution to the ESI Scheme.

19. In the case of smaller units, these facilities should be provided on a joint basis by a group of employers.

20. The Central and the State Governments should take necessary steps for periodical examination of workers where there is possibility of occupational diseases.

21. Hospitals and dispensaries set up by the ESI Corporation and by the State Government should be properly managed and staffed. These should avoid the tendency of acting as referral institutions.

22. Employers should provide clean and no-profit canteen facilities even in such units where the number of workers is less than the prescribed limit. The State Government should supply items at subsidised rates.

23. The Payment of Wages Act, 1936 should be suitably amended to incorporate the provision of deductions from the wages for credit purchases made from canteens.

24. Smaller units should be encouraged to start joint canteens. For this purpose the State Government should construct buildings for canteens in the middle of the newly developed industrial estates.

25. All the industrial units employing a certain number of women workers should be forced to provided creche facility. Smaller units should extend this facility on joint basis. The State Department of Social Welfare should supply free facilities to these creches as are provided in the case of *Balwaries* and *Anganwaries*.

26. The State Government and big industrial units should construct houses-hostels for industrial workers. Simultaneously, employers should encourage the formation of industrial workers' cooperative housing societies. These societies should be provided with subsidised loan facilities. The State Government should acquire and develop land near industrial estates and should make available at reasonable rates to these societies, or in the absence of such societies to interested workers.

27. Workers who cannot be provided with accommodation by the employers, should be duly compensated by paying satisfactory House Rent Allowance.

28. There should be proper entertainment facilities within and outside the establishments. These can be in the form of TV, cinema shows, sightseeing tours, sports, and by organizing cultural programmes. The cost of such facilities in the case of smaller units should be shared by the employers of such units and the State Government. Trade unions should also come forward to provide such facilities.

29. In all the industrial estates, the State Government should provide transportation facilities to the workers. Workers should be allowed to avail concessional bus pass facilities in State Transport buses.

30. Smaller units should share the burden of providing transportation facilities on joint basis.

31. In every industrial estate, there should be proper and adequate arrangement for education of children. The State Government should run schools upto matric in these estates.

32. Employers should extend certain benefits to deserving children of workers in the form of free uniform, stationery, books and scholarship. Employers should also provide vehicles to these school going children of workers.

33. If possible, employers should start their own schools and the State Government should provide them maximum grants.

34. Adult education should be arranged for industrial workers. The State Government should provide technical and financial assistance in this regard.

35. All the employers and the State Government should arrange for vocational training to workers' wives and family members in every industrial estate, so that the latter could augment family income and improve their standard of living.

36. Family planning programmes for industrial workers should be made a part and parcel of labour welfare programmes. For this purpose workers should be educated and motivated to adopt this programme. The State Government should supply free contraceptives and other devices to every industrial unit. The employers should also arrange family planning camps in their units. Workers undergoing sterilization, etc., should be provided financial incentives by the employers and by the State Government. Awards and Trophies should be awarded to employers for implementing this programme enthusiastically and vigorously.

Women Workers

37. Employment of women workers during night shifts and in hazardous tasks should be stopped forthwith.

38. Every worker should be made aware of labour welfare legislations. For this purpose provisions of such Acts should be displayed on notice boards and should be in a language which is easily understood by a majority of the workers.

39. The Government must ensure extension of all benefits by the employers to women workers as per the Maternity Benefit Act, 1952.

40. Women workers should be motivated to join and participate in trade union activities.

41. Separate labour hostels should be constructed in every industrial estate for women workers.

42. Employers should promote the habit of saving among industrial workers.

Trade Unions

43. Trade unions should contribute towards industrial growth. They should fight only for the genuine demands of their members and only through democratic means.

44. Trade unions should, as far as possible, keep themselves away from political parties. They should not let themselves be used as tools by their patron political parties.

45. Employers should provide adequate facilities to these trade unions in the form of furniture and accommodation.

46. Trade unions of Himachal Pradesh should also undertake welfare measures for their members like their counterparts in other states.

47. Suitable penalty should be imposed on the trade unions not complying with the Trade Unions Act, 1926.

48. Tendency of multi-trade unions in a single unit should be avoided because it creates conflict and in turn affects the bargaining capacity of workers.

49. Trade unions should improve their financial condition by avoiding unnecessary expenditure on legal matters, etc., and use that amount in labour welfare programmes.

50. Employers and trade unions should promote harmonious relations.

These suggestions, if implemented, will improve the socio-economic conditions of industrial workers, and then definitely, these workers could be expected to contribute towards

the growth of industrial development in this under-developed State of Himachal Pradesh in particular and India in general.

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IRRATIONAL MOVEMENT OF SHARE PRICES: EVIDENCES AND IMPLICATIONS

Malay K. Roy and Madhusudan Karmakar

There has been a long-standing debate in financial economics on the issue - whether share price movement can be justified by subsequent changes in future dividends. This paper attempts to test this hypothesis and reveals that stock price volatility over the period (1968-1991) appears to be far too high to be attributed to new information about future real dividends. Since price movement exceeds the level indicated by fundamental economic factors, the existence of 'fads' or 'bubbles' in price can not be ignored. The 'noisy' price indulges misallocation of scarce resources and ultimately reduces the welfare of the society.

Throughout the unprecedented stock market boom of eighties,[1] there was a popular belief of excessive movement in share prices. Increased volatility *per se* can not be criticised if the price movement can realistically be explained by fundamental economic factors. During the heydays of price rise there was an attempt both by academics and professionals to explain market volatility in terms of arrival of information. This is an essential feature of efficient market, a cherished belief of some economists about stock market behaviour [Cootner, 1962, Pp. 24-25; Sharpe, 1964, Pp. 425-443; Fama, 1965, Pp. 34-105; Fama, 1970, Pp. 383-417; Jensen, 1978, Pp. 95-102].

This academic approach of market behaviour was, however, shattered after unearthing of the ever-largest financial scandal in the history of India, popularly known as 'security scam'. The whole episode made a mockery of academic claim that stock price moves efficiently. It unveiled a number of imperfections about the functioning of the capital market and people clamoured for immediate market reform to prevent recurrence of such a debacle in the future.

Curiously, the whole debate on the present state of share price movement, its plausible explanations and development implications, is still simply based on general observation of market behaviour. Hence, it becomes imperative to study what ultimately is behind the day-to-day movement in share price. In a sense, the issue appears:

Can we trace the source of price movements in the recent time back in a logical manner to fundamental shocks affecting the economy? Or,

are price movements due to 'fads': waves of irrational optimism and pessimism, 'noise trading', 'feedback trading', or other market inefficiencies?

To test the above hypothesis, the plan of the study is designed as follows: In Section I we describe some theoretical issues directly related with the test of market efficiency. Empirical results of volatility test will be presented in Section II. In Section III we will interpret the findings of the study. Finally, the major policy implications that are directly related to the study would be highlighted in Section IV.

I Methodological Issues

A simple model that is commonly used to interpret movements in share price index asserts that real stock prices equal the present value of rationally expected or optimally forecasted future real dividends discounted by a constant real discount rate. This valuation model is often used by economists and market analysts to provide plausible explanations for movements in stock price index. Thus, these movements by definition can be attributed to 'new information' about future dividends. Mathematical representation of the above discussions may be stated in terms of the simple Efficient Market Model as follows:

According to the model, the real price P_t of a share at the beginning of the time period t is given by

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$$P_t = \sum_{k=0}^{\infty} \gamma^{k+1} E_t D_{t+k} \qquad 0 < \gamma < 1 \qquad \ldots(1)$$

Where D_t is the real dividend paid at (let us say, the end of) time t, E_t denotes mathematical expectation conditional on information available at time t, and γ is the constant real discount factor $= 1/(1+r)$, where r is defined to be the constant real interest rate.

The model (1) can be restated in terms of series as a proportion of the long-run growth factor: $p_t = P_t \cdot \lambda^{T-t}$, $d_t = D_t \cdot \lambda^{T-t-1}$ where the growth factor is $\lambda^{T-t} = (1+g)^{T-t}$, g is the rate of growth, and T is the base year. The growth factor λ^{T-t} has the effect of eliminating heteroscedasticity due to the gradually increasing size of the market. Multiplying (1) by λ^{T-t} and substituting we find

$$p_t = \sum_{k=0}^{\infty} (\lambda\gamma)^{k+1} E_t d_{t+k}$$

$$= \sum_{k=0}^{\infty} \bar{\gamma}^{k+1} E_t d_{t+k} \qquad \ldots(2)$$

The growth rate g must be less than the discount rate r if (1) is to give a finite price, and hence $\bar{\gamma} \equiv \lambda\gamma < 1$, and defining $\bar{r}$ by $\bar{\gamma} \equiv 1/(1+\bar{r})$, the discount rate appropriate for p_t and d_t series is $\bar{r} > 0$. The discount rate $\bar{r} = E(d)/E(p)$.[2]

The above model may also be written in terms of the *ex post* rational price series p_t^* as follows:

$$p_t = E_t(p_t^*) \qquad \ldots(3)$$

where $p_t^* = \sum_{k=0}^{\infty} \bar{\gamma}^{k+1} d_{t+k} = \bar{\gamma}(p_{t+1}^* + d_t)$.

Since the summation extends to infinity, we never observe p_t^* without some error. However, with a long enough dividend series we may observe an approximate p_t^*. If we select an arbitrary value for the terminal value of p_t^* then we may determine p_t^* recursively by $p_t^* = \bar{\gamma}(p_{t+1}^* + d_t)$ working backward from the terminal date. If we choose a different terminal condition, the result would be to add or subtract an exponential trend from the p^*. As we move back from the terminal date, the importance of the terminal value chosen, however, declines [Shiller, 1981, p. 425].

Using the efficient market model developed above, Shiller [1981, Pp. 421-436] deduced three variance inequalities to compare the variance of actual stock price to the variability of new information about future real dividend. The simplest inequality derived from model (3), puts a limit on the standard deviation of p_t in terms of the standard deviation of p_t^* [See Shiller, 1981, p. 422]:

$$\sigma(p) \leq \sigma(p^*) \qquad \ldots(I)$$

Other two inequalities have been derived from the model restated in innovation form which allows better understanding of the limits on stock price volatility imposed by the model. Thus the second inequality puts a limit on the standard deviation of the innovation in price δp in terms of the standard deviation of d [See Shiller, 1981, p. 427]:

$$\sigma(\delta p) \leq \sigma(d)/\sqrt{\bar{r}_2} \qquad \ldots(II)$$

where $\delta p \equiv \Delta p + d_{-1} - \bar{r}p_{-1}$ and $\bar{r}_2 = (1+\bar{r})^2 - 1$; and the third inequality puts a limit on the standard deviation of the change in price Δp in terms of standard deviation of d [See Shiller, 1981, p. 428]:

$$\sigma(\Delta p) \leq \sigma(d)/\sqrt{2\bar{r}} \qquad \ldots(III)$$

The definitions and terminologies used in the Efficient Market Model and variance inequalities, are illustrated in Table 1.

Applying the data set given below, we would use the above three variance inequalities to test the market efficiency i.e., to investigate whether actual price movement can realistically be justified by the subsequent changes in information about future real dividend. If these variance inequalities hold good in practice, the market can be designated as efficient, otherwise the existence of 'fads' or 'bubbles' in price can not be ignored.

TABLE 1. DEFINITIONS OF PRINCIPAL SYMBOLS

γ =	real discount factor for series before detrending; $\gamma = 1/(1+r)$
$\bar{\gamma}$ =	real discount factor for detrended series; $\bar{\gamma} \equiv \lambda\gamma$
D_t =	real dividend accruing to stock price index (before detrending)
d_t =	real detrended dividend; $d_t \equiv D_t \cdot \lambda^{T-t-1}$
Δ =	first difference operator $\Delta x_t \equiv x_t - x_{t-1}$
δ_t =	innovation operator; $\delta_t x_{t+k} \equiv E_t x_{t+k} - E_{t-1} x_{t+k}$; $\delta x \equiv \delta_t x_t$
E =	unconditional mathematical expectations operator. E(x) is the true (population) mean of x
E_t =	mathematical expectations operator conditional on information at time t; $E_t x_t \equiv E(x_t/I_t)$ where I_t is the information set known at time t.
λ =	trend factor for price and dividend series; $\lambda \equiv 1+g$ where g is the long-run growth rate of price and dividends
P_t =	real stock price index (before detrending)
p_t =	real detrended stock price index; $p_t = P_t \cdot \lambda^{T-t}$
p_t^* =	*ex post* rational stock price index (expression 3)
r =	one-period real discount rate for series before detrending
$\bar{r}$ =	real discount rate for detrended series; $\bar{r} = (1-\bar{\gamma})/\bar{\gamma}$
$\bar{r}_2$ =	two-period real discount rate for detrended series; $\bar{r}_2 = (1+\bar{r})^2 - 1$
t =	time (year)
T =	base year for detrending and wholesale price index

Data Set and Time Period

To conduct an empirical study of present nature, the commonly used series of data are the index number of share price and dividend series accruing to the portfolio represented by the shares in the price index. Since no such data package is readily available, we have to construct both the price index and dividend series based on same sample companies. Sample companies were selected on the basis of the following criteria - (1) accounting year must end on 31st March each year, (2) companies must pay regular dividend, and (3) their shares must be regularly traded in the market. Based on above criteria, 30 shares[3] across different industries were chosen to construct the initial portfolio. However it was necessary to reshuffle the portfolio time to time mainly to replace active by inactive shares. In the course of reshuffling also, only the companies that satisfy the above criteria were considered. The volatility tests are not affected by time to time reshuffling of portfolio, so long as the volatility of the price and dividend series are not misstated [Shiller, 1981].

The price series P_t for 1968-1991 is the monthly average price of 30 select shares for March when dividend was declared, divided by the average Wholesale Price Index for the year scaled to 1 in the base year 1991 [Shiller, 1981]. The dividend series D_t is the average dividends for the calender year ending March, accruing to the portfolio represented by the shares in the price series, divided by the same Wholesale Price Index of the year scaled to 1 in the base year 1991.

The relevant data used to construct the price and dividend series have been collected from different sources, namely, various issues of *The Economic Times*, Calcutta; *The Stock Exchange Official Directory*, Bombay; and *The Reserve Bank of India Bulletin*, Bombay.

The variable p_t for 1968-91 is the P_t times a scale factor λ^{T-t}. The variable d_t for the corresponding period is the real total dividends D_t times λ^{T-t-1}.

The period of the study is confined to only 24 years spanning over 1968-1991. Admittedly, it is a short period for a study of this nature. However, there is no readily available data package required for this type of analysis as mentioned earlier, that restrains us for considering a longer period of time.

II Empirical Evidence

Using the equation $p_t^* = \bar{\gamma}(p_{t+1}^* + d_t)$ and working backward from the terminal date we have determined p_t^* (p^* for 1991 was set at the average detrended real price over the sample) to compare

volatility of detrended real price series p_t to the *ex post* rational price series p_t^*. Both p_t and p_t^* series are displayed in Fig. I.

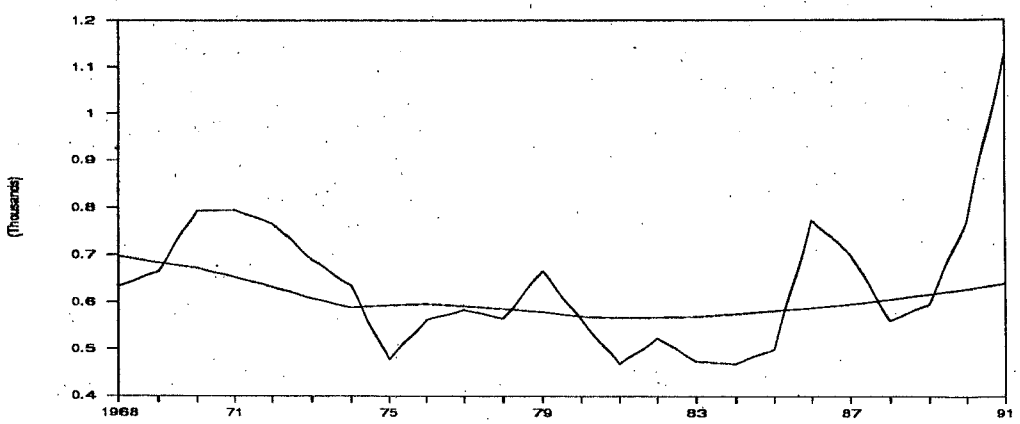
Fig. I shows a smooth and stable *ex post* rational price series p_t^* when compared with the actual volatile price series p_t. This behaviour of p_t^* is due to the fact that the present value relation relates p_t^* to a long-weighted moving average of dividends (with weights corresponding to discount factors) and moving averages tend to smooth the series averaged.

The elements of the inequalities (I), (II) and (III) are displayed in Table 2. Explanations of certain variables used for the inequality test are given below.

The long-run exponential growth path is estimated from the relation $p_t = p_o (1+g)^t$ which may be written in terms of natural logarithm as

$$I_n p_t = I_n p_o + t I_n (1+g).$$

Fig. I. Price (p) Volatility & Ex Post Rational Price (p*) Variability



Note: The solid line p_t is the real price series scaled by multiplying by $(1.00225)^{1991-t}$. The dashed line p_t^* is the *ex post* rational price series $[p_t^* = \bar{\gamma}(p_{t+1}^* + d_t)$, where d_t is the real dividend detrended by multiplying by $1.00225^{1990-t}]$.

By regressing $I_n p_t$ on $I_n p_o$ and time t, it is easy to estimate $I_n (1+g)$ or $I_n \lambda$. Then λ is set equal to e^b where b is the coefficient of time. The growth rate g is found to be 0.00225 i.e., 0.225 per cent over the period 1968 to 1991. This meagre growth rate might be due to the fact from the mid sixties to the beginning of eighties, the economy was suffering from stagflation.

The discount rate $\bar{r}$ (.058451) used to compute p_t^* from (3) is estimated as the average d divided by the average p. The discount rate of 5.84 per cent may appear to be unrealistic at least in view of our present experience. However, it is the minimum average inflation adjusted rate of return of the last 24 years from 1968 to 1991.

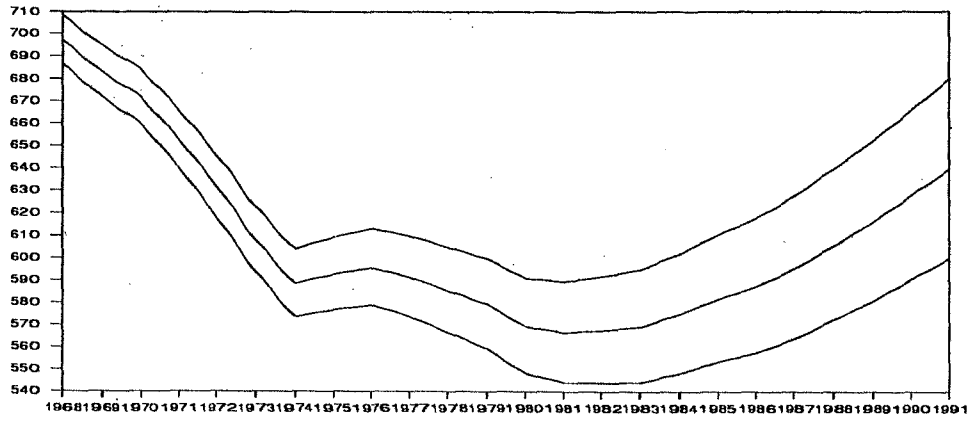
The terminal value of p^* is taken as average p. If a different terminal condition is chosen, the result would be to add or subtract an exponential trend from p_t^* shown in Fig. I. This is shown graphically in Fig. II, in which p_t^* was computed from alternative terminal values. Here also p_t^* remain smooth and stable as compared to the actual price series. As we move back from the terminal date, the deviation between p_t^* becomes minimum, hence the importance of the terminal value chosen declines.

TABLE 2. SAMPLE STATISTICS FOR PRICE AND DIVIDEND SERIES

	Sample period	1968-1991
1.	E (p)	639.7
	E (d)	37.39
2.	$\bar{r}$	0.0584
	$\bar{r}_2$	0.1203
3.	$b = I_n\lambda$	0.0022
	$\hat{\sigma}(b)$	(0.2087)
4.	$\sigma(d)$	12.4245
	Elements of Inequalities:	
	Inequality (I)	
5.	$\sigma(p)$	147.23
6.	$\sigma(p^*)$	38.58
	Inequality (II)	
7.	$\sigma(\Delta p + d_{-1} - \bar{r}p_{-1})$	118.31
	min(σ)	95.27
8.	$\sigma(d)/\sqrt{\bar{r}_2}$	35.81
	Inequality (III)	
9.	$\sigma(\Delta p)$	119.97
	min(σ)	96.61
10.	$\sigma(d)/\sqrt{2\bar{r}}$	36.33

Note: In this table, E denotes sample mean, σ denotes standard deviation and $\hat{\sigma}$ denotes standard error. Min (σ) is the lower bound on σ computed as a one-sided χ^2 95 per cent confidence interval. The symbols p, d, $\bar{r}$, $\bar{r}_2$, λ and p^* have been defined in Table 1 of Section I. Data sets have also been mentioned under separate heading of that section. Inequality (I) in the text asserts that the standard deviation in row 5 should be less than or equal to that in row 6, inequality (II) that σ in row 7 should be less than or equal to that in row 8, and inequality (III) that σ in row 9 should be less than or equal to that in row 10.

Fig. II. Alternative Measures of Ex Post Rational Price Series (p_t^*).



Note: (p_s^*) are obtained by alternative assumptions about the present value in 1991 of dividends thereafter. The middle curve is the (p_t^*) series plotted in Fig. I. The series are computed recursively from terminal conditions using dividend series d.

Table 2 reveals that all inequalities are dramatically violated by the sample statistics. The left-hand side of the inequality is 3.3 to 3.81 times higher than the right hand side. The $\sigma(d)$ over the entire sample was 12.42 while $\sigma(\Delta p)$ was 119.97. The upper bound on the standard deviation of Δp allowed by the inequality (III) was thus (disregarding sampling error in the estimation of standard deviation) 36.33, so upper bound was exceeded by 3.3 times. Putting it another way, the standard deviation of d would have to be at least 41 in order to justify $\sigma(\Delta p)$.[4] Fig. III(a) and III(b) gives an impression as to what extent price variation is being justified by the $\sigma(d)$.

Fig. III(a) Extent of Price Variation Explained by $\sigma(d)$

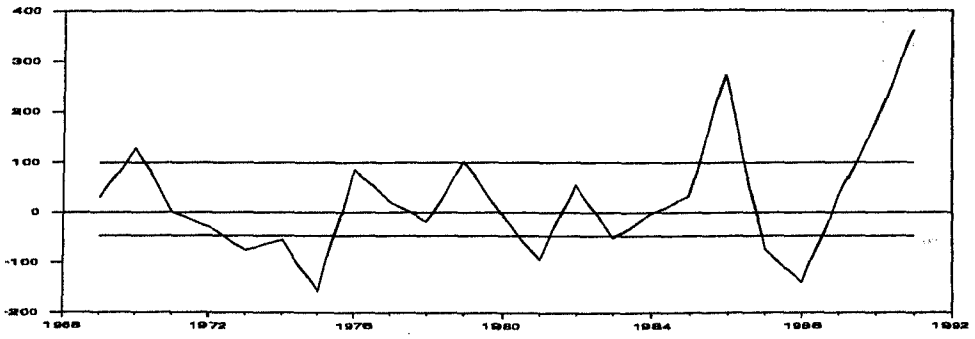
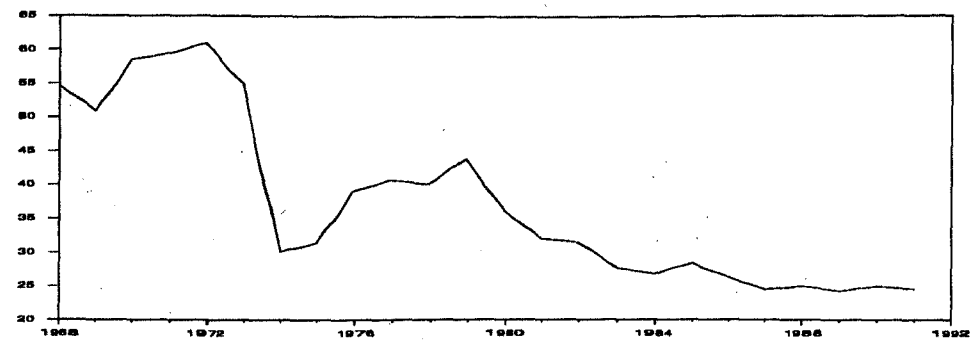


Fig. III(b) Extent of Price Variation Explained by $\sigma(d)$



Note: Upper plot: Δp_{t+1} where p_t is the real price series scaled by multiplying by $(1.00225)^{1991-t}$. Lower plot: d_t, real dividends for p_t series times $(1.00225)^{1990-t}$.

In Fig. III(a), Δp series ranges from -157.3 to 359.8, a range of over 4 standard deviations. The two extreme horizontal lines mark of a ± 2 standard deviation range from the mean $\mu(\Delta p)$ i.e., 25.90, where the standard deviation is $\sigma' = 36.33$ or the upper bound allowed for $\sigma(\Delta p)$ by inequality (III) given $\sigma(d) = 12.42$. So the area between the horizontal lines in fig-III(a) is the maximum limit of the variation of (Δp), justified by the magnitude of $\sigma(d)$ as shown in Fig. III(b). Thus the actual price volatility simply exceeds the level indicated by new information about the fundamental determinants of price.

If Δp_t is assumed normal and serially uncorrelated, the lower bound of a 95 per cent one sided χ^2 confidence interval for $\sigma(\Delta p)$ is 96.61, which is still over 2.6 times higher than the upper bound allowed by the measure of the observed vari-

ability of real dividend σ(d). The lower bound thus so dramatically exceeds the limit allowed by the σ(d) that it would seem impossible to attribute the excess volatility to such things as data errors, price index problems, etc.

The study clearly reveals that the share price volatility over the period 1968 to 1991 appears to be far too high to be attributed to new information about future real dividends. The movements of future dividend σ(d) offer only a partial explanation of variation of price (Δp) and a considerable part of the price movement still remains unexpounded. The simple efficient market models which focus on rational fundamental factors only, fail to consider other subjective variables that may also influence share price movement.

Hence questions arise what is the alternative model of share price movement? And how does it differ from traditional economic model? What are the variables ignored by economists that make their understanding about market behaviour imperfect? In the following section, we deal with the above investigation.

III Interpretations and Conjectures

In the traditional economic view, each investor has a demand curve that slopes downward to the right. Lower stock prices result more demand. The aggregate of individual demand curves also slopes downward to the right, but with a shallower slope. A given stock price change is associated with a larger change in demand than is the case with individual demand.

Fig. IV illustrates the difference and the relationship between demand and supply when the supply of stock is assumed to be fixed. In this case, the assumed shape of the demand curve assures that there will be a single equilibrium point, and that it will correspond to a reasonable price.

Given this model, changes in equilibrium price result through shifts in the demand curve. Fig. V illustrates the process. Assuming the demand curve shifts horizontally, equilibrium price increases with a shift to the right and decreases with a shift to the left. Positive information about fundamentals alone results in a shift of the curve to the right while negative information can cause the curve to shift to the left. Extent of price changes through shift in the demand curve will of course depend upon the nature and importance of information relating to fundamentals arriving in the market.

The market's continuity rests on two assumptions. The first is that the demand function is continuous in information and preference changes. The second is that the demand curve slopes downward to the right.

Traditional economic model of price formation seems inappropriate, as shift in demand very often results more from fashions and fads than that of change in the fundamentals. People under the influence of arbitrary elements buy when price rises and sell when it declines that further accentuate rise or fall in prices - the basic principle being 'buy high and sell low'. In the literature of finance this type of behaviour is often described as 'extrapolative expectations about prices' or 'trend chasing' [See Frankel and Froot, 1986; Soros, 1987; Andreassen and Kraus, 1988]. When investors chase trend, the slope of the demand curve must move upward (See Fig. VI). When price starts increasing, investors will then want to hold more stocks. But this is not possible with supply remaining fixed. Their buy orders will simply increase the bid price and the higher bid price will lead to still more demand. Similarly when price starts declining, all investors will want to hold less stock, but their sell order will simply reduce the offer price, leading to still less demand [Ferguson, 1989, Pp, 42-52]. When shift in demand of investors simply results from expectations based on extrapolations of past prices - prices that ultimately emerge can not be said as rationally determined [Case & Shiller, 1988, Pp. 29-45].

Figure VI is a simple description of price formation process in the stock market. Actual shape of the net demand curve as it is claimed by some researchers, will depend upon the relative balance of 'value based rational investors' and 'naive' or 'noise traders' in the market. Does rational value based investors really exist? Can they stabilize prices? This old question has been the subject of a large literature, dated back to Friedman [1953], Baumol [1957, Pp. 263-271], Telser [1959, Pp. 295-301], Farrel [1966, Pp. 183-193], and Samuelson [1971, Pp. 335-337]

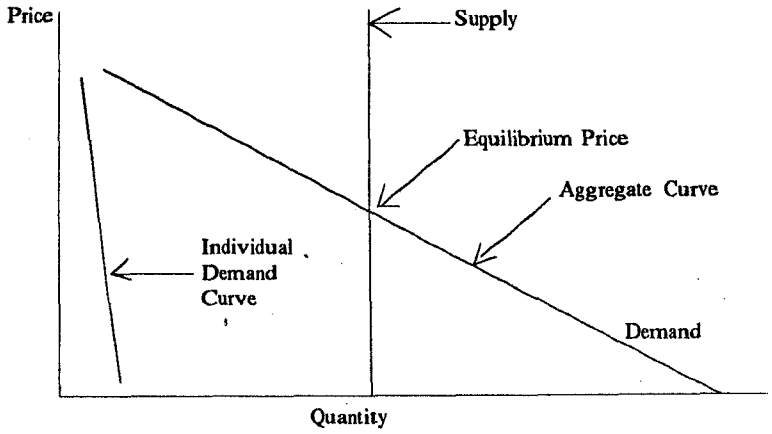


Fig. IV. Demand Curve with Fixed Supply

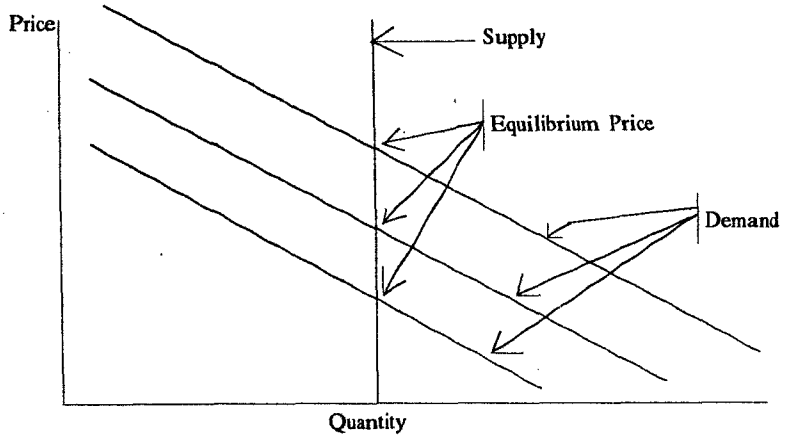


Fig. V. Change in Equilibrium

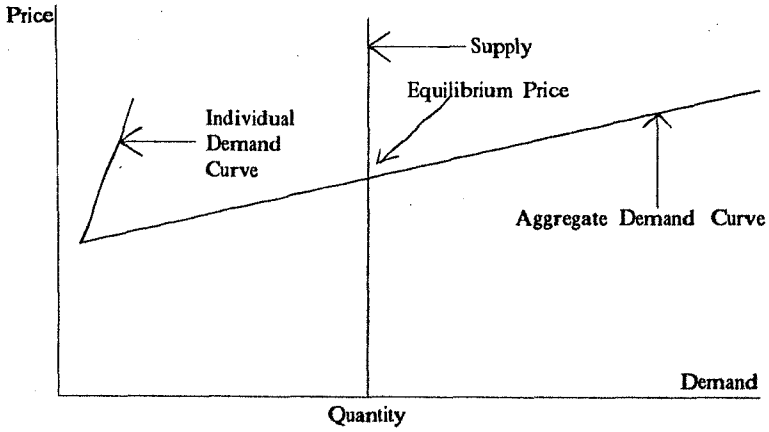


Fig. VI. Demand Curve of Alternative Approaches

among others. Experiences of all earlier speculative episodes including the present one have a few lessons for us. First, investors by and large are not rational. Their demand for shares depends much on their beliefs, sentiments and other arbitrary elements that are not fully justified by fundamental news. Secondly, even if 'value based rational investors' exist their capacity and willingness to counter investors sentiment, thereby to stabilize price is not beyond suspicion [See Keynes, 1936, p. 157; Shleifer and Summer, 1990, Pp. 19-33].

Thus investors' psychology or irrationality is an essential feature of the market behaviour which often forces asset price to deviate from fundamental or fair value. If asset prices do not reflect fundamentals well, then the confidence of economists in the efficiency of market allocations of investment resources is, to say the least, weakened [Stiglitz, 1990, Pp. 13-18].

IV Development Implications

Why should we care about market rationality? What are the implications of irrational behaviour of market for public policy? From public perspective, irrationality of market behaviour has both cost and benefit while very often the former outweighs the latter.

During boom, bullish investors who misperceive expected return over-invest in stocks. Theory shows demand for stock by noise traders increases in proportion to their misperception. Enthusiasm of noise traders usher liquidity, results in a shift in the flow of fund from non-productive to productive assets and economy benefits. In fact, the benefits that would have been accrued to the society are largely offset by misutilisation of scarce resources by inefficient firms. During boom, faulty security prices indulge investors to invest plenty of funds in all industries indiscriminately. When people realise the ills of misallocation of resources, cost of shifting capital within and between sector prevent them from doing so, ultimately economy suffers.

When the bubble bursts, investors soon realise that they have the asset with negative present value that is difficult to transfer to any buyer without incurring enormous capital loss. The risk of change in the noise traders opinion is often described as 'noise traders' risk'. Fundamental risk is of course the basic type of risk inherent in assets price [De Long *et al.*, 1990, Pp. 703-737]. Additional risk that noise traders add reduces capital stock thereby welfare of the economy.

Excepting some interesting cases, cost of irrational behaviour of market is mostly borne by rational investors. In each speculative bubble, noise traders outperform information traders, both in number and wealth, that results in redistribution of resources from information to noise traders that ultimately ensures noisy price[5] in the market [Figlewski, 1978, Pp. 581-597]. Blemish redistribution of wealth obviously has a welfare implication when welfare is computed with respect to correct distribution of return.

If stock markets are truly socially inefficient institutions for allocating capital, should it be replaced, where possible, with institutions that provide a more sober and hence more accurate measure of value? What should be our advice to former socialist countries, who now consider franchise and stock market as the most important requirements for economic growth? What counsel should we make to Brazil, Malaysia, Taiwan, South Korea and Thailand - all these developing countries- which over the last two decades have embarked upon programmes designed to develop their local capital markets. Should we suggest to them - stock markets are just driven by irrational waves of optimism and pessimism so that they should forget them and find some other capital market structure? Ultimately, this is a debate over whether relatively free markets are effective institutions or whether other institutions, typically featuring government control, are more effective. The debate is not likely to end soon.

NOTES

1. The buoyancy started at the beginning of the eighties and after a few setbacks it continued till March 1992 when it reached at the top followed by a slump. The market again started booming from the commencement of 1994.

2. Taking unconditional expectations of both sides of equation (2) we find

$$E(p) = \frac{\bar{\gamma}}{1-\bar{\gamma}} E(d)$$

using $\bar{\gamma} = 1/(1+\bar{r})$ and solving we find $\bar{r} = E(d)/E(p)$.

3. The following is the list of 30 shares initially used for P_t and D_t series.

1. Titaghur Paper Mills
2. Polychem Ltd.
3. Surat Electricity
4. Sutlej Cotton Mills
5. Tata Hydro Electric Power Supply
6. Tata Power Co. Ltd.
7. Tata Iron and Steel Co. Ltd.
8. Kesoram Industries & Cotton Mills
9. Metur Chemicals & Industries Corporation
10. Supreme Industries Ltd.
11. Aluminium Corporation of India
12. Hindusthan Gas & Industries Ltd.
13. Indian Dyestuff Industries Ltd.
14. Amalgamated Electricity Co. Ltd.
15. Ahmedabad Electricity Co. Ltd.
16. Andhra Valley Power Supply Co.
17. Bombay Suburban Electricity
18. Bajaj Electronic Ltd.
19. Asian Electronic Ltd.
20. India Cement
21. Kemp & Co. Ltd.
22. Sayaji Mills Ltd.
23. United Breweries
24. Indian Rubber Regenerating
25. Ruby Mills
26. Western India Plywood Ltd.
27. Cellulose Product of India Ltd.
28. Indian Cable
29. Universal Cable
30. Sirdar Carbonic Gas Ltd.

4. Inequality (III) states that

$$\sigma(\Delta p) \leq \sigma d/\sqrt{2\bar{r}}$$

or, $\sigma(\Delta p) \times \sqrt{2\bar{r}} \leq \sigma d$

or, $119.97 \times \sqrt{2(0.0584)} \leq \sigma d$

or, $41 \leq \sigma d$.

5. Noisy price, in fact, ensued massive participation of 'naive-trend chasing' investors that further increased the magnitude of noise in price.

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DATA USED FOR FIGURE I, II, III.

t	p_t	p_t^*	p_t^*[terminal value of $p^* = E(p)$]	p_t^* [terminal value of $p^* = 600$]	p_t^* [terminal value of $p^* = 680$]	Δp_{t+1}	d_t
1968	634.1	697.1	697.1	686.5	708.2	-	54.6
1969	664.2	683.2	683.2	672.0	695.0	30.1	50.9
1970	792.5	672.3	672.3	660.4	684.7	128.3	58.5
1971	793.5	653.1	653.1	640.5	666.3	1.0	59.4
1972	765.1	631.9	631.9	618.0	645.8	-28.5	60.9
1973	689.4	607.9	607.9	593.8	622.7	-75.6	55.0
1974	634.6	588.5	588.5	573.5	604.0	-54.8	30.2
1975	477.3	592.7	592.7	576.8	609.2	-157.3	31.5
1976	562.7	595.8	595.8	579.1	613.3	85.4	39.1
1977	583.2	591.6	591.6	573.9	610.0	20.5	40.8
1978	565.3	585.4	585.4	566.6	604.9	-17.9	40.2
1979	665.8	579.5	579.5	559.5	600.0	100.5	43.9
1980	562.2	569.5	569.5	548.3	591.2	-3.6	36.2
1981	468.2	566.6	566.6	544.2	589.6	-94.0	32.1
1982	523.1	567.6	567.6	543.9	591.9	54.9	31.5
1983	473.7	569.3	569.3	544.2	595.0	-51.4	27.7
1984	468.6	574.9	574.9	548.3	602.1	-3.1	26.8
1985	500.0	581.7	581.7	553.6	610.5	31.4	28.4
1986	773.7	587.3	587.3	557.6	617.8	273.7	26.3
1987	700.3	595.3	595.3	563.9	627.6	-73.4	24.5
1988	560.6	605.6	605.6	572.4	639.8	-139.7	25.0
1989	594.7	616.1	616.1	580.8	652.2	34.1	24.3
1990	770.2	627.9	627.9	590.5	666.0	175.5	25.0
1991	1130.0	639.7	639.7	600.0	680.0	359.8	24.6

HISTORICAL BEHAVIOUR OF THE BUSINESS CYCLE IN INDIA: SOME STYLIZED FACTS FOR 1951-1985

Neeraj Hatekar

In this paper, we investigate some of the stylized facts about the business cycle in India over the period 1951-52 to 1985-86. The business cycle is identified with Hodrick-Prescott filtered data. In all, sixty-four different time series are detrended and their historical time paths and comovements with other time series are described. Some business cycle regularities in respect of these features are documented. It is suggested that such stylized facts should form the basis of dynamic general equilibrium modelling of the business cycle.

I
INTRODUCTION

The establishment of stylized facts about the historical behaviour of the economy over the business cycle is of immense practical importance. Among other things, it allows us to investigate contemporaneous as well as leading and lagging comovements among various important time series. It is also possible to form a judgment about the relative volatility of the different economic activities. Since the exercise is relatively theory free, it can also be used to test the various theories of the business cycle. In fact, in a sense, the notion of 'stylized facts' describes what phenomena are to be explained by a theoretical modelling of the business cycle. It is specially important for the Real Business Cycle theory approach to business cycles, since this theory is primarily based on theoretical dynamic general equilibrium models instead of structural econometric models. The foundations of this approach were laid by Lucas [1977] in his programmatic article 'Understanding Business Cycles'. Here, small analogue economy models are developed and simulated. The quality of these simulation models is judged by how well they replicate the stylized facts of an actual economy. Hence, to be able to establish the validity of such models, stylized facts need to be established.

This approach has been widely utilized to analyze business cycles in the U. S. A. [Backus and Kehoe, 1992], Austria and Germany [Brandner and Neusser, 1992, Danthine and Girardine, 1989, Blackburn and Ravn, 1990, Englund *et al*, 1990, etc.]. These authors primarily investigate correlations among various Hodrick-Prescott filtered series (the Hodrick-Prescott filter is described briefly in Appendix 2). These correlations then throw up a great deal of information about the actual behavior of various economic activities over the business cycle. The notion of stylized facts has its roots in the early work of Burns and Mitchell [1946] whose basic idea was to provide "model free" observations. However, the Burns and Mitchell approach was essentially "chartist". Modern exponents of the stylized facts approach place greater emphasis on comovements among suitably detrended time series. As is well known, this rather "theoryless" approach came under the forceful criticism of Koopmans [1947]. Koopmans argued that economic theory must enter a description of the business cycle in two essential ways. First, the theory would serve to differentiate between the important facts and the non-important ones. Secondly, he argues that purposeful descriptions of economic phenomena cannot be obtained without specifying structural econometric models based on supply and demand schedules. Kydland and Prescott [1990] accept the first criticism but reject the second one. We too, reject the second part of the criticism. We think that a purely statistical description of the business cycle, without too much a priori theory is still insightful. Actually, it allows us a sort of a skeleton around which a theory can be built up. Such a skeleton, provided it is sufficiently comprehensive, can be a useful guide for the development of dynamic general equilibrium models of the business cycle.

Keeping this in mind, we thought that it would be useful to carry out one such exercise for the Indian economy. Currently, the only comprehensive business cycle study in the Indian context is that by Chitre [1982]. Chitre's study is a growth cycle work, that extends only upto the mid-seventies. The growth cycle methodology is indeed distinctive enough to appropriate a new name. However, certain problems can be associated with such an analysis. It is commonly

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known that logarithmic first differencing, which is what the growth cycle approach normally implies, will stationarise only time series that have a single unit root. Some time series, that are I(2), will require second order differencing. Hatekar [1993] has shown that Indian GDP can be regarded as an I(2) series. This would mean that the cyclical components obtained by the growth cycle approach will not be stationary. Similarly, time series that are already stationary will be "over differenced" by the use of the growth cycle approach. Besides these statistical problems, the context of the growth cycle approach is different from the more orthodox analysis of the business cycle in terms of the levels of the relevant time series. They can even reach opposing conclusions. For instance, even if prices are in an expansionary phase in levels, the acceleration can be negative as long as prices are increasing at a decreasing rate. Hence, independently of the growth cycle approach, an analysis of the business cycle in levels is important. Therefore, there is a need for a comprehensive statistical treatment of the business cycle on the lines of Backus and Kehoe [1992], Danthine and Girardine [1989], Brandner and Neusser [1992], etc. Below, we have attempted a similar description.

In all, sixty-four different time series have been analysed, (details are given in Appendix 1) whose features have been described in brief. The business cycle is identified with data detrended using the Hodrick-Prescott filter with a weight of 400. (All the time series except the Net Factor Incomes From Abroad series was first logged. The Net Factor Incomes Series could not be logged because of negative entries). Correlations of detrended GDP with various other detrended series are described. In this paper, we have concentrated mainly on the current period correlations among the relevant series without trying to establish leading and lagging comovements. Clearly, it is essential to establish stylized lead and lag comovements. We are carrying out such a project at the Department of Economics, University of Bombay. Again, as far as this paper is concerned, international comparisons are limited to comparing our results with those of Backus and Kehoe [1992] for ten developed countries and the results of Brandner and Neusser [1992] for Austria and Germany. A larger project for establishing common business cycle facts for developing economies in general and for some south Asian economies in particular is being carried out at the Department of Economics, University of Bombay. It will also be interesting to isolate stylized facts that India shares with the developed countries. As the meager results in this paper indicate, it is by no means a futile exercise to look for similarities across various stages of development. We hope to be able to report these results in the near future.

II
THE METHODOLOGY OF IDENTIFICATION OF THE BUSINESS CYCLE

Economists commonly decompose univariate time series into a secular "long term" growth component and a "short run" cyclical component. Various different approaches have been adopted in the literature towards detrending univariate time series. Among these, linear detrending and taking first differences have been the most popular so far.

It is generally assumed that the long run component is relatively smooth, and does not vary much over the duration of the cycle. Hence, it has been the practice to regress a time series on time (or some polynomial in it) and treat the residuals from the fitted regression line as the short run cyclical component, to be explained by business cycle theory [i.e., Bodkin 1969, Lucas 1973, Barro 1978, Sargent 1978, Taylor 1979, Hall 1980, Kydland and Prescott 1980, Chitre and Paranjpe 1987, and Chitre 1991].

However, as Nelson and Plosser [1982] have pointed out in a seminal paper, secular trends need not be modelled as deterministic processes. As shown in Blanchard and Fischer [1989], a unit root in the innovations to output can induce a unit root non-stationarity in real time series like GDP.

For such time series, business cycle models based on time trend residuals are misspecified. Chan Hayya and Ord [1977] and Nelson and Kang [1981] have pointed out that the autocorrelation function of the residuals from a regression of a random walk on time is a statistical artifact in the sense that it depends entirely on the sample size and implies strong positive autocorrelations at low lags with pseudo periodic behaviour at long lags. Thus, the persistence of the business cycle

will get overestimated.

Nelson and Plosser [1982] have suggested that series with a unit root can be made stationary by taking first differences of the data. Indeed, this methodology has been commonly used in stationarising data. However, as a technique for business cycle analysis, it has the following limitation:

First differencing eliminates low frequency components of the data. It also passes the maximum number of high frequency components. Such high frequency components will not be of much use for business cycle analysis which is primarily interested in medium to high frequency components. For instance, first differencing, at one extreme, may pass only random noise. The business cycle analyst, on the other hand, might be looking for a cyclical movement that lasts much longer, for instance, one to five years. Random noise is hardly likely to serve his purpose. This criticism is also applicable to the growth cycle approach.

For those series that are not I(0), detrending by regressing on time will give a misleading picture of the business cycle. Use of the first difference operator on stationary series will, on the other hand, lead to non-invertibility in the moving average part [Nelson and Plosser, 1982]. Apart from that, since the order of integration is different for different series, all of them would have to be differenced a different number of times. This may distort the relationships between series [Wallis, 1974]. Consequently, all the series have been detrended using the Hodrick-Prescott filter.

One disadvantage of the Hodrick-Prescott filter is that it is optimal only for a restricted class of models [King and Rebelo, 1989]. An alternative would be to extract the business cycle component on the basis of an elaborate model fitted individually to each series. For example, Beveridge and Nelson [1981] have suggested a decomposition based on a fitted ARIMA model for each individual time series. However, such an approach is extremely time consuming. Besides, in the Indian context, it is also not feasible because of the short lengths of most of the time series involved. Again, the trend and the business cycle are viewed as being driven by a homogeneous disturbance. There have been some attempts to model the business cycle components based on multivariate methods [Blanchard and Quah, 1989, Shapiro and Watson, 1988]. However, the identification restrictions are still controversial. Hence, we have decided to use the Hodrick-Prescott (HP) filter in spite of all the above objections. The HP filter still remains the simplest, easiest to use and the least controversial among the existing business cycle extraction technologies.

Table 1 gives the basic characteristics of the detrended data using this method. There, the variance of each series and its variance relative to GDP is presented. The technique of Hodrick-Prescott filtering is discussed in appendix 2. Below, we discuss the main findings of the paper.

III
STYLIZED BUSINESS CYCLE FEATURES FOR INDIA

GDP: The first trough to trough movement appears from 1953 to 1958. However, the decline in 1958 is a temporary disturbance, lasting only for a year. The real decline starts in 1965 and the fall continues till 1967. 1967-68 is marked by a recovery, that continues till 1971, from where a fresh decline starts that continues till 1975. There is again an upswing till the peak is reached in 1977-78. Following this, there is again a sharp decline and a recovery begins in the following year, lasting well into 1985-86. GDP fluctuations are rather sharp, in contrast to fluctuations in individual sectors like mining that are much smoother and much more persistent. The global peak appears in 1964-65, while the global trough appears in 1967. Most of the real output sectors show positive partial correlations with GDP, indicating the existence of a business cycle.

Agriculture and Primary Sector

Perhaps the source of sharp fluctuations in GDP is to be found in fluctuations in this sector. Agriculture and primary sector have contributed a very large proportion of GDP. Consequently, these fluctuations might appear decisive from the point of GDP fluctuations. Indeed, the partial correlation coefficients of GDP fluctuations with primary sector and agricultural fluctuations are 0.87218 and 0.86238, respectively. The relative sharpness of these fluctuations emphasizes the

relative dependence on weather and a lack of heavy investment and substantial linkages with the other sectors of the economy, resulting in a lack of significant propagation mechanisms. Actually, there are very few fluctuations in this sector that last more than a year. There is one upswing lasting from 1952 to 1965, except for a sharp temporary decline in 1957 and another in 1966-67. Even this decline gets converted into a boom by 1969. A new decline sets in by 1970. After that, there are no long lived cycles. It is possible to overemphasize the importance of agricultural and primary sector shocks for the rest of the economy. As can be seen from table 2, contemporaneous partial correlations of agricultural fluctuations with fluctuations in other sectors are quite low. For instance, partial correlations of agricultural fluctuations with fluctuations in secondary sector and tertiary sector are only 0.011982 and 0.020393, respectively. (Of course, in the case of agriculture, leading and lagging comovements with other sectors also need to be established). However, correlation of agricultural fluctuations with fluctuation in real domestic consumption expenditure is 0.72604. Also, its correlation with gross domestic product deflator fluctuations is -0.40402. Real budget deficit fluctuations are also negatively correlated with these, the correlation being -0.26825. The correlation of agricultural fluctuations with the individual subsectors of the index of industrial production never exceeds 0.35, while several sectors show very little correlation. Fluctuations in nominal money also show little correlation with agricultural output fluctuations. Thus, agricultural fluctuations might be of little relevance in explaining output fluctuations in outputs of other sectors, in the absence of strong linkages. A boom in agriculture generates incomes in agriculture, which raises consumption and lowers the aggregate price level. However, at least as far as contemporaneous effects are concerned, agricultural fluctuations do not seem to be playing a major part.

Forestry and Fishing

Apart from agriculture, this is the other component of primary sector output. Forestry and fishing move quite differently till 1970, after which they begin to move in tandem, rising and falling together. Fluctuations in forestry are more pronounced than fluctuations in fishing. From an all time high in 1951, forestry shows a decline till 1954, at which point a recovery begins. The recovery lasts till 1967, at which point a peak is reached and a decline sets in. From a decline in 1968 and 1969, a recovery begins, which apart from temporary disturbances lasting not longer than a year, continues till 1977. From that point, a decline again sets in till 1984-85, at which point a recovery begins, going well into 1985-86. For fishing, a recovery starts from 1954 and continues upwards till 1957-58. From that point a recession sets in and reaches a trough in 1963. After that there is a series of mild booms and depressions at short intervals, till the next large boom begins in 1974. This reaches its peak in 1976, from which point, there is a general decline till 1984. At this point, a new recovery starts again. However, from the point of view of the aggregate business cycle, these fluctuations are rather peripheral. Fluctuations in forestry have a rather large positive correlation with fluctuation in electricity, but obviously not every correlation implies a meaningful relationship. Forestry fluctuations are also rather anticyclical because they are negatively correlated with GDP fluctuations. Correlation of forestry fluctuations with agriculture fluctuations is also negative, indicating probably that forestry tends to be taken up as a residual activity when crop conditions are bad.

Mining

These fluctuations are much smoother and longer lasting in comparison to the GDP fluctuations. From a peak in 1952, there is a general decline till a trough is reached in 1959. A recovery starts again, and reaches a peak in 1963-64. In the following two years, there is a temporary decline, and in the next year, the global peak is reached in 1967-68. From that point, there is a sharp decline going all the way to 1979, apart from a temporary improvement in fortunes in 1977. From 1979, a new boom starts, going all the way to 1984-85. Mining fluctuations are only mildly procyclical, as indicated by a low positive correlation with

GDP. The tertiary sector fluctuations show strong positive correlation with mining fluctuations. Also, all the transport sectors show positive correlations with mining fluctuations. Net domestic capital formation fluctuations are very weakly correlated with mining when aggregate net domestic capital formation is concerned. But that hides the true picture. Mining fluctuations are more strongly positively correlated with two components of net domestic capital formation, viz, machinery and construction, and negatively correlated with change in stocks. Fluctuations in manufacturing and electricity also show moderate positive correlations with mining fluctuations. Mining fluctuations also have high correlations with fluctuations in the production of basic metals.

Secondary Sector and Manufacturing

Since manufacturing accounts for a predominantly large part of the secondary sector output, both the time series move together for the large part of the secondary sector fluctuations. From a high in 1951, secondary sector falls till a trough is reached in 1954-55. At that point, a moderate recovery sets in, which continues till 1957, from where a recession starts, which is carried on upto 1959. A great recovery starts in 1959-60, probably as the impact of the second five year plan begins to be felt. Manufacturing begins to do moderately better than the overall secondary sector output. The boom in manufacturing continues till 1965 from where there is a sharp decline and a trough is reached in 1968-69. The secondary sector as a whole, however, touches its all time low only in 1975. There is a steady decline in secondary sector output from 1965 to 1975. At that point, recovery starts till 1978, converts into a recession for secondary sector as a whole as well as the manufacturing sector and reaches a trough in 1981. A new recovery starts at this point. For the manufacturing sector, the effect of the first oil shock in 1973 is hardly felt. There is a decline for both the series around the time of the second oil shock in 1979. This clearly points to the long term decline in the secondary sector output from 1965 to 1975. Also, the peak reached in 1964-65 was not to be surpassed ever again. 1964-65 also marks the culmination of the second five year plan. The decline from 1964-65 to 1975 looks all the more dramatic because it is a fall from such a great height. This has often hidden the fact that the peak reached in 1977-78 was higher than the peak reached in 1956. Also, the trough reached in 1981 is not as deep as the trough in 1954. The fall after 1964-65 looks extremely marked because the second plan was highly successful in raising secondary sector output over the cycle.

The secondary sector output fluctuations show little correlation with primary sector and agricultural fluctuations. It has mild procyclicity, as can be inferred from the mild positive correlation with GDP fluctuations. Secondary sector fluctuations are strongly correlated with tertiary sector fluctuations, in particular with fluctuations in outputs of the three transport sectors, i.e., transport, communication and trade, transport, storage and communication, and railways. Fluctuations in trade, hotels and restaurants, finance and real estate, real balances also show mild positive correlation. The machinery component of net domestic capital formation shows strong positive correlation with secondary sector fluctuations. There is a mild positive correlation also with construction. Consumption fluctuations show little correlation. All the price level measures show mild negative correlations. Real balances are mildly positively correlated. High powered money fluctuations are weakly positively correlated. Time deposits are mildly negatively correlated whereas currency with the public is positively correlated. Deposit money shows negligible correlation. Net domestic capital formation is positively correlated, whereas the average propensity to consume is negatively correlated. It is worthwhile to note that consumption shows little correlation with secondary sector fluctuations, whereas net domestic capital formation shows weak correlations with the agricultural sector fluctuations. Consumption over the cycle moves with agricultural output whereas investment moves with industrial output. Finance and real estates also move with secondary sector output. Consumption and finance, in turn, show a weak positive correlation. The ratio of registered to unregistered manufacturing output shows fluctuations that are strongly positively

correlated with secondary sector fluctuations. This implies that over the cycle, registered manufacturing expands relative to unregistered manufacturing. This is borne out by correlations of registered and unregistered manufacturing with other time series. For instance, correlation of registered manufacturing with construction is 0.45893, while that of unregistered manufacturing is only 0.15. Similarly, correlation of registered manufacturing with electricity is 0.47987 whereas that of unregistered manufacturing is only 0.10329. The correlation of registered manufacturing with the tertiary sector is 0.76069, whereas that of unregistered manufacturing is only 0.31597. Except transport by other means and storage, all transport sectors show greater correlation with registered manufacturing fluctuations. That is true also of communications, trade, hotels and restaurants, finance and real estate, communication and personal services, etc. The correlation of net foreign incomes with registered manufacturing sector is small and negative, whereas correlation with unregistered manufacturing is small and positive. Registered manufacturing shows negligible correlation with consumption, whereas unregistered manufacturing shows weak positive correlation. The correlation of net domestic capital formation with registered manufacturing is 0.43774 while that with unregistered manufacturing is 0.045130. High powered money shows weak positive correlation with registered manufacturing and negligible correlation with unregistered manufacturing. The construction component of net domestic capital formation shows moderate positive comovement with registered manufacturing and negligible comovement with unregistered manufacturing. Textiles, in particular cotton textiles, show a stronger positive comovement with unregistered manufacturing. This is also true of paper and paper products and metallic products, and manufacture of transport equipment. It would be fair to conclude that over the boom, unregistered sector would account for the greater part of the manufacturing of these products. It is also clear that the unregistered sector is handicapped over the business cycle in terms of resource availability in comparison to the registered manufacturing sector. Consequently, over the boom, manufacturing output gets shifted into the registered sector, whereas a reverse process might be operating in the recession.

Construction

Construction fluctuations are relatively smooth compared to the overall secondary sector fluctuations. A fall begins from a peak in 1951 and continues till 1954. There is then an upswing till 1957, and a recession starts from that point, there is a small recovery and another recession till 1963. A major recovery begins here, continuing till 1968. Then, there is a recession upto 1975, where a new recovery begins. This phase lasts till 1978, and then there is a mild recession, continuing to 1983, from where a new upswing starts. Construction is mildly procyclical, since its correlation with GDP fluctuation is 0.31461. It has a higher correlation with some components of the secondary sector and the tertiary sector. It is highly to mildly positively correlated with all the transport sectors, trade, hotels and restaurants, and consumption. Construction is a highly volatile activity, as evidenced by a high variability relative to GDP.

Electricity, Gas and Water Supply

From a high point in 1952, output falls till 1957, from which point, there is a marked recovery. This recovery lasts till 1968, from where a recession begins, going on till 1975. There is another recovery till 1979, except for a momentary setback in 1977. From 1979, a recession begins, till 1981. There is then a small and slow recovery, lasting into the end of the sample period, that is 1985. This sector is only mildly procyclical. Its correlation is much higher with the secondary sector and tertiary sector fluctuations. It is highly positively correlated with all the transport sectors, except transport by other means and storage. It is also strongly positively correlated with trade, hotels and restaurants, and finance and real estate. The machinery component of net domestic capital formation is positively and strongly correlated with this sector.

Tertiary Sector

From a high in 1951, there is a marked fall till 1954. A slow and faltering recovery begins, all the way upto 1965. The boom breaks in 1966, and a great recession sets in till the worst fortunes are encountered in 1975. From that point, a slow hesitant recovery sets in till 1985. The tertiary sector is mildly procyclical. Its correlation with agriculture and primary sector fluctuations is very low. It is highly positively correlated with the secondary sector in general and manufacturing in particular. It is negatively correlated with net factor incomes from abroad. It has weak negative correlation with the GDP deflator, wholesale prices and non-administered prices. Except for petroleum products, beverages and metallic products, it has a moderate to high positive correlation with the individual sectors of the index of industrial production. It has a moderate positive correlation with consumption. It has weak positive correlation with net domestic capital formation, machinery and construction being moderately positively correlated, whereas change in stocks is weakly negatively correlated. The correlation of the tertiary sector with fluctuations in real budget deficits is negligible. Real balances show weak to negligible correlations with tertiary sector fluctuations. Currency with the public shows a moderate positive correlation. Deposit money and time deposits are weakly negatively correlated.

Transport Sectors

This sector is a subsector of the tertiary sector and consists of transport, communication and trade (trans1), transport, storage and communication (trans2), railways, and transport by other means and storage (trans3). As far as railways are concerned, we find a decline from 1951 to 1955, from when onwards a recovery sets in till 1967. There is then a slow decline, reaching a trough at the railway strike of 1974-75. A fresh recovery starts till 1978, from where there is a decline till 1981. There is then a temporary improvement, and a decline sets in again in 1982, which continues till 1985, from where the series moves upwards. All the transport series show high positive correlation with the secondary sector. Their correlations with agricultural and primary sector fluctuations are not large. In the case of railways, they are negatively correlated. The correlation of trade, hotels and restaurants with trans1 is as high as 0.97. It is also high for rail and trans2. Trans3 only shows mild positive correlation with trade, hotels and restaurants. Trans1 and trans2 also show a high positive correlation with community and personal services, and with public administration and defence. Net domestic capital formation shows moderate positive correlation with trans1. Construction activity shows a strong positive correlation with railways. Change in stocks is also moderately to weakly negatively correlated with railways. The general index of industrial production shows high to moderate positive correlation with all the transport sectors. Mining shows high positive correlations with trans1, trans2 and trans3, and a moderate correlation with railways. Beverages show strong positive correlation with only railways. On the contrary, textiles show moderate correlations with trans1, trans2, trans3 and negligible correlation with railways. For fluctuations in most of the sectors of the index of industrial production, transport sectors show positive mild to strong correlations.

Communications

This is also a subsector of the tertiary sector. This sector starts from a high in 1951, and falls till 1954. There is a sharp rise till 1957, from where there is a decline till 1961. A major recovery starts from 1961, and continues very rapidly upto 1965-66. After that, there is a great fall to 1975. From there, a hesitant and slow upward movement starts till 1985, from which point another recession might have begun. This sector is correlated highly with trans1 and public administration and defence. Apart from that, no clear pattern emerges regarding this sector's correlations with other sectors. This sector is also almost acyclical, as is proved by the rather small correlation with GDP.

Trade, Hotels and Restaurants

This sector, unlike communications, is strongly procyclical. It also has a weak and positive correlation with agriculture and primary sector fluctuations. It has a high positive correlation with the secondary sector, manufacturing and in particular registered manufacturing. It has moderate positive correlation with consumption and a mild negative correlation with all the price level measures. Its correlation with net domestic capital formation is 0.39376. It has a mild negative correlation with time deposits, but negligible correlation with high powered money, demand deposits and a weak positive correlation with currency with the public. Real balances are weakly positively correlated. Fluctuations in the general index of industrial production are strongly positively correlated with fluctuations in trade, hotels and restaurants.

Finance and Real Estate

From a high of 1951, there is a slow decline, interrupted by occasional small recoveries, right upto 1961. From that point, there is an upswing, going up all the way to 1963-64, from where a fresh decline sets in. The decline continues to 1968, which is a relatively mild recession. Business fortunes recover from here upto 1972. Then comes a great decline, where business reaches its all time low in 1975. There is again a recovery till 1979, and a new fall starts that lasts till 1982. Finance and real estate then onwards enjoy a recovery to the end of the sample period. This sector is moderately procyclical. It is more highly correlated with mining, secondary sector, and registered manufacturing. Its correlation with banking and insurance is as high as 0.79037. It is also moderately correlated with public administration and moderately negatively correlated with net factor incomes from abroad. It has a negative correlation with the price magnitudes and negligible correlation with average propensity to consume. It shows positive correlation with the currency with the public, moderate negative correlation with time deposits, and a high negative correlation with demand deposits with the public (demand deposits). It has got a high and positive correlation with real balances. The general index of industrial production shows weak to moderate positive correlation with finance.

Banking and Insurance

Upto 1957, banking and insurance shows rather erratic fluctuations. After 1957, a sustained recovery begins, that lasts till 1964. There, a downward movement begins, continuing till 1968. Then there is an upward phase till 1972, where a new recession begins. This recession continues till 1975, from when onwards there is an upward movement till 1979, where an all time high peak is reached. There is now a drop till 1982, from when a recovery begins afresh till 1985. This sector is a mildly procyclical one. It also has a moderate positive correlation with agriculture and primary sector fluctuations. It shows a moderate negative correlation with real estate, ownership of dwellings and business services. It shows a mild positive correlation with public administration and defence. It has a strong negative correlation with the gross domestic product deflator, though its correlation with wholesale prices is higher in absolute terms. It has a negligible correlation with net domestic capital formation. It is moderately positively correlated with the general index of industrial production. Overall, this sector does not seem to be playing a big part in the aggregate business cycle.

Real Estate, Ownership of Dwellings and Business Services

This sector shows an unmitigated sustained fall from 1951 to 1961. Thereafter, there is a rise till 1967, from which point a slow but steady decline sets in upto 1981. This trough is very mild and a slow recovery takes the sector to the end of 1985. This sector is weakly anticyclical. In particular, it shows mild negative correlation with agricultural and primary sector fluctuations. It has a mild negative correlation with banking and insurance. It shows a mild positive correlation with other services. It shows a strong positive correlation with the general price level measures, viz., gross domestic product deflator, wholesale prices and non-administered prices. It shows strong negative

correlation with time deposits, mild positive correlation with demand deposits and negligible correlation with currency with the public. It has a moderate to high negative correlation with real balances. Its correlation with the general index of industrial production is negligible.

Community and Personal Services

From 1951, there is a steady decline till 1956, from where again the sector picks up, and reaches a peak in 1965. From that point, there is a gradual decline to 1978, when a recovery sets in till the end of the sample period. This sector is only very mildly procyclical. It shows a very high positive correlation with public administration and defence, and other services. It is weakly positively correlated with consumption. It shows negligible correlation with aggregate price level magnitudes, but a weak positive correlation with the average propensity to consume. It shows negligible correlation with net domestic capital formation, and time deposits. Its correlation with currency with the public is however, high and positive. The correlation of this sector with real balances is negligible. It shows a mild positive correlation with the construction part of net domestic capital formation. It is mildly positively correlated with the general index of industrial production, mining and electricity subsectors of the general index of industrial production.

Public Administration and Defence

From a high of 1951, there is a sharp fall to 1956. At this point, a slow recovery begins, that gathers great momentum in 1962 and there is a very sharp upswing till 1965, from which point there is a slow decline upto 1977. From then onwards, there is again a sharp upswing till 1985. This sector is weakly procyclical. It shows weak negative correlation with agricultural and primary sector fluctuations and a mild positive correlation with mining, and secondary sector fluctuations, as well as fluctuations in other services. It shows a strong negative correlation with net factor incomes from abroad. It has a mild positive correlation with consumption and a weak positive correlation with all the measures of aggregate price level. Its correlation with net domestic capital formation is negligible. It is positively and mildly correlated with currency with the public, and mildly negatively correlated with other nominal money magnitudes. It has a weak positive correlation with construction component of net domestic capital formation. It has a mild positive correlation with the general index of industrial production.

Other Services

The sample period begins in the midst of a recovery by this sector. There is a smooth continuous upswing till 1961, from which point a downturn starts all the way to 1979. A sharp recovery begins there, with a quantum jump in 1979. From then onwards, recovery is steadily upwards till the end of the sample period in 1985. This sector is acyclical in the sense that its correlation with GDP fluctuations is negligible. However, it again shows a mild positive correlation with mining and weak positive correlation with secondary sector fluctuations. It shows strong to mild correlations with the transport sectors. It has a mild negative correlation with net factor incomes from abroad. It has negligible correlation with consumption, and with all the general price level measures. Currency with the public is mildly positively correlated with fluctuations in this sector, whereas time deposits exhibit only a weak positive correlation. Deposit money is highly negatively correlated with this sector. Correlation with net domestic capital formation is negligible. It has a mild positive correlation with the general index of industrial production.

Net Factor Incomes from Abroad

From 1951 onwards, there is a gradual upswing till 1956. From then onwards, there is a steady decline till 1973. This is followed by a marked upswing till an all time high is reached in 1981. Then, there is a great fall till an all time low is reached in 1985. This sector is mildly anticyclical, which means that domestic booms are accompanied by falls in the net factor income from

abroad. Backus and Kehoe [1992] found in their study of ten developed countries that net exports were generally counter cyclical. Our study has also made a closely related finding. Ilse Mintz [1959] found countercyclical trade balance for prewar United States. Backus, *et al.*, [1992] note the countercyclicity of the trade balance for the twelve countries that they have studied. In India, fluctuations in net factor incomes from abroad show strong to mild negative correlations with mining, secondary sector output, manufacturing, registered manufacturing, and a weak positive correlation with unregistered manufacturing fluctuations. It has a moderate negative correlation with consumption. It has negligible correlations with the gross domestic product deflator, a weak positive correlation with net domestic capital formation, and a negligible correlation with high powered money. Its correlation with wholesale price level is weakly positive. Similar is the case with the correlation with time deposits and currency with the public and demand deposits (demand deposits). Consequently, M_3 fluctuations become mildly positively correlated with the fluctuations in net factor incomes from abroad. Real balances (rb2) show a weak positive correlation with fluctuations in this sector. An interesting feature is the moderate negative correlation of the ratio of registered to unregistered manufacturing output with this sector. The change in stocks component of net domestic capital formation is also moderately positively correlated with these fluctuations. The general index of industrial production is weakly negatively correlated.

Real Domestic Private Final Consumption Expenditure

The sample period starts from an upswing in 1951. There is an upward movement till 1954. Then, a downturn starts till 1958. From then onwards, there is a series of irregular movements till 1966. At this point, there is a marked upward movement till 1971. Interestingly, this period corresponds to the great decline in a number of industrial sectors as we have seen above. From then onwards, there is a decline till 1977, after which there is again a series of more or less irregular movements. The irregular movements are so marked that it would perhaps not be appropriate to speak of any "business cycle" showing any systematic pattern in consumption. That is clearly because consumption is highly correlated with agricultural and primary sector fluctuations, which are highly weather dominated and are more in the nature of random fluctuations than systematic business cycles. Consumption shows a high positive correlation with primary sector and agricultural fluctuations and a weak to moderate positive correlation with secondary sector and tertiary sector fluctuations. Consumption is procyclical. This was also the finding of the Backus and Kehoe [1992] study for developed countries. In their study, the cross correlations between fluctuations in consumption and output ranged between 0.41 for prewar United Kingdom to 0.91 for prewar United States. Our figure falls well within this range, as can be seen from table 2. Not only that, Backus and Kehoe found that the ratio of the standard deviation of consumption to the standard deviation of output (HP filtered) was close to one. As can be seen from table 1, our study vindicates this finding for India. Hence, this seems to be a genuine business cycle regularity that holds internationally. On the other hand, average propensity to consume (apc) is mildly anticyclical. That can be taken to imply that the distribution of incomes becomes adverse over the boom. If income gets shifted over the boom into the hands of richer classes and is concentrated into poorer households during the recession, one can expect the average propensity to consume to fall. This is borne out by the fact that the average propensity to consume shows a mild positive comovement with the measures of the absolute price level. Over the boom, secondary and tertiary sectors expand, and the absolute price level falls. Real incomes of the fixed income classes go up. The fixed income classes are the generally better off middle classes, which reduces the apc. Over the recession, incomes tend to be withdrawn from these people, This leads to a rise in the apc. The fact that

consumption increases less than proportionately can also be adduced as evidence in favour of the permanent income hypothesis, where consumption over the cycle increases less than proportionately with rise in income. However, since GDP is an I(2) process, there is some doubt regarding the exact process followed by real personal disposable income, which should also be an I(2) process theoretically. However, consumption was found to be a process that is I(0) with a trend. Clearly, any attempt to explain movement of the average propensity to consume over the cycle in terms of the permanent income hypothesis would create the problem of explaining the excess smoothness of consumption over the trend. It seems more appropriate to consider distributional changes. It is also interesting to note that consumption shows a very strong positive correlation with agricultural and primary sector fluctuations, and negligible correlation with registered manufacturing, as also weak correlations with secondary and manufacturing sectors, but a mild positive correlation with tertiary sector fluctuations. Time deposits and deposit money (demand deposits) are mildly negatively correlated with consumption, whereas currency with the public shows mild positive correlation. Real balances show a weak positive correlation, The general index of industrial production shows a mild positive correlation with consumption fluctuations.

Measures of the Absolute Price Level

The measures of wholesale price level, viz., Gross Domestic Product Deflator, (GDPD), Index of Wholesale Prices (WPI) and Non-administered Prices (Nonad) are largely countercyclical. This was also found by Backus and Kehoe [1992] for the ten developed countries that they studied. In eight of these ten countries, post war prices were inversely correlated with output, and two countries (Canada and Germany) showed correlations that were close to zero. Brandner and Neusser [1992] also report the same finding for their study of Austria and Germany. Parallel findings have been reported using similar methods by Cooley and Hansen [1989], Kydland and Prescott [1990], and Wolf [1991] for the U.S. and by Corriea *et al.*, [1991] for Portugal. Hence, at least for the post-war world, countercyclicity of the price level measures seems to be a fairly well documented international feature. On the assumption that the covariance of the demand and supply shocks is zero, this perhaps suggests that the business cycle can be described by an aggregate supply schedule moving along a relatively stable demand schedule.

Our findings imply that in India, over the boom, there is a fall in prices, and a rise over the recession. In general, these measures show negative correlations with agricultural as well as industrial activity, though the comparative magnitudes are different. All the nominal money magnitudes are either weakly negatively correlated with prices or show negligible correlation. Thus, the picture is that of a price level driven over the cycle by real rather than by monetary factors, or by supply side rather than by demand side factors. At this stage, the evidence regarding prices is not particularly prejudicial to real business theory. However, price fluctuations are not neutral. As seen above, they could be redistributing incomes, leading to changes in the structure of production over the business cycle. Had price changes been neutral, average propensity to consume should have been acyclical. Since the price level is anticyclical, if money wages are reasonably rigid, real wages would also increase over the cycle in those sectors where labour unions are sufficiently strong.

Nominal Money Magnitudes

The nominal money magnitudes that have been considered here are 1) Currency with the public (Curr), 2) Time Deposits (TD), and 3) Demand deposits (referred to as demand deposits with public). 4) High powered money (HPM). 5) M_3. TD and HPM are mildly anticyclical. Curr and demand deposits have a negligible correlation with GDP fluctuations. As a result, M_3 is only weakly anticyclical. This agrees with the Backus

and Kehoe [1992] finding for post-war Canada, Italy and Sweden. Curr is weakly negatively correlated with agricultural and primary sector fluctuations. Time deposits show no correlations, whereas demand deposits show weak positive correlations. High powered money shows moderate negative correlation with agricultural and primary sector fluctuations. M_3 shows moderate negative correlations with almost all the production sectors in the economy. It shows a moderate positive correlation with the average propensity to consume. Curr shows moderate positive correlation with secondary sector and manufacturing output. Time deposits show negative correlations with the same sectors, whereas HPM shows weak positive correlations. It is interesting to note that real balances (rb1 which is M_3 divided by WPI and rb2 which is M_3/GDPD) show weak to mild procyclicity. Brandner and Neusser [1992] have found that real money balances are strongly procyclical for Germany, but anticyclical for Austria. There does not seem to be great international consensus on the movements of the money stock. In India, real balances are mildly positively correlated with GDP, agriculture, primary sector, secondary and manufacturing sectors. The general index of industrial production is also weakly positively correlated with rb1 and rb2. This is natural, because real balances are a normal good, and hence the demand for real balances increases with income. This is also consistent with an anticyclical price level. Nominal time deposits were negatively correlated with one period and more leading values of the fluctuation in secondary sector output, whereas the correlation of time deposits with leading GDP values were negligible at leads 1 to 4. Demand deposits were found to have negligible correlations as well. The correlations were as follows: correlation of HPM with one lagged value of GDP was 0.009, that for time deposits was 0.10, for demand deposits it was -0.21, for Curr too, it was -0.202. For M_3 as a whole, correlation with one lagged value of GDP fluctuation was -0.13. Real balances too showed negligible correlations, rb1 being -0.03, while rb2 being 0.089. More or less a similar pattern was found for one lagged value of secondary sector output. The correlation of HPM was 0.14, that for time deposits was -0.39, for demand deposits it was 0.21, (positive but rather small), for currency with the public it was 0.033. For M_3, the correlation was -0.19.

IV
CONCLUSION

These are the broad features of business fluctuations in India between 1951 and 1985. The price level is broadly anticyclical. Nominal monetary magnitudes are anticyclical, but real balances are procyclical. Consumption is procyclical and almost as variable as GDP fluctuations. These findings are also supported by international studies as has been pointed out in the text. Apart from these, many other results that serve to throw some light on the cyclical behaviour of the Indian economy over a wide spectrum of activities have been reported. Unfortunately, the number of turning points in the GDP cycle are too few to enable us to isolate leading and lagging indicators. Such an exercise would naturally have been valuable. However, in the absence of time series of sufficient length, that project does not look feasible as things stand. In spite of this, the stylized facts reported in this paper should serve as guidelines for forming dynamic economy wide general equilibrium models, which when simulated, will have to replicate these stylized facts. In the future, we hope to add more time series to the existing 64 that we have employed. Also, an establishment of leading and lagging comovements and an identification of those comovements which Indian data share with developing and/or developed countries will also be valuable. Our ultimate aim is to replace the current structural modelling of the business cycle that is prevalent in India by small analogue economy dynamic general equilibrium models that will be able to reproduce the above mentioned stylized facts when simulated.

TABLE 1. BASIC STATISTICAL PROPERTIES OF THE DETRENDED TIME SERIES (1952-1986)

Variable Name	N	MEAN	Standard Deviation	Variance	Variance, Relative to GDP
GDP	35	-0.15580E-03	0.25949E-01	0.67334E-03	1.00000
PRISEC	35	0.81960E-03	0.46474E-01	0.21598E-02	3.20759
AGRI	35	0.93503E-03	0.50006E-01	0.25006E-02	3.71373
FOREST	35	-0.40084E-02	0.61026E-01	0.37242E-02	5.53094
FISHING	35	0.77826E-03	0.36714E-01	0.13479E-02	2.00181
MINING	35	0.41340E-03	0.49868E-01	0.24868E-02	3.70000
SECOND	35	-0.22041E-02	0.37184E-01	0.13827E-02	2.05349
MFG	35	-0.91680E-03	0.36812E-01	0.13551E-02	2.01250
REGIS	35	-0.18267E-02	0.51177E-01	0.26190E-02	3.88957
UREGIS	35	0.32020E-03	0.25602E-01	0.65548E-03	0.97347
CONSTR	35	-0.55421E-02	0.66569E-01	0.44314E-02	6.58123
ELEC	35	-0.13391E-02	0.41181E-01	0.16958E-02	2.51849
TERT	35	-0.79603E-03	0.20382E-01	0.41542E-03	0.61695
TRANS1	35	-0.90303E-03	0.25725E-01	0.66176E-03	0.91721
TRANS2	35	-0.13208E-02	0.24160E-01	0.58368E-03	0.86684
RAIL	35	-0.19536E-02	0.41378E-01	0.17121E-02	2.54270
TRANS3	35	-0.99317E-03	0.30681E-01	0.94133E-03	1.39800
COMM1	35	-0.41500E-03	0.25155E-01	0.63279E-03	0.93977
TRADE	35	-0.71834E-03	0.28836E-01	0.83151E-03	1.23490
FINANCE	35	-0.60317E-03	0.19370E-01	0.37518E-03	0.55719
BANK	35	0.17240E-03	0.58588E-01	0.34325E-02	5.09698
REAL	35	-0.66494E-03	0.13164E-01	0.17330E-03	0.25737
COMM2	35	-0.68886E-03	0.29427E-01	0.86594E-03	1.28603
PUBAD	35	-0.24428E-02	0.40427E-01	0.16343E-02	2.42715
OTHER	35	0.35234E-03	0.22653E-01	0.51315E-03	0.76209
INCOME	35	1.6192	91.127	8304.1	
GNP	35	-0.86171E-04	0.25559E-01	0.65327E-03	0.97019
CONSUM	35	0.46063E-03	0.25817E-01	0.66653E-03	0.98989
GDPD	35	-0.32827E-02	0.57507E-01	0.33071E-02	4.91149
APC	35	0.56786E-03	0.13438E-01	0.18057E-03	0.26817
NDCF	35	-0.36399E-02	0.16408	0.26922E-01	39.98280
HPM	35	-0.50142E-02	0.73054E-01	0.53369E-02	7.92601
WPI	35	-0.34718E-02	0.65701E-01	0.43166E-02	6.41073
TD	35	0.16861E-02	0.10703	0.11456E-01	17.01371
CURR	35	-0.10535E-02	0.33505E-01	0.11226E-02	1.66721
DEPMON	35	-0.19818E-02	0.11297	0.12761E-01	18.95182
M_3	35	-0.34734E-03	0.38679E-01	0.14960E-02	2.22176
RB1	35	-0.16635E-02	0.76029E-01	0.57804E-02	8.59000
RATIO	35	-0.21447E-02	0.45035E-01	0.20282E-02	3.01215
RB2	35	0.17429E-05	0.70194E-01	0.49272E-02	7.31756
BUDGET	35	3.2642	264.18	69789.	
NONADP	35	0.26000E-05	0.72886E-01	0.53123E-02	7.88948
MACHINE	35	-0.54358E-02	0.71490E-01	0.51109E-02	7.88948
CONSTRC	35	-0.33221E-02	0.13316	0.17731E-01	26.33290
CHANGE	35	-5.5258	350.47	0.12283E-06	0.00018
			Manufacturing Sector		
GEN	35	-0.64040E-03	0.35241E-01	0.12419E-02	1.84438
MINE	35	-0.80680E-03	0.48022E-01	0.23061E-02	3.42486
ELEC	35	-0.24747E-02	0.39544E-01	0.15638E-02	2.32245
MFG	35	-0.42149E-03	0.40232E-01	0.16186E-02	2.40383
FOOD	35	-0.79957E-03	0.59154E-01	0.34992E-02	5.19678
BE-V	35	-0.44334E-02	0.12813	0.16417E-01	24.37104
TEXT	35	0.16244E-02	0.33750E-01	0.11390E-02	1.69156
COTT	35	0.20345E-02	0.32641E-01	0.10655E-02	1.58241
JUTE	35	0.16431E-02	0.88552E-01	0.78415E-02	11.64567
FOOT	35	-0.62496E-02	0.14301	0.20451E-01	30.37247
PAP	35	-0.11897E-02	0.59215E-01	0.35064E-02	5.20747
RUBB	35	-0.46220E-02	0.48731E-01	0.23747E-02	3.52674
CHEM	35	-0.14967E-02	0.46001E-01	0.21161E-02	3.14269
PETRO	35	0.50947E-02	0.21770	0.47394E-01	70.38643
NONMET	35	-0.64231E-03	0.58517E-01	0.34242E-02	5.08539
BASMET	35	-0.47209E-02	0.10946	0.11981E-01	17.79338
METPRO	35	0.58954E-03	0.10666	0.11376E-01	16.89488
NONELEC	35	-0.77277E-02	0.11668	0.13614E-01	20.21861
TRANS	35	0.14883E-01	0.19250	0.37057E-01	55.03460

TABLE 2. PARTIAL CORRELATIONS OF DETRENDED TIME SERIES (1952-1986) CORRELATION MATRIX

GDP	1.00000				
PRISEC	0.87218	1.00000			
AGRI	0.86238	0.99906	1.00000		
FOREST	-0.29573	-0.35511	-0.37921	1.00000	
FISHING	0.15098	0.22831	0.21000	0.21567	1.00000
MINING	0.14446	-0.18073	-0.20969	0.14771	-0.14921
	1.0000				
SECOND	0.46070	0.26978E-01	0.11982E-01	0.18372	-0.46581E-01,
	0.44576	1.0000			
MFG	0.44040	0.33890E-01	0.26186E-01	0.23283E-01	-0.10549
	0.39383	0.90329	1.0000		
REGIS	0.36681	-0.48739E-01	-0.59099E-01	0.11777	-0.85134E-01
	0.44889	0.90523	0.97009	1.00000	
UREGIS	0.44195	0.25090	0.25594	-0.22371	-0.79598E-01
	0.13113E-01	0.53543	0.66863	0.47561	1.0000
CONSTR	0.31461	0.18407E-01	0.55660E-04	0.33448	0.46995E-01
	0.31208	0.76219	0.41352	0.45893	0.15000
	1.0000				
ELEC	0.26279	-0.47727E-01	-0.71188E-01	0.45376	-0.46034E-01
	0.52915	0.60132	0.44155	0.47987	0.10329
	0.55727	1.00000			
TERT	0.49091	0.42020E-01	0.20393E-01	0.33613E-01	-0.81686E-01
	0.72823	0.76463	0.73357	0.76069	0.31597
	0.48720	0.62908	1.0000		
TRANS1	0.52549	0.11995	0.10014	0.14658	-0.10421
	0.63547	0.85963	0.78149	0.78437	0.47276
	0.63790	0.61971	0.88864	1.0000	
TRANS2	0.31150	-0.60785E-01	-0.79845E-01	0.94471E-01	-0.87061E-01
	0.68690	0.65736	0.60745	0.60087	0.40879
	0.45892	0.55168	0.81506	0.83860	1.00000
RAIL	0.10657	-0.18387	-0.19715	0.28003	-0.79177E-01
	0.44404	0.62586	0.46571	0.51130	0.21642
	0.62696	0.56575	0.56800	0.67747	0.65966
	1.00000				
TRANS3	0.36025	0.14592	0.13370	-0.81809E-01	-0.12084
	0.47306	0.32679	0.37614	0.30390	0.42032
	0.10552	0.27059	0.52200	0.52778	0.76506
	0.64850E-01	1.0000			
COMM1	0.90850E-01	-0.28630	-0.30097	0.56542E-01	-0.13276
	0.56489	0.59574	0.53548	0.56625	0.19625
	0.43890	0.41899	0.70535	0.61063	0.58270
	0.35617	0.31804	1.0000		
TRADE	0.57367	0.19840	0.18061	0.15031	-0.11028
	0.54415	0.86028	0.77592	0.77894	0.46563
	0.65405	0.59146	0.82771	0.97313	0.69267
	0.62200	0.38455	0.55132	1.00000	
FINANCE	0.36857	0.67855E-01	0.58687E-01	0.30173E-01	-0.16846
	0.30428	0.52974	0.50909	0.50153	0.22346
	0.33369	0.55160	0.56615	0.40828	0.23809
	0.26719	0.82893E-01	0.28418	0.43881	1.00000
BANK	0.39736	0.21903	0.22204	-0.14053	-0.10103
	0.27296E-01	0.41438	0.48483	0.46405	0.31567
	0.15682	0.27997	0.38327	0.28855	0.21588
	0.31704	0.55424E-01	0.12498E-01	0.29625	0.79037
	1.0000				
REAL	-0.13008	-0.27217	-0.28664	0.28024	-0.19432
	0.34666	0.11896	-0.26045E-01	0.10975E-04	-0.18822
	0.24774	0.41848	0.18104	0.11641	-0.39700E-01
	-0.10448	-0.14905E-01	0.42063	0.16373	0.28932
	-0.32653	1.00000			

(Contd.)

TABLE 2. (CONTD.)

COMM2	0.17798	-0.13193	-0.14774	-0.14089	0.20228E-01
	0.59753	0.28087	0.33193	0.39841	-0.66015E-01
	0.53178E-01	0.28623	0.74748	0.40654	0.54460
	0.21522	0.37936	0.61203	0.29276	0.26124
	0.12402	0.98238E-01	1.00000		
PUBAD	0.18416	-0.14908	-0.16726	0.75180E-01	-0.10365
	0.61957	0.38514	0.41108	0.48953	-0.81671E-01
	0.14524	0.54206	0.76304	0.47770	0.47551
	0.21699	0.30373	0.68437	0.41769	0.38058
	0.66991E-01	0.42264	0.87722	1.0000	
OTHER	0.52289E-01	-0.18524	-0.19529	-0.23628	0.91350E-01
	0.48152	0.18742	0.24458	0.27840	0.51288E-01
	0.10241E-01	0.34303E-01	0.57116	0.31965	0.59793
	0.28804	0.42229	0.46083	0.16027	-0.84496E-02
	0.95009E-01	-0.27638	0.84992	0.53299	1.0000
INCOME	-0.28290	-0.73557E-01	-0.48456E-01	-0.77241E-01	-0.17895
	-0.55203	-0.25115	-0.19444	-0.28360	0.27061
	-0.18363	-0.44726	-0.50177	-0.21002	-0.20229
	-0.62438E-03	-0.16177	-0.28913	-0.18234	-0.49012
	-0.22116	-0.30221	-0.60928	-0.63624	-0.33482
	1.0000				
GNP	0.99710	0.88698	0.87899	-0.31041	0.15032
	0.97071E-01	0.44260	0.42790	0.34583	0.46800
	0.29944	0.22435	0.45386	0.51042	0.29291
	0.99502E-01	0.34956	0.63067E-01	0.56243	0.33624
	0.38758	-0.15868	0.13004	0.13170	0.23727E-01
	-0.21126	1.0000			
CONSUM	0.80641	0.73443	0.72604	-0.36283	-0.64974E-01
	0.16047	0.22963	0.11971	0.63796E-01	0.16736
	0.30796	0.18477	0.37491	0.34041	0.14083
	-0.37381E-01	0.23862	0.12711	0.39972	0.27665
	0.16735	0.10452	0.22236	0.24253	0.51604E-01
	-0.32601	0.79288	1.0000		
GDPD	-0.46137	-0.39521	-0.40402	0.27655	0.77034E-01
	0.19768	-0.32755	-0.36901	-0.31300	-0.39824
	-0.17077	0.15214E-01	-0.15421	-0.17880	-0.62098E-01
	-0.18845	-0.39073E-02	0.16530	-0.21670	-0.38871
	-0.73674	0.50382	0.60190E-01	0.19119	-0.56023E-01
	-0.55765E-01	-0.47406	-0.26962	1.0000	
APC	-0.24701	-0.25303	-0.25581	-0.41007E-01	-0.52213
	0.23474	-0.21901	-0.31206	-0.26500	-0.38944
	0.71808E-03	0.93071E-02	0.33772E-01	-0.88115E-01	-0.68402E-01
	-0.90263E-01	-0.26891E-01	0.14084	-0.87854E-01	-0.23423E-01
	-0.21468	0.32437	0.22153	0.25808	0.12505
	-0.18678	-0.27428	0.30312	0.15989	1.0000
NDCF	-0.16665E-01	-0.12860	-0.13009	0.32433	0.16110
	-0.71081E-01	0.42241	0.34917	0.43774	0.45130E-01
	0.40524	-0.58235E-01	0.16853	0.32841	0.82743E-01
	0.34996-	-0.26523	0.20066	0.39376	-0.65076E-01
	0.13067E-01	-0.15642	-0.29895E-01	-0.23190E-01	0.73201E-03
	0.18090	-0.23402E-02	-0.15412	-0.22242E-01	-0.23995
	1.00000				
HPM	-0.25360	-0.36795	-0.36059	0.55886E-01	-0.27931
	0.91711E-01	0.16419	0.16072	0.21246	-0.29772E-01
	0.11140	-0.43724E-01	0.13919	0.11138	0.11289
	0.90580E-01	0.20434E-01	0.11301	0.92537E-01	0.99152E-01
	0.10161	-0.31680E-01	0.13745	0.50096E-01	0.18339
	0.81387E-01	-0.25672	-0.21669	-0.66382E-01	0.62349E-01
	0.34788	1.0000			

(Contd.)

TABLE 2. (CONTD.)

WPI	-0.38500	-0.25418	-0.26109	0.26097	0.41266E-01
	0.15989	-0.38186	-0.40823	-0.37246	-0.31758
	-0.21314	-0.85198E-01	-0.20658	-0.13855	-0.27556E-01
	-0.14788	0.54475E-01	0.18017E-01	-0.17439	-0.60176
	-0.83218	0.31363	-0.23789E-01	0.74790E-01	-0.44513E-01
	0.15039	-0.38235	-0.22261	0.90376	0.16063
	0.80501E-02	-0.70995E-01	1.0000		
TD	-0.19329	-0.15124E-01	0.80096E-02	-0.25455	-0.97629E-01
	-0.43840	-0.39255	-0.29416	-0.29908	-0.83095E-01
	-0.36366	-0.29629	-0.26386	-0.28077	-0.75595E-01
	0.93539E-01	-0.13669	-0.38996	-0.33005	-0.22591
	0.19047	-0.64809	-0.80472E-01	-0.28698	0.16570
	0.43383	-0.16420	-0.17362	-0.14678	-0.44442E-02
	-0.16317E-01	0.63178E-01	-0.15396E-01	1.00000	
CURR	-0.34670E-01	-0.24006	-0.23424	-0.12413	-0.11388
	0.13767	0.24273	0.30124	0.37427	-0.54231E-01
	0.63353E-01	-0.24062E-01	0.39520	0.19785	0.23487
	-0.27014E-01	0.19124	0.41410	0.14945	0.27008
	0.22455	-0.22155E-01	0.52464	0.43730	0.42205
	-0.21866	-0.53201E-01	-0.47051E-02	0.23699E-01	0.55048E-01
	0.39214	0.53145	-0.96983E-01	0.94677E-01	1.0000
DEPMON	0.65928E-01	0.14191	0.13196	0.38390	0.29430
	-0.15110	0.35517E-01	-0.12736E-01	-0.31016E-01	0.28437E-01
	0.10027	0.69243E-01	-0.20243	-0.72879E-01	-0.33524
	-0.13730	-0.30219	-0.19397	0.45236E-01	0.27671
	0.62431E-01	0.29638	-0.49221	-0.27350	-0.67469
	-0.40263E-01	0.72561E-01	-0.49988E-01	0.17289	-0.28404
	0.20355	-0.21006	0.69141E-01	-0.32942	-0.16129
	1.00000				
M_3	-0.15482	-0.75888E-01	-0.55818E-01	-0.11918	-0.89615E-01
	-0.40577	-0.17738	-0.10619	-0.10323	-0.17210E-01
	-0.17968	-0.29095	-0.13945	-0.13426	-0.12566
	0.24104E-01	-0.18837	-0.19103	-0.12297	0.76863E-01
	0.25270	-0.32499	-0.13511	-0.22327	-0.74207E-01
	0.39153	-0.12449	-0.16564	-0.13063E-01	-0.10591
	0.32309	0.24863	0.73350E-02	0.69725	0.47554
	0.19556	1.00000			
RB	0.25620	0.17845	0.19398	-0.24197	-0.65469E-01
	-0.35511	0.28544	0.33212	0.30496	0.28831
	0.14039	-0.42581E-01	0.10487	0.68009E-01	-0.21053E-01
	0.18099	-0.14772	-0.10647	0.10340	0.53818
	0.85415	-0.46825	-0.67647E-01	-0.19072	0.15127E-02
	0.71270E-01	0.26871	0.94536E-01	-0.82004	-0.21283
	0.18017	0.17653	-0.88764	0.35793	0.27818
	0.11498E-01	0.43821	1.0000		
RATIO	0.16558	-0.19802	-0.21266	0.26103	-0.51476E-01
	0.50266	0.72427	0.72225	0.86597	-0.28052E-01
	0.43623	0.48659	0.68479	0.62258	0.45041
	0.45798	0.10641	0.53188	0.62045	0.44286
	0.34783	0.10702	0.49026	0.60271	0.28720
	-0.47610	0.12693	-0.22651E-01	-0.12926	-0.79748E-01
	0.47176	0.25837	-0.24266	-0.29262	0.45612
	-0.51414E-01	-0.10753	0.18261	1.0000	
RB1	0.30442	0.28014	0.29764	-0.26853	-0.96886E-01
	-0.38291	0.21884	0.28151	0.24040	0.33729
	0.86313E-01	-0.14863	0.70727E-01	0.98776E-01	0.17993E-01
	0.21214	-0.91392E-01	-0.22081	0.13002	0.35330
	0.75823	-0.62431	-0.10891	-0.26914	0.35732E-01
	0.24900	0.33005	0.12523	-0.85528	-0.20912
	0.21843	0.19557	-0.76321	0.50539	0.21871
	-0.75884E-01	0.51370	0.92905	0.81407E-01	1.00000

(Contd.)

TABLE 2. (CONTD.)

BUDGET	-0.24929	-0.28026	-0.26825	-0.43428E-01	0.12425
	-0.37562	-0.20102E-01	0.53059E-01	0.18819E-01	0.15110
	-0.12153	-0.11908	-0.87954E-01	-0.24349	-0.26482
	-0.30118E-01	-0.39984	-0.91987E-03	-0.22122	0.20827
	0.20787	0.69276E-02	0.67846E-01	0.16357E-01	0.79168E-01
	0.12499	-0.24113	-0.25188	-0.23007	-0.13104
	0.99147E-01	0.12802	-0.31954	0.17388	0.15836
	0.35695E-01	0.25602	0.40430	-0.64545E-01	0.33256
	1.0000				
NONADP	-0.36748	-0.24271	-0.25025	0.27235	0.25100E-01
	0.16607	-0.38407	-0.42556	-0.38124	-0.37747
	-0.19464	-0.47281E-01	-0.20647	-0.17051	-0.99644E-01
	-0.21813	0.16572E-01	-0.50813E-02	-0.18797	-0.49279
	-0.79223	0.40448	-0.25488E-01	0.10514	-0.10797
	0.48559E-01	-0.37198	-0.15946	0.90983	0.21791
	-0.71551E-02	-0.48788E-01	0.97119	-0.66779E-01	-0.15214E-01
	0.15986	0.48850E-01	-0.85773	-0.21860	-0.76491
	-0.29533	1.00000			
MACHINE	0.24466	0.11979E-01	-0.30177E-02	0.34062	0.10228
	0.15971	0.66583	0.31688	0.35471	0.12398
	0.94750	0.49579	0.34107	0.51498	0.29685
	0.64809	-0.12568	0.34284	0.55868	0.32046
	0.16400	0.21556	-0.96032E-01	0.87392E-02	-0.12302
	-0.74106E-01	0.23849	0.24047	-0.14827	-0.57200E-01
	0.44777	0.19672E-01	-0.19694	-0.24606	-0.44880E-01
	0.24733	-0.47559E-01	0.19090	0.33257	0.13531
	-0.27839E-02	-0.17984	1.0000		
CONSTRC	-0.69588E-01	-0.23025	-0.23129	0.13682	0.20862
	0.14046	0.40994	0.46961	0.56903	0.65167E-01
	0.17518	0.61392E-01	0.32124	0.36134	0.22888
	0.48431	-0.23141	0.33481	0.37150	0.59253E-01
	0.16978	-0.18948	0.21231	0.20459	0.22016
	0.40797E-02	-0.70102E-01	-0.33540	0.66684E-02	-0.40598
	0.69751	0.21522	-0.54993E-01	-0.17194E-01	0.35082
	0.55287E-01	0.18222	0.16145	0.60956	0.12244
	0.17320	-0.11144	0.21702	1.0000	
CHANGE	-0.12445	-0.20495E-01	-0.15083E-01	0.21298	0.13151
	-0.25271	-0.14447	-0.48956E-02	0.93574E-02	0.33121E-01
	-0.28618	-0.30995	-0.12996	-0.45093E-01	-0.10451
	-0.24955	0.13646E-01	-0.98760E-01	-0.15585E-01	-0.41685
	-0.29001	-0.20863	-0.40996E-01	-0.66832E-01	0.24861E-01
	0.39480	-0.94944E-01	-0.20999	0.10652	-0.13988
	0.46087	0.35943	0.26754	0.16205	0.18957
	-0.76422E-01	0.19576	-0.12677	-0.81663E-02	0.23557E-01
	0.87392E-01	0.21103	-0.32559	0.18826	1.0000
GEN	0.62054	0.32656	0.31039	-0.12714E-01	0.20825E-01
	0.44658	0.72868	0.67751	0.66435	0.45567
	0.52719	0.39995	0.69512	0.76108	0.64450
	0.46358	0.46464	0.46480	0.73536	0.29967
	0.33020	-0.73849E-01	0.35766	0.35941	0.33269
	-0.24932	0.60787	0.36692	-0.47158	-0.17568
	0.17528	-0.11121E-01	-0.35158	-0.36558	0.63407E-01
	-0.14646	-0.34494	0.16476	0.49588	0.23775
	-0.19149	-0.39895	0.38861	0.23688	-0.12992
	1.00000				
MINE	0.25378	0.55979E-01	0.34289E-01	-0.38992E-01	0.31722E-01
	0.74270	0.28375	0.29076	0.33275	0.57836E-01
	0.14065	0.22488	0.61282	0.58689	0.70252
	0.35710	0.56432	0.43955	0.47842	-0.45413E-01
	-0.71573E-01	-0.43959E-01	0.56159	0.43836	0.59253
	-0.37112	0.22467	0.20546	0.17661	0.10095
	0.10379E-01	0.18112E-01	0.23779	-0.18475	0.87673E-01
	-0.28497	-0.30335	-0.35839	0.34525	-0.29137
	-0.48609	0.16158	0.33322E-02	0.26261	-0.38199E-01
	0.51692	1.00000			

(Contd.)

TABLE 2. (CONTD.)

ELEC	0.50318	0.30934	0.28445	0.27809	0.12422
	0.46930	0.52058	0.33009	0.34195	0.16130
	0.57133	0.75602	0.52126	0.60242	0.56120
	0.47033	0.38648	0.24832	0.57049	0.18859
	0.72211E-01	0.16152	0.21494	0.34271	0.12702
	-0.34486	0.47901	0.41409	-0.10746	-0.15379E-01
	-0.52303E-01	-0.17175	-0.42182E-01	-0.28864	-0.26369
	-0.10081	-0.50788	-0.16206	0.29688	-0.13883
	-0.29211	-0.69123E-01	0.46516	-0.86273E-01	-0.15295
	0.59465	0.37757	1.0000		
MFG	0.58709	0.30218	0.29077	-0.33701E-01	-0.40399E-01
	0.35981	0.72555	0.70419	0.67607	0.51960
	0.48601	0.36391	0.64425	0.71333	0.59263
	0.44438	0.41913	0.44536	0.69525	0.33037
	0.39514	-0.10852	0.30103	0.31237	0.28534
	-0.16875	0.58047	0.29751	0.54095	-0.22340
	0.17870	0.22029E-01	-0.42413	0.33504	0.90917E-01
	-0.13520	-0.28805	0.25685	0.47285	0.32422
	-0.10831	-0.47340	0.35574	0.24542	-0.12037
	0.97647	0.38648	0.52124	1.0000	
FOOD	0.33287	0.28937	0.29376	-0.88663E-01	-0.13219
	-0.12240E-01	0.28324	0.23770	0.28455	0.44606E-01
	0.26704	0.16821	0.19827	0.37330	0.20612
	0.45901	-0.36344E-01	-0.71091E-01	0.40987	-0.40442E-01
	0.20285	-0.35232	-0.53393E-01	-0.29531E-01	-0.57865E-01
	0.13430	0.34518	0.18769	-0.35227	-0.70010E-01
	0.21443	-0.16580E-01	-0.18355	0.23747	-0.81777E-01
	-0.13691	0.13247	0.24032	0.29801	0.37596
	-0.29349	-0.23537	0.27159	0.23664	-0.13928
	0.39018	0.16424	0.27067	0.38112	1.00000
BEV	0.46535E-01	0.10198	0.97713E-01	0.12051	0.22829E-01
	-0.42562E-01	0.18991E-01	-0.66909E-01	-0.55267E-01	-0.95166E-02
	0.18084	-0.10750	-0.53506E-01	0.76189E-01	0.72642E-01
	0.40517	-0.15283	-0.60569E-01	0.69923E-01	-0.11269
	0.10241	-0.29369	-0.16596	-0.21323	-0.29378E-01
	0.24578	0.65476E-01	-0.42618E-01	-0.21578	-0.28609E-01
	0.10923	-0.24144	-0.31722E-01	0.13713	-0.27859
	0.91797E-01	0.11790	0.98506E-01	-0.57393E-01	0.25211
	-0.18343	-0.10370	0.27040	0.15878	-0.24798
	0.32725	0.11279	-0.39063E-01	0.33823	0.43702
	1.0000				
TEXT	0.30995	0.10197	0.10812	-0.24331	-0.13693
	0.31303E-01	0.43276	0.50730	0.43320	0.52383
	0.17260	0.16770E-01	0.35186	0.30775	0.25167
	0.82668E-01	0.24675	0.27562	0.30191	0.35297
	0.40105	-0.96854E-01	0.21190	0.15596	0.24450
	-0.18607E-01	0.31421	0.13504	-0.46066	-0.19652
	0.99293E-01	0.14713	-0.45451	-0.15983	0.28127
	-0.75961E-01	0.14159E-01	0.40149	0.19445	0.39041
	0.37580	-0.44543	0.90325E-01	0.14383	0.52878E-01
	0.49721	-0.15870E-01	0.59787E-01	0.58410	-0.13545
	-0.32893E-01	1.0000			
COTT	0.23093	0.14836	0.15674	-0.35665	0.12289
	-0.75916E-01	0.19494	0.30006	0.21725	0.42331
	-0.24172E-01	-0.13698	0.11471	0.50560E-01	0.65278E-01
	-0.13361	0.16254	0.54874E-01	0.41581E-01	0.20113
	0.29707	-0.20470	0.98802E-01	-0.95706E-02	0.17783
	-0.10116	0.23212	0.65264E-01	-0.27821	-0.30821
	-0.95856E-02	0.40213E-01	-0.33942	-0.10937	0.23708
	0.54262E-01	0.31786E-01	0.30733	0.61931E-02	0.24549
	0.28261	-0.32189	-0.76115E-01	0.12684	-0.15119E-01
	0.23973	-0.49008E-01	-0.55181E-01	0.30938	-0.25343
	-0.19183	0.83227	1.0000		

(Contd.)

TABLE 2. (CONTD.)

JUTE	0.11499	-0.45522E-01	-0.37875E-01	-0.23491E-01	-0.30371
	-0.54265E-01	0.30347	0.43108	0.40907	0.33845
	0.18697E-01	-0.14741E-01	0.29795	0.23225	0.17889
	0.20566	0.56421E-01	0.26877	0.23050	0.27964
	0.40144	-0.14719	0.24309	0.22620	0.25247
	0.14665	0.12480	-0.22361E-01	-0.46500	-0.34348E-01
	0.19207	0.56965E-01	-0.38569	0.11826	0.21155
	-0.21324	0.14917	0.42098	0.27242	0.47842
	0.43853	-0.41381	0.66033E-02	0.20325	0.18698
	0.39118	-0.59842E-01	-0.85925E-01	0.47959	-0.10167E-01
	0.25973	0.62700	0.20330	1.00000	
FOOT	0.45272E-01	-0.22892	-0.25109	0.24562	0.41721E-01
	0.66648	0.43200	0.33613	0.42195	-0.46747E-01
	0.37745	0.48682	0.60145	0.55387	0.66431
	0.43035	0.42043	0.60256	0.45056	0.44732E-01
	-0.10859	0.19148	0.55188	0.55673	0.51427
	-0.38774	0.85249E-02	0.67021E-01	0.35309	0.75115E-01
	0.18226	0.16230	0.25497	-0.27123	0.26030
	-0.26339	-0.30900	-0.34463	0.50607	-0.41966
	-0.22801	0.22155	0.23908	0.38493	0.69518E-02
	0.28527	0.68077	0.43547	0.19238	-0.83606E-01
	-0.19980	0.48068E-01	-0.30829E-02	-0.69019E-01	1.00000
PAP	0.19739	0.65813E-01	0.55193E-01	0.72539E-01	0.10486
	0.25611	0.23013	0.15681	0.23204	-0.15972
	0.21466	0.44216	0.37025	0.15318	0.25049
	0.16930	0.10623	0.24302	0.90708E-01	0.15703
	0.13205	-0.88018E-02	0.54997	0.54629	0.42916
	-0.52269	0.15449	0.26898	-0.13244	0.14178
	-0.19434E-01	0.11227	-0.14996	0.32242E-01	0.26319
	-0.37192	-0.21509	0.63778E-01	0.35447	0.38958E-01
	0.11475	-0.11514	0.12863	-0.27806E-01	-0.73947E-01
	0.26953	0.15444	0.53068	0.22216	0.70969E-01
	-0.25651	-0.21677E-01	-0.71950E-01	0.45358E-01	0.31324
	1.0000				
RUBB	0.36476	0.15760	0.14770	0.73563E-01	-0.13718
	0.28487	0.44126	0.31642	0.30890	0.17604
	0.42850	0.46950	0.39757	0.33148	0.32776
	0.13104	0.34266	0.23626	0.30581	0.20731
	0.80931E-01	0.15395	0.32318	0.37222	0.24165
	-0.47660	0.32693	0.38196	-0.17206	0.13229
	-0.11811	0.59998E-01	-0.15909	-0.33006	0.55557E-02
	-0.28263	-0.51494	-0.64137E-01	0.25093	-0.82236E-01
	-0.50642E-01	-0.13896	0.27097	-0.21137	-0.17349
	0.46064	0.20159	0.60044	0.42215	0.65143E-01
	-0.20165	0.26624	0.12465	0.11058	0.33246
	0.57933	1.0000			
CHEM	0.31291	0.24927	0.23351	0.27880	-0.85406E-01
	0.29483	0.24634	0.88047E-01	0.98509E-01	0.45555E-01
	0.37931	0.53753	0.29396	0.36175	0.39304
	0.48883	0.22692	-0.94237E-01	0.32625	0.28772
	0.36382	-0.11689	0.17734E-01	0.66071E-01	0.40179E-01
	-0.18031	0.29769	0.29904	-0.34179	0.17792
	-0.14625	-0.13869	-0.18708	0.10407	-0.23359
	-0.14868E-01	-0.10495	0.14506	0.86043E-01	0.25204
	-0.24590	-0.18743	0.35201	-0.20417	-0.28009
	0.43963	0.20070	0.66276	0.40860	0.30956
	0.37208	-0.59451E-02	-0.13746	0.82237E-01	0.35891E-01
	0.37451	0.33509	1.0000		
PETRO	0.37833E-01	0.57513E-01	0.58236E-01	-0.50816E-01	0.28479
	-0.26298	0.10707	-0.37799E-02	0.20347E-01	-0.19299E-01
	0.25589	-0.30382	-0.10026	-0.87180E-01	-0.16616
	-0.24702E-01	-0.25709	0.28703E-01	-0.51908E-01	-0.10664
	0.22888E-01	-0.20712	-0.40438E-01	-0.21611	0.84141E-01
	-0.23408E-01	0.42164E-01	0.28564E-01	-0.40894	-0.49406E-01
	0.36402	0.40438E-01	-0.40988	-0.98404E-01	0.30261E-01
	-0.19624E-01	-0.98239E-01	0.34124	0.34061E-01	0.31896
	0.23513	-0.44223	0.28317	0.88310E-01	0.33712E-01
	0.22424	-0.11437	-0.63820E-01	0.22627	0.72554E-01
	0.13394	0.88635E-01	0.69113E-01	0.11816	-0.28223
	0.17324	0.64929E-01	-0.32877E-01	1.00000	

(Contd.)

TABLE 2. (CONTD.)

NONMET	0.42201	0.28438	0.27251	0.10952	0.36783
	0.90527E-01	0.40816	0.40686	0.46006	0.11926
	0.24692	0.28690	0.39886	0.35202	0.31881
	0.41946	0.34443E-01	0.60810E-01	0.33178	0.26304
	0.51181	-0.46697	0.28965	0.18722	0.33216
	-0.27733	0.41096	0.76052E-01	-0.51130	-0.37762
	0.32119	-0.12958	-0.44195	0.13986	0.80204E-01
	-0.44541E-01	0.72860E-02	0.43189	0.45498	0.47432
	0.13145	-0.47816	0.25253	0.36650	0.21667E-01
	0.54548	0.19799	0.41120	0.54138	0.34333
	0.22090	0.25824	0.13748	0.35033	0.14916
	0.43028	0.24922	0.37182	0.27546	1.0000
BASMET	0.34703	0.10094	0.82427E-01	0.17596	-0.22629
	0.64054	0.50767	0.49718	0.46829	0.38981
	0.31213	0.52877	0.60324	0.68901	0.77310
	0.50899	0.65766	0.31283	0.59377	0.14872
	0.15358	-0.63897E-01	0.31059	0.33472	0.36040
	-0.16384	0.33062	0.19171	-0.12012	0.29795E-01
	-0.45360E-01	0.43572E-01	0.57959E-01	-0.14678	-0.56340E-01
	-0.25976	-0.31414	-0.17427	0.31055	-0.38342E-01
	-0.39962	0.17640E-02	0.16291	0.12459E-01	-0.60840E-01
	0.69183	0.62986	0.66192	0.64974	0.24176
	0.20219	0.21487	-0.14685E-01	0.21855	0.48331
	0.25036	0.48605	0.58298	-0.31372	0.35168
	1.00000				
METPRO	0.27946	0.22657	0.22556	-0.55307E-01	0.75761E-01
	-0.15727	0.24822	0.23324	0.18414	0.25897
	0.20015	-0.17264E-01	0.50872E-01	0.16208	0.51680E-01
	-0.26313E-01	0.16016	-0.19833E-01	0.18916	-0.39581E-01
	0.13063	-0.11924	-0.12578	-0.12753	-0.89995E-01
	0.31764E-01	0.28688	0.25851	-0.34386	-0.49026E-01
	0.80757E-01	-0.18007	-0.31706	-0.14341	-0.12595
	0.19494E-01	-0.15711	0.22634	0.62009E-01	0.21828
	-0.78986E-01	-0.31680	0.18253	-0.59733E-01	-0.93647E-01
	0.33754	0.24367E-01	0.88655E-01	0.26108	0.21516
	0.17063	0.58152E-01	0.41705E-02	0.67054E-01	-0.84855E-01
	-0.23858E-01	0.20994	0.59754E-01	0.26661	0.10495
	0.11015	1.00000			
NOELEC	0.28376	0.15000E-01	0.76197E-02	0.14838	0.81716E-01
	0.11304	0.72504	0.62210	0.63013	0.40789
	0.61519	0.30719	0.46991	0.57828	0.46971
	0.46186	0.20619	0.47370	0.56713	0.99997E-01
	0.17699	-0.10539	0.21308	0.21778	0.28055
	-0.40148E-01	0.27922	0.13391	-0.39694	-0.15720
	0.46119	0.10804	-0.34351	-0.22464	0.12142
	-0.24508	-0.27290	0.24171	0.48415	0.25401
	0.83087E-01	-0.41032	0.53344	0.37741	0.64336E-01
	0.72788	0.22802	0.42572	0.70534	0.24539
	0.18320	0.35740	0.11675	0.41025	0.31639
	0.33397	0.47761	0.21763	0.45094	0.45427
	0.40403	0.53561	1.0000		
TRANS	0.33994	0.24150	0.24064	-0.35432	0.20795
	0.44630E-01	0.27063	0.36423	0.29746	0.43623
	0.47862E-01	-0.30253	0.22709	0.19936	0.16544
	-0.37624E-01	0.18168	0.27238	0.18654	0.24422E-01
	0.17676	-0.26063	0.22541	0.17930E-01	0.35961
	-0.16442E-01	0.34972	0.11791	-0.50234	-0.29022
	0.14514	-0.16869E-01	-0.43370	-0.26225	0.11868
	-0.16481	-0.22214	0.27136	0.90006E-01	0.30730
	0.14761	-0.49659	-0.20475E-01	0.18571	0.46623E-01
	0.59899	0.19485	-0.55173E-01	0.63991	-0.32900E-01
	0.19371	0.52401	0.43055	0.41652	-0.12052
	-0.32627E-02	0.31899E-01	-0.12638	0.60670	0.32713
	0.95695E-01	0.22450	0.47116	1.0000	

(Contd.)

TABLE 2. (CONCLD.)

GDP	PRISEC	AGRI	FOREST	FISHING
MINING	SECOND	MFG	REGIS	UREGIS
CONSTR	ELEC	TERT	TRANS1	TRANS2
RAIL	TRANS3	COMM1	TRADE	FINANCE
BANK	REAL	COMM2	PUBAD	OTHER
INCOME	GNP	CONSUM	GDPD	APC
NDCF	HPM	WPI	TD	CURR
DEPMON	M_3	RB	RATIO	RB1
BUDGET	NONADP	MACHINE	CONSTRC	CHANGE
GEN	MINE	ELEC	MFG	FOOD
BEV	TEXT	COTT	JUTE	FOOT
PAP	RUBB	CHEM	PETRO	NONMET
IBASMET	IMETPRO	INOELEC	ITRANS	

APPENDIX 1.

Series 1 to 27 refer to Gross Domestic Product at Factor Cost (at constant prices 1970-71 = 100). The data are annual.

1) GDP = Gross domestic product at factor cost.
2) PRISEC = Primary sector output.
3) AGRI = Agricultural output.
4) FOREST = Forestry and logging output.
5) FISHING = Fishing output.
6) Mining = Mining and quarrying output.
7) SECOND = Secondary sector output.
8) MFG = Manufacturing output.
9) REGIS = Registered manufacturing output.
10) UREGIS = Unregistered manufacturing output.
11) CONSTR = Construction output.
12) ELEC = Electricity, gas and water supply output.
13) TERT = Tertiary sector output.
14) TRANS1 = Transport, communication and trade output.
15) TRANS2 = Transport, storage and communication output.
16) RAIL = Railways output.
17) TRANS3 = Transport by other means and storage output.
18) COMM1 = Communication output.
19) TRADE = Trade, hotels and restaurants output.
20) FINANCE = Finance and real estate output.
21) BANK = Banking and insurance output.
22) REAL = Real estate, ownership of dwellings and business services.
23) COMM2 = Community and personal services output.
24) PUBAD = Public administration and defence output.
25) OTHER = Other services output.
26) INCOME = Net factor incomes from abroad.
27) GNP = Gross National Product.
28) CONSUM = Real domestic private final consumption expenditure (at constant 1970-71 = 100 prices).
29) NDCF = Net domestic capital formation (at constant 1970-71 = 100 prices).
30) WPI = Wholesale price index (1970-71 = 100).
31) GDPD = Gross Domestic Product deflator (Nominal GDP at factor cost divided by 1).
32) NONAD = Index of non-administered prices (1970-71 = 100).
33) HPM = High powered money.
34) TD = Time deposits with banks.
35) CP (or CURR) = Currency with the public.
36) DEPMON (or deposit money) = Demand deposits with banks.
37) $M_3 = M_3$
38) RB (or RB1) = Real balances defined as M_3 divided by the wholesale price index.
39) RB2 = Real balances defined as M_3 divided by Gross Domestic Product Deflator.
40) RATIO = Ratio of 9 and 10.
41) APC = Average propensity to consume (28 divided by real personal disposable income).

Series 42 to 60 refer to the Index of industrial production (1980-81 = 100) and its subcomponents at a 2 / digit level of classification.
42) GEN = General Index of Industrial Production (Crude).
43) MINE = Index of mining and quarrying.
44) ELEC = Index of electricity output.
45) MFG = Index of manufacturing (total).
46) FOOD = Index of manufacture of food products.
47) BEV = Index of manufacture of beverages and tobacco.
48) TEXT = Index of manufacture of textile products n.e.c.
49) COTT = Index of manufacture of cotton textiles.
50) JUTE = Index of manufacture of jute, hemp and mesta textiles.
51) FOOT = Index of manufacture of footwear, leather and leather products.
52) PAP = Index of manufacture of paper and paper products.
53) RUBB = Index of manufacture of rubber plastic, petroleum and coal products.
54) CHEM = Index of manufacture of chemical and chemical products.
55) PETRO = Index of petroleum and crude.
56) NONMET = Index of manufacture of non metallic mineral products.
57) BASMET = Index of output of basic metal and alloy industries.
58) METPRO = Index of manufacture of metal products except machinery.
59) NONELEC = Index of manufacture of machinery except electrical machinery.
60) TRANS = Index of manufacture of transport equipment.
61) BUDGET = Real annual budget deficits (defined as central government revenues expenditures divided by the GDP deflator).
62) MACHINE = Machinery component of NDCF.
63) CHANGE = Change in stocks component of NDCF.
64) CONSTRC = Construction component of NDCF.

Source for all data: *India Database: The Economy*, vols. 1 and 2 by H.L. Chandhok and the Policy Research Group, New Delhi, 1990.

APPENDIX 2

Hodrick-Prescott Filter.

Suppose we have observations $y_1,.....y_T$ on a non-stationary time series $\{y_t\}$ (Assume for simplicity that the non - stationarity arises from the trend). Consider the problem of decomposing this time series into a growth component $\{g_t\}$ and a cyclical component $\{c_t\}$ in such a way that

$$\{y_t\} = \{c_t\} + \{g_t\} \qquad (1)$$

Hodrick and Prescott (1980) propose to approximate $\{y_t\}$ by a smooth curve. They constrain the smoothness of the growth component by setting the sum of the squares of its second differences to be less than some finite number. Obviously, smaller the number, lower is the possible variability that can be attributed to the trend. Consider the following constrained least squares problem:

$$\min \sum_{t=1}^{T}(C_t) + \lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \qquad (2)$$

s.t.

$$y_t = c_t + g_t$$

The first part measures the fit of the curve. Obviously, it is minimised for $y_t = g_t$. The second term measures the smoothness of the series. It becomes zero when change in g_t is constant for all periods. Hence, the expression is minimised when g_t is linear. There is a tradeoff between t the first and the second terms in expression 2 and one must choose what weight to give to each. That job is done by an adequate choice of $\lambda \cdot \lambda = 0$ sets all the weight to the trend and gives a trend that always equals the actual series, with the cyclical component being zero throughout. On the other hand, λ near to infinity would result in a linear trend. λ must be set a apriori. We have used $\lambda = 400$. The algorithm for doing the calculations is given in Danthine and Girardine (1989). A rather low value was chosen for λ so that adequate allowance is made for the variability of the trend that time series of developing countries like India are likely to exhibit.

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DOCUMENTATION

The purpose of this section is to make available to the readers official documents such as reports of committees, commissions, working groups, task forces, etc., appointed by various ministries, departments, and agencies of central and state governments which are not readily accessible either because they are old, or because of the usual problems of acquiring governmental publications, or because they were printed but not published, or because they were not printed and remained in mimeographed form. It will be difficult and probably not worthwhile to publish the documents entirely. We shall publish only such parts of them as we think will interest our readers. The readers are requested to send their suggestions regarding official documents or parts thereof for inclusion in this section.

In the present section we publish:

1. Report of the Indian Irrigation Commission, 1901-03, Part I-General.
2. Royal Commission on Agriculture in India Report, 1928, Chapter 8.

REPORT OF THE INDIAN IRRIGATION COMMISSION 1901-1903
PART I - GENERAL

CHAPTER I
PRELIMINARY SURVEY

SECTION I - CONDITIONS AFFECTING THE USE AND VALUE OF IRRIGATION IN INDIA

1. *Introductory* - The vast extent of area embraced by our inquiries and the extreme diversity of local conditions preclude us from attempting, in this preliminary survey, more than a general description of the conditions which have led to the practice of irrigation in India from time immemorial. The actual utility of irrigation, or, as it is defined in the first of our terms of reference, its effect in increasing the produce of the land and in securing it against failure of the rainfall, must be left for subsequent consideration. We shall refer to it when we come to deal more in detail with the circumstances of each province or tract, and to consider the expenditure which may reasonably be incurred by the State on the construction of irrigation works as a protection against drought.

2. The main factors determining the use and value of irrigation in any part of India, whether from a purely productive or from a famine-protective point of view, are the rainfall, the soil, and the classes of crops suited to the soil, climate, and other local conditions. The rainfall may be so abundant and assured as to render irrigation superfluous, and even injurious; or, though ordinarily sufficient, it may be so liable to periodical failure or unseasonable incidence as to call for irrigation as a protection against its uncertainty; or it may in all years be so scanty as to make cultivation impossible without irrigation. The soil may be so inferior that the increased yield due to irrigation would not repay the cost of providing it; or it may be so retentive of moisture as to render artificial waterings unnecessary except in the driest year. The crop best suited to the locality and to the means of the cultivator may be rice, which in general benefits by a plentiful application of water, however heavy the rainfall; or it may be sugarcane or a garden crop, which in but few parts of India can be grown without irrigation; or wheat, which, in the absence of winter rains, requires as a rule at least three or four waterings to ensure a full crop. On the other hand, it may be barley or gram, which only require irrigation in a dry year; or cotton, which, over the greater part of India, is rarely irrigated even in a year of drought.

3. *The rainfall of India* - The rainfall is not only a main factor in determining the value of irrigation, it is in itself the primary source of all means of supplying it. It is essential, therefore, that at the outset of our report we should describe, however briefly, the chief characteristics of the rainfall of India - its unequal distribution throughout the seasons, its still more irregular distribution over the surface of the country, and its liability to failure or serious deficiency. It will suffice to state the facts as we find them, avoiding as far as possible all reference to causes and influencing conditions.

4. *Seasonal distribution* - By far the greater part of the rainfall is received between June and October, the period of the south-west monsoon. This is the chief season of rain over most of the peninsula, and over almost the whole of which is known as Northern India - the area between the Himalayas and the Vindhyas, containing the great alluvial plains of the Ganges and Indus rivers. Over a great part of the western half of Peninsular India, including nearly the whole of the Bombay Presidency, the rainfall is practically confined to this season.

5. In the south-eastern portion of the peninsula the season of heaviest rainfall is from October to December, the period of the north-east monsoon. In most years, the Central Provinces, Berar and Hyderabad, also receive during this season some showers of rain, which, though usually small in amount, are of great agricultural value, especially to the wheat-growing districts.

6. The latter part of the winter and earlier spring months are the season of the winter rainfall of Northern India. The extreme north-western districts receive at this period about half their average rainfall; and on all the outer ranges of the Himalayas, in the submontane districts, on the plains of the Punjab, and over the north-western districts of the United Provinces, rain, sometimes

heavy, occurs during these months. It extends, though somewhat less frequently and much less heavily, over the remainder of the United Provinces, occasionally reaching Bengal and the northern provinces of the peninsula.

7. During the hot weather, from March to May or June, thunderstorms are frequent in Bengal, and in and near the hills of Northern India; while to Southern India also, at this season, the 'mango showers' give a few inches of rain. But the Bombay Presidency and the plains of North-Western India receive practically no rain during these months.

8. *Geographical distribution* - The general distribution of the annual rainfall is shown on the map of India which accompanies this report [not given here]. One of the zones of heaviest rainfall lies naturally along the western coast of the main peninsula, where the monsoon striking the Western Ghats precipitates on their outer slopes an average rainfall of 100 to 250 inches. A second zone of heavy rainfall extends along the outer ranges of the Himalayas, widening out south of Sikkim to include Eastern and Lower Bengal, and Assam where, at Cherapunji in the Khasi hills, the annual recorded rainfall averages 461 inches.

9. From the Bay of Bengal to the western boundary of Bhopal in Central India, and from the Himalayas in the north to the Godavari in the south, stretches a wide tract of moderately high rainfall (40 to 70 inches). From Benares an offshoot runs up to the north-west through the Himalayan submontane districts nearly to the Indus river. In the south of the peninsula there are also two narrow strips with rainfalls of over 40 inches: one on the east coast, from the north of Madras to the south of Tanjore; the other lying along the eastern side of the Western Ghats, and extending northwards as far as Baroda. The remainder of India, excepting a small portion of Kathiawar, has a rainfall below 40 inches.

10. *Tracts with low average rainfall* - The blue lines upon the map show clearly the rapidity with which the rainfall decreases, from over 100 inches to under 25 inches, as the clouds drift eastward from the summits of the Western Ghats; leaving a long strip of varying width, extending from Kotah in Rajputana to Cape Comorin in the extreme south of the peninsula, in which the rainfall is both scanty and precarious. They show also the less rapid, but still steady, decline in the rainfall of North-Western India, from the 40-inch rainfall line which passes through the western districts of the United Provinces, to the 5-inch line which traverses the State of Bahawalpur.

11. *Variability of the rainfall* - The average rainfall over the whole of India, excluding the Himalayas and Burma, has been computed at 42 inches in the year; that is to say, "such would be the depth of the sheet of water, if the whole quantity that falls on this area were equally distributed over its whole surface instead of being concentrated in certain provinces to the great deprivation of others." Considering in this way the country as a whole, the rainfall may be said to vary but little from year to year, the greatest known variation amounting to under 7 inches in excess or defect of the general average of 42 inches. But if separate tracts are considered, it is found that in many parts of India the rainfall is liable to very great variations, which increase as the area of the tract is diminished, and become still more marked in the case of individual rainfall stations.

12. *Liability to deficiency* - The degree to which the rainfall of any year is liable to be so seriously in defect as to cause injury to the crops may be greater in one tract than in another with a very similar average rainfall; but, speaking generally, it may be said that the lower the rainfall the greater its liability to serious deficiency from the average. Where, however, the annual rainfall is below 10 or 12 inches, cultivation becomes practically impossible without irrigation. In parts of such tracts which are devoted to pasturing cattle, high prices or the drying up of natural grasses may lead to distress and famine, but famine from failure of crops need not be apprehended. On the other hand, in Eastern Bengal and Assam, and in the narrow strip between the Western Ghats and the Arabian

Sea, the rainfall, which exceeds 70 inches, has always been so abundant that the chance of its serious failure may be regarded as extremely remote. Between these areas, in which the crops are thus rendered safe by exclusive reliance on irrigation or by an assured and abundant rainfall, lies a vast tract of nearly a million square miles, of which, in the absence of irrigation, no portion can be deemed absolutely secure against the uncertainties of the seasons and the scourge of famine.

13. Within this tract the annual rainfall is liable to extraordinary variations. At many recording stations annual rainfalls of less than half the average are not uncommon; while at some, less than one-fourth the normal amount has been recorded in a year of severe drought. On the other hand, at many stations liable to these serious deficiencies the amount received in the year may equal and even exceed twice the normal. Some parts of the country, in fact, suffer as often, if not so severely, from excessive as from deficient rainfall. This is a condition which will not be overlooked when we come to discuss the value of irrigation in certain localities; but we are now considering only the liability of the various portions of this large area to receive a rainfall seriously in defect of the normal. A rainfall considerably below the average will no doubt, if favourably distributed, often produce a fair crop, while even an abundant rainfall may, if it is unfavourably distributed, lead to scarcity or famine. Tracts, again, in which the suffering from famine has at times been most intense, are not necessarily those in which the rainfall is most liable to periodical defect. On the contrary, the effects of drought when it does come are felt most in tracts like Gujarat, Malwa, and part of the Central Provinces, which owing to the sufficiency of the rainfall over a long series of years have come to be regarded as immune, and where the protection of the country by irrigation has in consequence been neglected. The quality of the soil, the classes of crops cultivated, and the character and resources of the people are also factors which greatly modify the effects of a deficiency of the rainfall. But, as a general rule, tracts in which the rainfall is most liable to be in considerable defect from the average are those in which famines are most frequent, and the injuries from drought, in the aggregate, greatest. The frequency, therefore, with which the rainfall in any tract falls seriously below the normal may be taken as the best general index of its need for protection by means of irrigation works.

14. The degree of least defect from the average which would, as a rule, cause injury to the crops is not easy to determine even for a given locality, and it is still more difficult to fix any general rule; but, for comparative purposes at least, it will be sufficiently correct to say that a deficiency of 25 per cent would be likely to cause some injury, and that a deficiency of 40 per cent would generally cause serious injury. The former we may call a dry year, and the latter a year of severe drought. A deficiency of 40 per cent on a rainfall of 45 inches would no doubt still leave a rainfall of 27 inches, while the same deficiency on a rainfall of 25 inches would leave only 15; but in the former case rice would almost invariably be the prevailing crop, and for it at least twice as much rain is required as for an ordinary crop of cotton or millet. Indeed there are some exceptional tracts, such as parts of Gujarat, in which a rainfall of 15 inches, or less than half the normal, has been found sufficient to give a fair crop when its incidence was seasonable.

15. From the records of a number of rainfall stations which have been supplied to us by the Meteorological Department, extending back for periods varying from twenty-five years to fifty years, we find that the average frequency of the occurrence of dry years and of years of severe drought at stations in different localities varies as shown below:-

Locality or tract	Average annual rainfall Inches	Number of Dry Years or Years of Severe Drought that may be expected in 50 years		Locality or tract	Average annual rainfall Inches	Number of Dry Years or Years of Severe Drought that may be expected in 50 years	
		Dry years, including years of severe drought	Years of severe drought			Dry years, including years of severe drought	Years of severe drought
NORTHERN INDIA				PENINSULAR INDIA			
Orissa	59	5	0	Central Provinces, East	55	6	0
Chota Nagpur	54	4	1	Satara, Belgaum, Dharwar	42	4	1
Central Bengal	56	6	1	Central Provinces, West and Central	47	7	2
Bihar	48	10	3	Madras, South and Central	31	7	2
United Provinces, Submontane	45	10	3	Mysore	34	9	3
United Provinces, East	41	10	3	Madras, North Coast	42	10	3
Punjab, Submontane	33	10	4	Berar	35	10	3
British Bundelkhand	36	10	5	East Coast, Central	33	9	4
United Provinces, West	29	10	5	Gujarat	44	10	4
United Provinces, Central	37	12	5	Hyderabad, North	35	11	5
Punjab, South-East	23	13	5	Sholapur, Bijapur and Ahmadnagar	26	11	6
Punjab, Central	23	13	6	Madras Deccan	25	13	7
Ajmer-Merwara	20	11	6	Hyderabad, South-East	26	11	8
Punjab, West	10	14	9				

16. *Soils* - The varieties of soils to be found throughout India are innumerable, but, with the exception of one important class, the cultivated soils are generally suitable for irrigation. It will be sufficient to recognize the broad distinctions between the main varieties characteristic of the principal geological divisions - the alluvial, the Deccan trap, and the crystalline and sandstone formations.

17. *The alluvial tract* - The alluvial formation covers the greater part of Northern India, from the foot of the Himalayas to the northern slopes of the Vindhyas, and extends in a narrow fringe round the coast line of the peninsula, increasing in width at the deltas of the great rivers which flow down from the Western Ghats or the table land of Central India. It occupies the greater parts of Sind, the Punjab, the United Provinces, and Bengal, and of the Godavari, Kistna, and Tanjore districts of Madras. The substrata consist usually of alternate layers of sand and clay, but sometimes, especially in Bengal, the sand beneath the upper layer of loam is of unknown depth. The surface shows every variety of soil, from the blown sands of the western deserts, to the rich loam and stiff clay of the Ganges Valley, or the fertile black loam of the Kistna and Godavari deltas. But the prevailing soil is a yellow or red-brown loam which, in general, takes water freely and yields a largely increased outturn under irrigation.

18. There are, however, in the Punjab and United Provinces, numerous irregularly distributed tracts which have been rendered worthless for cultivation by the soil containing an excess of soluble salts - sulphates and carbonates of soda. Under conditions favourable to evaporation the salts accumulate on the surface, covering it with a white efflorescence locally known as *reh* or *kallar*. Irrigation, if water is applied too freely in the neighbourhood of such tracts, leads to an increase of the efflorescence; but it has not been found to increase materially the extent of its area.

19. *The Deccan trap* - The Deccan trap formation covers an area of about 200,000 square miles in the north-western part of Peninsular India. It comprises almost the whole of the Bombay Presidency (including Kathiawar), the whole of Berar, the western third of the Central Provinces, and half of Hyderabad and Central India. Within the ranges of the Western Ghats and Satpuras, numerous varieties of soils are to be found, varying from the light sandy or gravelly soils of the ridges, to the rich yellow or red loams

of the inner valleys of the hills. Elsewhere in this wide tract, black cotton soil prevails. It is so called from its colour and from its suitability to the cultivation of cotton. It varies considerably in colour, consistency, and fertility, but all varieties are highly retentive of moisture. When dried by the heat of the sun, the soil contracts to an unusual extent, seaming the surface of the country with cracks to a depth of several feet; and in this condition the most fertile varieties crumble into small and friable fragments. To the black cotton soils generally, irrigation is not suited. But to many crops it can be applied freely and with profit to the cultivator, when the soil is not of great depth and where the substratum affords good natural drainage; even in the deeper soils rice can be irrigated with advantage; and, under all conditions of depth and sub-soil, irrigation is useful in affording the means of sowing a crop in a year of drought.

20. Black cotton soils are also to be found outside the area of the Deccan trap, generally in the valleys of streams and rivers. In such cases the soils are invariably alluvial and closely resemble, though they may not be identical with, the deposits similarly formed within the trap area. As a rule, owing to the greater depth of the subsoil and to is overlying an impervious substratum, these soils are less suited to irrigation than the 'sedentary' deposits, or soils formed *in situ* in the trap area. The chief districts outside the trap formation in which black cotton soils predominate are Bellary, Kurnool, and Cuddapah, in Madras; Surat and Broach, in Bombay; and Jalaun and Banda, in the United Provinces.

21. *The crystalline tract* - The crystalline and sandstone formations occupy the whole of Peninsular India outside the area of the Deccan trap and the narrow strip of coast alluvium. Their area comprises almost the whole of the Madras Presidency; the State of Mysore; half of Hyderabad; two-thirds of the Central Provinces; with the Bengal Divisions of Orissa and Chota Nagpur. Northwards it extends into and includes the whole or the greater part of the Sonthal Parganas and Birbhum districts of Bengal, the Mirzapur, Jhansi, and Hamirpur districts of the United Provinces, the Baghelkhand States of Central India, and the eastern half of Rajputana. The prevailing soils vary from a dark red loam in the bottoms, to the light sandy or stony soils of the arid uplands which produce the poorest of crops. The better classes of soils in this formation repay the cost of irrigation even more abundantly than the yellow loam of the alluvial tract of Northern India.

22. *The principal crops* - The crops may be divided broadly into two classes: the autumn crops, sown in the spring or summer and harvested in the autumn; and the spring crops, sown in the autumn and harvested in the spring. These are known throughout the greater part of India as the *kharif* and *rabi* crops. In Madras, however, they are called first and second crops. Both in Northern and Southern India the autumn crops are mainly millets, pulses, and rice. The principal spring crops are, in Northern India, wheat, barley, linseed and gram; and in Southern India, millets, rice, jute, and gingelly. The wheat area may be divided roughly from the spring millets and spring rice area by a line drawn from Bombay round the southern extremity of the Central Provinces and through the Patna district in Bihar.

23. The crops which are mainly or in a great measure dependent upon irrigation to ensure a full outturn in an average year are rice, wheat, and barley; sugarcane and garden crops; and indigo, where it is grown as an autumn crop. Cotton, when grown in black soil, and some of the staple *kharif* millets are said to receive but little benefit from irrigation even in a dry year.

SECTION II - NATURAL FACILITIES FOR IRRIGATION

24. *The alluvial tract* - Each of the three great soil divisions referred to in the previous section is characterized by special facilities, or by its lack of facilities, for irrigation. The level surface of the alluvial plains admits of their absorbing a large percentage of the rainfall; and except in the deserts of the Punjab and Rajputana the subsoil water is generally close enough to the surface to place the cost of lifting it within the means of the cultivator. In many parts of the Eastern Gangetic Valley, the subsoil consists as we have said of sand to an unknown depth, but elsewhere the substrata are usually suitable for the construction of wells.

25. These plains, again, are traversed by all the

great perennial rivers whose sources lie in the snows and glaciers of the Himalayas or under the assured and abundant rainfall of the Western Ghats; while the level surface of the country presents no serious obstacle to distributing the river-waters over the length and breadth of the land. So marked are these facilities for the construction of canals compared with those elsewhere, that within the alluvial tract are to be found all the great canal systems of India.

26. But the flatness of the surface, which lends itself so readily to the construction of canals, is an obvious obstacle to the construction of reservoirs for the storage of water. Thus, within this large tract there is practically no irrigation from artificial tanks, except in some of the rice districts of Bengal where the slightly undulating surface of the country admits of water being stored in shallow tanks to tide the crop over a break in the rains. In parts, however, of the United Provinces, irrigation is extensively practised from water stored in natural depressions.

27. *The crystalline tract* - This tract is traversed by all the great rivers which rise in the Western Ghats, but, for the most part, their channels are too deep and their gradients too small to admit of their being utilized for irrigation outside of their narrow valleys. Even when the water can be raised to the level required for commanding the country, the broken and uneven surface renders it impossible to construct, at a practicable cost, systems of canals at all comparable in size to the great canals of the alluvial tract.

28. On the central table-land, the rainfall is generally too scanty, and the drainage too rapid, for the accumulation of an abundant supply of water in the subsoil. There is no permanent underground flow as in Northern India, and the supply being usually dependent on mere local percolation, the wells have to be of large diameter. Their large size and the rocky nature of the substratum render their construction more expensive than in the alluvial tract.

29. With the waters of its large rivers generally unavailable, and with its wells at the best affording a costly means of irrigation and one unsuited to rice, the principal irrigated crop, this tract has to depend for its protection mainly upon storage of the local rainfall. For this fortunately the broken and undulating nature of the surface affords good facilities; and the numerous tanks which stud the surface of the country, and collect the rainfall from a large portion of its area, are the chief characteristic of the crystalline and sandstone formations.

30. *The Deccan trap* - Within the area covered by the Deccan trap formation, the general configuration of the country is somewhat similar to that of the crystalline tract, but it is even more broken by numerous hills and ranges of hills. The Nerbudda and Tapti rivers have their sources within this tract, and leave it only as they approach the sea. The Godavari traverses it in the first four hundred, and the Kistna in the first two hundred miles of its course. The moisture retaining properties of the soil and the impervious nature of the subsoil cause the local streams to be of a more perennial nature than those in the crystalline and alluvial tracts; but they also prevent the free flow of surface water into the subsoil. Thus, except in some favoured localities the wells are deeper and yield a less copious supply than those of the other two tracts, while the numerous cracks which form as the soil contracts in the heat of the sun necessitate a frequent or a very copious application of water to an irrigated crop. On the other hand, the soil retains sufficient moisture in all ordinary years to bring the staple crops to maturity without aid from irrigation. In this tract, therefore, there are comparatively few irrigation works of any kind, and irrigation is confined for the most part to the more valuable crops.

31. *Comparative extent of irrigation in the three tracts* - These differences in the facilities for irrigation in the three tracts have led naturally to corresponding differences in the relative areas protected by the various means of irrigation. This is clearly exhibited in the following tabular statement. The figures given are for areas for which there are fairly reliable statistics, including Native States:-

Division or tract	Area annually cropped Thousands of acres	Percentage of cropped area irrigated from				
		Canals	Tanks	Wells	Other sources	Total
Alluvial	135,000	12.4	1.8	7.3	3.6	25.1
Crystalline	100,000	1.5	7.3	4.2	2.5	15.5
Deccan trap	58,000	0.2	0.3	2.4	0.3	3.2
Total	293,000	6.3	3.3	5.3	2.6	17.5

32. Evidently the alluvial tract is, as we have stated, specially favoured by the facilities for canals and wells, for in it lie all but an insignificant portion of the canal area, and about two-thirds of the well area. On the other hand, there is but little tank irrigation, the small area shown under that source being watered chiefly from natural depressions. The crystalline tract contains nearly all the irrigation from artificial tanks. It has practically no canal irrigation, and much less well irrigation than the alluvial tract. In the trap area, where, speaking generally, irrigation is least required and most difficult to provide, there are practically no canals or tanks, and the area watered by wells is inconsiderable.

SECTION III - DEVELOPMENT AND PRESENT EXTENT OF IRRIGATION IN INDIA

33. *Definition of irrigation works* - The surplus rainfall becomes available for use in artificial irrigation when it accumulates or flows, either upon the surface or in the subsoil, at a level sufficiently high to admit of its being diverted or raised on to the land. But in all cases before this can be done certain works of construction are necessary. These are called works of irrigation, or, briefly, 'irrigation works.' Thus the term irrigation works includes works of many varieties and magnitudes, ranging from the rude contrivances which enable the cultivator by swinging a basket to raise water from a pond, to the huge embankment of earth or masonry holding behind it a lake of many square miles; or from the small temporary well, a mere hole in the ground lined with brushwood, to the great canal which, carrying for some hundreds of miles a volume of water equal to that of a large sized river, delivers it into a network of smaller channels for the irrigation of over a million acres.

34. *Classes of irrigation works* - The irrigation works of India may be divided into three main classes; canals, tanks, and wells. Under 'canals' are classed all works of any considerable size for diverting the waters of streams or rivers, and carrying them on to the land; under 'tanks,' all works for the storage of water, and all natural depressions of which the water is used for irrigation; and under 'wells,' works for giving access to the subterranean supply, or to the waters of rivers which, running deep below the general level of the ground, have to be lifted vertically before they can be made to flow on to the fields. Canals are of the 'perennial' or 'inundation' type according as they are designed to draw their supplies from the river at all seasons of the year, or only when it is in flood. In the former case it is almost always necessary to make a weir, temporary or permanent, across the river so as to divert the water into the canal, and this is often one of the most expensive parts of the canal works. Inundation canals have no such weirs. Once cleared of silt they go on taking in water from the river until, at the close of the flood season, its surface falls below a certain level, and the canals then remain dry until the next flood season.

35. *Distinction between State and private works* - In the case of large tanks or canals, works have to be made and subsequently maintained which are beyond both the means and management of individuals or village communities. Such works are therefore generally constructed and controlled by the State; and we have thus a second classification of irrigation works into 'State works' and 'private works.' All works which have been constructed or which are maintained or partially maintained by the State, are classed as 'State works.' The irrigation from 'private works' is entered in the annual statistics of areas irrigated under the heads of canals, tanks, wells, and 'other sources;' the last including irrigation from rivers and streams, and from channels which are too

small to be classed as canals. The distinction between canals and the smaller channels is nowhere clearly defined, and the classification adopted varies from province to province and even from district to district.

36. *Early history of irrigation works in India* - In the early records of the peoples of India, dating back to many centuries before the commencement of our era, there are frequent references to the practice of irrigation. Wells have been in use from time immemorial; most of the almost innumerable tanks of Southern India have been in existence for many generations - two in the Chingleput district of Madras, which still irrigate annually from two to four thousand acres, are referred to in inscriptions which are said to be of the 8th and 9th centuries of our era; the practice of drawing off the flood waters of the Indus and its tributaries by means of small inundation canals has been followed from a very early date; and in the submontane districts of Northern India are still to be found the remains of ancient irrigating channels which have been buried for centuries in the undergrowth of the forests. But the numerous large works which now exist for utilizing the supplies of the larger rivers are of comparatively recent date; and little seems to have been done in this direction before the country came under British rule. The most notable exceptions are the 'Grand Anicut' across the Coleroon river in Madras, some of the inundation canals on the Indus and its tributaries, and two canals taking out of the Jumna river at a point where, passing through a gorge in the outer ranges of the Himalayas, it debouches on to the plains.

37. To the 'Grand Anicut,' tradition assigns a period corresponding to the close of the second century, though it is probably of a much later date. This work is, so far as is known, the greatest engineering work carried out in India before British rule began. It consisted of a solid mass of rough stones, over 1,000 feet in length, 40 to 60 feet in breadth, and 15 to 18 feet in depth, stretching across the whole width of the Cauvery river. It fulfilled its purposes for some centuries, and in 1830 was still in operation, but the vagaries of the river had not been watched, and by that time the main stream had begun to flow down a northern channel known as the Coleroon, and the district of Tanjore had lost much of its former prosperity.

38. Most of the existing inundation canals in the Multan, Muzaffargarh, and Dera Ghazi Khan districts, were constructed by the former Muhammadan and Sikh rulers, and on many of these canals a high degree of efficiency was attained under the management of the great and energetic canal maker, Diwan Sawan Mal.

39. A canal, known as the Hasli, was also constructed by the Sikh or Muhammadan rulers of the Punjab to carry water to Lahore from a point on the Ravi river at a distance of 130 miles. When the Punjab came under British rule, the area irrigated by the canal was paying a revenue of eighty-five thousand rupees. Its general alignment was fairly good, but in detail there had been so many errors that to rectify them would have cost more than making an entirely new channel. The Hasli has been replaced by the Bari Doab Canal, which has more than twenty times its carrying capacity, and is one of the most important irrigation works in India.

40. Owing to the proximity of the Jumna to Delhi, the Muhammadan rulers of India turned their attention at an early period to utilizing the waters of that river for the irrigation of the higher lands on both banks. In the fourteenth century, Firoz Shah Tughlak constructed a canal taking water from the right or western bank of the Jumna, a distance of about 150 miles, to irrigate his favourite hunting grounds at Hissar. This canal, which had silted up, was repaired during Akbar's reign by the Governor of Delhi for the irrigation of lands in his private estate, but for want of repairs it again stopped flowing. About the year 1647 A.D., the canal was repaired under the direction of Ali Mardan Khan, the celebrated Engineer of Shah Jahan, and a new channel excavated to carry water into the city of Delhi. During the decline of the Mughal empire the canal again gradually silted up until it ceased to flow. The canal on the eastern bank of the Jumna was also constructed during the Mughal Dynasty, probably during the reign of Muhammad Shah (1718-1748); but it appears to have been very soon abandoned, if indeed it had ever been used for the carriage of water. In 1784 the work was

partially restored by a Rohilla Chief who succeeded in bringing water to some short distance below Saharanpur, and there are traditions of serious injury having been caused thereby to the towns of Saharanpur and Behut. No masonry works of any kind were constructed in connection with the canal; and in their absence, owing to the excessive slope of the country, if any considerable volume of water had been allowed to enter the channel, it must have led in time to a fatal retrogression of bed-levels.

41. Doubts have been expressed as to whether these works, in their former condition, ever irrigated any considerable areas or conferred much benefit upon the people. Be this as it may, it is certain that it was the existence of the 'Grand Anicut' in Madras, and the remains of the old Muhammadan channels in the Punjab and United Provinces, which suggested and led to the construction of the earliest works carried out under British rule. India, therefore, in a great measure owes to her former rulers the first inception of her present unrivalled systems of State irrigation works. The most efficient and useful works which were constructed in former times are, however, the smaller works - tanks, weirs, and river-channels - which are to be found scattered throughout the Peninsula, and in Upper Burma. They are most numerous in the Madras Presidency, where to this day they irrigate collectively an area equal to that irrigated by all the larger works which have been constructed by the British Government in that Presidency.

42. *Early development of State irrigation works under British rule* - With the early history of the construction of irrigation works by the British Government, two names must always be inseparably associated. Those of Sir Arthur Cotton and Sir Proby Cautley - the former in Southern, and the latter in Northern India. In 1836, Sir Arthur Cotton constructed what is known as the 'Upper Anicut' across the Coleroon river, so as to maintain the level required for the full utilization of the ancient dam or 'Grand Anicut' across the Cauvery, which he also strengthened and restored. To this work carried out at a cost of about 15 lakhs, the district of Tanjore, which pays annually to the State a revenue of $58\frac{3}{4}$ lakhs, owes its present agricultural prosperity. Subsequently Sir Arthur Cotton designed the works which, constructed and improved at a cost of about three crores, irrigate more than two million acres in the Godavari and Kistna Deltas. It would be difficult to find in any country three works of similar magnitude or cost which have conferred the same degree of benefit upon the people and the State.

43. In Northern India, at a still earlier date, during the administration of the Marquis of Hastings (1814-1823), the canal of Ali Mardan Khan, on the western bank of the Jumna, was restored, and the work of reconstructing the eastern canal was put in hand. Subsequently, in 1837, Captain Cautley, an Artillery Officer quartered at Dehra, a town which from some time in the seventeenth century had been supplied with drinking water by means of a small canal from the Rispana river, was deputed to make an estimate of the cost of a small canal from the Tons, a tributary of the Jumna. Here, and subsequently on the Eastern Jumna Canal, Captain Cautley gained the knowledge and experience which he afterwards utilized to such wonderful effect in the construction of the great Ganges Canal - a work which in magnitude and boldness of design has not been surpassed by any irrigation work in India or elsewhere. By the construction of this work was laid the foundation of the numerous large canal systems which now carry their waters so widely over the plains of North-Western India.

44. *Cultivated and irrigated areas* - The present state of development of Government and private irrigation works will be described in subsequent chapters of this report. It will, however, be convenient to show here the total areas irrigated in the various provinces, and by works of all kinds. The area irrigated in each province is shown in the following statement, and is compared with the total area, the population, and area annually under crop. The areas sown and irrigated are gross areas; that is, areas which are twice sown, or twice irrigated, are included twice over. For Bengal, accurate statistics are not available, and the areas entered as sown and irrigated are based upon an estimate supplied by the Director of Agriculture:-

Provinces	Area in square miles	Population	Average area annually sown	Area ordinarily irrigated	Percentage of irrigation on area sown
			Acres	Acres	
Punjab	114,000	22,357,000	28,207,000	10,430,000	37.0
Bombay	76,000	14,529,000	24,327,000	1,077,000	4.4
Sind	47,000	3,211,000	3,323,000	2,923,000	88.0
Madras	142,000	37,690,000	36,574,000	10,532,000	28.8
Central Provinces	87,000	9,877,000	16,814,000	700,000	4.2
Bengal	151,000	73,047,000	63,664,000	6,349,000	10.0
United Provinces	107,000	47,692,000	41,086,000	11,055,000	26.9
Upper Burma	87,000	3,846,000	4,666,000	828,000	17.7
Baluchistan	22,000	308,000	....	5,000	...
Ajmer-Merwara	3,000	477,000	388,000	142,000	36.6
Berar	18,000	2,754,000	6,820,000	56,000	0.8
Coorg	2,000	181,000	195,000	1,000	0.5
Total	856,000	215,969,000	226,065,000	44,098,000	19.5

45. The figures show that out of 226 million acres annually under crop in the irrigating provinces of British India, in round numbers 44 million acres, or $19\frac{1}{2}$ per cent, are ordinarily irrigated. The areas in the various provinces are, however, liable to considerable fluctuations. Thus in the United Provinces, with a good monsoon followed by good winter rain, the area irrigated by works of all kinds may fall to under six and-a-half million acres; while in a dry year it rises to over twelve millions. On the other hand, a drought reduces the supply available from tanks in all parts of India, and there is a corresponding reduction in the area irrigated by this class of works. Similarly in Southern, and in some parts of Northern India, a prolonged drought greatly reduces the area irrigated from wells.

46. *Areas irrigated by State and private works of all kinds* - The following statement shows the areas irrigated by each class of works, both State and private; and the percentage which the area under each class bears to the whole irrigated area:-

Class of work		Area irrigated by each class of works	Percentage of total irrigated area
State works		Acres	
Canals		15,644,000	35.5
Tanks		2,944,000	6.7
	Total	18,588,000	42.2
Private works			
Canals		1,235,000	2.8
Tanks		5,194,000	11.8
Wells		12,895,000	29.2
Other sources		6,186,000	14.0
	Total	25,510,000	57.8
	Grand Total	44,098,000	100.0

Of the total area irrigated, $18\frac{1}{2}$ million acres or 42 per cent is watered by State works, and $25\frac{1}{2}$ million acres or 58 per cent from private works. Of the latter rather more than one-half is from wells. The area shown 'under other sources' of private works includes a large area (5,000,000 acres) irrigated in Bengal from private canals and from water held up in natural depressions and in shallow artificial tanks.

47. *Increase in irrigated area during the past 25 years* - In the statement given on page 86 of the Report of the Famine Commission of 1878-80, the area ordinarily irrigated in British Territory in a favourable year is said to have amounted to 29,220,000 acres or 14.8 per cent of the 'cultivated area.' It is not easy to understand

how the figures for some of the provinces were arrived at, and certainly in the case of the United Provinces the irrigated area appears to have been considerably overestimated. In those provinces, during the past 28 years, there has been an increase of $1\frac{1}{2}$ million acres in the areas irrigated by Government works, and of at least $\frac{3}{4}$ million acres in the area irrigated by wells. The area irrigated in a favourable year should, therefore, have risen from $11\frac{1}{2}$ to $13\frac{3}{4}$ million acres, but in the most favourable recent year the area did not exceed $12\frac{1}{4}$ million acres. Twenty-five years ago the statistics of areas irrigated by private works were not sufficiently accurate in many of the provinces to admit of reliable estimates being framed. It seems useless therefore to compare our figures with those given by the Famine Commission. There are, however, accurate statistics which show that during the past 25 years the area irrigated by Government works has been increased by 8 million acres, or by eighty per cent; and from an examination of such records as are available, we have no doubt that within the same period the area irrigated by private works has been increased by at least three million acres. There has therefore been within the past 25 years a total increase of not less than 11 million acres, or of 33 per cent, in the area irrigated in British territory.

48. *Irrigation in Native States* - For the more important Native States, excluding those of Burma and Baluchistan, it has been possible to obtain what appear to be fairly correct statistics of the irrigated areas. In the case of some of the smaller States the correctness of the figures supplied to us is open to doubt. In the following statement we summarise the information which has been furnished to us:-

State or administration	Area to which statistics refer	Population	Average are annually sown	Area irrigated in an ordinary year	Percentage of cultivation under irrigation
	Square miles		Acres	Acres	
Baroda	8,000	1,953,000	2,550,000	184,000	7.2
Hyderabad	83,000	11,141,000	16,000,000	772,000	4.8
Mysore	28,000	5,449,000	6,132,000	945,000	15.4
Central India	69,000	5,920,000	10,668,000	595,000	5.6
Rajputana Agency	113,000	8,475,000	6,491,000	1,172,000	18.1
Madras States	9,000	4,144,000	1,090,000	625,000	57.3
Bombay States	60,000	7,254,000	20,131,000	963,000	4.8
Bengal States	7,000	877,000	1,237,000	353,000	28.5
United Provinces States	1,000	533,000	402,000	39,000	9.7
Punjab States	35,000	4,220,000	4,225,000	1,958,000	46.3
Central Provinces States	25,000	1,360,000	2,150,000	157,000	7.3
Total	438,000	51,326,000	71,076,000	7,763,000	10.9

49. *Total irrigation in the Indian Empire* - A number of States in which there is little or no irrigation have been omitted from the statement above; besides many smaller States for which no information is available. Most of these latter are, however, situated in Bengal or in hilly tracts, and the irrigated area within them must be inconsiderable. From the figures for some of the States the areas of *jagir*, or alienated, lands are excluded. Making an allowance for this, and for the States from which no returns have been received, the total area irrigated annually within the Indian Empire, excluding the Native States of Burma and Baluchistan, is estimated at about 53 million acres. Of this area 19 million acres are irrigated from canals, 16 million from wells, 10 million from tanks, and 8 million from other sources.

CHAPTER II - THE LIMITATIONS OF IRRIGATION

50. *Small percentage of rainfall now utilized in irrigation* - The data required for determining the extent to which the rain-water is utilized for irrigation, are in many respects incomplete. The

actual volume of the rain which falls annually over the greater part of the country, can be ascertained with a near approach to accuracy from the very complete data published by the Meteorological Department. But for determining with scientific exactness the proportion of the rainfall which flows off the ground surface, and which might be made available for canals or for storage, the necessary information is not available for many of the most important river-basins. For the Godavari, Kistna, Cauvery, Penner, Palar, and Ponnair, there are records of the surplus flow, from the greater part of the catchment, extending back for a sufficient number of years to admit of a fairly accurate estimate being framed of the average flow; and in the case of the Indus the detailed observations made during recent years by the Indus River Commission are of material assistance. For the Ganges also the daily gauge readings at Benares, and the few observations which have been made of the flow in the river, afford material for a rough estimate of the average flow past that place; and for the Mahanadi records are available of the daily discharge throughout one recent year. But for the Ganges below Benares, for the Nerbudda, Tapti, and Subarnrekha, there are no records to show the surplus passing to the sea. In these cases reliance must be placed upon a co-efficient of run off, selected with regard to the rainfall and other conditions, and to the co-efficient of actual flow determined for other catchments. The estimates arrived at by this method must be regarded as mere rough approximations. There are, moreover, no records to show what percentage of the volume used for irrigation is restored to the rivers by percolation through the subsoil or otherwise. It is, however, probably very much less than is indicated by observations made in America, and for our purposes it will be sufficiently correct to assume that the total surface flow is made up of the volume passing to the sea plus that utilized for irrigation. Nor are the records of the volumes used in irrigation always procurable; but for most of the larger and for many of the smaller works, accurate records are kept of the volumes entering the main channels. Figures can, therefore, be arrived at, which, as a whole, will exhibit fairly correct results.

51. In the accompanying diagram [not given here] we show, with as near an approach to accuracy as seems possible with the data at present available, the total volume of rainfall over the catchments of the principal rivers or groups of rivers, the resulting surface flow, and the extent to which that flow is utilized in irrigation. The area included in our estimate comprises the basins of the Indus and Ganges, and the rest of India which lies between their southern boundaries and Cape Comorin; the catchment basins of the Brahmaputra, and of the Irrawadi and other Burmese rivers, and all that part of Baluchistan which lies westward of the Indus watershed being excluded from the calculation. Over this area, covering 1,434,000 square miles, the average annual rainfall is $37\frac{1}{2}$ inches, giving a total volume of 125 billion cubic feet of water. Of this, a volume of 51 billion cubic feet, or 41 per cent, results in surface flow; and of this again $6\frac{3}{4}$ billion cubic feet is held back or diverted for purposes of irrigation. Of the water which is thus held back or diverted, only a proportion, certainly not more than 50 per cent, is actually delivered on to the fields. But if the whole volume were to reach the fields, it would represent a depth of $3\frac{3}{4}$ feet over the total area of 40 million acres which, making a rough allowance for areas watered by river floods, may be taken as the area irrigated from all sources except wells. The depth varies from about $2\frac{3}{4}$ feet in the Northern India, where the irrigation is chiefly that of *rabi* crops from canals and natural depressions, to a feet or more on the rice fields of Southern India.

52. Of the 59 per cent of the rainfall which remains to sustain plant life, to evaporate into the atmosphere, to moisten or saturate the soil, or to replenish the waters of the subsoil, a small percentage is drawn off through wells and utilized for irrigation. There are very few data available for estimating this percentage with any pretence to accuracy. But in Northern India, where three-fourths of the well irrigated area is to be found, the aggregate depth of the waterings given to each crop does not, on the average, exceed a foot in depth. In Southern India, where sugarcane

and garden crops constitute a large proportion of the area watered from wells, the total depth of the waterings may be taken at two and-a-half feet. At a rough estimate, therefore, one billion cubic feet, or 0.8 per cent of the rainfall, is utilized in well irrigation.

53. Thus, roughly, it may be said that, out of a total rainfall averaging $37\frac{1}{2}$ inches in depth, 59 per cent, or 22 inches, is absorbed in sustaining plant life, in maintaining moisture in the soil, and in replenishing the subsoil water-supply, or is lost by evaporation; 6 per cent, or $2\frac{1}{4}$ inches, is utilized in artificial irrigation of all kinds; while the balance of 35 per cent, or $13\frac{1}{4}$ inches, is carried away by the rivers. Again, according to our calculations the surface flow amounts to 51 billion cubic feet, and of this only $6\frac{3}{4}$ billion cubic feet, or 13 per cent, is utilized in irrigation. The balance of $44\frac{1}{4}$ billion cubic feet, or 87 per cent of the total surface flow, passes to waste in the sea.

54. By those who have no knowledge or only an incomplete knowledge of local conditions, it may be thought that a large part of the great volume of water, amounting to more than 44 billion cubic feet, which now passes uselessly to the sea, might have been utilized, or could be utilized in the near future, for an enormous extension of irrigation and the effectual prevention of famine. We have seen that, although there are extraordinary local variations of the rainfall, the total amount received over the whole of the Indian Peninsula does not vary very appreciably from year to year. Why then, it may be asked, should it not be possible to utilize the surplus of one tract to make up the deficiency of another; or, where the physical conditions render this impossible, why should not the surplus of wet years be stored up in readiness for a year of drought in every tract of which the rainfall is liable to failure? We are, as we shall presently show, far from considering that irrigation in India has reached its ultimate limit. We cannot state, as the result of our inquiries, exactly what that limit may be; but we are convinced that there are many parts of India where the utmost use of every available means of irrigation will fail to afford complete protection against failure of the rainfall. It seems necessary, therefore, to state a few facts and considerations in order to dispel any erroneous impressions that may have arisen from a study of the figures which we have given, and to prevent over-sanguine expectations being raised as to the possibility of utilizing in irrigation any very large share of the enormous surplus volumes which our calculation shows to be carried off annually by the rivers of India.

55. *Conditions limiting the extension of irrigation* - The main conditions imposing a limit to the use which can be made of the surplus drainage of the country for the prevention of famine are:

(1) the geographical and seasonal distribution of the rainfall;
(2) the physical configuration of the country;
(3) the difficulty of holding up water stored in years of good rainfall as a provision against a year of drought;
(4) the character of the soil; and
(5) the large number of different States and territories into which the country is divided and sub-divided.

56. *Limitations imposed by the distribution of the rainfall* - In its geographical distribution, the rainfall displays a diversity which is said to be without parallel in any other country in the world; the average annual fall varying in different localities from under five to nearly five hundred inches. Leaving mere questions of distance and cost of consideration, the general contour levels of the country will frequently offer an insuperable obstacle to the transfer of water from regions of copious and assured rainfall to those where it is scanty and capricious. At the same time, the seasonal distribution of the rainfall, which is confined for the most part to a few months of the year, presents a condition most unfavourable to its economical storage and use; for if the water is to do more than merely tide the autumn crop over breaks in the monsoon, the storage reservoir must be made large enough to carry the subsequent crop to maturity by means of the volume stored in a single rainy season. Over the greater part of the country, there is little or no chance of subsequent rain refilling the reservoir after its water has been

partially utilized.

57. *Difficulties connected with the surface conformation* - The general conformation of the surface adds still further to the difficulty and cost of storage. On the flat surface of the alluvial plains of Northern India, storage on any considerable scale is, as we have said, almost impossible. If we allow for evaporation and percolation, it involves generally the submersion of an area at least as large as that which would receive benefit from the water. There are no doubt portions of these plains in which water is held up by embankments during the rainy season so as to moisten the lands above and prepare them for the autumn sowings. But this can hardly be designated storage in the proper sense of the word; and the system is adopted only when the rainfall is especially liable to failure; and the population so scanty that the loss of the submerged land for the growth of the *kharif* crop becomes a matter of secondary consideration.

58. On the other hand, in the Western Ghats, where the assured rainfall might be stored at a sufficient elevation to admit of its being carried into tracts where the rainfall is scanty and peculiarly liable to failure, the steep slopes of the valleys necessitate, as a rule, the construction of a dam at least one hundred feet in height if water is to be stored in any considerable volume; and for this, sound foundations and suitable materials within a reasonable distance are essential. Again, if these are procurable, the site must be such that the length of the dam shall not make the cost prohibitive in proportion to the volume stored; and when all these advantages have been secured, the construction of the work may involve the submergence of many thousand acres of what are generally the most fertile lands, or even the removal of whole towns or villages. The future safety of the work will depend upon adequate provision being made for the discharge of flood water during cyclonic storms, and this, in many otherwise excellent sites, can only be arranged for at an enormous outlay. Finally, the construction of the necessary works for carrying the supply across the rough and broken surface of the country to the area requiring irrigation, may involve the most serious difficulties, and necessitate the rejection of a site that would be suitable in all other respects. Many of these difficulties could, no doubt, be disposed of, if no regard were paid to the cost. But, even where the object is prevention of famine, there is a limit to the expenditure which the general community can be expected to incur for the benefit of a particular tract.

59. *Impossibility of conserving water for a year of drought* - With regard to storing the rainfall of good years for use in a year of drought, we may say that if there is one point upon which our inquiries have convinced us, it is that where, as in many parts of India, the only possible source of supply is in uncertain and often insufficient rainfall, it will not be possible to provide, at any practicable cost, the amount of storage required to counteract the effects of severe and prolonged drought. There are no means of predicting a year of drought, and any attempt to hold over water, even from one year to the next, would entail the loss of an enormous proportion of the supply by evaporation and percolation. In these circumstances it would obviously be bad economy, and fatal event from a purely protective point of view, to limit the cultivation under a tank, and to refuse to give out water to the cultivators, which they could utilize advantageously from year to year, in order to hold it up as an insurance against a possible drought. The drought might come next year; but on the other hand it might not come for five or even ten years, and meanwhile the cultivators would have been deprived of all the benefits which they might have derived from the annual use of at least twice the quantity of water that could be held over for the year of drought. Moreover, famine is not usually the result of one dry year. The worst famines have been the result of two or even three dry years in succession; and whatever might be the possibility of holding over water for the first dry year, to do so for the second or third would be entirely out of the question.

60. *Unsuitability of soil* - We have already referred to the general unsuitability to irrigation of the black cotton soils which cover such a large portion of the area of India. In addition there are large areas of inferior sandy or stony soils which would never repay the cost of artificial watering. And, we may add, there are enormous areas of forest and uncultivable waste, where water cannot be used, however great the facilities for providing

it. In British territories alone, in the area under consideration, the forests cover an area of more than eighty thousand square miles, or eleven per cent of the surface; and there is nearly twice that area of uncultivable waste. About one hundred and twelve thousand square miles are said to consist of lands fit for cultivation which are now lying waste, but a very considerable proportion of this has a soil too poor to repay the cost of cultivation.

61. *Territorial difficulties* - The numberless territorial divisions of the country, and the manner in which the various States and territories are intermingled, have also been a material obstacle in the past to the development of irrigation. The only suitable site for a storage work may lie in a territory whose people would not only derive no benefit, but might even be put to considerable loss and inconvenience, by the construction of the work; or the full utilization of an available supply may only be possible by the co-operation of two or more States who are unwilling to combine. We have found numerous instances in which these and other territorial considerations have offered in the past a serious hindrance to the construction of irrigation works; but we believe that in the settled condition of the country, these difficulties will be found capable of adjustment by friendly co-operation of the States concerned with each other and with the Supreme Government.

62. *Limiting effects of the conditions in certain river basins* - The general effect of each or all of these obstacles in retarding or hindering the utilization of the surface drainage in the development of irrigation, will best be exemplified by a brief survey of the general conditions in the catchments of some of the principal rivers.

63. The Palar river in the Madras Presidency affords an excellent instance of the extent to which, under favourable conditions, the surface waters can be stored or diverted on to the land; and yet of their inadequacy under certain conditions to afford full protection against drought, even when supplemented by a fair share of well irrigation. Within this catchment the surface conformation is generally favourable to the construction of tanks; and the rainfall, due to both monsoons, is spread over seven or eight months of the year, so that in ordinary years the tanks are frequently refilled after a portion of the supply has been drawn off for irrigation. To such an extent have these facilities been utilized that in most years there is but little surplus flow from the basis of this river. Almost the whole of the available rainfall from an area of nearly 9,000 square miles, lying in this and the adjoining minor river-basins, is stored in tanks or diverted into canal channels. And yet the Madras districts of North Arcot and Chingleput, and the eastern portion of the Kolar district of Mysore, which lie in this area, are liable to suffer periodically from scarcity or famine. They have suffered severely from failure of the rainfall as recently as in 1891 and 1896, although in both of those years practically no water was allowed to run to waste. Nor can it be said that water could have been stored from the surplus of the preceding years; for , if the small surplus volume of each of those years had been stored, it could have had no appreciable effect in increasing the area under irrigation.

64. South of the Palar lie the basins of the Ponniar and Cauvery rivers, in each of which nearly 60 per cent of the surplus flow is used in irrigation. To proposals for drawing off further supplies from the Ponniar catchment, the French Government have raised objections on the ground of possible reductions in the supplies now available for their existing irrigation works in Pondicherry. In the case of the Cauvery, of which one-third of the total catchment of 31,000 square miles lies in the Native State of Mysore, the main obstacle to the further utilization of the surplus flow resulting from an average rainfall of 38 inches, lies in the fact that, throughout the upper part of its course, the river flows through a deep and wide valley at right angles to the general direction of the drainage from the Western Ghats on its right bank. It thus cuts off all this drainage from the dry tract on its left bank where the water would be of the greatest value. This tract therefore is dependent for its irrigation upon a local rainfall which, though usually sufficient, has sometimes failed. When, as in 1875-76, the drought is prolonged, the tanks and all local sources of irrigation must, as we have shown, fail to afford full protection to cultivation.

65. Selecting now an instance from the more central portion of the peninsula, we find that in

the basin of the Godavari $12\frac{1}{2}$ per cent of the flow from a catchment of 121,500 square miles, with an average rainfall of 43 inches, is used in irrigation. But of the volume thus utilized 33 per cent is accounted for in an area of under 2,000 square miles where, near the mouth of the river, the first surface of the delta affords excellent facilities for the irrigation of the greater part of its area. Only 8 per cent of the total flow is utilized in the rest of the catchment, while the balance of $87\frac{1}{2}$ per cent, more than $3\frac{1}{2}$ billion cubic feet, passes away in floods, chiefly during the short period of the south-west monsoon. A small percentage of the surplus can be utilized in the Bombay Deccan if storage works are constructed, as we have recommended, on the main river, or on the Mula, or at Maladevi on the Pravara; a little more could be utilized in the valley of the Wainganga tributary, a comparatively small tract in which until recently the rainfall has never seriously failed; and small works may be proposed in the upper part of the Godavari district in Madras. There is little scope, elsewhere in British territory, for the further utilization of the surplus flow. Nearly one-half of the whole basin lies in the territories of Native States; and of the area in British territory over a third consists of black soils which are generally unsuited to irrigation.

66. In the adjoining basin of the Krishna, or Kistna, river there is an average rainfall of 34 inches, of which 38 per cent, or a volume of 3 billion cubic feet, results in surface flow. Of this only 355,000 million cubic feet or 12 per cent is now utilized in irrigation. Within this catchment lies a larger extent of exceptionally insecure country than is to be found in any other river basin in India, and within a hundred miles or less of a great part of that area stretches a long strip of hilly country within the region of the assured rainfall of the Western Ghats. We have already referred to the obstacles which interfere with the full utilization of this abundant and certain supply. But we are hopeful that within the next twenty years it will be found possible to store or divert sufficient water for the irrigation of a considerable area in the insecure Deccan districts of Bombay. There are also possibilities of irrigating a very large area in the equally insecure Deccan districts of Madras, and in the adjoining district of Nellore. In Mysore, the great Marikanave tank will afford the means of storing 30,000 million cubic feet - a volume but little short of that held up by the great Nile reservoir at Assuan; and there are, in addition, a number of minor schemes proposed for the utilization of the supplies of the smaller rivers or for the storage of local rainfall. This river basin will therefore be the great field of operations for the construction of protective irrigation works during the next twenty or thirty years. But if every project that has been proposed by us or brought to our notice is pushed to completion, the result will be to effect a reduction of not more than two-thirds of a billion cubic feet, or of about one-fourth, in the volume now running to waste. Sixty-five per cent of the total surface flow will still pass to the sea.

67. In Orissa, the Mahanadi, Brahmani, and Subarnrekha, carry annually to the sea more than 5 billion feet or 97 per cent of the water which flows on their catchments. With a fairly steady rainfall which averages over 54 inches, and which falls below 50 inches only in one small tract, there is but little demand or necessity for irrigation over the greater part of the basins of these rivers.

68. To the west of the Mahanadi, and flowing westward, the Nerbudda and Tapti carry into the Arabian Sea 99.9 per cent, or practically all, of the surface drainage from an area of 65,000 square miles. The prevalence of black cotton soil throughout almost the whole of the catchments of these rivers accounts for the infinitesimal percentage of water utilized. We do not despair of the possibility of making some use of the water in certain tracts of suitable soil, but at the best there will be held back from the sea only a mere fraction of the $2\frac{1}{2}$ billion cubic feet of the surface drainage of these two river catchments.

69. Finally, before leaving the peninsula and passing to Northern India, we may point to the enormous volume of 8 billion cubic feet, or nearly 16 per cent of the whole surface flow of India, which annually rushes down to the Arabian Sea from the steep slopes of the Western Ghats. By the bold device of constructing a reservoir at Periyar on the outer slopes of the Ghats, and carrying the water by means of a tunnel through the intervening hill on to the eastern table-land,

the Madras Government have been able to utilize about 10,000 million cubic feet or 0.125 per cent of this flow. The chances of being able to repeat this measure in the Ghats further north do not appear to be promising. No final opinion can be passed upon this point until every possible site has been examined; but there are certainly no prospects of ever making any appreciable reduction in the enormous volume now annually lost along this coast.

70. In Northern India, in the great valley of the Indus river, we find conditions which are on the whole exceptionally suitable for the effective utilization of the surface waters. The snows and glaciers of the Himalayas provide storage on a scale that man cannot hope to rival; the level alluvial plains lend themselves to the economical construction of large canals; while the demand of the thirsty soil for water renders all such works remunerative in the highest degree. And yet, under these exceptionally favourable conditions, only 9 per cent of the total rainfall, or 30 per cent of the surface flow, is retained for purposes of artificial irrigation. We have no doubt that, notwithstanding the enormous areas already irrigated in this catchment, amounting if well irrigation be included to 18 million acres, it will be possible to make very large extensions of irrigation by utilizing a portion of the present surplus drainage. But if all the works which are now conceived to be possible in the Punjab and Sind are constructed, although they may absorb an additional half billion cubic feet, not a single large tract that is especially liable to famine will be appreciably affected thereby, and 60 per cent of the surface water will still run to waste in the sea. No human skill or ingenuity will carry any portion of this volume of $3\frac{1}{2}$ billion cubic feet to the high lying plains of Jaipur and Marwar, or over the ridge of the Indus valley to famine-stricken tracts in other parts of India.

71. In the Ganges Valley, with a more copious rainfall and consequent smaller demand for water, out of 17.5 billion cubic feet of surface flow, only 2 billion, or 9 per cent, is utilized. In the portion of the basin which drains into the river above Benares only 0.6 billion cubic feet is retained, although the waters of the Jumna and Ganges proper are drawn upon to the greatest extent that has been found possible by the highest engineering skill. No means have yet been found for storing any portion of the enormous floods which are brought down from the Himalayas during the few months of the monsoon season. In the outer ranges, where the rainfall is greatest, the steep valleys of the hills, with their deep and porous beds of loose boulders and shingle, hold out small hope of affording any suitable sites for reservoirs; and even if a site could be found and a reservoir constructed, it would, in all human probability, slit up in a very few years. The fine and slowly settling sediment of the Nile or the Betwa can be carried through a reservoir many miles in length, but the coarser materials of hill streams sink to the bottom as soon as their velocity is appreciably checked. On the right bank of the Jumna, in the tract drained by the large tributaries of that river, with their sources in the Vindhyas or the table-land of Central India, more than three-fourths of the catchment lies in the territories of Native States. In the comparatively small tract in British territory there are, no doubt, at least six districts which are peculiarly liable to suffer from drought; and to some of these it will be possible, although at a considerable annual loss to the State, to afford a fair measure of protection by storing and utilizing a portion of the supplies of the larger rivers. But there will still remain a number of tracts in which the sources of irrigation will lie in a deficient and capricious local rainfall. And, even if every measure which might reasonably be contemplated for increasing the area of irrigation in these British districts is carried to completion, the addition to the utilized volume will not exceed 200,000 million cubic feet. Thus more than 85 per cent of the surface drainage will still flow past Benares.

72. Over the catchment which drains into the river below Benares the rainfall gradually increases towards the north, east, and south, both in amount and certainty, and there is a corresponding reduction in the need for irrigation. There lie, however, within this portion of the catchment many tracts which are to a greater or less extent in need of further protection. But, when in the whole catchment of the Ganges all has been done that can be done, it may safely be asserted that, unless there is a remarkable change

in the physical or agricultural conditions, the river will still carry annually to the sea at least 15 billion cubic feet of water. Thus, from this single catchment and from the outer slopes of the Western Ghats, there will still be a loss of over 23 billion cubic feet - a volume which falls but little short of half the total surface flow of India, excluding Burma and Assam.

73. In another chapter we put forward a programme of new irrigation works, which should, if completed, have the effect of increasing the area under irrigation by $6\frac{1}{2}$ million acres. This will involve the subtraction of about one billion cubic feet only, or of less than $2\frac{1}{4}$ per cent of the surplus volume which now runs to waste in the sea.

74. *Limits to the extension of well-irrigation* - In the preceding paragraphs we have discussed the limits up to which irrigation from the surface flow of water is capable of extension. There remains the question of the degree to which the subsoil water-supply can be more widely utilized than at present. We have estimated the volume of water expended on irrigation from wells at about one billion cubic feet, or not more than $1\frac{1}{2}$ per cent of that portion of the rainfall which penetrated the soil. As far as supply is concerned, this percentage might no doubt be more than quadrupled; but the quantity of water in the subsoil can no more be taken as a measure of the possibilities of well irrigation, than the volume of surface flow passing into the sea can be taken as a measure of the possibilities of irrigation by works other than wells. The limitations, however, to which irrigation from wells is subject are no less positive and definite than those of irrigation from the surface flow. The soils and crops which are unsuited to the latter class of irrigation, are generally equally unsuited, and in some cases even less well suited, to the former. Thus on some black soils, even where canal or tank irrigation might prove advantageous, at any rate in a year of drought, well-irrigation very often would not pay, owing to the inordinate expense of raising the large quantities of water required. For the maturing of the rice crops well irrigation rarely, if ever, pays. But the principal distinctive limitations to the extension of well-irrigation consist in the amount and quality of the subsoil supply, the depth at which it is found below the surface, the conditions of soil and subsoil favouring or impeding construction, and the consequent expense of construction and raising the water. In the alluvial tracts of Northern India, down to the line of the Jumna river, the subsoil supply of good water is practically inexhaustible, and its depth generally moderate; the soil and subsoil also generally favour construction. It is difficult, therefore, here to place any limit to the eventual extension of well-irrigation, except the requirements of cultivation. There are already districts of the Punjab and United Provinces which have all the wells they require. South of the Jumna the water lies deeper, and is less abundant; it is also more liable to exhaustion in times of drought; rock has to be penetrated, and the expense both of construction and lifting is greater. In addition more numerous waterings are required, the total area irrigated is smaller, and well-irrigation generally does not pay except for a valuable crop. Here the extension of well-irrigation must be exceedingly gradual, and can only increase *pari passu* with a development of the general resources of the people. But while this extension cannot be rapid, it can and doubtless will continue long after the extension of irrigation by flow has ceased; and it may not be over-sanguine to look forward to a period when the area under well-irrigation throughout India will have doubled. At the same time, there will always remain extensive tracts, such as the black soil plains and stony uplands of the Deccan trap and crystalline areas, where wells are impossible or will never pay; and which will be protected from famine, by means of irrigation, no better than at present, notwithstanding the utmost development which may be effected in the multiplication of wells.

75. *Conclusions* - From this brief sketch of the conditions prevailing in a number of the principal river-basins, and of the general conditions imposing a limit to the extension of well-irrigation, it should be evident that in many tracts which are necessarily dependent upon the local rainfall, even the utmost possible use of the available supplies of water will fail to afford complete protection against famine; that the volume of the rainfall, or of the waters which pass

unused to the sea or percolate into the subsoil, affords no index to the possibilities of extending irrigation; and that the limits to its further extension are those imposed by the local and other conditions which have here been briefly indicated, and which are discussed in fuller detail in subsequent chapters of this report. But, although there are limitations to the protection that irrigation can be made to afford, the very impossibility of its affording complete protection makes it all the more incumbent to utilize to the utmost such means as exist for its extension.

CHAPTER III - STATE IRRIGATION WORKS

76. *Classes of works* - The State irrigation works in India consist essentially of two kinds: small works originally constructed by the former rulers of the country or the owners of the soil and now controlled and maintained by Government; and large works which have been constructed or reconstructed by the British Government as productive or protective public works, or, in other words, as financial investments which were expected to be either directly or indirectly remunerative. The most important, though not all, of the latter are technically classified as 'major works,' while the class 'minor works' includes all of the former and also a few of the latter. The minor works consist for the most part of small local works which are maintained by Government in consideration of the revenue derived from or dependent upon them, but so little capital outlay has been incurred on them by the British Government that capital accounts have not been opened for them. Between works of this kind and major works there is, however, an intermediate class, known as 'minor works for which capital and revenue accounts are kept.' Some of the works in this class are old native works which have been improved or enlarged by Government at a considerable cost; others are new works, generally of small size, which have been constructed by the British Government, but which have not, for reasons which it is unnecessary now to consider, been classed as major works. State irrigation works must, therefore, be considered under three heads:-

(a) Major works.
(b) Minor works for which capital and revenue accounts are kept.
(c) Minor works for which capital accounts are not kept.

MAJOR WORKS

77. *Financial results* - The following table exhibits the financial results attained on major works during the year 1900-01, which may be regarded as fairly normal in the aggregate, though not in all cases for individual provinces:-

Province	Number of works	Capital outlay to end of 1900-01	Percentage of Net Revenue		Total area irrigated in 1900-01	Average Rates per Acre		
			On total capital outlay	On gross revenue		Average value of crops	Revenue assessed	Working expenses
		Lakhs of rupees			Acres	Rs	Rs	Rs
Punjab	7	10,73.0	10.5	70.0	4,642,852	27.5	3.4	1.1
Sind	5	1,79.3	7.7	76.5	961,434	15.6	1.9	0.4
Bombay	9	1,87.6	1.2	52.2	84,472	77.2	4.8	2.5
Madras	9	7,29.6	8.5	79.6	2,915,271	36.7	4.1	0.9
Bengal	3	6,16.8	0.8	28.8	716,271	34.4	1.9	1.7
United Provinces	6	8,77.4	7.3	66.4	1,888,091	39.2	4.3	1.7
Total	39	36,63.7	7.1	67.8	11,208,391	31.6	3.5	1.1

It will be seen that the works in Bombay (Deccan and Gujarat) and in Bengal do not earn enough revenue to cover the interest charges on capital outlay. Not one of the twelve works in these provinces has proved remunerative, and with the possible exception of the Sone Canals in Bengal, there is no prospect that any of them will ever become so. In all other provinces the works, as a whole, have proved highly remunerative; but there are three works in Madras, and one in the United Provinces, which give no promise of ever fulfilling the conditions of a productive public work. Nevertheless, taking the works for all provinces together it will be seen that regarded merely as a financial investment the works have been very profitable, and now yield a net revenue which is equivalent to a return of 7.1 per cent on the capital cost, and some of the works, however, are not yet fully developed, and a higher return than this may be confidently anticipated in the future.

78. *Protective value* - It would be difficult to overestimate the value to the country of these fine systems of irrigation works, which may be said, with some slight reservation in respect of the Cauvery works in Madras, to have been entirely created by the British Government within the last eighty years. They irrigate annually over 11 million acres, and completely protect from famine an area which, except in the Madras and Orissa deltas, may be said to vary from twice to four times the area annually irrigated. In some parts, as in Sind, there can be no cultivation, and therefore no population, without canal irrigation. In others, the effect of the works in maintaining or raising the level of the subsoil water, on which the well-irrigation depends, is of the utmost value and importance. The value of the crops irrigated by the canals in a single year is about equal to the whole capital cost of the works; and in years of famine the produce of the irrigated area, being largely available for transport to distressed tracts, becomes an important item in the general food supply of the country.

79. *Magnitude of the works* - Excluding the Cauvery works, which merely regulate the supplies in the river channels of the delta, the combined discharging capacity of the head channels or main lines is over 100,000 cusecs.* The works in Bombay and Madras have also storage reservoirs with a combined storage capacity of over 30,000 million cubic feet, while the total length of Government channels, including main lines, branches, and all distributaries, is about 36,000 miles. It may be added that the table which we have given does not include two important works which were completed and opened in 1901-02, viz., the Jhelum Canal in the Punjab and the Mandalay Canal in Burma. These two works will probably irrigate before long over 700,000 acres.

Minor Works for which Capital and Revenue Accounts are kept

80. *Character of the works* - Under this head are included a fw small works which have been initiated and carried out by the British Government, but the majority of the works of this class were constructed by former rulers of the country or in their time. They have, however, been enlarged and improved by means of expenditure which has been charged to a capital account, and the works are credited with the increase of revenue which is attributable to that expenditure. In the Punjab and in Sind, minor works consist almost entirely of groups of inundation canals from the Indus or its tributaries, which irrigate very large areas. In other provinces they consist partly of tanks or storage reservoirs, and partly of small canals or groups of canals which generally take off from above weirs built across the smaller streams of the country. There are, in all, seventy-three minor works for which capital accounts have been opened.

81. *Financial results* - The following table shows the financial results attained on these works during 1900-01:-

* Throughout this report the word 'cusec' is used for 'cubic foot per second'.

Province	Number of works	Capital outlay to end of 1900-01	Percentage of net revenue in 1900-01 on capital outlay	Area irrigated	Rate of revenue assessed per acre
		Lakhs of rupees	Per cent	Area	Rs
Punjab	5	25.46	12.8	602,189	1.8
Sind	7	39.84	26.2	882,956	2.3
Bombay	27	74.47	-1.6	39,922	1.7
Madras	24	97.90	5.2	511,603	3.3
Bengal	1	7.06	-0.2	-	-
United Provinces	4	29.70	5.1	113,793	2.3
Rajputana	3	29.49	-0.1	34,767	3.8
Baluchistan	2	16.12	0.8	5,232	6.7
Grand Total	73	320.04	6.0	2,190,462	2.4

In Bengal and Bombay these minor works are, it will be seen, even less remunerative than the larger systems; in fact they fail to yield a net revenue sufficient to cover the working expenses. The works in Rajputana and Baluchistan are also unremunerative, but for the former province the results for 1900-01 are distinctly below the average, and in all ordinary years a return of 2 or 3 per cent, is realized. Taking the works as a whole, it will be seen that they yield an average return of 6 per cent on capital cost, and are almost as profitable to the State as the major works. This result, however, is mainly due to the large returns earned by the inundation canals in Sind and the Punjab.

82. *Protective value and magnitude of the works* - The works irrigate over 2 millions of acres annually, but the irrigation is more variable and uncertain than that effected from the large works, both inundation canals and tanks being liable to fail in unfavourable seasons. Nevertheless the protective value of these minor works is very great when compared with the capital outlay incurred on them. The total length of the Government channels pertaining to them exceeds 7,000 miles, and there are storage reservoirs with an aggregate capacity of over 25,000 million cubic feet.

Minor Works for which Capital Accounts are not kept

83. *Nature of the works* - We have next to consider what may be called the indigenous State irrigation works, the maintenance of which has been undertaken by Government. These works are essentially of the same kind as those which we have just been considering, the difference being that in respect of these no charges have been made to a capital account. It must not be supposed, however, that Government has never undertaken anything more than the bare maintenance. Considerable sums have been spent in improving and developing the works, but it has been found more convenient to charge such expenditure against a revenue account, and to avoid the complications of a capital account.

84. Under this head are included all the inundation canals in the Punjab and Sind which have no separate capital account, and also all the old or native irrigation works in Upper Burma, which resemble those in Southern India, and consist of either tanks or small canals taking off from above temporary or permanent weirs across the beds of minor rivers. But collectively the most important item under this head is the 40,000 tanks, river channels, or other petty irrigation works, which are to be found in the Madras Presidency, and which irrigate between them more than three million acres.

85. *Financial results* - The following statement shows the areas irrigated by all works of this class, the revenue due to them and the expenditure incurred on them during the year 1900-01:-

Province	Area irrigated	Revenue receipts	Charges	Net revenue
	Acres	Lakhs of rupees	Lakhs of rupees	Lakhs of rupees
Madras	3,173,250	79.86	22.83	57.03
Punjab	707,525	7.06	4.27	2.79
Bombay, including Sind	1,297,368	32.23	10.16	22.07
Bengal	28,619	0.26	0.41	-0.15
Burma	576,936	19.51	13.38	6.13
Total	5,783,698	138.92	51.05	87.87

Here also the revenue due to two small works in Bengal was insufficient to cover working expenses; but, taking the works in all provinces as a whole, it will be seen that they irrigate nearly six million acres, and that the outlay incurred by the State amounts to about 40 per cent of the revenue derived from them. It must be remembered, however, that part of this expenditure is incurred on improvements which will tend to increase the efficiency of the works and the amount of the revenue derived from them. This is particularly the case on the inundation canals, and on the works in Burma, where heavy expenditure has been incurred since annexation in putting the old works into thorough order, and in rendering them more substantial and permanent.

86. *General financial results for works of all classes* - The general financial results attained in the year 1900-01, on all the irrigation works then in actual operation, may now be brought together as exhibited in the table below:

Class of work	Capital outlay to end of 1900-01	Interest charges @ 4% on capital outlay	Net revenue in 1900-01	Net revenue less charges for interest
	Lakhs of rupees	Lakhs of rupees	Lakhs of rupees	Lakhs of rupees
Major works	36,63.72	1,46.55	2,59.70	1,13.15
Minor works for which capital accounts have been kept	3,20.04	12.80	19.18	6.38
Other minor works	...	...	87.87	87.87
Total	39,83.76	1,59.35	3,66.75	2,07.40

From this it will be seen that in 1900-01, which may be taken as a normal year, the net revenue derived from all the State irrigation works then in operation exceeded all charges for interest on the capital outlay and for maintenance by over two crores of rupees.

87. *Abstract of irrigated areas* - The areas irrigated in 1900-01 by each of these three classes of works in the several provinces may also be brought together as shown below:-

Province	Major works (productive and protective)	Minor works for which capital accounts are kept	Other minor works	Total
	Acres	Acres	Acres	Acres
Punjab	4,642,852	602,189	707,525	5,952,566
Sind	961,434	882,956	1,297,368	3,266,152
Bombay	84,472	39,922		
Madras	2,915,271	511,603	3,173,250	6,600,124
Bengal	716,271	...	28,619	744,890
United Provinces	1,888,091	113,793	...	2,001,884
Rajputana	...	34,767	...	34,767
Baluchistan	...	5,232	...	5,232
Burma	...	...	576,936	576,936
Grand Total	11,208,391	2,190,462	5,783,698	19,182,551

In round numbers it may therefore be said that the State irrigation works yield a net revenue after meeting all charges including interest of about two crores, and irrigate annually over nineteen million acres.

88. *Expansion of the area under irrigation since 1880 and 1898* - The Famine Commission of 1898 gave a table in paragraph 551 of their report, comparing the areas irrigated under the three classes of irrigation works known as productive, protective, and minor, during the three years ending 1896-97, with the areas during the three years ending 1878-79. We have hitherto considered productive and protective works under the one head of 'major works,' but for purposes of comparing the areas irrigated during the last four years with those given in the report of 1898, it may be convenient to adopt the classification there followed, as in the table below, in which the average areas for three triennial periods are compared with the figures for 1900-01:-

Class of work	Average area irrigated annually during the triennium ending with the year			Areas for 1900-01
	1878-79	1896-97	1899-1900	
	Acres	Acres	Acres	Acres
Productive works	4,645,091	7,774,860	10,465,882	10,868,976
Protective	...	221,030	309,566	339,415
Total major works	4,645,091	7,995,890	10,775,448	11,208,391
Minor works	5,956,277	7,290,343	6,869,355	7,397,224
Grand Total	10,601,368	15,286,233	17,644,803	18,605,615

The areas irrigated in Upper Burma, which had not been annexed in 1878-79 have been excluded from the table. With regard to them it will be sufficient to state that the areas, which are all under minor works for which capital accounts are not kept, have increased gradually from 254,000 acres recorded in 1894-95 to 576,936 acres in 1900-91.

89. *Slow rate of expansion on minor works* - An inspection of these tables shows that, although there has been a remarkable and continuous expansion since 1880 of the area irrigated by major works, the increase has been mainly under the head productive. The absolute increase of area under protective works during recent years has been small. Few works of this kind have been sanctioned, and those which have been sanctioned are not yet completed or in operation. It is more important, however, to note the very small increase which has occurred in the area under minor works. It seems probable that in the course of a few years the area under major works will be nearly three times as great as the average for the triennium ending 1878-79, but that the minor works will show an increase for the same period of less than 25 per cent. It is not difficult to account for the slow rate of increase under minor works. As long as the expenditure on the construction of new minor works, or the improvement and extension of the older works, is charged against general revenues, progress is sure to be slow and uncertain, and there is a constant tendency to restrict the grants to amounts that are hardly more than sufficient to meet the cost of upkeep of existing works. We have pointed out, in some of our Provincial Chapters, the great field which exists for extensions of the area under minor works, many of which are likely to be directly remunerative; and the figures which we are now considering confirm the conclusion that too little has been done in the past for works of this most useful class.

90. *Other State expenditure on minor works* - We have endeavoured to give in this chapter a general view of the financial, productive, and protective results attained on State irrigation works throughout India, and have referred in greater detail to particular works in the corresponding sections of our Provincial Chapters. We may observe, however, that the figures which we have given relate only to those works, the accounts and returns for which appear in the administration reports of the Irrigation Branch of the Public Works Department, and that the idea

which they give of the connection of the State with irrigation works is not quite complete. There are some works, such as the Kabul River Canal, or the Firozpur District Canals in the Punjab, or others undertaken for the improvement of estates belonging to or under the administration of Government which are carried out or managed by Civil officers, with or without occasional technical assistance from the Public Works Department, and are practically State works, but of which no account is taken in the chapter; there are also other important works which have been undertaken and carried out in Native States under the advice or supervision of Government officers. Lastly, we have excluded from these statements a considerable expenditure which is met from the minor works grant and incurred by the Public Works Department on irrigation and agricultural works, such as the flood embankments in Bengal, Burma and Madras. Works of the latter kind may have a great protective value in tracts which are liable to heavy floods, but we have thought it more convenient to confine our attention in this chapter to works which give protection against drought. It is difficult to obtain reliable information as to the protective value of flood embankments, but in Burma alone between 400,000 and 500,000 acres are annually assessed at rates averaging more than Rs 2 per acre on account of the protection afforded by such works, on which a capital outlay of nearly forty lakhs has been incurred.

91. *Comparison of areas irrigated by State and private irrigation works* - Before concluding this chapter we would invite attention to the statement given in paragraph 46, from which it appears that great as is the area which is now irrigated from State irrigation works, the area dependent on private irrigation works is even greater, although it is not always so fully and reliably protected. Out of a cultivated area of 226 millions of acres in British India over $18\frac{1}{2}$ millions receive irrigation from State works; whereas the area reported as irrigated from wells, private canals, tanks, and other sources, amounts to over $25\frac{1}{2}$ millions of acres, of which more than half is under wells. Considering both the extent and the efficiency of the protection afforded, it may be said that State and private irrigation works play an almost equal part in the protection of the country from drought. We shall consider in the two following chapters the scope which exists for the extension and development of both these means of irrigation.

CHAPTER IV
SCOPE FOR FURTHER EXTENSIONS OF STATE IRRIGATION WORKS

SECTION I - PROTECTIVE VALUE OF IRRIGATION

92. *Introductory* - It has been laid down in our instructions that the main question as regards new works is not whether they will be likely to prove directly remunerative, but whether the net financial burden which they may impose on the State, in the form of charges for interest and maintenance, will be too high a price for the protection against famine which they may be relied on to afford; and that it is from this point of view that we should consider proposals for the extension of irrigation in districts in which cultivation is very insecure and precarious. This instruction renders it necessary that we should consider very carefully the financial prospects of all proposals, with a view to determining the actual price which the State will have to pay for the protection which they will afford, and the real value of that protection.

93. *Indirect advantages of irrigation* - It has often been urged that the indirect advantages of irrigation in India are so great and incontestable that the question of the direct financial return which may be anticipated on the capital outlay is one of minor importance to which very little regard should be paid. This proposition is not likely to commend itself to those who are responsible for finding the large sums of money required for the construction and maintenance of irrigation works; and it seems desirable to form a clear idea of the nature of the indirect advantages which are claimed for irrigation works, and of their comparative, if not absolute value to the State in different circumstances. These advantages are of three kinds, each of which must be considered separately:-

(a) The increase in the general wealth and prosperity of the community resulting from the increase in the produce of cultivation due to irrigation even in years of normal or more than normal rainfall.
(b) The effect of irrigation and of large water storage works in increasing the humidity of the air, and in raising the level of the underground water-supply.
(c) The prevention or mitigation of the horrors and the cost of famine.

94. The value of irrigation in increasing the wealth and food supply of the country cannot be doubted; and although the amount or percentage of this increase varies greatly for different tracts, it can generally be estimated approximately for particular tracts in which irrigation works have been for some time in operation. There are, however, obvious limits to the permanent charges which the State may reasonably be expected to meet for the purpose of increasing the produce or the profits of cultivation in particular tracts. The value of the crops which have been irrigated in a single year is often compared with the capital cost of the works. The comparison may be interesting, but it is very misleading as an indication of the value of the work. In the first place, the value of the crops which receive irrigation from a canal does not always represent the value of the increase of produce due to irrigation. It may do so in parts of Sind and the Punjab where cultivation without irrigation is impossible, but not on the Orissa or Kurnool-Cuddapah Canals; on the former canal, owing to the generally copious rainfall, the difference in the value of irrigated and unirrigated crops is small in ordinary years; and on the latter the people find it more profitable to cultivate large areas of dry crops, for which the rainfall is ordinarily sufficient, than to put a smaller area under wet (rice) cultivation. But when the increase in the value of produce due to irrigation has been determined, it must be compared not with the capital cost of the works, but with the annual net charge for interest and maintenance which they impose on the State. We have found that there are many works on which this charge varies from Rs 5 to Rs 8 per acre irrigated. *Prima facie*, there is no more reason for calling on the State, or, in other words, on the general tax-payer, to bear a permanent charge of, say, Rs 6 per annum, for the sake of increasing by irrigation the produce of an acre of land belonging to a private owner, than there would be for calling on it to pay a similar amount for the purpose of supplying another man's acre with manure. Apart from the question of famine protection, which will be considered separately, the maximum permanent charge which the State may reasonably undertake in providing irrigation, should theoretically be limited by the share of the increase in the value of produce due to irrigation which it will be able to recover indirectly. It is hardly necessary to say much here as to the manner in which a share in the increase of the wealth of the community comes back, in some indirect form or other, to the State, as by the increase in railway earnings or in the revenue derived from excise, stamps, income-tax etc., or by other ways in which the State shares in the prosperity of the country; but a measure of this share may be proposed which will be sufficient for our present argument.

95. The best measure of the increase in the profits of cultivation due to irrigation appears to us to be the amount which the people are willing to pay for it, that is, the gross revenue of the works. The two main factors in this item are the area under irrigation and the pitch of the water rates, with each of which the increase in the value of produce is likely to vary more or less directly. We have found that water rates vary from one-twelfth to one-fifth of the value of the crops irrigated, the proportion depending to a great extent may be taken as a measure of the profits accruing to the cultivator from irrigation, a certain percentage of this revenue may again be taken as a measure of the indirect return to the State which results from these profits. We cannot say what this percentage should be, but for comparative purposes the exact rate is not a matter of great importance, and we will assume it at 25 per cent. That is to say, that if the State receives Rs 4 per acre from the cultivator as water rate, in consideration of the increase in the profits of cultivation which he will derive from irrigation, it may be assumed that it will receive 25 per cent of this amount, or Re. 1 per acre, in some indirect way, either from the cultivator himself or from those who share in his

prosperity. This will probably be thought an outside estimate of the share of the increase in the wealth of the country which comes back indirectly to Government; but it enables us to form a definite idea of the comparative effect of the indirect advantages on the financial position of an irrigation work, as shown in the following table which has been prepared for a number of typical canals or systems of canals. The term 'indirect return' is used in it, and in this chapter, in a special sense to represent the intangible return which is assumed to accrue to Government, and not in the technical sense referred to in paragraph 229 (Chapter VIII). This indirect return is assumed to be in each case one-fourth of the gross revenue shown in column 4. It is added to the net revenue in column 5, and the return on the capital cost shown in the last column is then struck.

Names of works	Area irrigated annually in thousands of acres	Capital cost in lakhs of rupees	Gross Revenue in lakhs of rupees	Net Revenue in lakhs of rupees	Return on Capital (per cent)		
					Direct	Indirect	Total
1	2	3	4	5	6	7	8
Punjab Major Works (a)	4,357 (c)	920.76	146.16	103.14	11.2	4.0	15.2
Godavari and Kistna Canals(a)	1,375 (d)	269.69	60.54	45.16	16.8	5.6	22.4
Kumool-Cuddapah Canal (a)	61	217.33	1.77	0.68	0.3	0.2	0.5
Sone Canals (b)	481	267.52	11.12	5.07	1.9	1.0	2.9
Orissa Canals (b)	202	264.48	3.99	-0.52	-0.2	0.4	0.2
Betwa Canal (a)	33	45.07	0.57	-0.36	-0.8	0.3	-0.5
Bombay Canals, Class B (e)	46	86.71	1.58	0.68	0.8	0.5	1.3

(a) For the year 1900-01
(b) Averages for 3 years ending 1901-02
(c) Exclusive of 286,000 acres irrigated on Native States branches of Sirhind Canal and Patiala Section of Sirsa
(d) Exclusive of 50,000 acres assumed as old irrigation.
(e) Averages for 10 years ending 1900-01.

96. We have no hesitation in admitting that there is a real, although intangible, indirect return on successful irrigation works, which may properly be taken into account when new works are proposed; but the foregoing table indicates how easily these indirect returns may be exaggerated. As might be expected, they are considerable when the direct returns are high, but of little absolute value when these are low. On the provisional assumption that they amount to 25 per cent of the gross revenue, the indirect return for the great productive works in the Madras deltas and in the Punjab will vary from 4 to 6 per cent on the capital cost; but for unremunerative works the percentage is fractional and the amount of the indirect receipts very small. If we assume a lower percentage on the gross revenue, they will become quite inconsiderable. The rate of interest to be charged on future capital expended on irrigation works is $3\frac{3}{4}$ per cent; but, if allowance be made for interest charges during construction and until irrigation is fully developed, it may be assumed that no work will fulfil the conditions of a productive work unless it will yield a return of 5 per cent on the actual capital cost, excluding charges for interest during construction. If a work is likely to yield this return, it is unnecessary to consider the question of indirect returns; and if it will not yield a return of 3 per cent, the indirect returns in themselves are not likely to be considerable enough to justify its construction. Where the direct return is likely to vary between 3 and 5 per cent, more weight may be given to the claim of indirect returns, and the work may probably be constructed without involving much risk of any real loss to the State. Speaking generally, we may say that, although the indirect returns on a highly productive work, and the increase in the wealth of the country, of which they are a measure are great and undeniable, they are small and inconsiderable on works which are unremunerative, and that it is only in a few cases that it will be necessary to take them into account. When the advantages offered by irrigation works are so small or restricted that the people who enjoy them are not able to pay the cost of providing them, it

may be inferred that whatever value they may have in years of famine, their effect in increasing the wealth of the country is also small. This may seem almost a truism; but so much is often said about the great indirect value of irrigation works which will not pay their way, that we have thought it necessary to discuss the subject at some length.

97. When the charge for irrigation takes the form of an enhancement of land revenue, there is a consequent increase in the proceeds of local cesses which deserves notice. This increase is not credited to the works because the money is spent locally in providing improved roads, schools, dispensaries, etc., for the benefit of those who contribute it. It is not therefore a State asset; but one of the indirect advantages of new irrigation works lies in the fact that they lead to increase in the cesses, or local funds, available for the betterment of the agricultural community.

98. The effect of irrigation and of large storage works in increasing the humidity of the air, or in raising the spring level in wells, can hardly be disputed; but its value necessarily varies very much in different localities. It can be of little benefit in the deserts of the Punjab and Sind, where the spring levels in wells are at unworkable depths, and dry hot winds are continually blowing; or in the Orissa delta, where there is a normal rainfall of 60 inches and well irrigation is hardly practised; or in tracts which now suffer from water-logging and very high spring levels. But tanks and irrigation may have a great indirect value in such tracts as Bundelkhand, Central India, the Rajputana States, and the Bombay or Madras Deccan. The exposure of large surfaces of water to evaporation must tend to increase the humidity of the air, and water evaporated in one place will be precipitated in another. Still more important, or at any rate more palpable, is the effect on the spring level, and on the percolation flow which can be picked up from the beds of streams by spring channels or from above small weirs. But it is impossible to assign any quantitative, and still less any money value to these effects. It is sufficient to recognize them as operative in various degrees in the tracts in which protective irrigation works are most required, and as constituting an additional argument for their construction, although it is one upon which, by itself, much stress cannot be laid.

99. The important question of the value of protective irrigation works in preventing or mitigating the cost and horrors of famine, has next to be considered. We have already observed that, *apart from the question of famine protection*, there is no reason why the State should accept a permanent charge on the revenue for the sake of increasing the productiveness of land belonging to private owners; and that at any rate such charge should be limited to the amount which may be recouped by the share of the increased produce which will come back to it in an indirect form. The reservation in respect of famine protection is, however, all-important. The obligation on the State to incur whatever expenditure may be necessary to save life during famine, involves future liabilities which cannot be evaded, and of which full account must be taken. We have therefore to consider what immediate expenditure on unremunerative protective works may be justified by the reduction that it will effect in the amount of these future liabilities; or, in other words, what reduction in the future direct cost of famine to the State may result from a given expenditure on such works. For the present we may disregard the indirect cost of famine to the State, and the loss and misery which famine imposes on the people; and confine ourselves to the purely economical question of the comparative demands on the tax-payer, involved in an immediate expenditure on protective irrigation works, and in the future relief of the distress which may be anticipated if these works are not constructed.

100. This is a question to which we have devoted a great deal of attention, but of which a direct and satisfactory solution appears to be hardly possible. If we could obtain reliable particulars of the expenditure on different groups of villages, enjoying different measures of protection by means of irrigation, but all situated within an area in which all other conditions affecting the cost of relief were approximately identical, it might be possible to estimate the saving in the cost of relief which could be attributed to every irrigated acre; and to equate the estimated annual cost to the State

of extending the irrigated area with the saving which would result in the cost of famine relief, on the recurrence of famines of similar intensity after assumed intervals of time. The available statistics do not, however, show the expenditure on relief works by villages, but by works, and it is not possible to ascertain the number of units from particular villages who were relieved on the works. The conditions which induced the people to resort to relief works varied so much in adjacent areas, and even at different times within the same areas, that no reliable conclusions could be derived from details of the attendance, even if they were available. It is unnecessary, however, to explain at length all the difficulties which prevent a satisfactory solution of the problem which we are considering; but a few figures may be given which will indicate a maximum limit to the expenditure which may be justified as a preventive of the direct cost of famine.

101. There are few districts in which the cost of famine relief has been greater than that of Sholapur in the Deccan. During the last 33 years, or third of a century, this district has suffered from famines, as noted below:-

1876-77	Severe famine, expenditure not known
1891-92	Scarcity - no relief given, but it would probably be given now under similar conditions.
1896-98	Acute famine - cost 45 lakhs
1899-1902	Intense and prolonged famine - cost 70 lakhs

The amounts shown as the cost of the last two famines have been based on figures supplied by the Collector of Sholapur, which give all expenditure to the end of November 1901, including the losses due to irrecoverable advances and to remissions of land revenue. Five lakhs have been added to the cost of the last famine as shown by the Collector, to cover expenditure incurred subsequently to November 1901. If we assume that one famine such as that of 1899-1902, and two famines such as that of 1896-98, are likely to occur in every third of a century, we may estimate the cost of 160 lakhs, or say 5 lakhs a year. Capitalized at 4 per cent this amounts to 125 lakhs, which is the arithmetical limit to the unproductive expenditure which may be incurred for the sake of avoiding the future cost of famine relief. If more than this is spent, the payment of the annual charges for interest is likely to impose a heavier burden on the tax-payer than the cost of famine relief.

102. *Protective value of an irrigated acre* - The next question to be considered is the additional area to be brought under irrigation in order to protect the district to the extent necessary to prevent any charges for famine relief in future. The Sholapur district has a population of 721,000 and the area normally sown and cultivated may be taken at 2,000,000 acres, or about $2\frac{3}{4}$ acres for each head of population. After considering the relation of the protected area elsewhere to the normally cultivated area and to the population, and to the demands for famine relief, we think that the minimum area that should be protected by irrigation in order to prevent charges for famine relief in future, cannot be estimated at less than 0.4 acres per head of population, which should, however, be assumed at 800,000, to allow for future increase. The population in this district decreased by 30,000 during the decade ending 1900-01, and this decrease will no doubt be more than made good with the return of more favourable seasons and the extension of irrigation. For such a population there should be a protected area of not less than 320,000 acres, of which it may be said that 100,000 are now protected by wells and existing irrigation works, leaving 220,000 acres for which irrigation should, if possible, be provided. Assuming that Rs 1,25,00,000 is the maximum unproductive expenditure which may be incurred on the strength of the saving anticipated in the future cost of famine relief, the amount which may be thus spent for every acre brought under irrigation will be Rs 57. This may be called the "*direct protective value of an irrigated acre*" in the district of Sholapur. If it be thought that a larger area than this must be brought under irrigation in order to prevent all liability for the cost of famine relief, the direct protective value of an acre will be so much the less.

103. It has already been observed that when allowance is made for interest charges during construction and up to the time that an irrigation is fully developed, a work cannot be considered as likely to prove directly remunerative if the

ultimate net revenue will yield a return of less than 5 per cent on the capital cost, excluding charges for interest. The limit to the capital cost per acre for a remunerative work will thus be the capitalized value at 5 per cent of the net revenue which may be expected per acre of average annual irrigation. Thus, if the net revenue from a work in the Sholapur district were estimated at Rs 2-8 per acre, the work would be remunerative if the capital cost did not exceed Rs 50 per acre. But if allowance also be made for the direct protective value of an irrigated acre, a capital expenditure of 50 + 57 = Rs 107 per acre might be contemplated. There is, however, very little prospect of any irrigation work being constructed in Sholapur at so low a rate as this.

104. It will, however, be said, and truly said, that the protective value of an irrigated acre cannot be limited to the saving that it may effect in the future cost of famine relief. There is an indirect loss of revenue due to famine, of which account must be taken, in the loss of land revenue due to land going out of cultivation or to the great impoverishment of the cultivators; and there are corresponding losses in the revenue from excise, customs, salt, stamps, etc., all of which are likely to continue for some time after famine has passed away. The total of these losses, if it could be fairly estimated, would possibly not fall short of the recorded actual cost of famine relief, including remissions of land revenue, etc., which is all that we have hitherto considered. But, over and above all this, it may be contended that the expenditure which Government may legitimately incur on famine prevention cannot be limited by a consideration of the reduction in the future cost of famine to the State which will result from such expenditure; and that a much higher scale of expenditure may be justified, for the sake of saving the inhabitants of insecure tracts from all the losses and demoralisation and miseries of famine.

105. It is unnecessary to expatiate on this argument which we should be the last to contest. It is difficult to propose any limit to the expenditure which the State may incur in order to prevent what has been called the scandal of famine. But vague generalities on the indirect profits of irrigation and losses of famine are of little use in considering the question whether the net financial burdens which particular works may impose on the State, are too high a price to pay for the protection which they will afford. A scale of some kind is necessary by which we can measure the comparative weights of these burdens, and the corresponding protective advantages; some definite idea is wanted as to the share of unproductive expenditure on a work which may be justified on the ground of the saving that will be effected in the future direct cost of famine to the State; and it may be left to Government to decide how much more than this may be contemplated for the sake of protecting the community from all the evils of famine.

106. The best scale which we can suggest is that afforded by the direct protective value of the irrigated acre. It may be estimated, as we have shown, for any particular tract, by considering, in the light of past experience, the probable cost of famine relief in the future, the population, the area usually cropped, the area which may be regarded as protected, and the minimum area that should be protected in order to tide over a period of severe drought. The calculation which appears to us most suitable may be expressed symbolically by the formula-

$$x = \frac{F}{P_{n-a}}$$

Where x = The direct protective value of an irrigated acre, or the capitalized value at 25 years' purchase, of the saving in average annual cost of famine which will be effected by every acre brought under irrigation.

F = Estimated total cost of famine in the given tract for a period of 25 years, or quarter of a century.

P = Population of the tract, with necessary addition for prospective increase.

n = Area in acres which should be protected by irrigation for each head of the population.

a = Area in acres already protected.

The co-efficient n will vary in each tract, but for insecure tracts it will probably never be less than 0.3 or more than 0.5. Other things being equal, the value of n should diminish as the area normally

cropped per head of population increases; but the character of the cultivation, nature of staple crops, and other points affecting the question, require consideration; and when possible the conditions in villages which are adequately protected within the same tract should be considered. The value of x (Rs 57) which we have proposed for Sholapur may probably be regarded as nearly a maximum for a whole district, as there are few districts which have suffered so much from famine. If therefore the value could be worked out for all districts (although a smaller unit, such as the *taluka*, would be preferable), we should expect to find it varying from a maximum of Rs 60 in the Deccan, to *nil* in those districts which may now be regarded as secure.

107. *Permissible capital outlay per acre* - As we have before stated, we do not desire to propose that the unproductive share of the capital cost of bringing an acre under irrigation should be limited to the value of x; although it should probably be limited with reference to this value, for the direct protective value of an irrigated acre will be a very fair measure of its total, or direct and indirect, protective value; or, in other words, the recorded famine expenditure is a fair measure of the intensity and severity of the famine. Let it be assumed, for the sake of example, that this total protective value may be taken at three times the direct protective value, or x; that is to say, that we may contemplate an unproductive capital expenditure of $3x$ rupees per acre, in consideration, not only of the reduction which will be effected in the future direct cost of famine, but also of the indirect profits which will accrue to the State under the heads (a) and (b) referred to in paragraph 93, of a reduction in the unreported, or indirect, cost of famine, and, above all, of the protection to be afforded to the community from all the evils of famine. Then, if it be assumed as before, that every acre of average annual irrigation will yield a net revenue of Rs 2-8, a capital expenditure of Rs 221 per acre might be contemplated on new irrigation works for the Sholapur district $[(20 \times 2.5) + (3 \times 57) = 221]$; or generally, if

C = Permissible capital cost per acre.

x = Direct protective value of an irrigated acre.

r = Anticipated net revenue per acre of average annual irrigation.

m = A multiplier, representing the ratio of the total protective value of an irrigated acre to its direct protective value.

Then $C = 20r + mx$

108. Our inquiries indicate that the cost of irrigating an acre in many parts of the Deccan, by canals with a plentiful or reliable supply, is likely to exceed Rs 200 per acre, while the net revenue per acre may vary from Rs 2 to Rs 3. If canals are to be constructed in this tract at all, it would seem that a value for m not differing very widely from our proposed value of 3, must be accepted; or, in other words, that Government must be prepared to face an expenditure equal or nearly equivalent to three times the estimated future cost of famine relief and remissions of revenue, for the sake of preventing famine altogether. Then, if the average direct cost of famine in Sholapur be estimated at 5 lakhs per annum, the annual cost of preventing this expenditure may be estimated at 15 lakhs. The net direct cost to the State would therefore be 10 lakhs. Some of this would be recovered by the avoidance of all the losses of revenue indirectly due to famine, but the balance will represent the cost of substituting a policy of famine prevention for one of famine relief.

109. We do not mean to say that this value of the ratio m is too high, or that it will involve, in the particular cases to which it may be applied, an expenditure out of all proportion to the advantages to be gained by preventing famine in place of relieving it. The protection which it would furnish would not be more costly, when considered with reference to the liabilities for famine expenditure which it would prevent, than that which has been afforded by such works as the Orissa, the Kurnool-Cuddapah, and the Betwa Canals, and many of the existing irrigation works in Bombay. It is true that the construction of these works was not deliberately sanctioned, with a full foreknowledge of the unsatisfactory financial results which would be attained; but we believe that the protective value of all has been great enough to prevent any one from regretting that

they were constructed. We are inclined to think that the value of this ratio *m* which we have assumed, is not too high; provided always that it is applied only to cases in which the water-supply is so secure that the contemplated protection may be regarded as assured even in the worst years of drought, when the protection will be most urgently needed. When there is doubt on this point a much lower value should be taken. We think, too, that the value proposed should be regarded, at any rate for some time to come, as a maximum. But the final determination of the limits to the expenditure which may be legitimately incurred for the sake of preventing, so far as irrigation works can prevent, all the great evils of famine, does not rest with us. All that we can do is to direct attention to some of the elements of the problem; and to point out, in reply to those who contend that the whole of India can be securely protected against famine by the construction of irrigation works that even when this is physically possible, there is a limit to the expenditure which may be incurred, and a risk of imposing a burden on the country which may be even greater than that of famine itself.

110. We have considered here what we have called the protective value of irrigated acre, as the only possible method of approaching the problem to be dealt with. If we could have obtained for every famine district reliable estimates of the cost of all the protective irrigation works which could be proposed, of the net revenue which would be derived from them, and of the areas which they could efficiently protect, we might probably have hazarded a conjecture as to the probable net cost to the State of carrying out such works. But such estimates were not and could not have been available. The cost and the net returns of a protective irrigation work cannot, like those of a protective railway, be approximately estimated at so much a mile. Nor can we say, as has actually been said, that inasmuch as the capital cost of the Godavari works has not exceeded Rs 18 per acre, it is sufficient to allow something more than double this rate, or Rs 40 per acre, as the probable cost per acre of the great Tungabhadra project. The mere cost of the works in any particular case, and especially when storage is involved, can only be approximately estimated after long investigation and careful inquiry. But this is nothing to the difficulty in determining the areas which will be irrigated in wet, in normal, or in dry years, or the revenue which can be derived from irrigation - factors which profoundly affect all estimates based, as all estimates must be, on acreage rates. Reliable estimates on all these points, without which it would be very imprudent to sanction any expensive work, can only be submitted separately for consideration on their merits. It will not be possible to protect every tract which is in need of protection, and individual estimates will relate only to small portions of these tracts. It thus becomes necessary to form some idea of the permissible capital cost per acre to be irrigated in any particular tract, as the only possible guide to the probable net cost to the State of carrying out such projects as may be proposed.

111. It must not, however, be supposed that we estimate that the probable net cost of protecting any tract which is now liable to famine, at a sum which is equivalent to three times the probable expenditure on famine relief. There are no doubt many tracts in which protection cannot be provided at a less cost than this, and they are generally the tracts in which protection is most urgently required. But there are others in which it may be hoped that the unproductive outlay will be much less. Works which will be productive, or in which the capital cost is not likely to exceed 20 times the net revenue, will not involve any unproductive outlay, and it will be unnecessary to consider the question of their protective value at all. And we think that, in all tracts in which the cultivation is at all insecure, protective works may be sanctioned without hesitation whenever the capital cost is not likely to exceed thirty times the net revenue, or whenever a net return of more than 3 per cent on the capital outlay may be anticipated. The indirect returns which will accrue on the expenditure, and the protective value of the work, will certainly suffice to justify the sanction. When a lower return than this is anticipated, it will be necessary to pay closer attention to all the circumstances of the case; and especially to the urgency and the certainty of the protection which the work is designed to afford. In such cases the work will either be abnormally costly to construct

or maintain, or the value of irrigation, except in years of extreme drought, will be so small or doubtful as to justify caution in according sanction. This examination of the subject leads to the conclusion that, however great may be the indirect value of irrigation works which may be classed as productive, it will diminish rapidly for works on which the direct returns are likely to fall below the productive standard, and may become so inappreciable, even in districts which are liable to frequent famine, as to render the construction of the works inexpedient.

SECTION II - PROBABLE COST OF NEW WORKS

112. *Productive works* - It has been shown that the major irrigation works hitherto constructed by the State have, on the whole, proved so remunerative that they yield a surplus revenue, after all charges for interest have been met, of over 113 lakhs, the net revenue being equivalent to a return of 7.1 per cent on the capital cost. The first point that strikes us, in approaching the question of the scope for further extensions of State irrigation works, is the limited field for the construction of new works which are likely to be equally remunerative, or even to be at all directly remunerative. There is not a prospect of new irrigation works, on any considerable scale, proving directly remunerative in any of the provinces in which protective irrigation is most urgently required, namely, the Deccan districts in Bombay and Madras, the Central Provinces, and Bundelkhand. The only provinces in which there is a considerable field for new irrigation works which are almost certain to be remunerative are the Punjab, Sind, and possibly Madras. In the Punjab, there is first the great project for the irrigation of the Lower Bari Doab, which will probably prove highly remunerative whatever may be the form which it will ultimately take, or whatever may be the magnitude of the scheme. The prosecution of this work is likely to extend over several years, and if the next great Punjab project, the Sind-Sagar Canal, is then undertaken, it will probably be in the expectation that it will fulfil the conditions of a productive irrigation work, although it is not likely to prove highly remunerative. Any other new works that may be proposed in this province are likely to be remunerative; and the same may be said of Sind, where all capital expenditure on the inundation canals has hitherto proved exceedingly profitable. Almost all proposed new works in Madras involve the construction of storage works, and although many of the existing storage works in the Presidency are remunerative, there are some which are not; and it is at least doubtful whether many of the new works will be so, and almost certain that the greatest of them all, the Tungabhadra project, will not. If a sufficiently large area of rice-growing land can be commanded, it is possible that the proposed Tapti Canal may fulfil or nearly fulfil the conditions of a productive irrigation work; but this is at present doubtful, and it is almost certain that no other large work can be proposed in Gujarat which will be directly remunerative. All existing works in the United Provinces, north of the Jumna, are highly remunerative; but there is not much scope for new works outside the Sardah project, and it may be doubted whether that would fulfil the conditions of a productive work if carried out as originally proposed, but this we have not recommended. The new works proposed south of the Jumna, or in Bundelkhand, are certain to be unremunerative. In Bengal no irrigation work hitherto constructed has proved remunerative; although it appears not improbable that the Tribeni Canal, now under construction, may nearly fulfil the prescribed condition, as it has the great advantage of an assured and ample supply, and it commands a rice-growing country in a very insecure tract. We have, however, been unable to propose any new works in Bengal which are likely to be remunerative.

113. Although the field for new productive works is limited, there is scope in almost every province for considerable expenditure in extending or developing existing works. Expenditure of this kind, which is chargeable to the open capital accounts of the works, is almost certain to be remunerative, even when the works themselves taken as a whole are not.

114. Many of the new productive works that may be proposed in future, including almost all extensions of existing works, will be situated in provinces or districts which are already adequately protected, and they will not be urgently

required for protective purposes. Nevertheless all productive works must be regarded as essentially protective. The direct revenue which they earn is a valuable asset, more especially as it is usually at a maximum in years of drought when so many other sources of revenue are liable to contract. As already shown, it is a measure of the increase in the wealth of the country due to the works, a large share of which comes back to the State indirectly. Population is attracted from the more congested districts, and in times of famine many emigrants from distressed tracts find agricultural employment on the new areas brought under cultivation. Every extension of irrigation increases the security of the food supply of the country in years of drought, and, in these days of cheap railway freights, the produce of irrigation can be carried to those parts in which it is most required. For these reasons we think that the programmes of future expenditure on irrigation works should provide for the construction of as many productive works as can be proposed, in whatever parts of the country they are situated, and without reference to the urgency of protection for the locality. Promising projects should be held in abeyance only when funds cannot be allotted for them without interrupting progress on irrigation works of any kind which have been actually commenced, or withholding money from works more urgently required for protective reasons; or when adequate establishment is not available for carrying out the works; or when the success of the works depends upon colonization operations which it may be more convenient on general grounds to postpone.

115. *Protective works* - We have next to consider the class of works which are called protective, not necessarily because they have a greater protective value than the productive works, but because they have been sanctioned in consideration of their protective value although they were not expected to fulfil the condition of a productive work. The majority of new works are likely to be of this kind, or only partially productive.

116. It is not difficult to understand why the works to be constructed in future should be much less promising, as financial investments, than those which have been constructed in the past. Before those works were constructed, the districts in which they were situated all needed protection, and it was but natural that attention should first be directed to schemes which promised not only the best financial results, but also a much larger measure of protection to the country at large, than could be attained by works of a less remunerative character. The result of this policy has been an increase to the revenue of the country which now exceeds three-quarters of the amount of the Famine Grant, and will before long fully equal that amount - an increase which may now be fairly utilized, as recommended by the Famine Commission of 1878-80, in extending the blessings of irrigation to tracts which are less able to pay for them. But, although this sufficiently accounts for the fact that possible new works are much less promising as financial investments than the works which have been constructed, the fact itself may be expressed in another way. The works of the past have, with few exceptions, been canals fed from large rivers, on which storage works were unnecessary. Even the exceptions are significant. For the excepted works have all proved unremunerative, owing either to the great cost of the storage or to the inefficiency of the work for want of storage. For the works of the future, storage will be essential. Except in the provinces of the Punjab, Sind, and Oudh, not a single work of any importance can be proposed which does not involve the construction of expensive storage works, or for the full development of which storage works will not eventually be required. We have already given reasons for anticipating that, in many tracts, the net cost to the State of protective irrigation works may be equivalent to not less than three times the cost of relieving famine within the area to be protected. This is mainly due to the great cost and uncertain operations of storage works, which are so seldom adequately realized that it may be convenient to consider the subject in greater detail.

117. The Provincial Chapters of this report show how much has been done for the protection of the country by existing storage works; and we have just pointed out that all future extensions of irrigation, in the provinces of India which are most subject to famine, depend on the construction of storage works. But to us the word 'storage' is as suggestive of the limitations as of the

possibilities of irrigation as a means of protection. We have pointed out the difficulties connected with the construction of storage works, and the physical considerations by which the possibility of impounding any large proportion of the waters which now flow uselessly to the sea is limited. We shall here consider, therefore, only the limitations which are imposed by the question of cost.

118. We have obtained particulars of the cost of twenty storage works in the Bombay Presidency, with an aggregate capacity above outlet level of 20,792 million cubic feet, the capacity of individual works varying from 15 to 5,500 million cubic feet. We find that the actual cost of the reservoirs, including dam, escape, outlet, and compensation for land, but excluding establishment charges, has averaged Rs 465 per million cubic feet. This is the actual cost of impounding water, to which has to be added the cost of the canals, distributaries, and other works for conveying the supply to the area to be protected, and all charges for establishment, tools and plant, etc. With these additions, the total cost of the works averages Rs 1,275 per million cubic feet. With these figures may be compared those for the Periyar project in the Madras Presidency, in which there is a storage of 6,480 million cubic feet. The cost of the reservoir, including the outlet, has been at the rate of Rs 653, and that of the whole project at the rate of Rs 1,364 per million cubic feet.

119. The area that can be irrigated, per million cubic feet impounded, varies very much according to the circumstances of supply and demand, the range being from 2 to 12 acres. In some works, like the Periyar or Lake Whiting (Nira Canal), the reservoir impounds only a portion of the annual yield of the catchment, and for several months in the year there may be an abundant surplus which greatly brings up the duty. Other tanks seldom or never fill, they have no surplus, and rarely store up to their full capacity. The area will also depend upon the kind of crop sown - an acre of sugarcane taking as much water as, perhaps, eight acres of wheat - and also on the character of the season. The average area irrigated from the Bombay works during 10 years has not exceeded 3.6 acres per million cubic feet; but the maximum rate which is attained in dry years in which the tank supply has not failed, may be taken at 6 acres. If this rate could be worked up to in all years - a consummation which may perhaps be hoped for as the advantages of irrigation become more appreciated - the capital cost per acre would not be less than Rs 212. If a net revenue of Rs 2-8 assumed and capitalized at 5 per cent, the share of the capital cost which would be productive may be taken at Rs 50, leaving Rs 162 upon which no direct return would be received. This is a much better result than has yet been attained, and there are reasons for anticipating that the net cost of new works in the Deccan may be even greater than that of those already constructed, and that, after deducting the share which may be regarded as productive, it may not fall far short of Rs 200 per acre. The irrigation of 500,000 acres at a rate of Rs 180 per acre would involve a permanent charge on the revenues of the country of Rs 45,00,000 per annum, and would not entirely prevent famine even if very evenly distributed. We do not say that the advantages of such exemption from famine as the works would afford, would not be worth the cost. But it is obvious that we are approaching a limiting rate beyond which protective irrigation will become financially impossible for any Government; and that, even at the rate assumed, there are limits to the area which Government can prudently undertake to protect.

120. The net cost of storage works per acre irrigated will probably be less in other provinces, even if the cost of impounding and distributing a million cubic feet of water be the same; although this also should be much less in tracts well suited for tank irrigation, as for instance the Bhandara district in the Central Provinces. In Madras a higher rate of net revenue per acre will probably be obtained, and in the Central Provinces a higher duty may be expected. But these more favourable tracts are, as a rule, in less urgent need of protection; and, although the cost of protection may be less, its ratio to the probable future cost of famine in the tract concerned may not be less than it is likely to be in the Deccan. From this point of view there is a limit to the expenditure which may be legitimately incurred on famine protection, even when the actual cost of the works is not very high. It may, for instance, be better to spend

Rs 180 per acre in Bombay than Rs 90 per acre in Chhattisgarh.

121. It must also be pointed out that, on most of the works which we have been considering, the areas irrigated in a year of keen demand have been limited only by the capacity of the storage reservoirs, which have not been designed to hold more than a year's demand. It is unnecessary to discuss here the question of the ratio which the capacity of a storage work should bear to the minimum or average yield of the catchment area, or to the average demand for irrigation. Each particular case must be considered on its merits. There is an undoubted risk that storage works which are not situated in the regions of unfailing rainfall may fail seriously in a year of drought, although experience shows that failure occurs less often than might be supposed. If, in order to meet this risk, storage works are designed, as has sometimes been suggested, to hold a supply equal to twice the requirements of the area which they are intended to protect, the cost per acre irrigated will be very much higher than in the examples which we have considered; and the double capacity, although it will reduce the risk, will not be a complete insurance against failure, especially if a succession of dry follows a series of wet years. It may often be very desirable to provide excess storage; but in many storage works complete insurance against failure can only be obtained by a prohibitive increase in cost.

122. Irrigation by means of storage works is, in fact, subject to the same practical limitations as the storage of electrical energy. Secondary batteries or accumulators are of the greatest value for the purpose of equalizing the supply, and for continuing it when the machinery has broken down or stopped; but unless they can be recharged at frequent intervals, their size and cost are so great as to render their use impossible. So it is with irrigation. Storage will be indispensable in almost all works of the future, and, in spite of their cost, they will be of the greatest value in maintaining a supply for irrigation through all the vicissitudes of a single season. They can do more than this only if they are constructed in a region of unfailing rainfall, or with a capacity greatly in excess of the average annual demand; but compliance with either of these conditions must often result in an increase of cost which will be regarded as prohibitive. Storage is so costly, even in the most favourable circumstances, that very few irrigation works which depend on it are remunerative; and under adverse conditions it becomes financially impossible.

SECTION III - CONSTRUCTION PROGRAMME AND FORECAST.

123. *Introductory* - We have shown that very few of the new State irrigation works which can be proposed are likely to be remunerative, as the most promising projects have already been carried out, and almost all those which remain will depend on such uncertain sources of supply as to necessitate the construction of expensive storage works. We have also discussed the relation which the net cost to the State of these works is likely to bear to their value as a protection against famine. It remains to summarize the various schemes which are recommended in the Provincial Chapters (Part II) of this report; and to frame a construction programme, and a forecast of the expenditure to be provided for if our proposals are generally accepted. For this purpose it will be convenient to assume a period of 20 years; but the actual length of the period, or, in other words, the rate of annual expenditure, will depend on the funds which Government can provide for the purpose, and on the rate of progress which can be attained by the local Public Works Departments. The period for each province can be extended or shortened when these points have been fully considered.

124. We must also premise that we are unable to base a programme on any accurate estimate of the cost of the works which are to be included in it. We have endeavoured, by a study of the records of existing works and of estimates for some new schemes which have been prepared in different degrees of detail, to form some idea of the cost of providing irrigation in those tracts in which irrigation appears to be possible, and in which protection is most urgently required; and also of the probable scope and protective value of the works proposed. Investigations of particular projects have also been undertaken on our recommendations, and reports and detailed estimates relating to them will no doubt be submitted in due course for the orders of Government; but our

present programmes and forecasts must necessarily refer to general schemes of irrigation rather than to particular projects. It may be added that the programmes relate only to capital expenditure upon works for which regular capital and revenue accounts will be kept. Whatever expenditure may be incurred in future on minor works, of the kind for which we propose (paragraph 251) that no capital accounts should be kept, will be met from the ordinary minor works grant, and will be outside the programme which we are now considering.

125. *Classification adopted in forecast* - It will be convenient to divide all the proposed works in our programme into three classes, which may be called *productive, intermediate,* and *unproductive.* We assume, as we have done elsewhere in this chapter, that a work may be considered productive if it is likely to yield, ten years after completion, a net revenue equivalent to a return of not less than 5 per cent, on the direct and indirect capital outlay. This definition is more convenient for our purpose than the technical or codal definition usually adopted (paragraph 224); and the two will be identical when the accumulated excesses of interest charges over net revenue, at the end of the tenth year after completion, do not exceed one-third of the total capital cost. They should not exceed this in the case of a moderately productive work if, after the work has once been commenced, construction is carried on vigorously until completion. Works that are certain not to pay 5 per cent have been classed by us as *unproductive*; while works of which it cannot be said with any certainty that they will be either productive or unproductive are treated as *intermediate.*

126. *Punjab* - The first place among new productive works in the Punjab must be assigned to the Lower Bari Doab project. There is a doubt at present as to the ultimate form which this project may assume; but whether the canal be fed from the Sutlej, involving the construction of additional weirs lower down the river, or from the Chenab, with a feeder from the Jhelum, an expenditure of 600 lakhs is the least that should be provided for. Another 300 lakhs should be added for work on the Sind-Sagar project; and an expenditure of no less than 150 lakhs should be contemplated on the open capital accounts of both perennial and inundation canals, for all of which we have recommended that in future regular capital and revenue accounts should be kept.

127. We have also recommended a moderate expenditure of 50 lakhs on new minor works, such as small inundation canals, for tracts which cannot be included in existing systems. No special or separate provision has been made for new works in the North-West Frontier Province, but part of this sum may be applied to such works.

128. *Bombay: Sind* - We allow 100 lakhs for extensions of certain canals in Sind and for improvements of existing works. All this expenditure is likely to be highly productive.

129. *Bombay: Gujarat* - The most important work that can be proposed is that for a canal from the Sabarmati; but we have been unable to recommend the small project which has been put before us, partly because of the uncertainty of the supply, and partly because its construction might prevent the construction of a work of much larger scope which would be possible if a suitable site for storage works can be found. We have entered 100 lakhs for possible expenditure on this project and the Mahi river scheme, both of which should be investigated as soon as may be practicable; but we do not think that either work will be productive. Without storage they will be very ineffective, and the demand for water will be small. On the other hand, storage will involve a great addition to the capital cost. An expenditure of 20 lakhs may also be allowed for other protective works, such as tanks, which may be proposed in certain parts of Gujarat. We have entered 50 lakhs for a canal from Tapti which should be constructed if further inquiry shows that there is a fair, although not necessarily an assured, prospect of its proving remunerative. If a sufficient area of rice land can be commanded, the canal may possibly prove remunerative without expensive storage works, the construction of which on Tapti we are unable to recommend, after full consideration of the circumstances in the Surat district.

130. *Bombay: Deccan* - We have allowed 600 lakhs for the construction of storage works at the most eligible sites in the Western Ghats, and for canals therefrom into the Deccan districts of Bombay; and 50 lakhs for smaller works and for

the completion of some of the storage works on which relief labour has been employed. We estimate that this expenditure will lead to an increase in the average irrigated area of about 325,000 acres, which may amount to 500,000 acres in a year of extreme drought. The amount of protection thus provided is of course far from commensurate with the necessities of this famine-stricken tract, but the physical conditions are such that further provision, at any reasonable expenditure, will be wholly impracticable (II, 171).

131. *Madras* - The three most important works proposed in this Presidency are the Tungabhadra project, the Kistna project, and the proposed storage work on the Cauvery or one of its tributaries. For the latter, 140 lakhs may be allowed, and there is reason to suppose that it will be a productive work. We would also propose an expenditure of 100 lakhs, to be charged against the open capital accounts of existing works, to provide for such works as the improvement of the Kurnool-Cuddapah Canal, the Divi Island pumping scheme, and the provision of additional storage on the Periyar, Rushikulya, and Srivaikuntam projects. We assume that three-fourths of this expenditure will prove remunerative, while one-fourth may be classed as intermediate. We would also propose a further expenditure of 100 lakhs on new storage works of moderate size, of the kind hitherto classed as minor works for which capital and revenue accounts are kept. We think that half this expenditure is likely to be fully productive, while the remainder will fall into the intermediate class.

132. From the information laid before us regarding the Tungabhadra project, we can hardly hope that it will prove a productive work, although it is urgently needed for protective purposes. It is possible that, in spite of its great cost and the doubtful character of the demand for irrigation, it may in time prove less unremunerative than many of the works proposed in Bombay and the Central Provinces, but we cannot at present classify it as anything but an unproductive work. We can form no idea of the ultimate cost of the complete project, which will depend mainly on the storage that can be arranged for; but for the purpose of a forecast we allow 600 lakhs for expenditure within the next 20 years.

133. We have also included 600 lakhs for the proposed Kistna storage work, although it may be doubted whether it could be undertaken in addition to the other works during the period assumed. It may, however, possibly take the place of some of them. After it has been more fully investigated, a better opinion can be formed as to its probable cost and the place to be given to it in a construction programme. It is thought that it may prove a productive work, but we consider it safer to class it as intermediate.

134. *Central Provinces* - The works proposed in these Provinces are not likely as a whole to be productive, but there may be exceptions, especially in the case of river channels, or such works as the Ramtek project. We would, however, propose an expenditure of three hundred lakhs for the whole period.

135. *Bengal* - Although unable at present to form any opinion as to the feasibility of the proposed Karamnassa scheme, we allow 90 lakhs for it in our forecast, as we consider that if possible something should be done for the protection of the Bhabua Sub-division of the Shahabad district. We can hardly, in the light of past experience in Bengal, suppose that the work will be other than unproductive; but it is possible that it may in course of time yield a net revenue sufficient to cover the charges for interest on its cost, just as we think the Sone Canals might now be made to do. For works in North Bihar we have allowed a sum of 80 lakhs. We doubt if a large sum can be spent on irrigation works in this tract, as long as the people are unwilling to take or pay for the water except during periods of drought. We have recommended a systematic expenditure of about 1 lakh a year in Chota Nagpur on petty works for conserving the water-supply of the country. These works will not be wholly unremunerative if they receive credit for the enhancement of rentals in Government lands which may be expected to ensue on their construction. We have, in addition, made a provision of 30 lakhs for expenditure on the open capital accounts of existing works. It is doubtful if it will be fully productive.

136. *United Provinces* - In the United Provinces the only expenditure which is certain to be productive is that which will be incurred against the open capital accounts of existing productive works; for this 50 lakhs have been allowed. Provision is made of 100 lakhs for a modified Sardah project; but we cannot regard this as certain to be productive, and have classed it as intermediate. For the Ken Canal, and other new works in Bundelkhand and other tracts south of the Jumna river, 90 lakhs have been allowed. The whole of this may be regarded as unproductive outlay.

137. No provision has been made for any expenditure that may be incurred in diverting the waters of the Sardah and Ganges rivers, for the purpose of setting free a share of the Ganges and Jumna supplies for the proposed Eastern Ganges Canal, and for the protection of the insecure tracts in and adjoining the district of Hissar in the Punjab. Our only reason for omitting provision for these important proposals is that at present our information is quite insufficient to admit of even a rough estimate being framed of their probable cost or of the areas which may be brought under irrigation. We do not, however, think that the proposals should be allowed to stand over indefinitely. We regard it of great importance that the question of utilizing the unfailing supply of the Sardah, in those tracts in which it will have the greatest protective value, should be thoroughly investigated with as little delay as possible, and that, if a satisfactory project can be prepared, it should be included in the detailed provincial programme.

138. *General* - Some allowance must be made for the cost of investigating projects which are not afterwards proceeded with, and for small works in other administrations such as Berar, Coorg, Baluchistan, and British Rajputana. For this we have entered 80 lakhs, which will be generally unproductive.

139. *Abstract* - The forecast of expenditure for each province may now be abstracted as below-

Area to be irrigated in thousands of acres	Province	Forecast of expenditure in lakhs of rupees			
		Productive	Intermediate	Unproductive	Total
2,600	Punjab	1,050	50	...	1,100
400	Sind	100	...	...	100
170	Gujarat	...	50	120	170
325	Deccan	....	...	650	650
1,925	Madras	265	675	600	1,540
450	Central Provinces	...	...	300	300
200	Bengal	45	45	130	220
400	United Provinces	50	100	90	240
30	General	...	...	80	80
6,500	Total	1,510	920	1,970	4,400

We have indicated the area likely to be irrigated for the expenditure proposed, but this can only be very roughly estimated at present. The table does not include Burma, nor the expenditure to be incurred on works in other provinces which have already been sanctioned and are in progress. The period of forecast may, therefore, be regarded as commencing about two years hence, when most of the works now in progress will have been completed and detailed estimates of many of the new projects will probably have been considered and sanctioned.

140. *Net cost to the State* - Taking a return of 5 per cent on the capital outlay as the standard of a productive work, we may assume an average return of 6.25 per cent on those which we have classed as likely to be fully productive; and allow for works of the intermediate class an average return of 3.75 per cent, and one of only 1.25 per cent for works which are classed as unproductive. The direct financial loss on the works as a whole would then stand as follows:-

Lakhs		Percentage	Annual profit lakhs	Annual loss lakhs
1,510	Productive at	6.25 - 5.0	18.88	...
920	Intermediate at	5.00 - 3.5	...	13.80
1,970	Unproductive at	5.00 - 1.0	...	78.80
		Total	18.88	92.60

There would thus be a net loss of 73.72 lakhs, as a set-off against which the finances will be relieved by the reduction in the future cost of famine which will result from this expenditure. If it were possible, in sanctioning protective works, to be guided by the principle which we have suggested, that the net burden which the expenditure would impose on the State should never exceed three times the amount of expenditure on famine which would be averted by the works, we could safely estimate the reduction in the cost of famine, due to the construction of works of the intermediate and unproductive classes, at a great deal more than one-third of 92.60 lakhs, that being the proportion in the worst or most unfavourable cases only. As a matter of fact, it is of course impossible to determine accurately either the direct cost of future famines, or the effect of every acre of irrigation in reducing that cost. But, if an attempt were made to regulate sanctions in accordance with some such principle as that which we have proposed, we might fairly assume that at least one-third of the net cost of the works, or say 31 lakhs per annum, would be covered by a reduction in the direct cost of famine, and that the permanent charge on the State would be reduced to about 43 lakhs. We have not, however, considered the saving in the cost of famine which will be caused by the productive works, as we have no means of measuring this. The actual saving in cost of famine relief will not be very large, because most of these works will be constructed in tracts which do not suffer from famine. The cultivation on these works will, however, reduce the cost of famine indirectly in other ways, by increasing the available food supply of the country, and by attracting labour from adjacent distressed districts. The net burden on the State will, therefore, be a great deal less than forty-three lakhs; but it will be further reduced by the share in the increase of the wealth of the community which will accrue to the State indirectly in all years, and also by some reduction in the indirect cost of famine. The residual burden, whatever it may be, will represent the cost to the State of preventing distress within the areas to be protected, instead of providing relief when it occurs - relief which is almost necessarily restricted to the bare protection of human life. It is not for us to propose any final limit to the expenditure which may be legitimately incurred with this object; in which are involved not only the credit and good name of the State, but also the well-being of the millions who, in all but the most unfavourable years, add to its revenues and to the wealth of the country by the precarious cultivation which they carry on in these unprotected tracts. We cannot but think that the programme which we now put forward will not, if our calculations are even approximately correct, impose an undue burden on the State. But our main purpose is rather to indicate what that burden is likely to be, than to offer an opinion as to the limits beyond which the State cannot be expected to go.

141. *Detailed provincial programmes* - This programme must be regarded merely as an outline. We have endeavoured to distribute the proposed expenditure between provinces in accordance with what we conceive to be the requirement and capacity of each; and as it can never be said in what part of the country famine may next occur, we think that protective operations should be undertaken, in accordance with some definite scheme, in all provinces. If our proposals are favourably regarded, we would suggest that each Local Government and Administration be invited to submit its own programme, which will be prepared on the same lines, but in greater detail and not necessarily so as to work up to the amounts which we have proposed. It will then be possible to prepare a revised general programme, in accordance with which future financial arrangements will be framed. When the provincial programmes have

been accepted, Local Governments should be held responsible for their being systematically and fully worked up to, material deviations from the prescribed plan being made only with the sanction of the Government of India. We consider it also of the greatest importance that when the commencement of a work has once been sanctioned, progress should never be interrupted for want of funds. The local officers should be encouraged to complete the work as quickly as may be possible, and the commencement of other works should not be sanctioned if this will involve any diversion of the grants required for works in progress.

142. *Slow construction of irrigation works* - In connection with these provincial programmes there is a limitation to the rate of progress which must always be borne in mind in comparing forecasts of expenditure on new irrigation works and on railways. The annual outlay on canals can never equal that which has been attained in the construction of railways, the greater part of the cost of which is incurred on permanent-way, iron work for bridges, fencing, etc., and rolling-stock. The earthwork forms a minor charge. When it is desired to push on a railway very fast, it is only necessary to call for more tenders for iron and steel plant, and the markets of Europe and America can meet the supply with little delay. On an irrigation work, on the other hand, almost the whole outlay is on account of earthwork and masonry works, the progress of which depends to a great extent on the local supply of labour. Thus, we have contemplated spending on new irrigation works in the Deccan the sum of six hundred lakhs, but we have been told that an outlay of 25 lakhs per annum would exhaust the labour available in the neighbouring districts. We have no doubt that it will be possible to attain a higher rate of progress than this, if establishments are suitably strengthened, and if Government will commit itself to a continuous policy of irrigation extension, which will induce private enterprise to import labour. But, even allowing for this, the same rate of progress will never be possible on irrigation works as can be attained without difficulty in railway work, on which six crores could be spent in a few years. This facility of rapid construction is one of the many advantages which tend to make railways most valuable protective works. Much more time is required not only for the actual construction of irrigation works, but also for the preliminary investigations and detailed designs; but, on the other hand, the outlay incurred is spent almost entirely in the districts which the works are intended to protect.

143. *Present programme not exhaustive* - We should add that the programme which we put forward must not be regarded as exhaustive. We do not propose to limit future expenditure on irrigation works to 44 crores of rupees, nor do we consider that irrigation cannot be extended, by new State works, to a greater area than $6\frac{1}{2}$ million acres, so long as the condition that they must be directly remunerative is set aside. But we have thought it better to submit a definite programme for a limited period, than to consider all the unexhausted possibilities of irrigation. If some such programme can be carried out within the period proposed, we have no doubt that by the time it approaches completion other projects will be forthcoming, and a new programme will be prepared. But, although much may then remain to be done, we cannot but express an opinion that the limits to the area which can be protected by State irrigation works at a cost which will not be prohibitive, will then be within sight. Even now there are many areas which such works cannot reach, or which have been, or may be, more effectively or economically protected by other means which we shall now consider.

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CHAPTER X
IRRIGATION

INTRODUCTORY

266. Irrigation plays so large a part in agriculture in India that no investigation into rural conditions in this country would be complete which failed to examine its present position and future possibilities from the agricultural point of view. The problems which the irrigation engineer is called upon to solve necessarily differ widely in different parts of India, but it may be said that, in general, these problems fall into three main classes.

In the first class, the problem is how best to utilise the waters of rivers without recourse to the construction of storage works. In some cases, this is possible without raising the natural level of the river. In others, it entails the construction of weirs. The problem is in general solved by conducting the water drawn off from the rivers along contour levels sufficiently high above the general level of the fields to be irrigated to permit the water to flow on to them by gravity. The irrigation canals of the Punjab supply notable examples of overcoming the difficulties of crossing secondary lines of drainage, and of so aligning the main courses and subsidiary channels that the maximum area of the country is benefitted.

The second main division consists of the problems arising out of the management of the deltas of rivers in such a way as to combine the protection of cultivation from wandering rivers with the regular supply of water necessary to the full development of cultivation in these fertile areas. The chief examples of the successful solution of these problems are to be found in the management of the deltas of the Godavari, the Kistna and the Cauvery in the Madras Presidency. We shall have occasion to notice, later on in this chapter, the need for examining what can be done in the case of the far more difficult problems presented by the Ganges delta in Bengal.

The third class of works are those in which the surplus water, whether the result of monsoon rains or melting snows, is stored by means of dams across the line of flow and released gradually as required for the purposes of cultivation. Some notable works of this character have already been constructed and, when the great projects now in progress for utilising the waters of the rivers are completed, it will be, in the main, only from works of this class that any large extension of irrigation may be anticipated.

The reasons which have led to the construction of irrigation works vary as greatly as do the types of those works. In some cases, for example, in Sind and over large areas of the Punjab, where the rainfall is normally insufficient to ripen the crop, no cultivation is possible until schemes of irrigation carry the essential water to the land. In other cases, as in parts of the Deccan, the rainfall, though normally sufficient to ripen the crop, is yet so precarious that without irrigation there can be no assurance to the cultivator that his crops will mature. Yet again there are cases where irrigation is needed more as a precaution against famine than as a requirement of the normal year. The canals in the United Provinces, Bihar and Orissa and the Central Provinces provide examples of this type.

The last general examination of the position in regard to irrigation in India was carried out by the Indian Irrigation Commission which was appointed in 1901. The Report of that Commission which appeared in 1903 was so comprehensive and its recommendations so exhaustive that no further enquiry of a similar character has been considered necessary. The great development of irrigation which has since taken place has been, in the main, on the lines laid down by the Commission.

STATISTICAL

267. In Chapter I, we have mentioned the obstacles to agricultural development consequent on the unequal distribution of the rainfall of India over the country, its frequently irregular distribution throughout the season and its liability to failure or serious deficiency. Except in the submontane tracts of the Himalayas, East Bengal, Assam, Lower Burma and the narrow strip between the Western Ghats and the Arabian Sea, the absolute security of the harvest throughout India depends on the existence of some form of irrigation. From time immemorial, therefore, the cultivators have sought to supplement and conserve the rainfall by the construction of wells and storage reservoirs, and by *bunding* streams. In some parts of India, considerable capacity for

organisation was developed for this purpose as the *phad* system of irrigation which still exists in the Nasik and Khandesh districts of Bombay Presidency and the innumerable tanks in the Madras Presidency, many of which are undoubtedly of great antiquity, bear witness. There are some notable instances of large irrigation works carried out in ancient days in India. The oldest and most famous of these is the Grand Anicut across the Cauvery in Madras which dates back some 1600 years and, even before the improvements effected in the nineteenth century, irrigated over 600,000 acres. In the north, two canals were constructed from the Jumna; that now represented by the Western Jumna Canal is attributed to Firoz Shah in the fourteenth century and was renovated by Akbar in 1568 and remodelled by Ali Mardan Khan in 1628, which work on the second, which developed into the existing Eastern Jumna Canal, was started by Shah Jehan in the seventeenth century. The original Upper Bari Doab Canal was built by early rulers and brought water to Lahore and to the sacred tank of Amritsar. Some of the inundation canals taking off from the Indus are also of ancient date. These examples suggested the construction of those large perennial irrigation works which have been such a notable feature of British administration.

The Table below shows the development of irrigation in British India since the year 1908-09, the first year in which figures for irrigation were recorded in the 'Agricultural Statistics of India' in a fairly complete form:

Year	Gross area sown* Acres (in 000's)	Percentage increase or decrease over 1908-08	Gross area irrigated† Acres (in 000's)	Percentage increase over 1908-09	Percentage of area irrigated to area sown
1908-09	246,189	..	45,681	..	18.6
1914-15	260,641	5.9	50,644	10.9	19.4
1920-21	239,202	-2.8	52,519	15.0	22.0
1924-25	259,784	5.5	48,429	6.0	18.6
1925-26	256,991	4.4	50,813	11.2	19.8

The area irrigated in 1920-21 was the largest which has yet been recorded. The fall in subsequent years was due to the fact that timely rains, and especially timely winter rains, considerably reduce the demand for water everywhere, more especially in the United Provinces and the Central Provinces.

The part which irrigation plays in the rural economy of the different provinces varies greatly from province to province as will be seen from the Table given below which brings out clearly its importance in Sind, the Punjab, the North-West Frontier Province, Madras, the United Provinces and Bihar and Orissa. The figures are averages of the five years 1921-22 to 1925-26:

Province	Gross area sown Acres (in 000's)	Gross area of crops irrigated† (from government and private sources) Acres (in 000's)	Percentage of area irrigated to area sown
Assam	6,379	364	5.7
Bengal	27,777	1,710	6.2
Bihar and Orissa	31,021	5,386	17.4
Bombay Proper	27,764	1,092	3.9
Sind	4,451	3,281	73.7
Burma	17,172	1,436	8.4
Central Provinces and Berar	26,726	1,110	4.2
Madras	37,691	11,208	29.7
N.W.F. Province	2,673	919	34.4
Punjab	30,970	13,644	44.1
United Provinces	43,739	9,630	22.0
Minor Administrations	807	156	19.3
Total	257,170	49,936	19.4

* Areas sown twice are counted twice.
† Areas sown twice under irrigation are counted twice.

The figures in the above Table have been extracted from the latest issue of the 'Agricultural Statistics of India.' Figures for government irrigation systems, that is for irrigation under works which have been constructed or which are maintained, wholly or partially, by the State are given in the Table below, the figures in which are taken from the 'Annual Review of Irrigation in India':

Province	Net area sown (average for 5 years 1921-22 to 1925-26)	Area irrigated by government irrigation works (average for 5 years 1921-22 to 1925-26)	Percentage of area irrigated to total net area sown	Capital cost of government irrigation works to end of 1925-26	Percentage net return on capital cost of irrigation works (average for 5 years 1921-22 to 1925-26)	Estimated value of crops raised on areas receiving State irrigation (average for 5 years 1921-22 to 1925-26)
	Acres (in 000's)	Acres (in 000's)		Rs Lakhs		Rs Lakhs
Ajmer Merwara	269	20	7.4	35	..	7½
Assam	5,842	..	..	..	..	..
Baluchistan	240	23	9.6	32	0.3	5½
Bengal	23,504	100	0.4	4,20	-0.4	84
Bihar and Orissa	25,222	922	3.6	6,27	2.6	6,54
Bombay Proper	27,072	433	1.6	9,50	1.6	5,01
Sind	4,069	3,466	85.2	8,26	6.2	10,77
Burma	16,580	738	4.4	3,85	6.1	7,98
Central Provinces and Berar	24,395	438	1.8	5,41	-0.3	2,68
Madras	33,099	7,196	21.7	12,47	7.6	38,62*
N.W. F. Province	2,340	389	16.6	2,87	3.2	2,90
Punjab	26,491	10,383	39.2	28,04	15.8	56,76
United Provinces	35,399	2,473	7.0	18,30	5.2	18,06
Total	224,522	26,581	11.8	99,84	7.4	1,50,29

* Exclusive of the value of crops raised on some three million acres irrigated by non-capital works.

It will be seen that, on the average of the five years ending with 1925-26, 11.8 per cent of the entire cropped area of the country was irrigated by government irrigation works and that the collective value of crops so irrigated amounted to one-and-a-half times the total capital expended on the works.

GENERAL DESCRIPTION OF IRRIGATION WORKS

268. The works which, between them, irrigate approximately fifty million acres of the land are classified in the statistics published by the Government of India under four heads: canals, tanks, wells and 'other sources.' As explained by the Irrigation Commission, under 'canals' come all works of any considerable size for diverting the water of streams or rivers, and carrying them on to the land; under 'tanks,' all works for the storage of water, and all natural depressions of which the water is used for irrigation; and under 'wells,' works for giving access to the subterranean supply, or to the waters of rivers which, running deep below the level of the ground, have to be lifted vertically before they can be used for flow irrigation. 'Other sources' have never been clearly defined but consist for the most part of temporary *bunds* for the storage of rainfall, of lift irrigation from rivers, and of channels from rivers and streams which are too small to be classed as canals. The areas irrigated from the different classes of works are given in the following Table. The figures are averages of the five years 1921-22 to 1925-26:

(Acres in 000's)

Province		Canals	Wells	Tanks	Other sources	Total
Assam		191	..	1	172	364
Bengal		289	32	615	557	1,493
Bihar and Orissa		1,812	628	1,709	1,205	5,354
Bombay	Proper	290	531	109	38	968
	Sind	2,930	43	1	127	3,101
Burma		889	18	195	299	1,401
Central Provinces and Berar		946	117	(a)	46	1,109
Madras		3,803	1,654	3,362	467	9,286
N.W.F. Province		769	89	..	57	915
Punjab		9,836	3,385	15	120	13,356
United Provinces		2,080	4,737	65	2,317	9,199
Minor Administrations		28	88	28	..	144
	Total..	23,863	11,322	6,100	5,405	46,690*

Canals are thus of greater importance than the other three classes together. Irrigation under tanks is most extensive in the Madras Presidency where there are over 35,000 of them, of which about 28,000 are in the *ryotwari* area of the province; of the latter about 25,000 are in charge of the Revenue Department and the remainder in charge of the Public Works Department. The total area irrigated by tanks in that province is nearly as large as that irrigated by canals. Well irrigation is most important in the United Provinces where it accounts for more than half the total irrigated area. Even in the Punjab, where the irrigation under tanks and 'other sources' is negligible, the area irrigated by wells amounts to a quarter of the total irrigated area. The greater part of the area under 'other sources' is contributed by the United Provinces (2.3 million acres) and by Bihar and Orissa (1.2 million acres).

Possible Development of Irrigation Under Canals
(i) The Punjab

269. We do not propose to describe in detail the existing canal systems of India or the projects for their extension which are now in process of construction or are contemplated. The importance of irrigation to Indian agriculture is, however, so profound and, notwithstanding recent developments, the possibilities of its extension are still so great that some mention of these projects is inevitable. The very brief description of the most important of them which is all that can here be given must not be regarded as in any way indicating a preference on our part for a particular scheme.

Although, by the skilful utilisation of the waters of the Indus and of its tributaries as well as of those of the Jumna, the area under irrigation from government works in the Punjab has steadily increased from 2.3 million acres in 1887-88 to an average of 10.4 million acres from 1921-22 to 1925-26 and vast tracts of precarious cultivation and even of actual desert have been converted into most fertile agricultural land, the possibilities of further expansion are far from exhausted. The Sutlej Valley project will, when completed in 1933-34, provide perennial irrigation for two million acres. It will also greatly improve the irrigation of another three million acres which are at present dependent on inundation canals, that is, on canals which have no weirs at their head and the supplies in which consequently fluctuate with the natural water level in the river. Of the area under perennial irrigation, over a million-and-a-half acres will be in the Bahawalpur and Bikanir States. This is the only large project at present under construction in the Punjab but other great schemes are under consideration. The Thal project, if carried out even on a much smaller scale than was at first contemplated, will command an area of nearly a million-and-a-half acres in the Sind Sagar Doab in the desert districts of Mianwali and Muzaffargarh. The Haveli project will bring perennial irrigation to an area of about

700,000 acres in tracts in the Jhang and Muzaffargarh districts. All these projects comprise weirs or barrages to raise the level of the water in the river bed.

The next stage in the exploitation of the Punjab river system will involve the construction of storage works. The Irrigation Commission pointed out that only six per cent of the rainfall is utilised in artificial irrigation, and that the rivers carry off uselessly to the sea a volume of water six times greater: on the other hand, they concluded that 'storage is so costly even in the most favourable circumstances that very few irrigation works which depend on it are remunerative.'

The Sutlej Dam project proposes the construction of four storage reservoirs: of which the first, the Bhakra Dam - 400 feet high - would impound 112,385 million cubic feet, and add two million acres of *rabi* cultivation between the Sutlej and the Jumna rivers. A project for the utilisation of the Woollar Lake in Kashmir as a storage reservoir from which to supplement the supplies in the three linked canals at the commencement of the *rabi* season was prepared in 1915 but is at present in abeyance as it has not yet been possible to reach an agreement with the Kashmir Darbar.

It should here be mentioned that progress with the Thal project has been indefinitely postponed pending the settlement of the dispute which has arisen between the governments of Bombay and the Punjab in regard to the further utilisation of the waters of the Indus. We have no comments to offer on the merits of the question but, in a subsequent paragraph, we discuss the question of machinery for the settlement of disputes of this character.

(ii) SIND

270. As the agricultural problems of Sind are entirely different from those of the remainder of the Bombay Presidency, to which it is attached for administrative purposes, it is convenient to deal with it as a separate entity. The existing canals in Sind are entirely of the inundation type. It is only from May to September, when the Indus is in flood, that they provide water and then only in fluctuating quantities. The Sukkur Barrage which is being constructed across the Indus just below Sukkur and which, when completed, will be the greatest work of its kind in the world, will completely change this. It is anticipated that it will irrigate over five million acres, of which two million acres are at present very unsatisfactorily irrigated from the existing inundation canals. We deal in detail with the problems presented by this great project in paragraph 290 and 291 below.

(iii) THE UNITED PROVINCES

271. The only project of importance which is under construction or in contemplation in the United Provinces is the Sarda Canal which is designed primarily to irrigate the Sarda-Ganges Doab. It is estimated that the canal will irrigate annually an area of about 1.7 million acres. The area irrigated annually by the existing canals in the province in a year of keen demand reaches nearly three million acres. The Sarda Canal, when fully developed, will add over fifty per cent to that area and will raise the total maximum area irrigated annually to close upon four-and-a-half million acres.

The completion of the Sarda Canal will for all practical purposes mark the completion of the present projects of canal irrigation in the United Provinces. All the principal available resources for perennial irrigation will then have been tapped. It may, at some future date, be found feasible to construct a Lower Sarda Canal, but, in the immediate future, the only openings for expansion lie in carrying out certain protective works such as supplementary storage reservoirs on some of the existing canals. Works of this character can at most add not more than two or three hundred thousand acres to the total canal irrigation for the province.

(iv) MADRAS

272. The great irrigation systems of the Madras Presidency, the Godavari, the Kistna and the Cauvery, differ completely in character from those already described. They are, in the main, deltaic and the problem has been to regulate the

supply rather than to extend it to new areas. So successfully has this been done that river conservancy has been achieved at the same time and no problems have arisen in the deltas of the Madras rivers analogous to those which perplex the engineers of Bengal, Burma and Orissa. Credit for this cannot, however, be entirely taken by the irrigation engineers; for, as they would be the first to admit, the character of the soil which derives from the uplands of the peninsula has made their task much easier than that which has been presented to the engineers who deal with the soils of northern India. The works consist of weirs by which a sufficient head of water is obtained to irrigate the lands of the deltas and of sluices and regulators by means of which the water is conducted over these lands. By works of this character on the Godavari, the Kistna and the Cauvery rivers, some 2.4 million acres of fertile deltaic lands have been afforded the benefits of an assured supply of water. There has been no great expansion of irrigation in these tracts since the Irrigation Commission reported, but there is undoubtedly scope for development, though on entirely different lines from those which have hitherto been followed. The only example of a great storage reservoir in the Madras Presidency at present is the Periyar system. The main feature of this system is the impounding, by the construction of a large dam, 3,000 feet above sea level, of the waters of a river which would otherwise have flowed into the Arabian Sea and their diversion to the other side of the peninsula through a tunnel bored through the main watershed of the country. The new works under construction or consideration would also be storage reservoirs which would impound the waters of the great rivers of the province, their tributaries and other streams. They would not only supplement existing supplies which, even now, are not always sufficient for the whole of the area normally irrigated in the first crop season but would also make possible the cultivation of second crops which, if grown at all, are now grown as 'dry' crops. Such storage works are in reality a combination of tank and canal irrigation and, as they are expensive to construct, it will be necessary to levy a comparatively high rate for the water supplied to the cultivator. It is estimated that the Cauvery-Mettur project, which is at present under construction, will improve the supply of an area of 1.04 million acres already under irrigation and will bring under irrigation a new area of 221,000 acres of first crop and 90,000 acres of second crop. It will also supplement the supply to an existing wet area of 80,000 acres now irrigated by inferior and unreliable sources of supply. The construction of the Cauvery-Mettur project was only rendered possible by an agreement with the Mysore Darbar which was reached as recently as 1924. Of the same type, but of larger scope, are two projects, which have long been under consideration, the Kistna and the Tungabhadra projects. Hitherto, technical and financial considerations and the fact that an agreement with an Indian State, that of Hyderabad, in regard to the use of water was involved have stood in the way of their execution. Attention is now being concentrated on a revised scheme for impounding the waters of the Tungabhadra by the construction of a reservoir at Timmalapuram in the Bellary district. This would provide water for a wide extension of irrigation, mainly in the districts of Bellary, Anantapur and Kistna; and would protect a large area of dry cultivation in a tract liable to scarcity. As in the case of the irrigation projects under consideration in the Punjab, we have mentioned these projects here merely as an indication of the opportunities which still exist for an extension of irrigation on a large scale in the Madras Presidency, with all the advantages that would thereby accrue to the agricultural population. We are not in a position to express any opinion as to the feasibility of the Kistna or the Tungabhadra projects either from the financial or the technical point of view, but we cannot refrain from pointing out the transformation which would be effected by the construction of the latter project in that part of the Madras Presidency which is at present least immune from famine and

scarcity. In our opinion, however, the project should in no case be proceeded with until a thorough investigation has been made and a definite decision reached as to the suitability of the black cotton soil of that area for irrigation, a question on which the evidence before us showed that there was considerable difference of opinion.

A much smaller project for utilising part of the supplies available from the Tungabhadra river is at present under consideration. This is the Bellary West project which would bring under irrigation an area of 57,600 acres in the Bellary district. A larger project, the Upper Bhavani project, which provides for the irrigation of 110,000 acres of first crop and 60,000 acres of second crop in the Coimbatore district, a tract which needs protection, deserves mention here as it marks a new departure in irrigation in Madras. It is primarily designed for the irrigation of dry crops, instead of rice which is much the most important crop grown under irrigation in Madras.

(v) THE BOMBAY PRESIDENCY PROPER

273. In the Bombay Presidency proper, irrigation by canals is confined to the Deccan and (on a very small scale) to Gujarat. The most important works are of the reservoir type in which Bombay led the way. The Khadak Wasla Dam across the Mutha river, ten miles above Poona, was completed in 1879 and was the first of its kind in India. The total area irrigated from government works in the Bombay Presidency proper is only about 450,000 acres and as the works were, in the main, designed for protective purposes, there is, with very few exceptions, a heavy annual loss on their working. Financial considerations, therefore, seriously limit the possibilities of extending works of this class. This is the more unfortunate as the rainfall of the Western Ghats which they utilise is unfailing. Such opportunities of extension as present themselves are, however, receiving due attention. A new dam, the Lloyd Dam at Bhatgar, which we visited in the autumn of 1926, and the subsidiary canals are designed to protect three talukas in the Sholapur district, which are specially liable to famine, and also to improve existing irrigation.

WELLS AND TANKS

274. The figures we have given in paragraph 268 show that, after canals, wells are the most important source of irrigation. These vary greatly in construction and capacity. They may be mere holes in the ground, elaborate masonry structures of great width and considerable depth, or tubes of small bore, from which, by power pumping, large supplies of water can be obtained continuously throughout the year. Wells of the first of these types may irrigate an acre or two in their immediate vicinity, wells of the last may have a capacity of 35,000 gallons an hour and may irrigate as much as 150 acres in addition to affording protection to another 100 acres. Between the two extremes come masonry wells in the floor of which perforated pipes have been sunk which tap largely increased supplies, often at no great depth. Wells of this type have been most successful in the United Provinces. In Madras, small wells, sunk for the purpose of supplementing irrigation from tanks the supply of which is precarious, are very common.

The type of well used is largely determined by the geological formation and the conditions for successful well-sinking are generally far more favourable in northern than in peninsular India. This is specially true of tube wells. Notwithstanding the differences in the local conditions, there is no province in India in which well irrigation might not be largely extended with advantage.

Tanks, like wells, comprise a great diversity of works, varying from storage reservoirs the distributary channels from which irrigate several thousand acres to works which irrigate a few acres only. Occasionally they act as regulators and storage reserves for canals, and sometimes their purpose is to maintain the water level in the wells in their immediate neighbourhood. The larger tanks are, with very few exceptions, government works as are the numerous small tanks in the *ryotwari* areas of Madras and in Bombay. Elsewhere, the smaller tanks are, for the most part, owned by village communities and by private individuals.

NEW IRRIGATION SCHEMES

275. In our questionnaire, we specially invited suggestions for new irrigation schemes and for the extension or improvement of existing schemes. We also asked for mention of any local obstacles to the promotion of irrigation by canals, tanks and wells and for opinions as to whether the existing methods of distributing canal water to cultivators gave satisfaction. The views expressed by witnesses were not confined to these subjects and, as our enquiry progressed, other matters assumed importance.

We have already explained the circumstances in which we refrain from comment on the suggestions we received in regard to new irrigation schemes and the improvement of existing schemes. The technical advisers of the provincial governments are in a far better position than we are to pronounce on the feasibility of these suggestions and we trust that they will receive due consideration. In these circumstances, we have only one recommendation to make under this head. It appears to us that no sufficient provision has anywhere been made for a systematic review of the position in regard to outstanding irrigation projects. For financial or other adequate reasons, it may be impossible to proceed with a scheme, however promising, when it is first worked out. We consider that, until a definite decision to take no further action has been reached, the scheme should be periodically reviewed by the provincial Government. If this is done, any change in circumstances which makes it feasible to proceed with it will be brought to notice. If a definite decision is reached to take no further action by the State, a public announcement should be made of the reasons which have led Government not to proceed with the scheme.

EXTENSION OF PROTECTIVE IRRIGATION

276. As the result of the constitutional changes which followed on the passing of the Government of India Act of 1919, irrigation, with certain limitations which will be mentioned later, became a provincial subject administered by the reserved side of the local government. This alteration in the constitutional position removed the previously existing restrictions on the powers of the provincial governments to undertake protective schemes of irrigation. Prior to 1919, irrigation works were, from the point of view of their financial results, divided into three classes: 'productive works,' the capital outlay on which had been sanctioned against loan funds in the expectation that the works would prove directly remunerative; 'protective works' which were not considered likely to fulfil the conditions of a productive work but which were sanctioned against the Famine Fund on the ground of their protective value; and 'minor works,' outlay on which was met from general revenues and which included all works which were not classed as productive or protective. Protective works were thus financed from the general revenues of the country. After the great famine of 1877-78, it was decided to set apart every year a sum of Rs 150 lakh, known as the Famine Relief and Insurance Fund, for famine relief, the construction of protective works, and the avoidance and reduction of debt. Of this amount, one-half, or Rs 75 lakh, was to be allotted to protective railways and canals; the charge on the Fund on account of protective railways, however, ceased to be imposed and the whole of the Rs 75 lakh became available for irrigation works. In 1910, the allotment was found to be insufficient for the programme of construction then contemplated and the Secretary of State sanctioned the provision of an annual subsidy not exceeding Rs 25 lakh for the purpose. The full allotment of Rs 100 lakh was, however, never worked up to; Rs 86 lakh were spent in 1913-14 and Rs 84 lakh in 1914-15, after which expenditure was restricted owing to circumstances arising out of the war. The expenditure of this amount was governed by the principles laid down by the Irrigation Commission. The Commission considered that, in general, it would be permissible to spend up to three times its direct 'protective' value of each acre irrigated, worked

out by a formula* which they suggested, to which might be added the capitalised value of the net revenue anticipated from each such acre, in payment of the water provided. The sum of these items was the so-called 'permissible capital outlay per acre' and, in the case of every protective work submitted for sanction, it had to be shown that the permissible outlay would not be exceeded. The restrictions thus imposed were removed on the introduction of the Reforms. In cases in which local governments are unable to finance protective schemes of irrigation from current revenues or from the Famine Insurance Fund which, under the Devolution Rules, they are bound to maintain, it is open to them to raise the funds required by loan provided that, if the project appears to the Governor General in Council to be one which is unlikely to yield a return of not less than such percentage as he may from time to time prescribe, arrangements are made for the amortisation of the debt. We trust that the recent relaxation of the rules on this point will encourage, so far as the financial situation may allow, the construction of further protective works.

DISTRIBUTION OF WATER

277. The evidence we received did not establish the existence of serious dissatisfaction amongst cultivators with the present method of distributing water. It is true that we received complaints in regard to short supplies, arbitrary withdrawal of supplies and the like, but, in a business so extensive as the distribution of water in India has become, isolated complaints of this character are to be expected and are not in themselves sufficient to show that the system of distribution generally is at fault. We have, however, examined the question in some detail as it has an important bearing on the subject matter of our enquiries.

That there is an enormous waste of water by the cultivator in the canal-irrigated tracts of India is universally admitted. It has been estimated that the amount of excess water applied to crops such as wheat in northern India is from thirty to fifty per cent. The contrast in this respect between land irrigated by canals and land irrigated by wells is very striking. The waste of canal water is usually attributed to the fact that, when the cultivator lifts water from a well, he realises that he is paying in time and labour for every gallon he uses; when he irrigates his land from a canal, the water is provided for him and he pays not by the amount he uses but by the area he irrigates or, in the Punjab, by the area of the crop matured. He has, therefore, little incentive to economise water and to see that it is not wasted between the government channel and his fields. This is not, however, the whole explanation. No small proportion of the wastage is due to uncertainty of supply. With a well, the cultivator has the source of supply entirely at his disposal and can, without risk, give a light watering if he considers that is all that is required; with canal irrigation, he often does not know definitely when the next watering will be possible; he, therefore, applies water in large quantities, in the hope that this will tide him over the period of unknown length during which it is not obtainable. Unfortunately, the evil effects of this uneconomic use of water are not confined to the wastage of water which could be used more profitably elsewhere; they often extend to definite damage to the soil. The marked deterioration of some ten per cent of the total area commanded by the Deccan canals in the Bombay Presidency must

*the formula suggested was :

$$X = \frac{F}{Pn - a}$$

Where X = The direct protective value of an irrigated acre, or the capitalised value, at 25 years' purchase, of the saving in average annual cost of famine which will be effected by every acre brought under irrigation.
F = Estimated total cost of famine in the given tract for a period of 25 years, or quarter of a century.
P = Population of the tract, with necessary addition for prospective increase.
n = Area in acres which should be protected by irrigation for each head of the population.
a = Area in acres already protected.

The co-efficient 'n' was a variable one in each tract, but the Commission held that in insecure tracts, it would probably never be less than 0.3 or more than 0.5 and that other things being equal such as the character of the cultivation and the nature of the staple crops, the value of 'n' should diminish as the area normally cropped per head of population increased.

largely be attributed to this cause.

The problem of preventing this waste of water, of securing greater certainty to the cultivator as to the supply he will receive and of relieving him from any harassment and interference from the staff which records his irrigation has long engaged the attention of irrigation experts in India. The view taken by the Indian Irrigation Commission was that it would be a great advantage both to the Government and the cultivators, if the latter could be induced to take over their supplies at the outlets, to arrange all details of internal distribution between themselves and to relieve the canal administration of all further responsibility and of the great expense of recording the details of the irrigation and of making the final measurements and assessments. Their general conclusion was, however, that the system of charging by volume could not, in spite of all its advantages, be safely introduced in India until a system of distribution by modules of the type which it might be proposed to use had been in force for a time sufficiently long to enable the people to understand what was proposed. They held that, even then, the change in the system of assessment should not be forced but should be introduced gradually, as the people learned to appreciate its advantages. They added that it was an end to be aimed at and that irrigation officers should be encouraged to design and experiment on modules which would be suited to the conditions to be met with in practice, until the work of distribution could be carried out with all the regularity and certainty which were essential to the success of any scheme of charging by volume.

We have quoted the views of the Irrigation Commission on this point at length as they mark the starting point of investigations into the possibility of more scientific and equitable distribution of water which appear, in the Punjab and Bombay, to have crystallised into scepticism on the part of the engineers as to the possibility of the sale of water by volume. It was represented to us that assessment at volumetric rates instead of by areas irrigated, though advantageous to the big cultivator, is quite unsuited to the interests of the smaller men; that no reduction in staff or in working expenses would be secured by its adoption; that no meter is yet obtainable at reasonable cost which will give measurements as accurate as measurements by area; that there is no meter which cannot be tampered with, so that, with quantity measurements, the temptation to dishonesty would be enormously greater than with area measurements; that the charges for water would not be in proportion to the profits of the cultivators which have hitherto been considered the fair basis for assessment; and, finally, that the staff would lose touch with the conditions of the cultivators and their difficulties and that irregular practices due to laziness and dishonesty would arise which would reduce the general efficiency and cause damage in adjoining areas.

We fully admit the force of these objections but, none the less, we feel that it is impossible to hold that the system of sale of water by volume has yet received the fair trial which alone can determine whether it is worthy of adoption on its merits. The suggestion was made to us that, if the cultivators could be induced to experiment roughly for themselves, progress in the solution of what is unquestionably a most complicated problem would be more rapid. Suitable meters might be installed on each outlet of one or more channels and water charged for on one outlet by volume and on the next by area. The figures obtained should prove very useful and worth the expense involved, especially as the cultivator who paid by volume should speedily develop economical methods, and a comparison of his crops with those of his neighbours should indicate whether excessive irrigation not only means loss of water but also actual damage to the growing crop. We consider that this view has much to commend it and that further investigation and experiment are eminently desirable, both in the Punjab and elsewhere, before a final decision against the sale of water by volume is reached.

The scepticism of irrigation engineers in regard to the sale of water by volume does not mean that no progress has been made in recent years in the improvement of the system of distribution. This is far from the case. Every distributary in the Punjab has been, or is being, fitted with a meter so that the exact amount of water passed into the distributary is known. The meter functions with a module, which is an apparatus designed to fix

the proportion of water taken from the canal and to give as even a distribution as possible from the head to the tail, independently of any rise or fall in the level of the water in the canal. By this means, considerable economy of supply has been effected, enabling irrigation to be extended to areas for which water was not previously available, and the opportunities for harassment and interference by the subordinate staff have been greatly reduced. It is held that the new system inspires confidence in the cultivator, especially in the small man, but there is one respect in which there appears reason to doubt this. Even under the area system of distribution, there are some cultivators who make their water go much further than others. It was represented to us that the good cultivator who utilises his water in the irrigation of a larger area than his neighbour is promptly penalised by a reduction in the capacity of his outlet. It would appear obvious that, once the cultivator is aware that he will not be permitted retain the benefit of an economical use of water, he ceases to have any incentive to economy. It was stated in evidence that the saving of water thus effected might enable the cultivators at the tail end of a distributary to receive water of which they would otherwise be deprived and that the Irrigation Department has an obligation to fulfil its responsibilities to these cultivators by every means possible. We agree that this is a strong argument for the economical use of water in general, but we are unable to accept it as justification for reduction of supply to a specially skilful cultivator. If savings are to be effected, it is the careless and wasteful user of water who should first be penalised. We are of opinion, therefore, that the cultivator should be regarded as having a right to an outlet of a definite and uniform capacity in proportion to his area and that no reduction in this capacity should be made in any individual case solely because it is found that a larger area is irrigated than that for which the outlet was designed.

AGENCY OF DISTRIBUTION

278. As regards the agency of distribution, we can see no advantage in the proposal made to us by several witnesses that this should be transferred from the irrigation to the agricultural departments. Closer co-operation between the two departments in this and other matters is no doubt very desirable and we recur to this point later, but the acceptance of this suggestion would involve the diversion of the agricultural departments from their legitimate functions to work for which they are wholly unfitted. As between government and private agency, we are of opinion that there is at present no practical alternative to the system of government control over distribution down to the field distributaries. The question of agency is closely linked with that of methods of distribution and, as we have already indicated, there can be little doubt that the general introduction of the sale of water by volume would greatly facilitate the substitution of private for official management of the minor distributaries. Co-operative action in this respect has so far made little headway. One instance in which the co-operative distribution of water on an acreage basis- on the Nira Canal in the Bombay Deccan by cultivators in the village of Malegaon- has proved successful was brought to our notice in the Bombay Presidency. Irrigation *panchayats* for the management of minor irrigation works and of branch channels have in some instances worked with fair success in Madras and the possibilities of the *panchayat* system for the control of field distributaries were hopefully spoken of, on the basis of recent experience, by a Chief Engineer for Irrigation in the Punjab. It is important that the real obstacle to entrusting the distribution of water to private agency should be clearly grasped. It is not the lack of facilities to measure water accurately and to control supplies to distributaries from canals and their main branches. Meters and modules have been devised which are held to measure and control water in a satisfactory manner. The fundamental obstacle is the attitude of the cultivator himself. Water is so vital a need to him that he is not at present prepared to entrust his interests in this matter to the decision of his fellows. The formation of irrigation *panchayats* for the management of field distributaries points the way and it is collective action in this limited sphere which will best develop the mutual confidence necessary for the successful management of the larger distributaries. The progress of education, and the

experience gained in other directions, such as the communal management of forests and the co-operative supply of credit, should also play their part in rendering the distribution of water by private agency possible.

MINOR WORKS

279. The figures we have given in this chapter have shown the importance to the cultivator of the smaller storage works and of 'other sources' of irrigation. We do not consider that the construction, preservation and improvement of these minor works have, in the past, received the attention from Government which that importance justifies. To mention only one instance, we were informed by the Secretary for Irrigation to the Government of the United Provinces, that there was endless scope for small tank schemes in that province. In Madras, the fact that over wide areas the only source of irrigation is the conservation of the annual rainfall has ensured that due attention is paid by Government to works of this character. Up to date, nearly a crore-and-a-half of rupees have been spent on the restoration of tanks. In that province, all government works irrigating less than 200 acres, except such as for special reasons have been transferred to the charge of the Public Works Department, are in charge of a 'Minor Irrigation Department' which works under the Collector of the district and is, in effect, a subordinate branch of the Revenue Department. The maintenance of minor irrigation works by the Revenue Department is, as a rule, limited to the repair of masonry and earth work and the reconstruction of damaged works. If anything beyond this is required, the assistance of the Public Works Department is invoked. In Bombay, special attention has recently been paid to this subject and, in 1925, a superintending engineer was placed on special duty 'to investigate natural resources for the protection of lands from famine' for which purpose he was given a staff of three assistant engineers and eight survey parties. His operations are, however, confined to the insecure tracts of the Bombay Presidency, except that two subordinates have been placed under his orders to give advice to cultivators outside those tracts. In the Punjab, a Rural Sanitary Board which was first started in 1920 as a Drainage Board, has been responsible for various minor irrigation works in the course of its work of supervising or co-ordinating operations for the prevention or cure of waterlogging.

We are of opinion that much could be done to promote the development of minor works, if the example of the Bombay Government were followed in other provinces, and we would also suggest that the operations in Bombay should be extended to districts outside the insecure tracts. In our view, an agency is wanted, to which the cultivator who wishes to improve his land by utilising the natural sources of water supply can turn for technical advice and assistance. This agency should not wait for the cultivator to consult it, but should go to him and urge him to adopt the scheme best calculated to utilise his available water supply to the fullest advantage. The personnel should regard its function as educative rather than purely advisory. The Madras system does not provide such a staff, but there is probably less scope for the construction of small private irrigation works in the *ryotwari* tracts of that province than there is elsewhere. Had such advice and assistance been available in the past, it is probable, to say the least, that many *taccavi* loans to cultivators for land improvement would have been utilised to better purpose than they have been.

We refrain from proposing detailed arrangements for giving effect to our recommendations under this head as we apprehend that a suggestion for the formation of a separate Minor Irrigation Department might give rise to administrative difficulties. The object we have in view would be achieved if, in each province, one or more officers with suitable subordinate staff were made directly responsible for the investigation of the possibilities of small irrigation works and for advising and assisting the cultivators in regard to all questions connected with such works. Special attention should be devoted to the formation and assistance of co-operative irrigation societies for the construction of small works and for keeping existing works in proper order by the removal of silt and the repairs of embankments. The officer or officers entrusted with these duties would ordinarily be selected from the Irrigation Branch

of the Indian Service of Engineers. It is essential that the work should be done in the closest association with both the revenue and agricultural departments. In thus recommending the formation of a special agency within the provincial irrigation departments to deal with the investigation and construction of minor works, it is far from our intention in any way to criticise those departments for any failure in this respect in the past. Where small schemes possessing no engineering features of interest have to compete for attention with important projects presenting problems which demand the highest professional qualities for their solution, it is both natural and proper that they should take the second place. In these circumstances, we are persuaded that it is only by making minor works the definite responsibility of a special agency that they will receive the attention to which their value to the cultivator, especially to the smaller man, entitles them.

TUBE WELLS

280. Irrigation from tube wells is a comparatively recent development in India. There were few such wells in existence when the Indian Irrigation Commission reported. Wells of this type are almost entirely in private ownership and, except in the United Provinces, are privately financed, though a loan under the Land Improvement Loans Act may be given for their construction. Technical advice and assistance are, however, freely given by the government department concerned and the well is, in fact, usually installed by that department subject to the payment of moderate fees for the services it renders. In Madras, pumping and boring operations have been entrusted to the Department of Industries and, in the Central Provinces, to the Public Works Department; in other provinces they are in the charge of the Agricultural Department.

The assistance given in the United Provinces in the construction of tube wells goes much further than that described above. In that province, the landholder pays the cost price of the actual material left in his possession on the completion of the work, that is, for the tube, the engine and pumping plant, all overhead charges and depreciation and interest on the capital invested in the boring equipment being borne by Government. The following figures have been supplied to us by the Director of Agriculture, United Provinces, as giving 'a reasonably accurate estimate of the 'all in cost' of a 15 inch strainer tube well and pumping plant giving 35,000 gallons of water per hour' :

		Rs
(i)	Paid by landholder	8,000
(ii)	Overhead charges borne by Government (1926)	4,987
(iii)	Depreciation (ten per cent) and interest (six per cent) on capital invested in boring equipment	900

Thus, towards the expenditure of a well costing in round figures Rs 14,000, Government contribute about Rs 6,000. In addition to the assistance thus given, zamindars, who undertake to multiply seed for Government or to lease land to Government for demonstration purposes, may receive, in special cases, grants-in-aid up to a maximum of Rs 3,000. We understand, that, in practice, such grants are invariably applied for and are given at the maximum rate.

The main points for examination in connection with tube wells are three in number, the conditions under which they can be regarded as a paying proposition, the degree of responsibility which Government should assume for their construction and the department of Government which should be charged with that responsibility.

The point at which the cost of sinking and operating a tube well becomes such that the undertaking ceases to be profitable is obviously not a fixed one, but must vary, not only with the first cost of sinking the well, but also with the flow of water per hour, the character and extent of ground irrigable, the nature of the crops grown and the marketing facilities which are available. All that can be said with confidence, in present conditions, is that irrigation from tube wells is never cheap as compared with canal irrigation. The Director of Agriculture in the United Provinces informed us that it does not pay unless intensive cultivation is adopted and unless a valuable crop such as sugarcane, potatoes or tobacco is grown. He added that it is not a business proposition to irrigate only wheat or other *rabi*

crops grown on the indigenous system, with yields of fifteen *maunds* per acre, except in cases in which the discharge is high and the lift low. We consider that a landholder is entitled to obtain from the Agricultural Department sufficiently definite information to enable him to decide whether, if water is found at a certain depth and with a certain minimum discharge at the surface, it will pay him, in the local conditions of soil and of marketing facilities, to install such a well. The department entrusted with the charge of pumping and boring operations should make detailed investigations with a view to the collection of this information. These investigations should include a systematic survey of the subsoil water supplies.

The degree of responsibility which should be assumed by Government for the development of tube well irrigation should be limited to the supply of the economic data just mentioned and of expert advice, to the provision of finance, where required, on the *taccavi* system and to placing at the disposal of the landholder, on payment of a reasonable fee, the boring equipment and skilled labour required. We can see no justification for the system of subsidies which has been adopted in the United Provinces and recommend that it should be terminated. In so far as the subsidy may have served to popularise tube wells, we are of opinion that more satisfactory results would have been obtained if the work had been undertaken directly by the Agricultural Department. If the wells had been sunk in typical areas and utilised for intensive cultivation under the close supervision of the department, it would now be in a position to supply the data on the absence of which we have commented. The benefits of the subsidy have so far been entirely confined to the large landholder. If the wells had been operated as we have suggested, under the supervision of officers whose business it would have been to supply information to all enquiries, this might have led to developments in the direction of co-operative action which would have assisted the small cultivator. We would mention that the Punjab Government have recently approved a scheme for the installation of an experimental battery of sixteen tube wells, operated by one prime mover, which will irrigate an area of 6,400 acres. This scheme, when it comes to operation, should throw much valuable light on the economics of tube well irrigation.

The equipment required for pumping and boring operations is at present provided by Government and in tracts in which the scope of tube wells is limited or in which they are still a novelty, this must, we think, continue to be the case for some time to come. But in areas such as those in the United Provinces in which wells are being sunk in increasing numbers, private enterprise should not be discouraged by government competition in the manufacture of the plant, in hiring it out and in the provision of the skilled staff required to operate it and to effect repairs when necessary. Government cannot undertake responsibilities of this kind for an indefinite period and on an ever increasing scale. The limits of justifiable pioneering enterprise in this respect appear to us to have been already exceeded in the United Provinces. Even in areas in which tube wells are not at present in great demand, the longer the transfer to private enterprise is postponed, the more difficult it will eventually prove.

Except in Madras and the Central Provinces, the Agricultural Department is the department which is responsible for pumping and boring operations. Apart from the fact that the agricultural engineers in the United Provinces and the Punjab have given special attention to the design and the technique of sinking tube wells and to the manufacture of the plant required, we consider that it is the department which is best fitted to undertake the work. The greatest incentive to private enterprise in sinking tube wells obviously exists in areas which have not the benefit of canal irrigation, that is, in tracts outside the normal operations of the Irrigation Department which would not, therefore, be in a position satisfactorily to supervise their construction and working. At the same time, it should be mentioned that the winking of tube wells in waterlogged areas is often the most appropriate method of lowering the subsoil water. Again, the question whether, in any locality, a tube well is likely to prove a paying proposition depends, in part, on the depth from which the subsoil water has to be lifted and, in part, on the agricultural possibilities of the land to be irrigated and the marketing facilities available in the neighbourhood. There are matters in regard to

which the Agricultural Department and its agricultural engineers are in the best position to advise. We would here reiterate the view already expressed in paragraph 106, Chapter IV, that, where pumping and boring operations are in progress in any province on a considerable scale, a separate branch of the engineering section of the Agricultural Department should be constituted which would concentrate on them alone, [Chapter IV, paragraph 106, not given in this documentation].

ORDINARY WELLS

281. There has, on the whole, been little or no expansion in the area under well irrigation since the Irrigation Commission reported, as the figures in Appendix VII show. The area irrigated by wells in British India in 1902-03 was 11.6 million acres; in 1925-26, it was 11.7 million acres. There were great fluctuations in the intervening period and the immense value of wells in years of drought is shown by the figures for the bad years, 1907-08, 1918-19 and 1920-21, in each of which the area irrigated by wells was over 14 million acres. The figures include those for tube wells, but the area under these is too small to affect them appreciably. The figures hardly give a true impression. Where there has been extensive construction of canals, these have superseded wells in several areas, the cost of irrigation from canals* being but a fraction of that from wells.† This is specially true of the Punjab.‡ Even when the expansion of canal irrigation, which has rendered wells unnecessary in large areas, is taken into consideration, it is disappointing that so little progress in sinking ordinary wells should have been made since the beginning of this century. Difficulties and cost of construction, the tenure on which land is held, the fragmentation of holdings, disputes amongst co-sharers, the uncertain return on the money invested and the power available for lifting water have all, either singly or in combination, proved limiting factors in this respect. Lack of water is rarely an obstacle in the alluvial tracts of the north; in peninsular India, it is often a difficulty.

The construction of wells is essentially a matter for private enterprise, but there are many ways in which the agricultural and irrigation departments can help the landholder. The agency for minor irrigation works which we have recommended in paragraph 279, the agency for research into irrigation problems which we propose in paragraph 287 and the branch of the engineering section of the Agricultural Department which, under our suggestions in paragraph 106, Chapter IV, would deal with water-lifts should all be able to give the cultivator substantial assistance in the appropriate direction, [Chapter IV, paragraph 106, not given in this documentation]. Much useful work can be done in investigating the methods of constructing and of lining wells most suitable to his conditions. The systematic surveys of subsoil water supplies, which we have recommended in the preceding paragraph, will enable advice to be given him in regard to the probabilities of finding water. The agricultural engineer should be able to work out for him the cheapest and most efficient method of raising water when it has been found. If assistance is given in these ways, any reluctance to sink wells which arises from uncertainties as to whether they will pay or from lack of skill in constructing them should be overcome. Difficulties will still remain. Where holdings are very small, the cost of construction of a well may prove out of all proportion to the benefits to be derived from it by the individual cultivator. The only remedy in such circumstances lies in sharing the cost of construction amongst a number of small holders, but the risk of disputes is likely to prove a deterrent to joint action. The difficulty might be overcome by the formation of a small co-operative society for the sinking and working of the well. An increase in the number of ordinary

*About Rs 3-8 per acre.
†About Rs 22 per acre.
‡Area irrigated from wells in the Punjab:

	Acres
1968-69	4,612,000
1918-19	3,829,000
1926-27	3,484,000

The decline is due to the extension of canal irrigation to tracts formerly dependent on wells.

wells is so desirable that we consider that every effort should be made to encourage the formation of such societies. It is a matter for regret that, in some parts of India, the number of abandoned wells is large. In tracts such as the Bombay Deccan, this is doubtless due to a fall in the subsoil water level which has made the working of wells unprofitable; but, in general, the abandonment of wells would seem to be due to fragmentation of holdings and disputes in regard to the division of the supply. We would suggest that, in tracts where the number of abandoned wells is at all numerous, a special enquiry should be made by the Revenue Department into the reasons why the wells have fallen into disuse with a view to ascertaining whether the difficulties can be removed.

OTHER SOURCES

282. As has already been explained in paragraph 268, the other sources of irrigation are of very various kinds. Although, in the aggregate, over ten per cent of the total irrigated area is irrigated from these sources and they are thus of great importance to cultivation, each individual work is usually quite small. There is great scope, we consider, for extending works of this character and also for increasing the efficiency of those already constructed. We trust that this development will be assisted by the suggestions made in paragraph 279 for the extension of minor works generally, of which these 'other sources' form an important part.

We desire, in particular, to draw attention in this connection to the possibilities of extending irrigation from small streams by means of power-driven pumps placed on the banks, or on temporary stages or floats where the permanent bank is at some distance from the water. We consider that this source of irrigation provides opportunities for fully protecting the harvest over many thousands of acres. Failure to turn these opportunities to account in the past has probably been due to several causes, amongst others, to the difficulties of securing suitable pumps, especially pumps combining a low lift with a high discharging capacity, the general lack of knowledge how to manage them and of facilities for effecting repairs, the cost of installation which places them beyond the reach of the small cultivator, unless he is able to combine with his neighbours, and the obvious difficulties of such combination. The difficulty of combination is probably the most serious and can, we think, be best overcome by the formation of co-operative societies, the encouragement of which we have urged in the preceding paragraph in the case of ordinary wells. But there is also a wide field of opportunity for the branch of the agricultural engineering section, which will be responsible for pumping operations under the suggestions made by us in Chapter IV, to devise cheap and efficient pumps with suitable staging or floating platforms, where these are required to mount them and to induce private enterprise to undertake their multiplication and the establishment of a repairing service for them, [Chapter IV not given in this documentation].

RELATIONS BETWEEN THE AGRICULTURAL AND THE IRRIGATION DEPARTMENTS

283. In its administrative aspect, irrigation presents in a marked degree the problem of co-ordinating satisfactorily the relations between two highly skilled services of technical officers. The *raison d'être* of the Irrigation Department is to assist the agriculturist by providing an assured supply of water. Each scheme of irrigation presents its own special agricultural problems. It might be thought, therefore, that no new project would be initiated by the Irrigation Department without the fullest consultation with the Agricultural Department both in regard to the suitability of the soil for irrigation, including the conformation of the subsoil, the nature of the crops that would be grown and the character of the supply that would be required for them. Such preliminary consultations do not, however, appear to be the universal practice. We were informed by the Director of Agriculture, Madras, that he and his department had no contact whatever with the Irrigation Department. Dr. Mann, the late Director of Agriculture, Bombay, expressed a desire for closer relations between the two departments. On the other hand, the directors of agriculture in the Punjab, the United Provinces and the Central Provinces declared themselves satisfied with the degree of contact maintained between the two departments which, however, is of a personal character and owes little or nothing

to official organisation directed to that end. Yet it is from the Punjab that there comes a striking illustration of the need for consultation of the kind here contemplated. Two years after the colonisation of the Lower Bari Doab canal area was commenced, a soil survey revealed the fact that the area of culturable land was very considerably less than that which had been originally anticipated. While we agree with the view that successful co-operation between any two departments must depend in very large measure on the personality of the heads of those departments, we are of opinion that the existence of formal official orders stressing the necessity of such co-operation would be salutary. Orders directing that the views of the Director of Agriculture must be obtained at an early stage on the agricultural aspect of all new irrigation schemes would serve as a reminder to both departments of the need for that close co-operation between them which alone can secure the adequate discharge of their responsibilities to the agricultural community.

We are further of opinion that, when there is occasion for consultation between the heads of the agricultural and irrigation departments, their views should be placed formally on record. Conditions of service in India make frequent changes of officers inevitable and it is, therefore, all the more important that a permanent record should be kept of the views of those responsible for important decisions, together with any relevant data. Our object is to secure that the documents which are really material to the decisions reached by heads of departments should be readily available.

We have little doubt that co-operation between the agricultural and irrigation departments would be rendered easier if the officers of the one department possessed a more intimate knowledge of the working of the other than they do at present. We would suggest, therefore, that the possibility of instituting a short course in agriculture for irrigation officers and in irrigation for agricultural officers should be carefully examined. Such instruction could, we think, best be given at the agricultural colleges.

In regard to the curriculum at these colleges, we are aware that little, if any, scope is left for the inclusion of new subjects and it may be found undesirable to add to it even a short course of lectures in irrigation especially if any effort is made, as it should be, to give the student a practical insight into the workings of the irrigation system of the province. The institution of a short post-graduate or post-certificate course in irrigation will, therefore, in all probability be found preferable. This course would be open to all students but would be compulsory for junior officers of the agricultural departments. It would be confined to an exposition of the salient features of the irrigation systems of the province, their problems and potentialities, the methods of distribution of water and the ways in which the agricultural officer can assist the irrigation engineer. The irrigation engineer, on the other hand, would be expected to acquaint himself with the agricultural aspect of the soils of the province, the nature and requirements of the crops grown under irrigation and the agricultural practices of the cultivators in the irrigated tracts. If care is taken to select suitable instructors, much could be learnt in a short course modelled on the lines of the rural economy course held at the Lyallpur Agricultural College to which we have already referred in paragraph 233, Chapter VIII, [Chapter VIII, paragraph 233, not given in this documentation]. This course lasts one month and is designed to give officers of the Irrigation and other departments an insight into the work of the Punjab Agricultural Department. The knowledge acquired should, if possible, be tested by an examination.

THE IRRIGATION DEPARTMENT AND THE CULTIVATOR

284. We consider that the time has come to devise means whereby the cultivators, for the furtherance of whose interests the irrigation departments exist, should have a more direct avenue of approach to the responsible officers of the department and to Government. At present, though full advantage is taken of the opportunities afforded by visits of inspection from the superior officers of the irrigation and revenue departments and by the right of interpellation possessed by members of the provincial legislatures, the representation of their needs is, in the main, effected through the subordinate officials of the

irrigation and revenue departments. We do not wish to minimise the value of any of these channels of communication, in particular that provided by the provincial legislatures, which should certainly constitute the cultivator's ultimate protection. But something further is required to prevent questions arising out of the distribution of water from reaching a stage at which any section of the rural community regards itself as aggrieved. We would therefore suggest the creation, in those provinces in which irrigation is of importance, of an organisation on the analogy of the local railway advisory committees which would be composed of representatives of the irrigation, revenue and agricultural departments, with a majority of non-official members who should, if possible, be cultivators. The functions of this organisation would be to examine representations made to it by individual cultivators and by associations of cultivators, and to arrange that such of them as contained points of substance should receive careful attention at the hands of Government. Whether an organisation of this character should be constituted for a province as a whole or for particular irrigation systems is a matter we would leave to the discretion of the provincial governments, but we consider it essential that the non-official members of it should themselves be landholders or cultivators in the irrigated tracts for which it is formed. Advisory committees for irrigation already exist in the Godavari, Kistna and Cauvery deltas in Madras and appear to be working effectively. In the Central Provinces, there is a Standing Committee for Irrigation composed mainly of members of the Legislative Council, but its duties appear to be the consideration of important new proposals rather than the examination of grievances. The more thoroughly such grievances are aired and the sooner they receive a preliminary investigation and sifting at the hands of the district officers and of local agricultural associations and kindred bodies the better for all concerned, but there should remain a definite right of access to some central organisation constituted as we have suggested.*

CENTRAL ORGANISATION

285. Before the constitutional changes which followed the passing of the Government of India Act of 1919, the Government of India were the real owners of every major irrigation work in India, the position of the provincial governments being very much akin to that of managing agents. The capital required for the works was found by the central Government and no original estimate could be sanctioned by any lower authority. After the Secretary of State or the Government of India had accorded sanction to a new major work, a term which included all productive and protective works, some of them costing even less than a lakh of rupees, the project was constructed by the local governments as agents of the Government of India, whose control was exercised through the medium of the Inspector General of Irrigation. The position was completely changed by the Reforms as the result of which, as already mentioned, irrigation became a provincial subject, administered by the reserved side of the local governments. Although, under the new Constitution, the funds for all new works have to be provided by the local governments, a specific limitation has been placed on their powers. It is laid down that the sanction of the Secretary of State is necessary to capital expenditure on irrigation and similar works, if the project concerned materially affects the interests of more than one local government, if the original estimate exceeds Rs 50 lakh, if a revised estimate exceeds by fifteen percent an original estimate sanctioned by the Secretary of State or if a further revised estimate has been proposed after one revised estimate has been sanctioned by the Secretary of State. The effect of this limitation is to give the Government

*Mr. Calvert dissents from this recommendation. He considers that where the Northern India Canal and Drainage Act is in force and where suitable rules have been framed thereunder, ample provision exists for full consideration of cultivators' grievances and opportunity is provided for appeal to Superintending Engineers and Commissioners. Elsewhere in temporarily settled provinces, he considers that the Collector is the most suitable authority to deal with such grievances. Organisations of the kind recommended would, he considers, be of little use to the cultivators while they would provide yet further opportunity for misrepresentation.

of India a greater measure of control over irrigation matters than they possess in regard to other reserved subjects. For the exercise of this control they rely upon the advice of their Consulting Engineer who has replaced the Inspector General of Irrigation. The position thus created has given rise to difficulties and we were informed by Mr. Harris, who, at the time he gave evidence before us, was performing the duties of Consulting Engineer to the Government of India, that it had been ascertained that whilst provincial governments were agreed that it was very desirable that they should be able to obtain a second opinion on their irrigation projects, they strongly objected to interference once a project had been sanctioned.

Rivers and drainage lines do not respect provincial boundaries, and the evidence we received in the course of our enquiry convinced us of the urgent need for the creation of an organisation which would not only enable provincial governments to obtain a second opinion in regard to their irrigation projects but would also be in a position to give the Government of India authoritative advice in regard to the settlement of disputes between provinces arising out of claims to the same source of supply. In these circumstances, we welcome the recent constitution by the Government of India of a Central Irrigation Board, of which the Consulting Engineer to the Government of India and all the chief engineers for irrigation in the provinces are members. The Board will work through sub-committees consisting of those engineers with recent experience of works akin to those to be discussed. These sub-committees will be convened by the Government of India at the instance of the local government concerned when a new project is about to be sanctioned or when a province finds itself in difficulties in any technical matter. We understand that three such sub-committees have already been convened. This arrangement has many advantages, not the least of which is that, as the Government of India have the right to convene sub-committees for their own purposes, they have now a ready means of obtaining competent advice on such central questions as irrigation schemes affecting two provinces, or a province and an Indian State, and on irrigation schemes which they are required to submit for the sanction of the Secretary of State in Council. The Consulting Engineer to the Government of India is not necessarily a member of all sub-committees and the incumbent of the post has, therefore, been required to take up, in addition to his technical work, the duties which formerly devolved on the Deputy Secretary to the Government of India in the Department of Industries and Labour.

Whilst the constitution of the Central Irrigation Board and the manner in which it will function will result in the benefit of experience gained in one province being placed at the disposal of other provinces, we are of opinion that something more than this is required. We do not consider that it is, in itself, sufficient to secure that general dissemination of technical information throughout the provincial irrigation departments which we regard as desirable. We have been impressed in this, as in so many other directions, with the ignorance in one province of what is going on in others. Unless steps are taken to remedy this defect, that ignorance will become even more marked with the establishment of the provincial stations for research into irrigation matters which we recommend in the following paragraph. We, therefore, propose the establishment of a Central Bureau of Information for Irrigation, the headquarters of which would be at Delhi and which might suitably be placed in charge of the Consulting Engineer to the Government of India. The main functions of the Bureau would be to establish and maintain a comprehensive library of irrigation publications, both Indian and foreign, which could be consulted by irrigation engineers and to act as a clearing house of information needed by provincial officers. It should, however, be something more than a mere repository of information and a centre for answering enquiries. It should endeavour to reach a wider public than the irrigation departments and to keep agricultural officers, and the public generally, in touch with irrigation developments in India and abroad.

An additional means of bringing the irrigation engineers in the provinces into closer touch with each other would be provided by annual or biennial meetings and we consider it very desirable that such meetings should be arranged. They

should be held in rotation in the different provinces and in localities which possess features of special interest to the irrigation engineer.

THE NEED FOR IRRIGATION RESEARCH

286. The Irrigation Commission expressed itself as struck by the small amount of attention which appeared to have been given by the departments of agriculture and public works to matters connected with the application of water to cultivated crops and recommended that systematic experiments should be made and carried on continuously for a series of years, with the object of solving the numerous problems which arise in connection with the distribution and application of water to the land. The waterlogging of land as a result of defective irrigation was forced on the attention of Government so long ago as 1832, and the long history of the Western Jumna Canal, one of the oldest in India, has afforded ample lessons in hydraulic engineering. The experience thereby gained, however, was not sufficient to prevent the recurrence of the evil in the new canal colonies of the Punjab. The problem has received continuous attention from the Government and its engineers, but the difficulty is to discover a measure that would not be too costly. Experiments in drainage, in lining the canals, in limiting irrigation, and so on, have been tried and, in 1925, a special committee of enquiry was appointed.

The revised problem of desiccation or sinking of the water table is presented in the Jullundur Doab and is ascribed to the great increase of well irrigation. A detailed investigation confirmed popular opinion on the subject but led to no other recommendation than a restriction on the construction of new wells.

The treatment of alkaline lands has received more prolonged attention, but the investigation has suffered from interruptions and more systematic and continuous research is required to discover measures to deal with this widespread evil.

The water requirements of crops have been studied on empirical lines by irrigation engineers who keep a careful record of the depth of water supplied per acre irrigated, and they incline to the opinion that nothing further of practical value is likely to accrue from research. The scientific study of the problems was began at Pusa some years ago but was not continued; the Bombay Irrigation Department is carrying out an investigation of considerable interest at Hadapsar, but elsewhere little is being done. Even in the Punjab, where the importance of irrigation is almost supreme, it is only recently that a scientific research officer has been appointed for irrigation research and the question of a farm where problems could be studied under field conditions has not gone further than the earmarking of an area of land. No scheme for its working has so far matured and no staff has yet been appointed. It is hardly necessary to add that, when the era of construction of large irrigation works draws to a close, as there is every reason to believe that it soon will, economy in the use of water will be the determining factor in the extension of cultivation.

ORGANISATION OF IRRIGATION RESEARCH

287. We are strongly of opinion, therefore, that more attention should be paid in all provinces in which irrigation is of importance to research on the problems to which it gives rise. The value of irrigation research has, as we have noted, been recognised of late in Bombay, where a special irrigation division was formed in 1916 to enquire into problems which the agricultural and irrigation departments had till then been investigating from different points of view; and in the Punjab, where the scientific research officer mentioned above, who will shortly have a permanent and suitably equipped hydrological laboratory, was appointed in 1924. In both these provinces, there are now officers engaged on the investigation of a wide range of irrigation problems such as the study of movements of the water table and their effect in producing waterlogging on the one hand or desiccation on the other, the water requirements of crops under field conditions, improved methods of irrigation both as regards the distribution of water by modules and the lay out of land for irrigation and hydrodynamical problems connected with such questions as the design of irrigation works and water-borne silt. Whilst we consider that the example set by the Punjab and Bombay should be followed in other provinces, we have no desire to lay down any hard and fast lines on which such research should be

conducted and would leave it to each province to decide upon the organisation it requires. In some provinces, a single officer assisted by a subordinate staff may prove sufficient; in others, a special research division of the provincial irrigation department may be required. Much depends on the nature of the problems to be investigated. Waterlogging, for example, primarily requires investigation by an engineer, but he will need to learn from the agriculturist the minimum depth below the soil surface to which the water table must be kept in order to ensure successful cropping in the locality. Agricultural experience is also wanted to determine the amount of water which a crop requires and its distribution through the period of its development in order to produce its maximum yield. Yet again, in attacking the problem of alkali formation, the services of the chemist as well as of the agriculturist and the engineer have to be requisitioned. Whilst we do not advocate any rigid type of organisation for irrigation research, we would insist most strongly on the closest association between the irrigation and agricultural departments in regard to it. In the Bombay Presidency, we found that the irrigation research station at Hadapsar and the neighbouring agricultural farm at Manjri were not agreed on the aim to be pursued in studying the water requirements of crops.. At the Hadapsar station, the aim was to discover the minimum amount of water which would mature an average crop so that the water available might be spread over the maximum area; at Manjri farm, it was to ascertain the amount of water which should be given in order to secure the greatest yield. Such disagreement not only involves waste of energy but also if, as it obviously must, it results in conflicting advice to the cultivator, it gravely militates against the usefulness of both stations. It is, therefore, in our view, essential that the heads of the two departments should collaborate in the presentation to the local government of an agreed list of the irrigation problems to be investigated in the order of urgency and importance. Where the nature of the problem requires the establishment of a research station, it may also be desirable that they should submit a scheme for staffing it jointly with irrigation and agricultural officers. We cannot stress too strongly the necessity for continuity in this, as in other branches of research, if any results of value are to be obtained.

It should, we think, be made clear to both irrigation and agricultural officers that the institution by Government of a special research organisation is not intended in any way to indicate discouragement of research by officers who have not been specially detailed for such work. Individual irrigation engineers in the Punjab at various times during the past thirty years have, for instance, done valuable research work on the evolution of modules and on materials for waterproofing canals and distributaries. It should, therefore, be one of the most important duties of the officers in charge of the special research stations to watch for useful suggestions from all quarters and to encourage the efforts of those who make them by placing apparatus and information at their disposal so far as this can be done without detriment to the regular work of the stations.

In this connection, we would draw attention to the part which could be played by the scientific staff of the Indian universities in the solution of irrigation problems for which geological, chemical or mechanical knowledge is required. It has, for example, been suggested that a sunken range of rocks is a factor which influences the water table of the Punjab plains: the verification of the existence of such a range and the determination of its features is work for the geologist but it might prove of the greatest value to the irrigation engineer. The discovery of a suitable material for lining canals which would bring the cost of that method of preventing waterlogging within the sphere of practical politics might well prove the decisive factor in restoring waterlogged areas to cultivation. In these and other directions, the scientific staff of the Indian universities could render material help to the irrigation engineer.

The investigation of the problems of irrigation in the Empire generally will doubtless receive an impetus from the prominence given to the subject in the Imperial Agricultural Conference held in London in the autumn of 1927. We have no doubt that irrigation engineers in India will be able to make a valuable contribution to the solution of these problems. The precise way in which this contribution can best be made will need careful

consideration. We are confident that Indian opinion would warmly welcome a decision to establish an all-Empire research station in India. The new experience thus made mutually available between the staff of the station and the officers of the irrigation and agricultural departments should contribute much towards the advancement of research in irrigation both in India and throughout the Empire. The authorities responsible for the decision on this point may be assured that Indian opinion will welcome an arrangement by which the personnel of an all-Empire station in India would be controlled, and the administration conducted, in precisely the same manner as in the case of the other stations in the chain.

NECESSITY FOR A CENTRAL STATION FOR IRRIGATION RESEARCH

288. If, as we hold, the necessity for research into irrigation problems in all provinces in which irrigation is of importance has been established, the question arises whether much of the work could not be carried out at a central station with consequent saving in staff and expense. The number of officers qualified to undertake research of this character is limited and the establishment of a central station might enable their services to be utilised to greater advantage. But, apart entirely from the administrative problems which are presented by the fact that irrigation is now a provincial subject, we are doubtful whether the problems arising out of irrigation are sufficiently common to all provinces to make the establishment of a central research station either necessary or desirable. Of these problems, that presented by alkali formations is undoubtedly the one which is most common to the irrigated tracts of India but such little work as has been done on it goes to show that these formations are by no means universally due to the same causes. Again, the problem presented by waterlogging in the alluvial tracts of the north is entirely different from that in the trap and crystalline formations of the south, whilst the water requirements of the crops grown in sub-tropical India differ greatly from those of the crops grown in the peninsula. In such circumstances, we are inclined to doubt whether any provincial irrigation department would be willing to accept and work on the results obtained at a research station situated in another province without further independent enquiry. The object we have in view, that of making the experience of one province available to other, can, we think, best be secured by the Central Bureau of Information, the establishment of which we have recommended in paragraph 285 above. The work carried on at each provincial research station should be reviewed from time to time by a committee appointed by the local government in consultation with the Central Board of Irrigation and the Council of Agricultural Research. Whilst we do not recommend the establishment of a central research station, it will be obvious that an officer who has made a special study of a problem in one province would be in a position to render substantial help to another province even though the local conditions in that province might be different from those in his own. We consider, therefore, that the interchange between provinces of specialist officers- the number of which is, in the nature of the case, bound to be very limited- should be encouraged.

DRAINAGE SURVEYS

289. It would appear that many of the troubles which have arisen in the irrigated tracts of India in regard to waterlogging and the formation of alkali lands have been due to failure properly to correlate a new irrigation system with the natural drainage of the tract. We have little doubt that the lesson has been learnt and that, where this is not already the practice, a careful drainage survey which should include estimates for drainage construction will, in future, form an integral part of all new irrigation projects. The importance of the control of surface drainage is not, however, confined to canal-irrigated areas. We have drawn attention to one aspect of it in connection with soil erosion. In paragraph 292 below, we draw attention to yet another aspect of it in Bengal. The Indian Sugar Committee pointed out the importance of proper drainage as a factor in the successful cultivation of sugarcane and drew special attention to the system of drainage which is practised in Java. The Committee recommended that a drainage survey should be carried out in the submontane tracts of the United Provinces in which, from Saharanpur to Gorakhpur, with the

exception of Bahraich, the area under sugarcane is large. The necessity for a complete drainage scheme was also brought prominently to our notice in the North-West Frontier Province. In these circumstances, we support the suggestion made by Mr. Howard in his book on *Crop Production in India* that drainage maps should be drawn up by competent engineers who possess the necessary agricultural insight. As he points out, once such maps have been constructed, it will be easy to control all such undertakings as the construction of roads, railways, canals and embankments and to see that nothing interferes with crop production. From the drainage maps it will be a short step to the preparation of a series of monographs on the river systems of India such as already exists in European countries like Italy. Those of our members who have visited Egypt have been impressed with the attention there given to the systematic drainage of irrigated land. We understand, too, that in the United States of America, where large irrigation schemes have been carried out, drainage questions have now assumed first place in importance among subjects receiving the attention of research workers; since it is found that, if the free downward percolation of water is arrested, alkali troubles almost invariably follow.

IRRIGATION IN SIND
(i) PROBLEMS AND POSSIBILITIES

290. Whilst we have not been in a position to present an exhaustive review of the irrigation problems of the different provinces, there are four questions to the importance of which we desire to draw special attention. These are the problems and opportunities which arise from the prospective wide extension of irrigation in Sind and the irrigation problems in Bengal, the North-West Frontier Province and Baluchistan.

We have mentioned that the great Sukkur Barrage which is now being constructed across the Indus below Sukkur, the work on which we inspected in March, 1927, will provide perennial irrigation for some five million acres of land, of which two million acres now receive an unsatisfactory supply from inundation canals and three million acres are uncultivated for lack of irrigation. It is anticipated that water will be available in 1931 and that, although it may take forty years before irrigation is developed to the final stage, the most rapid progress will take place from 1935 to 1938. There can be no doubt that this vast project provides a unique opportunity for putting into practice the lessons to be drawn from irrigation experience elsewhere in India. There is every reason to believe that the greatness of the opportunity thus presented is fully realised but there are a few points we wish to emphasise. We have carefully examined the project from the point of view of its effect on cultivation and on the welfare of the rural population. There is at present considerable difference in the agricultural conditions on the right and left banks of the Indus. The area on the left bank is mainly a cotton area, the agricultural organisation of which is based on one irrigated crop in three years. Wheat and rice are the principal crops on the right bank and a crop is taken every year. The first question for special investigation is the kind of crops the cultivation of which can confidently be recommend to the cultivator in all tracts to be brought under perennial irrigation. It should be ascertained whether the distinction between the crops which are grown on the right and left banks is based on a real difference in conditions of soil, water supply or climate, in fact, on anything more definite than a preference on the part of the cultivator. It should further be decided how far it is prudent, in the left bank area, to rely on cotton only as the main crop or whether efforts should be made to find alternative money crops which can be grown successfully in this tract. We note that *berseem* has been grown with success. The Agricultural Department should examine the possibility of encouraging the development of a dairy industry based on fodder crops grown on irrigated land. A system of mixed farming might well prove of much value both from the point of view of direct financial return and in its effect in promoting and maintaining soil fertility; but this last advantage will depend upon the adoption by the cultivator of sound practice in conserving and using natural

manure. We need hardly emphasise the desirability that the water requirements of the crops which will be grown when perennial irrigation is assured should be determined as soon as possible and that from the outset, investigations should be carried out with a view to ensuring that the problems which have arisen in other irrigated tracts from waterlogging and alkaline formations do not appear in this tract. We attach great importance to obtaining timely and authoritative information in regard to these and kindred matters which affect the welfare of the cultivator. The tract appears to us to be one in which the establishment of a joint irrigation and agricultural station for research into irrigation problems at the earliest possible moment is eminently desirable. In 1924, the Government of Bombay appointed a committee to consider the administrative developments that were necessary for the provision of agricultural advice to zamindars confronted with an entirely novel system of irrigation; and the opening of the research and experiment station at Sakrand in 1925 has been the first step in a programme of vast importance.

No decision appears to have yet been taken on the point whether the Agricultural Department in Sind should be separated from the department in the Presidency proper and placed under a separate Director. The urgency of the closest collaboration between agricultural, revenue and irrigational officers has been already set forth, and we deem it our duty to advise the Government that the chief revenue and irrigational officers should have ready access to agricultural advice at the headquarters of the Province of Sind. The agricultural problems of Sind, will, in our opinion, assume such importance as a result of the construction of the Barrage that we consider the province should have its own Director of Agriculture with headquarters at Karachi. The work at the Sakrand farm and its sub-stations will fully occupy the time of a deputy director of agriculture.

We recognise that Sind under Barrage irrigation will contain as important and comprehensive a system of agriculture as Egypt has to-day and we consider that the welfare of the people demands a chain of experimental stations subsidiary to Sakrand, and a full staff of competent officers. We are convinced that the financial returns to the State from expenditure on a far-sighted policy will be on the most generous scale.

The training of the staff for Sind is a matter of considerable difficulty. We are informed that the arrangement with the Punjab Government, whereby Sindhi candidates attended the college at Lyallpur, was given up owing to a financial disagreement; and we would suggest that this matter should be adjusted at the earliest possible date.

We trust that, in the very natural preoccupation due to the construction of the Sukkur Barrage, the possibilities of irrigation development in other parts of Sind will not be entirely lost sight of. The evidence we recorded at Karachi showed that there are certain areas outside the area commanded by the Sukkur Barrage project in which there are considerable possibilities for schemes for pumping water from rivers, canals and other sources, as the water requires to be lifted a few feet only. The problem which is thus one of evolving a suitable pump combining a low lift with a high discharging capacity should be investigated by the engineering section of the Agricultural Department.

(ii) THE PRINCIPLES TO BE ADOPTED IN DISPOSING OF GOVERNMENT LAND

291. The principles which should be adopted in disposing of such of the areas which will come under irrigation as are still at the disposal of Government require to be settled without delay. We conceive that these fall into three main divisions. In the first place, the claims of the indigenous population in the face of the general immigration from outside which will be essential to the proper development of the tract will require careful consideration. We trust that some equitable solution will be found which will ensure to the labourer *(hari)* as well as to the landholder in Sind a first claim to those lands in the newly irrigated tracts which are at the disposal of Government. We consider, however, that the immigration of a certain number of progressive

cultivators, including those familiar with the possibilities of irrigation elsewhere, should have a beneficial effect on the local standards of cultivation, and we, therefore, recommend that provision for them should be included in the allocation of such lands.

In the second place, it is important that the manner in which the areas at the disposal of Government should be allocated should be determined as soon as possible. In such schemes, the small holder must form the backbone of any intensive system of cultivation and should be encouraged in every possible way. But it will probably be as important here as in the Punjab colonies, to insist that the small holder shall himself cultivate his grant and shall not be allowed to grow into a petty absentee landlord. In the Punjab, it is a condition of all peasant grants that the grantee shall settle permanently on the estate and build himself a house there. These conditions must be fulfilled before occupancy rights can be acquired, and even when, later, the grantee is permitted to acquire proprietary rights, the sale is conditional on the continued observance of this condition. The value of the small holder is so linked up with his residence on the estate that we think that the attempt should be made in Sind to ensure observance of this condition on lines conformable to the prevailing systems of tenure.

If any applicants for larger grants are forthcoming who can be trusted to carry on agriculture by progressive methods and who possess such public spirit as would lead them to contribute substantially to the social advancement of their smaller neighbours, then we consider that an improvement in social and economic conditions will be likely to result from interspersing a suitable proportion of these amongst the population. We are also of opinion that provision should be made for a few large grants of land of some 2,000 to 4,000 acres on terminable leases to individuals or groups of individuals. The actual cultivation would, no doubt, be carried on by tenants, but these would have skilled guidance and the grant as a whole would derive all the benefit that follows from a single control. In this way, as the Indian Cotton Committee pointed out, the agricultural development of the tract would be greatly facilitated. Further, the large scale production, which these grants would mean, would assist the surrounding small holders in marketing their produce, and should go far to solve the difficult problem of securing a proper price for it.

In this connection, we are impressed by the many advantages attaching to the planting of extensive and homogeneous areas with a single variety of cotton well suited to local conditions. Where this can be achieved, the risk of deterioration by cross-fertilisation between the improved variety and inferior cottons is removed. Furthermore, the fact that local ginneries handle no cotton other than the approved variety insures to the cultivators a supply of pure seed at the lowest possible cost. Again, marketing arrangements are greatly facilitated by the existence in the tract of a large volume of one variety of high class cotton. Purchasers soon discover that cotton from such a tract can be relied upon both for purity and quality. The reputation of the district for cotton is established and soon becomes widely known, and, if marketing arrangements are satisfactory, the cultivator is thus assured of the maximum premium for the high quality of his produce. The information at our disposal goes to show that, in the Indian State of Rajpipla, where regulations have been enforced over a period of four years compelling the cultivator to grow cotton of an approved variety, highly encouraging results have already been obtained. Again, Government in the Sudan have taken power to enforce the creation and maintenance of areas in which one variety of cotton only is grown. Here also results have, we are told, entirely justified the wisdom of this provision. With these facts in mind, we would suggest to the Government of Bombay that they should very carefully examine the possibilities of attaching to occupancy rights in Crown lands to be newly colonised as part of the Sukkur Barrage scheme, the obligation to sow only such cotton as may be provided or approved by the Department of Agriculture. The cotton of the entire tract could then kept pure by the application of the Cotton Transport Act. We are

well aware that such a suggestion involves a departure from existing practice, but we are of opinion that the benefits in terms of financial advantage to the cultivator and to the community are likely to be so considerable as fully to justify a bold experiment in the direction indicated.

The third problem to be considered is that of securing adequate fuel supplies to the irrigated area. It is clear from the Punjab experience that no private person is likely to undertake the formation of plantations in irrigated areas owing to the length of time which must elapse before they yield a return in any way comparable with that from ordinary cultivation. The evidence we took in the Punjab showed that such plantations do not come into full bearing for fifteen years, after which they may yield a net profit of as much as Rs 25, or, allowing for the water rate paid per acre, Rs 28. It is estimated that the interim revenue received from the plantation during the first fifteen years should meet, and, perhaps, slightly exceed, the cost (including interest on capital outlay) of its formation and maintenance. It is possible that Government would obtain a larger return from land placed under plantations than would be received if the land were disposed of in the ordinary way. For the reasons given in our chapter on Forests, the establishment of such plantations is most desirable if they can be shown to be profitable, [chapter on Forests not given in this documentation]. We recommend that the financial considerations involved should be carefully examined and that, if the result is satisfactory, the Forest and Irrigation departments should, in consultation, decide what percentage of the area at the disposal of Government can suitably be allotted to the establishment of such plantations and how far the provision of a wider belt of land along the canal banks than it is customary to devote to the growth of trees would meet the case. The two departments should then work out a definite scheme for the formation of plantations, either along canal banks or in isolated blocks elsewhere.

THE POSITION IN BENGAL

292. The problem in Bengal differs from that in most other parts of India in that it arises from the presence of too much rather than of too little water. Even in the west of the province, which has a comparatively short rainy season and, therefore, offers considerable scope for the extension of irrigation, the liability of low lying lands to inundation by river flood is a serious obstacle to the extension of cultivation of such a profitable crop as sugarcane. The intimate relation between the drainage system of the province and the prevalence of malaria and water-borne diseases and the bearing this has on the well-being of the population are fully realised. The improvement of the drainage system has accordingly long been regarded as the most potent weapon which can be forged in the fight against disease. It is essential to the transport of jute and other agricultural produce in a province which depends so largely on its waterways as a means of communication that they should be kept open to navigation, but, in their upper reaches, the rapid extension of the water hyacinth makes this a task of ever increasing difficulty and they are throughout liable to silting and deterioration owing to changes in the general drainage system. The Irrigation Department, which has thus to fulfil a multiplicity of functions which do not fall to the lot of similar departments elsewhere, only became a separate department in 1921, when it was formed out of the Public Works Department. It is a small department which consists, in its superior ranks, of the Chief Engineer and Secretary to Government and four superintending engineers. The relative importance of the activities of this department in regard to irrigation, navigation and embankments and drainage can be gauged from the following figures taken from its report for 1925-26:

	Area irrigated		Length of main and branch channels	
	Acres		Miles	
I. Irrigation-				
Midnapur Canal	75,698		70	
Eden Canal	23,836	99,534	27	97
II. Navigable canals	..	..		1,886
III. Embankments and drainage- total length of embankments				1,298

Thus the Irrigation Department in Bengal has to deal more with the improvement of navigation and sanitary conditions and the control of flood water than with irrigation proper.

As we have mentioned, there are areas in Bengal, especially in the west of the province, which are suited for an extension of canal irrigation and of minor works of all kinds. We would refer in passing to the excellent work which is being done in the Bankura and, to a lesser extent, in the Birbhum districts by co-operative irrigation societies. We are glad to note the assistance which is given by the Irrigation Department to these societies.

It is not, however, the problems connected with irrigation proper that have caused us concern so much as those which arise in regard to drainage and the preservation of existing river channels from deterioration. These problems are singularly complex and difficult.

No single department can be expected adequately to deal with all the water problems of Bengal and the first step which should be taken towards their solution is the complete separation of the irrigation branch from the navigation and embankments and drainage branches and the formation of two entirely separate departments.

No general survey of the irrigation possibilities of Bengal has yet been made. The first duty of the new Irrigation Department would, therefore, be to formulate a general scheme for irrigation development based on a survey in such detail as would ensure ordered progress. This is a point of special importance in tracts which, in the nature of things, do not lend themselves to large projects and where facilities for the construction of a number of small schemes exist in the same drainage area.

We would next draw attention to the critical importance of the work which awaits the new department which would deal with navigation, embankments and drainage and which might be re-named the Waterways and Navigation Department.

The problems of the Gangetic delta and the Damodar river are typical of those associated throughout the world with rivers whose courses lie through broad alluvial plains and at whose mouths extensive deltas have developed. Such rivers, in their natural state and when uncontrolled by the hand of man, tend in seasons of flood to overflow their banks and to spill their water over large areas of alluvial land. By the action of the swollen current upon the soft soil of which their banks and beds are composed, they tend also to change their course, sometimes by many miles from season to season. Thus, both the raising of the land level and the creation of new deltaic land take place more or less evenly over the whole lateral area of the tract. It is these two processes in combined action that have built up the alluvial deposits of the sub-continent and also the deltaic lands lying at the mouths of the great rivers. They are continuous in their operation and to-day, as in past centuries, it is by them that the rock masses of the Himalayas are compelled to pay constant tribute alike to the rich plains of the interior and the extending mud banks of the Sunderbunds.

Favourable agricultural conditions and convenience of communication and transport, combined often with considerations of military advantage, lead man to build his habitations and to prosecute his commercial activities on the banks of great rivers. In order to protect himself and his property against risk of floods, he

heightens the river banks by building embankments, *bunds* or, as they are known in America, levees; and so contrives, even during periods of flood, to confine the stream within its normal channels. But the waters of the river continue to carry their burden of silt and, at seasons when the stream is slack, large quantities of this are deposited in the bed of the river. The force of the current tends in flood season to scour, and so to lower, the river bed. But in the flat reaches of a river where the stream is broad and the current slow, the tendency often is for deposit to outweigh denudation and thus, over a series of years, to raise the bed of the river and with it the flood level. This, in turn brings about the necessity for the construction of still higher embankments, until finally a stage is reached at which the surface of the river, flowing high above the level of the adjacent lands, has ceased altogether to relieve the riparian tracts of their superfluous water: the river can no longer drain the lands through which it flows.

Where no *bunds* prevent the river from overflowing its banks, the floods of each succeeding season bring a further deposit of fertile silt to wide areas of territory: while, at the same time, the flood waters cleanse and purify the surface of the land, sweeping away decaying vegetable and animal matter and purging the streams, ditches and ponds of insects and impurities, many of them harmful to man and beast. Inevitably the *bunding* of such rivers must, to some extent, incline both to arrest this natural regeneration of fertility and to give rise to a deterioration in the health of the population in the riverain tracts. There can be little doubt that certain districts have tended, as a consequence of the interference by man with the forces of Nature, to decline in natural fertility and to become the breeding ground of malaria and other diseases. This process is occasionally, and sometimes seriously, aggravated by the construction of railway and road embankments across the lines of natural drainage.

This group of problems is by no means confined to north and north-eastern India. It has presented itself with tragic emphasis in the United States by the devastating floods of 1927 in the Mississippi Valley. It is known to exist in many other parts of the world.

The problems that await solution in Bengal, if, indeed, all the problems presented can be completely solved, are thus complex in the extreme. The order in which they should be attacked, the nature of the measures to be adopted, and the amount which can properly be spent on them, having regard to other urgent calls on the public purse, will all require most careful investigation and the provincial legislature will rightly require an authoritative opinion on these questions as a preliminary to granting its approval to any scheme which may be put before it. We accordingly recommend to the earnest consideration of the Bengal Government the desirability of appointing a committee of experts which should include among its members at least one who is familiar with the management of the deltas of large rivers in other countries, such as, for example, that of the Mississippi and we would suggest that one of the specific directions to such a committee should be to consider and report upon the advisability of setting up a Provincial Waterways Board.

Irrigation in the North-West Frontier Province

293. The irrigation problems of the North-West Frontier Province must be considered not in respect of the magnitude of the irrigation systems of that small province but in relation to their importance to the well-being of the agricultural community. The province possesses three government canal systems which, between them, irrigate 370,000 acres or sixteen per cent of the total cropped area, a percentage which is only exceeded in Sind, the Punjab and Madras. More important in the aggregate, however, are the district and private canals which, between them, irrigate another 400,000 acres. By far the greater part of this is under the district canals which, with the exception of the Paharpur Canal in the Dera Ismail Khan district which was constructed by the Punjab irrigation engineers, were constructed by the people themselves with or without the help of Government and are in the charge of the deputy commissioner of the district. They were constructed without competent, or, indeed, any technical supervision and it is not surprising, therefore, that they are badly aligned, scantily provided with drainage crossings, ill regulated

and altogether badly equipped. We were informed that the canals in the Dera Ismail Khan district, which at the time of our inquiry had no engineering staff in charge of them, are in a specially unsatisfactory condition, which arises, in the main, from the fact that there is no direct outlet to the Indus for the waters of the many torrents which come down from the surrounding hills in violent spate during the monsoon months and which, in consequence, wipe out *bunds*, breach canals and turn valuable lands into a network of ravines. The result is that considerable areas are going out of cultivation and many villages are being forsaken.

We would suggest that the possibility of transferring the most important district canals, if not all of them, to the charge of the Irrigation Department should be examined. We were informed that such a transfer was effected in the case of the Kabul River Canal in 1903-04 and that the area under irrigation on that canal increased by forty-five per cent in seven years from that date. If, for reasons of the existence of which we are not aware, there are objections to the transfer of the canals to the Irrigation Department, we are of opinion that steps should be taken to ensure that the deputy commissioners have the assistance of a competent staff in dealing with them.

IRRIGATION IN BALUCHISTAN

294. We have heard two witnesses in regard to the agricultural position in Baluchistan and we are impressed by the testimony which they both gave as to the extent to which agricultural progress in that area must be dependent upon enhanced supplies of water. Since we heard this evidence, we have been informed that the officer who is investigating water control in Waziristan will also examine the possibilities of extending irrigation in Baluchistan. We consider that it is impossible for one officer to carry out, adequately, investigations in areas so extensive and so widely separated as Waziristan and Baluchistan. We, therefore, recommend that an examination of the possibilities of extending irrigation in Baluchistan should be forthwith undertaken by an officer specially selected for that purpose and that he should be assisted by a suitable subordinate staff.

HYDRO-ELECTRIC DEVELOPMENT

295. The natural reserves of water power available in certain parts of India, notably in the submontane districts of the Himalayas and in the Western Ghats, including the Nilgiris, are considerable. It is also probable that opportunities exist for obtaining power by utilising falls of a few feet on rivers in the plains, and by the construction of similar falls on canals by a suitable alignment of the canal gradients. As regards canals, we understand that attention is now being paid in new irrigation projects to this source of power, which should certainly not be neglected in view of possible future demands for power both for industrial and agricultural purposes. The possibilities of this source of power have been strikingly illustrated by the success of the hydro-electric scheme carried out by our late colleague, Sir Ganga Ram, at Renala in the Lower Bari Doab Canal Colony of the Punjab, which we visited in February, 1927, where 80,000 acres are irrigated by a six feet fall.

From the agricultural standpoint, electric power has at present two main uses, as a motive power for machinery including pumps, and as a means of obtaining supplies of synthetic nitrogen from the air. Experiments are being conducted with a view to applying electricity on a commercial scale as a stimulus to plant growth. This is a possibility which need hardly be seriously considered at present and, in any event, the power required would probably be insufficient to make generation for this purpose alone economic. The desiderata in all these cases are cheapness and wide diffusion. The circumstances of the Indian cultivator make it improbable that, for a long time to come, if ever, there will be an appreciable demand for electric power for agricultural machinery or that there will be much scope for the use of electricity as a stimulus to plant growth. In paragraph 89, Chapter IV, we have given reasons for doubting whether the manufacture, in this country, of synthetic nitrogen from the air likely to prove a commercial proposition,

[Chapter IV, paragraph 89, not given in this documentation]. In existing conditions, therefore, the immediate openings for electric power for agricultural purposes are confined to pumping schemes. The experience of other countries suggests that, in the present state of electrical development, power can only be profitably developed for urban and industrial purposes and that its economic use in agriculture must depend upon the availability of a surplus which is not required for these purposes and which would otherwise go to waste. We recognise, however, that the possibility of utilising electricity for the purpose of raising water from wells may make its use profitable in India, otherwise than as a mere surplus of power required for urban and industrial purposes. We have been informed that a considerable development of the industrial use of electric power may be expected in Lahore and Amritsar and their immediate neighbourhood. Such an area as this, we consider, offers the best prospects for testing the agricultural uses to which electric power, surplus to industrial requirements, can be put and we have no doubt that the Government of the Punjab will see that full advantage is taken of this and of any other opportunity which may present itself.

Whilst the development of its hydro-electric schemes is now a matter for which each province is entirely responsible, we consider that, as in the case of irrigation problems, it would be of great value to the provinces if some central organisation existed from which information in regard to hydro-electric developments in India as well as in other countries could be obtained. We recommend, therefore, that the Central Information Bureau, the formation of which we have proposed in paragraph 285 above, should also act as a clearing house of information on hydro-electric matters and that a section of its library should be devoted to literature on the subject. Expert advice in regard to any particular scheme of development can, we think, be best obtained from a firm of consulting engineers of which there are many of recognised eminence. This is a course which, to mention two instances, has been followed in regard to the Yunzalin hydro-electric project for the water supply of Rangoon and the Pykara hydro-electric project in Madras. It should prove less expensive than that of retaining the services of an expert permanently at the headquarters of the Government of India and has the further advantage that it in no way involves any interference with provincial independence in the matter.

As regards the orderly development of hydro-electric schemes throughout India, it is, perhaps, fortunate that the natural centres of hydro-electric development are widely separated and it does not seem probable that problems similar to those which have arisen from the conflicting claims of more than one province to irrigation supplies will here occur. The contingency that when the development of natural sites has made greater progress, questions affecting more than one province may arise cannot, however, be entirely overlooked. If such a situation should occur, the best method of dealing with it would probably be the appointment of an *ad hoc* committee of experts.

Another contingency which has to be provided against is the premature development of easily accessible sites in the lower reaches of rivers where they debouch from the hills on to the plains. The effect of such development would be to create vested interests which might ultimately impede the development of sites which may exist further upstream in the recesses of the hills but which have yet to be surveyed. These remote sites may represent sources of power of the greatest importance and no action should be taken which would hinder their ultimate utilisation. We commend this point to the special attention of local governments.

Summary of Conclusions and Recommendations

296. The conclusions and recommendations in this chapter may be summarised as follows:

(1) There should be a periodic revision of the position in regard to all outstanding irrigation projects (paragraph 275).

(2) The relaxation of the financial rules which formerly governed the construction of protective works should furnish a stimulus to the construction of this class of works (paragraph 276).

(3) Further investigation and experiment should be undertaken before a final decision against the sale of water by volume is reached (paragraph 277).
(4) No reduction in the capacity of an outlet should be made in individual cases if it is found that irrigation is done over a larger area than that for which the outlet was designed (paragraph 277).
(5) No change should be made in the agency charged with the distribution of water but the formation of irrigation *panchayats* should be encouraged (paragraph 278).
(6) The construction and maintenance of minor irrigation works should be entrusted to a special agency (paragraph 279).
(7) The department entrusted with the charge of pumping and boring operations should make detailed investigations into the economics of tube well irrigation and should also carry out a systematic survey of subsoil water supplies (paragraph 280).
(8) Government assistance in regard to the construction of tube wells should be limited to the provision of information, of technical advice and of finance, where required, on the *taccavi* system and to placing boring equipment and skilled labour at the disposal of the landholder on payment of a moderate fee (paragraph 280).
(9) The system of subsidising tube wells at present in force in the United Provinces should be discontinued (paragraph 280).
(10) Private enterprise in the construction and maintenance of tube wells should not be discouraged by Government competition (paragraph 280).
(11) Pumping and boring operations should be entrusted to the agricultural departments (paragraph 280).
(12) The construction of ordinary wells is essentially a matter for private enterprise, but there are many ways in which the agricultural and irrigation departments can help the landholder (paragraph 281).
(13) In districts where holdings are very small, every effort should be made to encourage the co-operative sinking and working of wells (paragraph 281).
(14) In tracts in which the number of abandoned wells is at all numerous, a special enquiry should be made into the cause of abandonment (paragraph 281).
(15) The extension of irrigation from small streams by means of power driven pumps should be encouraged (paragraph 282).
(16) Closer relations should be established between the agricultural and the irrigation departments (paragraph 283).
(17) Short courses in agriculture for irrigation officers and in irrigation for agricultural officers should be instituted (paragraph 283).
(18) An organisation on the analogy of local railway advisory committees should be established to deal with complaints in regard to irrigation matters (paragraph 284).
(19) A Central Bureau of Information on irrigation matters should be established (paragraph 285).
(20) Frequent conferences of irrigation engineers should be held (paragraph 285).
(21) More attention should be paid to research on irrigation problems in all provinces in which irrigation is of importance (paragraph 287).
(22) There should be the fullest collaboration in such research between the agricultural and irrigation departments (paragraph 287).
(23) The assistance of the Indian universities in irrigation research should be enlisted (paragraph 287).
(24) The necessity for a central station for irrigation research has not been established but the work of each provincial station should be reviewed from time to time by a committee appointed by the local government in consultation with the Central Board of Irrigation and the Council of Agricultural Research (paragraph 288).
(25) The interchange between provinces of officers engaged in research on irrigation is desirable (paragraph 288).
(26) Drainage maps should be prepared (paragraph 289).
(27) In view of the importance of the Sukkur Barrage project, the chief revenue and irrigational officers should have ready access to agricultural advice at the headquarters of the Province of Sind.

The appointment of a Director of Agriculture with headquarters at Karachi is, therefore, recommended (paragraph 290).

(28) In addition to the station at Sakrand, a chain of subsidiary research stations should be established and there should be a full staff of competent officers for all the stations (paragraph 290).

(29) The question of training agricultural students from Sind at the Lyallpur Agricultural College should be re-examined (paragraph 290).

(30) The possibility of developing irrigation in parts of Sind not commanded by the Sukkur Barrage project should not be lost sight of (paragraph 290).

(31) The principles which should be adopted in disposing of the areas which will come under irrigation under the Sukkur Barrage project and which are still at the disposal of Government should be determined without delay more especially in regard to the claims of the indigenous cultivators, the manner of allocating the areas and the provision of fuel supplies (paragraph 291).

(32) The Irrigation Department in Bengal should be divided into two entirely separate departments, one to deal with irrigation proper and the other with navigation, embankments and drainage (paragraph 292).

(33) The first duty of the new Irrigation Department should be to formulate a general scheme of irrigation development (paragraph 292).

(34) The problems presented by the river systems of Bengal require investigation by a committee of experts (paragraph 292).

(35) The possibility of transferring the district canals in the North-West Frontier Province to the charge of the Irrigation Department should be examined (paragraph 293).

(36) An examination of the possibilities of extending irrigation in Baluchistan should be forthwith undertaken (paragraph 294).

(37) The Central Bureau of Information for Irrigation should also deal with matters arising out of hydro-electric development (paragraph 295).

(38) Advice in regard to provincial hydro-electric schemes should be obtained from firms of consulting engineers (paragraph 295).

(39) Should disputes between provinces in any matters arising out of hydro-electric development occur, these should be referred to committees appointed *ad hoc* (paragraph 295).

REVIEW ARTICLE*

TAX REFORMS IN INDIA: AN EVALUATION

G. Thimmaiah

1. Introduction

Tax reform refers to introducing changes in the existing tax base, rates, exemptions, rebates, concessions and administrative procedures. Tax reforms embody periodical repairs to the tax structure after it is designed and put into operation. Once a tax is designed on the basis of some objective normative criteria, it goes into operation as soon as it is implemented. From its practical operations, the Government and tax administrators, besides the tax payers, learn about its merits and demerits. The merits and demerits of a tax/tax structure are identified with reference to the major objectives which the tax or tax structure is supposed to achieve. These objectives may be the given economic philosophy of the time or those identified by the government of the day as important and legitimate. The generally accepted objectives of a tax include promoting higher growth rate of national output, reducing wide inequalities of income and wealth and maintaining stability of the growth of output, prices and balance of payments. Though these are broad objectives of any democratic society in normal times, other objectives like winning a war, rehabilitation of the people before or after the war and other diverse calamities may also emerge. Such specifications of objective functions is also necessary from the point of view of convincing the tax payers about the justifiability of the tax. But in the ultimate analysis we proceed from the individual welfare function to social welfare function. Social welfare function is decided by the government keeping in view the preference of the majority of the voters who are also tax payers. Hence, it may be assumed that a spectrum of individual objective welfare functions ultimately get reflected in the national policy objectives of the government. Any tax or tax structure which is designed is expected to serve these objectives.

If in the course of operation a tax or tax structure is not found to be serving such predetermined objectives, then introducing required corrections into the tax structure becomes necessary. This is the core of tax reform. It starts with a thorough examination of the tax or tax structure in relation to economic policy objectives, collecting empirical facts about its defects, identifying the causes for defective operation, evaluating the alternative measures to set right the defects and recommending specific tax reform measures in order to restore its effectiveness. The tax reform exercise also involves outlining the relative merits and demerits of alternative tax reform measures leaving the choice to the policy makers.

Tax reforms may also be necessitated by the changed social economic and political situations and changed perception of the government in power about the objectives. Changes in the economic structure may call for structural changes in the tax structure to achieve the same objectives. Change in the government may require change in the priority of different objectives and/or addition of new objectives and hence necessary required changes in tax structure become inevitable [Thimmaiah, 1984, Pp. 2-6].

In democracies anybody who is engaged in recommending tax reforms should take for granted certain realities of the existing tax structure. Any radical changes if recommended will be slow in getting implemented in the existing tax structure. It is also necessary to remember that it would be difficult to sell radical tax measures in democratic countries not only because of the operation of the psychological law that an 'old tax is a good tax', but also because of the complex reactions which radical tax reform measures might encounter from the self-interest pressure groups. Further, tax reform is a continuous process. Socio-economic circumstances change very fast necessitating corresponding changes in the objectives of economic policy of the Government. Hence, it is unrealistic to think of tax reforms for long duration.

Whenever some tax reform measures are introduced there is a tendency to evaluate them by the tax payers, tax administrators and experts. The tax payers evaluate them from the point of view of the additional burden which they might

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**Reports of the Tax Reforms Committee, 1992*, Chairman, Dr. Raja J. Chelliah, 1991-93, Ministry of Finance, Government of India, New Delhi.

impose on them, including tax payment as well as tax compliance cost. The tax administrators evaluate them in terms of revenue which the reforms are going to yield and the simplicity of the task of collecting the revenue. Tax experts have tried to develop some specific evaluation criteria which comprehend the evaluation criteria of the tax payers and the tax administrators. These are: first, the tax reform measures should make the tax or the tax structure more elastic in its revenue yield to changes in the tax base and/or the GNP. This has come to be known as the built-in-elasticity. This automatically comprehends the least cost of tax compliance and of cost of collection. The second criterion is progressivity of taxation. This is more a socio-political objective which has now come to be underplayed in the name of redefining the concept of fairness in taxation. The third criterion is that the tax reform measures should make a tax or a tax structure neutral in regard to their impact on prices. While built-in-elasticity goes beyond the test of revenue neutrality, planned neutrality expects the tax or tax structure not to create any cascading effect on the prices or distort the relative prices in the economy. Finally, the tax reform measures should simplify the tax compliance and tax collection procedures ultimately resulting in lower tax compliance and collection costs.

2. *Tax Reforms in India*

After Independence the perspectives of the government of free India changed radically. Consequently the objectives of the government's economic policy in general and of tax policy in particular also changed. Therefore, there was need for introducing tax reforms with a view to making the tax structure to serve these changed objectives. Accordingly, the Government of India introduced several tax reforms starting from the period of First Five Year Plan. For instance, tax reform measures were introduced on the recommendation of the Taxation Enquiry Commission of 1953- 54 [Mathai, 1954]. However the tax reform measure which attracted worldwide attention were those introduced in 1957 on the recommendation of Kaldor. Nicholas Kaldor recommended an integrated direct tax system for India with a view to raising increasing revenue by reducing evasion and also to reduce wide inequalities of income and wealth [Kaldor, 1956]. Again, during the 1970s many tax reforms were introduced on the recommendations of Direct Taxes Enquiry Committee [Wanchoo, 1971], and Indirect Taxation Enquiry Committee [Jha, 1978]. During the 1980s the influence of supply side economics brought about far reaching changes in the thinking of the Government. This got reflected in the tax reform measures introduced by the then Union Finance Minister, Mr. V.P. Singh, in his budget for 1985-86. The Chelliah Committee Report is only the latest attempt to continue the supply side economic philosophy in the sphere of taxation. What is noteworthy in all these reforms is that most of them were recommended by independent expert committees. This ensured a high degree of objectivity and sufficient sophistication in modernising the tax structure. Similar tax reform measures have also been introduced at the state level on the recommendations of several expert committees. In spite of all these reforms, if the Indian tax structure still suffers from any defects, or is not sufficiently modernised, it is mainly because of the constitutional limitations and political compulsions which have prevented the government from implementing all the required reforms.

3. *Chelliah Committee Recommendations*

The Chelliah Committee presented an Interim Report in December 1991 and two subsequent Final Reports in August 1992 and January 1993. The Committee identified its approach in the following words: 'As is now well-known, our general approach is that the best results, in terms of compliance, (and, therefore, revenue), efficiency and equity are obtained through a system incorporating moderate rates on a broad base' [Chelliah, 1992, Part I, p. 11]. In other words, the broad approach of the Committee in formulating its recommendations relating to tax reforms is that the rates of tax should be moderate, and the tax base should be widened, so that the tax reform measures are not only revenue neutral in the short run but will be elastic in the long run. The most

important recommendations of the Committee may be grouped under the following tax reform measures: (1) tax rate cut measures (2) measures for widening the tax base (3) modernisation of indirect taxes and (4) simplifying assessment and compliance procedures so as to reduce the cost of compliance.

The tax rate reduction measures were recommended in the Interim Report as well as in the Final Report. In the Interim Report the rates of personal income tax were recommended to be reduced to 20 per cent on the first slab, to 27.5 per cent on the second slab and to 40 per cent on the third slab of above Rs 2 lakh taxable income. Thus the marginal rate of tax on personal income was recommended to be reduced to 40 per cent and the number of slabs was reduced to three, with a further recommendation of reducing these to two rate slabs subsequently. In regard to corporate tax, the Committee recommended that the corporate profit tax should be reduced to 40 per cent over a period of three years from 1992-93 to 1994-95. The Committee also recommended abolition of surcharge on corporate tax in 1993-94, bringing down the rate of corporate tax from 51.75 per cent to 45 per cent in 1993- 94, and further down to 40 per cent in 1994-95. Of these recommendations, the Government has already accepted and implemented the recommendations relating to personal income tax and corporate tax rates. However, surcharge on corporate tax has not yet been abolished owing to revenue impact on the budget.

In regard to indirect tax reforms, the Chelliah Committee recommended reduction of the rates of union excise duties by reducing the multiplicity of rates to 2 or 3 rates of 10 per cent, 15 per cent or 20 per cent with a selective excise duty on non-essential commodities like cigarettes, etc., at the rate of 30 per cent, 40 per cent or 50 per cent. In regard to customs duties, the Committee recommended in Part-II of its Final Report that in keeping with the trade liberalisation measures, there should be gradual but sharp reduction of import duties to a range of 5 per cent to 20 per cent. The government has already reduced the customs duties to 65 per cent and in some specific cases to as low as 20 per cent. It is expected that the general rate is going to be reduced further in the ensuing budget for 1995-96.

The Committee recommended removal of unnecessary tax shelters with a view to broadening the tax base of personal income tax and corporate tax. In particular, the Committee recommended taxing of allowances and other perquisites of Members of Parliament and State Legislatures; more importantly, the Committee recommended covering of hard-to-tax groups through presumptive tax and estimated income scheme. The Government of India has accepted and implemented the presumptive tax scheme from 1993-94, but has not yet implemented taxation of the estimated income.

The Committee recommended widening the tax base of indirect taxes. In regard to excise duties, the Committee identified about 30 commodities which were fully exempt and suggested levy of 10 per cent *ad valorem* excise duty on them. Further, the Committee suggested a tax at 10 per cent on advertising services, services of stock brokers, services of automobile insurance, services of insurance of residential property, personal effects and jewellery, and telephone services. At the same time, the Committee suggested that the Central Sales Tax (CST) should be reduced and the proposal to empower the state governments to levy consignment tax should be withdrawn. The Committee tried to ensure broad base for the corporate profit tax by recommending retention of depreciation allowance at 25 per cent. The Committee also recommended the inclusion of agricultural incomes above Rs 25,000 with income from non-agricultural sources, for the purpose of taxation. The Committee recommended for the abolition of an earlier tax on income from interest earnings. The Committee also recommended raising of exemption limit of gift tax to Rs 30,000.

The most important and controversial recommendation relates to the introduction of the Value Added Tax (VAT) in place of excise duty upto the point of wholesale. No doubt VAT is a more modern and economically a rational tax in place of the existing indirect taxes. While reduction of tax rates would make taxation acceptable to the tax payers, VAT would make indirect taxes neutral in their price impact and self-policing in the collection process.

4. Tax Reform Efforts in Retrospect

It may be observed in this context that even before the re-discovery of the supply side economics, the Indian Finance Ministers had recognised the futility as well as unproductiveness of high tax rates. The philosophy of high marginal tax rates was the result of the socialistic ideology which guided the Indian economic policy making. We are all aware of Kaldor's recommendation to levy a personal expenditure tax, wealth tax, capital gains tax and gift tax in addition to the already existing income tax and estate duty [Kaldor, 1956]. It should be remembered in this context that Kaldor wanted these taxes to be levied at moderate rates. But unfortunately the philosophy of socialistic pattern of society carried the day and the then Finance Minister introduced all these taxes with very high marginal rates which resulted in large scale evasion and even failure of some taxes like the expenditure tax. The Government of India took the advice of Kaldor seriously and relied too much on his integrated system of direct taxes for reducing the inequalities of income and wealth in the country. What is more, by introducing this package of direct taxes, the Government of India tried to convince the masses that the rich people were bearing heavy tax burden and therefore the masses should also contribute to whatever extent possible through indirect taxes for the developmental efforts of the country. This led to frequent revision of rates and coverage of indirect taxes. Such unprecedented increase in indirect taxation also gave a lever to the private sector, which was protected from foreign competition, to use increased rates of indirect taxes as an excuse for increasing the profit margin by pushing up the prices. While the government was lulled to complacency on the assumption that the increased taxation would reduce the consumption and bring down the price level and also that the system of integrated direct tax system would prevent evasion of direct taxes and would reduce the inequalities of income and wealth, in actual practice the prices went on rising as and when rates of indirect taxes were increased and the really rich and self-employed income earners and wealth owners went on evading taxes. By the 1970s it was proved that most of the direct taxes, except income tax, were becoming either proportional or regressive in terms of effective rates and other progressivity measures [Thimmaiah, 1984, Pp. 211-230].

High rates no doubt compelled the direct tax payers to resort to evasion; such evasion was encouraged by complicated direct tax laws, particularly numerous deductions and concessions which were built into tax laws under the excuse of achieving horizontal equity as also for providing incentives for some specific economic activities. For instance, the maximum rate of income tax above the taxable income was as high as 97.75 per cent in 1973-74. The corporate sector started hiring competent tax planners to enable it to legally avoid corporate tax. The inarticulate people were forced to evade taxes. Consequently, the proportion of revenue from direct taxes went on declining. When the government started facing such a situation of unproductive taxes as a result of high nominal tax rates with too many deductions and concessions, the only way left for the Union Finance Minister was to go on increasing the indirect taxes to make good the loss of revenue. This resulted in a cascading effect of taxes and added to the price rise every year. Thus a vicious circle of high rates of tax and tax evasion started operating in the Indian tax system. This naturally alarmed the Union Finance Minister. During the early 1970s the Union Government appointed the Direct Taxes Enquiry Committee which recommended that the only way to cut this vicious circle was to reduce the rates of taxes. Accordingly, the then Union Finance Minister, while presenting the Budget for 1974-75 observed: 'The Committee has expressed the view that prevalence of high rates is the first and foremost reason for tax evasion because this is what makes the evasion, in spite of attendant risks, profitable and attractive. The Committee has accordingly recommended that the maximum marginal rate of income tax including surcharge should be brought down from its present level of 97.75 to 75 per cent. Simultaneously, there should be a reduction in tax rates at the middle and lower levels. This recommendation of the Committee has been

accepted by the government with modification. I, accordingly, propose to lower taxes of all levels of personal incomes' [Budget Speech, 1974-75].

Two years after reducing the personal income tax rates the then Union Finance Minister, while presenting the budget for the fiscal year 1976-77 observed: 'As Honourable Members will recall, the rates of income tax of personal incomes, were reduced in 1974 on the basis of the recommendation of the Direct Taxes Enquiry Committee. While presenting the Budget for 1974-75, my distinguished predecessor had expressed the hope that reduction in rates would lead to better tax compliance. This expectation has been fulfilled and is reflected in the striking increase in income tax collections during the last two years. While some other factors including the relentless drive against tax evaders and other economic offenders, have played a part in improving collections, it is also obvious that the reduction in tax rates has played a major role in promoting for better compliance. The remarkable response to the voluntary disclosure scheme, where the maximum rate was 60 per cent, lends considerable support to the judgment that the majority of the Indian tax payers would prefer to abide by the law and pay taxes as due, provided the tax burden is reasonable. I, therefore, propose to reduce the rates of taxes on personal incomes and wealth' [Budget Speech, 1976-77].

Accordingly, maximum rate of income tax was further reduced to 67 per cent in 1976. But such repeated tax rate deductions did not improve the tax honesty mainly because of the continuation of numerous deductions and allowances. Thus the Indian tax structure had acquired some of the characteristics of a bad tax system. It had lost progressivity. Evasion was too much because the incentive for evasion was very high and tax planning was made profitable. In other words, Indian tax structure put a premium on tax honesty.

Thus even before the supply side economic philosophy was re-discovered in the west, the Indian Finance Ministers were already implementing the supply side economic philosophy of tax rate cuts. However, during the 1980s the supply side economic philosophy became prominent in the west mainly because of unprecedented proliferation of the government role in the national economic activity. Such expansion necessitated very high tax rates, which were supposed to have reduced incentive for saving and investment, and high level of Government expenditure financed by heavy taxation led to inflation. Therefore, the supply side economic philosophy, which is nothing but the economic philosophy advocated by Adam Smith, propagated tax rate reductions, reduction in public expenditure, including that on social security, and scrapping of government control and regulations on private sector economic activity.

In the sphere of taxation, the supply side economic philosophy of tax rate cut assumes that high level of taxation has been responsible for the growth and expansion of the government, high degree of tax evasion, disincentives for savings and investment and discouragement to the private sector. Therefore, the supply side economic philosophy advocates that the tax rate cut will remove all these hurdles. The reduction of tax rates will increase household and corporate savings, will promote private investment, which will enhance the GNP, and will yield indirectly more revenue. The tax rate cut is also assumed to promote honesty among tax payers.

India was not free from the influence of the supply side economic philosophy. It influenced the economists and policy makers in the mid 1980s. V.P. Singh's budget for 1985-86 was completely guided by the supply side economic philosophy. The tax reform measures introduced in 1985-86 included raising of exemption limit of personal income tax from Rs 15,000 to Rs 18,000, reducing the number of slabs from 6 to 4, reducing marginal rate of tax from 67 per cent to 50 per cent, abolishing compulsory deposit scheme and surcharge on income tax. Raising of exemption limit on wealth tax from Rs 1,50,000 to Rs 2,50,000 with a maximum effective limit of Rs 7.5 lakh, reduction of marginal wealth tax rates with only half percent on first slab, abolition of estate duty and reduction of corporate tax on all types of companies. Besides these, there were many other tax relief measures such as removing the 20 per cent ceiling on business expenditure incurred in connection with sales promotion. He

also announced a Long Term Fiscal Policy outlining the possible further reduction in corporate tax and rationalising other taxes [Budget Speech, 1985-86]. These measures were followed by reduction of central excise duties during 1986 and introduction of the modified system of value added tax (MODVAT) in place of excise duty on certain commodities. All these measures were consistent with the supply side economic philosophy. But these measures did not achieve the avowed objectives of promoting tax honesty and increasing revenue yield, mainly because they were not accompanied by other fiscal stabilisation measures and also the consequential structural reforms (economic liberalisation) measures. Tax rate cut measures resulted in substantial revenue loss and the resultant increase in revenue deficit. Though high marginal rates of tax do become counter-productive, there is no objective basis for reducing them to a particular level. Whatever reduction that has been effected has been mainly based on revenue consideration. In other words, the supply side economic philosophy has provided only vague guideline and has not thrown up any objective paradigm for introducing specific tax policy changes. This fact should be kept in mind while determining the extent of tax rate reduction. It is also necessary to concede the fact that high tax rates do encourage tax evasion leading to a vicious circle of evasion and high rates. Even so, it is very difficult to pinpoint at what level the tax rates encourage tax honesty. While reduction of tax rates to a reasonable level reduces tax dishonesty, there is no guarantee that tax honesty and tax rates are inversely proportional. It is also open to dispute that reduction of tax rate would automatically increase household and corporate savings. As a matter of fact, when V P Singh reduced the tax rates in 1985-86 the corporate savings did not increase sufficiently [Thimmaiah, 1990, p. 45]. The money saved by households on account of excise duty reduction went to increase their consumption, because the consumer electronics became cheap consequent on reduction of excise duties.

Another interesting impact of supply side economic philosophy of tax rate cuts was that it not only justified reduction of tax rates but also forced the tax policy makers to redefine the degree of tax progressivity of direct taxes. If we examine the actual tax reform measures recommended by the Expert Committees in the UK, Canada, New Zealand and other countries we find that many of them comprised not merely tax rate cuts and switch over to VAT but also a redefinition of the classical philosophy of fairness in taxation. We are all aware of the fact that the theory of progressive taxation came to be firmly grounded on the socio-political philosophy of reducing wide inequalities of income and wealth and the Keynesian macroeconomic theoretical foundation of diverting the idle purchasing power from the rich to the government with a view to maintaining the desired level of aggregate demand. The socio-political philosophy was carried to extremes in developing countries like India. This led to a steep increase in the legal marginal tax rates to as high as 98 per cent. The government used the socialistic philosophy to justify them and the public also accepted them without questioning their operational feasibility. But the supply side economic philosophy questioned the theoretical validity as well as practicability of such steep tax rates. Widespread tax evasion resulted in generation of black money. The government was forced to announce several tax amnesty schemes to unearth this black money. Thus supply side economic philosophy has been responsible for moderating the degree of progressivity in tax structure by advocating moderate tax rates. The philosophy of fairness in taxation has come to be redefined in such a way that it ultimately boils down to a variant of proportional taxation. In other words, progressivity in taxation has come to be reinterpreted as that the effective rate of tax on all people should be as far as possible the same. This invariably justifies reduction of marginal rate of tax, multiplicity of slabs and reduction of rebates, concessions and exemptions.

The supply side economic philosophy has caught the imagination of the World Bank and the International Monetary Fund (IMF), which started selling it to all the member countries whenever they approached them for funds. These institutions started developing their own version of supply side economics while suggesting reforms in the tax structures of member countries. For instance, the World Bank has been advocating

that the rates of corporate tax and personal income tax should be the same though it has not explained why this should be so. Is it because the corporations which are legal entities behave in the same way as individuals or because there will be substitution if the rates are different? In other words, the supply side economics which has given rise to a long wave of tax reforms in the 1980s has only provided a direction and not a theoretical paradigm and precise analytical tools comparable to the theory of optimum taxation.

A more important recommendation of Chelliah Committee is in regard to replacement of the existing excise and sales tax by value added tax. Though value added tax can also be attributed to the supply side economic philosophy, as ultimately it amounts to reducing the tax burden on the consumer, it should be treated as an instrument of modernising the tax structure. This is because VAT predates emergence of the supply side economic philosophy. While VAT was first introduced in Africa in the 1960s, the supply side economics emerged in the 1980s. VAT was designed as a new tax handle to promote trade and commerce across the boundaries of the European countries which had formed a common market. It was also intended to reduce the cascading effect of other indirect taxes like excise, sales tax, etc. Such VAT captured the imagination of the tax experts and Finance Ministers all over the world. It was introduced in other European countries during 1970s and it spread to Asian and Latin American countries during the 1980s. Since the experience of most of these countries has been uniformly favourable to trade and commerce, the Chelliah Committee probably felt that it cannot close its eyes to the international trend towards replacing old indirect taxes by modern VAT. It should be mentioned in this context that the Jha Committee, which reported in 1978, in which Dr. Chelliah was a member, examined the desirability of introducing national VAT. But because of the administrative and constitutional problems involved, the Jha Committee recommended that a modified version of value added tax may be introduced in place of excise duty on certain specified commodities. This recommendation was accepted by V.P. Singh and MODVAT was introduced in 1986. Under this tax the total tax liability is calculated by setting off the taxes already paid on inputs, that is in the form of tax rebate or tax set-off. The Chelliah Committee strongly recommended for a switch-over to a nationwide VAT in the near future in place of the present indirect taxes system. The Committee suggested two alternatives. One is the most ideal alternative and the other is the second best feasible alternative. The Committee maintained: 'The ideal solution, from the economic point of view, would be to have a single VAT at the central level, reaching down to the retail stage in replacement of most indirect taxes other than protective duties and sumptuary excise duties- the Central excise, the State sales taxes, the Municipal octroi, the Goods and Passengers Tax and the Electricity Duty. The proceeds of VAT will be shared among the three levels of government' [Chelliah, 1992, Part I, p. 46].

However, recognising the political realities of the Indian federation, the Committee opted for gradual switch-over to VAT in place of the union excise duties and MODVAT. The Committee recommended for the extension of such VAT to wholesale point also which is the tax domain of the state governments. The second best solution is defended on the ground that it will reduce excise duty evasion and it is also a legitimate right of traders and industrialists to have a most rational tax system.

5. Evaluation of Chelliah Committee Recommendations

We concede the point that there is consensus in the country on the need to reform the present indirect tax system by introducing VAT because of its two virtues, namely, that it reduces the cascading effect and it is self-policing thereby preventing tax evasion and increasing the revenue yield in the long-run. However, there is no consensus on the issue of the level at which VAT should be introduced in India, whether at the central government or at the state government level. At present, the system of union excise duties bristles with many administrative problems of which two are very serious- the problem of classification of excisable goods and the problem of their valuation. There is also a feeling

that the state government's sales tax creates cascading and trade diversion effects and it has been injurious to the operation of the united common market which has been guaranteed by the Constitution. In other words, both these important sources of revenue of the central and the state governments are found to be inefficient instruments of the Indian tax structure. Therefore, there is merit in Chelliah Committee's recommendation to levy a national value added tax in place of all indirect taxes in the country. But such a tax measure is not acceptable in the near future at the state level. Even the second best solution of extending central VAT upto the point of wholesale, is also not acceptable to the states because most of the state governments levy their single point sales tax at the first point of sale which is the wholesale point. Sales tax revenue constitutes about 60 per cent of the total tax revenue of the state governments. Of this, almost about 90 per cent of the revenue (of the sales tax) comes from the single point sales tax levied at the wholesale point. If the central VAT is extended to the wholesale point, so much of revenue will be lost to the state governments which cannot be made good from any other source. It should in all fairness be mentioned here that Chelliah Committee categorically recommended that the state governments should be allowed to collect the central VAT at the wholesale point in collaboration with the central VAT administrators, which means that there will not be any loss of revenue to the state governments. But the rates will be determined by the central government and the state governments will be allowed to collect and appropriate that revenue. In other words, the central VAT when extended to the point of wholesale, will be in the form of a central sales tax. Most of the state governments are not happy with the central sales tax arrangement because it has led to large scale evasion through consignment transfers. In the absence of a tax on consignments to capture this clandestine inter-state sale, VAT at the point of wholesale will substantially reduce the revenue for the state governments. Further, VAT at the wholesale point will not fully protect the revenue of the state governments unless the rates are pitched too high, because the tax base will become net value added and not the total sale value as in the case of the present sales tax. This can be off-set by allowing the state governments to tax services also. This will be a positive incentive to induce the state governments to agree for central VAT at the wholesale point. But the state governments would always look upon any such proposal from the central government with suspicion because of their bitter experience of the past. This was evident from the opposition to the alternative proposals presented to the State Finance Ministers by the Union Finance Minister in May 1994. The failure of the central government to fulfil all the terms of agreement under additional union excise duty arrangement, namely, raising the incidence of additional union excise duties to 10.8 per cent of the value of clearance, increasing the ratio of basic and additional union excise duties to 2:1 and conversion of specific duties into *ad valorem* duties, stands out as a classic example of untrustworthiness. Further, the central government which promised on several occasions to enact the empowering legislation to enable the states to levy consignment tax has been turned down on the recommendation of Chelliah Committee. Third, the central government has not bothered to tap the sources of revenue provided under Article 269 for the benefit of the states. Finally, the central government has been evading the issue of sharing the revenue from corporate tax even after the recommendations of the Sarkaria Commission. All these have convinced the state governments to believe that the central government will not keep up any promise and is bent upon making further inroads into the tax domain of the state governments with false promises. This psychological resistance based on firm historical experience will not allow the central government to levy VAT at the wholesale point. Then what is the way out?

Definitely we need to modernise our indirect tax system to catch up with the advanced as well as many developing countries which have switched over to VAT. Switching over to VAT is a part of globalising process. This is an important step towards globalising the Indian economy. Therefore, there is no disagreement on the need to introduce VAT in the country. This disagreement is only on who should experiment it

first. Since the central government has been the culprit all along in creating mistrust of the states, the central government should come forward to prove its bona fides first. Since the central government has already acquired some experience in levying a variant of VAT by levying MODVAT, it would be better to replace union excise duties by VAT. The presently operating union excise duty system bristles with many problems and hence it needs to be reformed much more urgently than the reform of sales tax at the state level. Problems of valuation and classification of duties have become insurmountable in the case of union excise duties. The recent judgment of the Supreme Court relating to the definition of what constitutes manufacturing has further complicated the matter. Technological developments have made the distinction between manufacturing and wholesale a grey area. Even the distinction between goods and services has come to be blurred because of the technological developments. Therefore, it would be better if the union excise duties are replaced by VAT all over the country. This will provide a useful experience for a period of say 5-7 years; if such VAT succeeds, then the state governments may be persuaded to go for state level VAT in place of sales tax. This is a more feasible and practicable way of modernising the tax structure of the country.

Any tax reform measures should be revenue neutral unless tax rate reduction programme is deliberately intended to provide tax incentives for specific sectors or groups of people as a part of overall fiscal policy. The Chelliah Committee was guided by the supply side economic philosophy of tax rate cut to promote tax honesty and corporate savings. The Committee tried to make the tax rate cut measures revenue neutral by suggesting measures to widen the tax base. For this reason, the Committee recommended the imposition of presumptive tax and introduction of estimated income scheme for the purpose of income tax. The Union Finance Minister introduced a presumptive tax on difficult-to-tax income groups in 1993. But the yield has been discouragingly low. The estimated income scheme has not yet been tried. In other words, the attempt of the Committee to make its recommendations revenue neutral has not been successful. The nominal revenue from the direct taxes may have increased because of the growth of economic activity and the resultant growth of the GDP. The net effect of the Chelliah Committee recommendations has been revenue loss under direct, as well as, under indirect tax reforms. It may be observed from Table 1 that the growth rates of yield from major taxes of the central government have been fluctuating during the period of tax reforms. The loss has been substantial under indirect tax measures particularly as a result of excise duty reductions and reduction in import duty level. It is pertinent to ask the question that when the revenue deficit of the Government of India has been so high, whether continued tax rate cut measures are a wise tax policy programme. How is it that the Chelliah Committee recommended raising of exemption limit of gift tax from Rs 20,000 to Rs 30,000 without bothering to recommend introduction of the scheme of assessing the gift tax in the hands of donees as contemplated by the former Finance Minister, Madhu Dandavate? In fact, because of the failure of the Union Finance Minister to reduce revenue deficit, as a result of revenue loss, in spite of reduction in subsidies, he was compelled to reduce the capital expenditure with a view to reducing the fiscal deficit. The Chelliah Committee Report, no doubt, attempted to globalise the Indian tax structure, but in the process has compelled the Union Finance Minister to postpone the objective of achieving fiscal stability.

The most controversial aspect of the Chelliah Committee recommendation is that some of the recommendations are patently anti-state governments. The recommendation to levy central VAT upto the wholesale point, the recommendation not to levy consignment tax and the recommendation to reduce rate of central sales tax from 4 per cent to 1 per cent are clearly intended to reduce the taxing power of the state governments. The Chelliah Committee openly advocated for the central government making inroads into the tax domain of the state governments just to satisfy traders and businessmen. This is not going to promote harmonious centre-state relations in the

country. These recommendations, when carried to their logical end, will create political tensions. The concept of a united common market is a theoretical one. Even the Supreme Court has accepted the fact that in a federation, free movement of goods and services are subject to the states' right to regulate them within their own boundaries. When the whole country is talking about decentralisation, the Chelliah Committee advocated centralising fiscal process.

TABLE 1. VARIATIONS IN MAJOR REVENUE RECEIPTS OF THE CENTRAL GOVERNMENT

(Rs Crore)

Year	Income Tax Receipts (Gross)	Annual Percentage Growth	Union excise duties (Gross)	Annual Percentage Growth	Customs Duties (Net)	Annual Percentage Growth	Corporation Tax	Annual Percentage Growth	Tax on Wealth	Annual Percentage Growth	Gift Tax	Annual Percentage Growth	Total Revenue (Net)
1985-86	2,509.3	-	12,955.7	-	9,525.8	-	2,865.1	-	153.0	-	11.6		28,884.0
1986-87	2,878.0	14.69	14,470.0	11.69	11,475.0	20.46	3,160.0	10.29	174.0	13.73	9.00	-22.41	34,768.0
1987-88	3,187.0	10.74	16,426.0	13.52	13,702.0	19.41	3,433.0	8.64	101.0	-41.95	8.00	-11.11	38,992.0
1988-89	4,237.0	32.95	18,841.0	14.70	15,805.0	15.35	4,407.0	28.37	122.0	20.79	7.00	-12.50	45,740.0
1989-90	5,004.0	18.10	22,406.0	18.92	18,036.0	14.12	4,729.0	7.31	179.0	46.72	8.00	14.29	54,614.0
1990-91	5,371.0	7.33	24,514.0	9.41	20,644.0	14.46	5,335.0	12.81	231.0	29.05	3.00	-62.50	57,650.0
1991-92	6,724.0	25.19	28,110.0	14.67	22,257.0	7.81	7,853.0	47.20	307.0	32.90	8.00	166.67	69,117.0
1992-93	7,888.0	17.31	30,832.0	9.68	23,776.0	6.82	8,899.0	13.32	425.0	38.44	10.00	25.00	74,128.0
1993-94(RE)	9,500.0	20.44	31,750.0	2.98	22,500.0	-5.37	10,500.0	17.99	200.0	-52.94	10.00	0.00	76,166.0
1994-95(BE)	10,925.0	15.00	36,700.0	15.59	25,200.0	12.00	12,480.0	18.86	NA	NA	NA	NA	86,084.0

Source: *The RBI Bulletin* and *Report on Currency and Finance*, (Various Issues), Reserve Bank of India, Bombay.

The most important component of tax reform required to modernise Indian tax structure is shifting the tax structure from scheduler rate structure to non-scheduler global rate structure. The Committee did not pay much attention to this aspect. No doubt the glaring scheduler income tax system which is operating in India is the result of the constitutional division of power to tax incomes between the central and state governments. In an attempt to integrate them the Committee recommended taxing of agricultural income above Rs 25,000, if such income is derived by non-agricultural income tax payers. The constitutional validity of such a measure is yet to be tested.

But the Committee failed to recommend abolition of Hindu undivided family as a unit for income tax assessment. Further, the income from capital gains from trading in stocks and shares is separately taxed at 30 per cent for companies, firms and associations and at 20 per cent for individuals. This is uncalled for. Similarly income from lottery prizes is taxed at 33.3 per cent. The Committee overlooked the scheduler rates operating under income tax for different sources of income. In other words, the Committee did not bother to modernise Indian tax structure in keeping with the policy of updating industrial technology. It concentrated mainly on tax rate reductions to earn appreciation of business and industry.

The Chelliah Committee recommended many procedural simplifications in the tax assessment and payment of taxes. It is very difficult to assess the net impact of all these procedural reforms on the cost of collection and of tax compliance. The simplification of tax assessment and collection procedures should not only reduce the cost of collection but, more importantly, it should reduce the cost of compliance- both real and monetary. The Committee did not look into the need for reducing the cost of compliance. The Committee suggested measures to simplify tax procedures intended to reduce tax harassment, i.e., to reduce the real cost of tax compliance. We are all aware of the fact that over the years the Indian tax structure has shifted the cost of collection to the tax payer by increasing the cost of compliance. Expert committees and experts have not noticed this invisible change that has taken place in the tax law and administration. When the cost of tax compliance increases it would offset the benefit of tax rate cuts and the net impact of tax rate cuts would be reduced. The Committee did not pay sufficient attention to this aspect of tax reform.

Finally, the tax incentives given for savings in the Indian direct tax structure were mainly intended to augment public sector borrowings, i.e., to encourage household savings to flow to the financial institutions which were compelled to

subscribe to government loans. In other words, the existing tax incentives for savings continue to divert household savings to public sector borrowing and investment where the capital use efficiency is the lowest. The Chelliah Committee which propounded supply side economic philosophy of tax rate cuts should have recommended broad basing of tax incentives for savings, so that savings would flow to the private sector where the capital use efficiency is relatively better than that in the public sector. For this purpose the Committee should have recommended extending the tax incentives for private sector mutual funds, company deposits and bank deposits. This is another area which has not been touched by the Chelliah Committee.

On the whole, the Chelliah Committee has carried forward the supply side economic philosophy and has attempted an impracticable approach to modernise the Indian tax system. Many recommendations made in its Interim Report have already been implemented. Probably the most difficult recommendation to implement is in regard to VAT. The issue will have to be sorted out by proper understanding of the political, economic and fiscal relations between the centre and the states. Economic liberalisation should not imply promoting centralising fiscal process. It should leave the states free from day to day interference and dependence on the central government. The Chelliah Committee recommendations particularly relating to VAT will have to be appropriately modified, if we want to retain the federal character of the Indian fiscal system.

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BOOK REVIEWS

Dhawan, B.D., 1993; *Trends and New Tendencies in Indian Irrigated Agriculture*, Commonwealth Publishers, New Delhi, Pp. xiii+294, Price: Rs·325/-.

The development of irrigation potential was one of the immediate priorities of post-Independence (post-partition) India in its efforts towards agricultural development. Our Five Year Plans, have given greater attention to the development of irrigation, in terms of massive allocations for construction of major/medium and minor irrigation systems. It is certain that irrigation systems have played a crucial role in India's agricultural development.

Dhawan's book, entitled *Trends and Tendencies on Indian Irrigated Agriculture* is the outcome of a thorough investigation into the Indian irrigation data base. The fourteen chapters can be grouped into six sections based on the nature of issues addressed.

Section one (chapters 1, 2 and 3) examines the relationship between intensity of cropping and irrigation at the aggregate (national) and disaggregate (State) levels. The analysis of 'irrigation induced yield' throws light on the disparities across the States in terms of their differential status in irrigation endowments and geographical setting. Issues like creation and utilisation of irrigation potential- both surface and ground water- and the infirmities in Indian irrigation data base have been critically examined in section two (chapters 4, 5 and 6). Section three (chapters 7, 8 and 9) gives a better understanding of the problems in irrigation water management in India.

The idea of 'conjunctive use of irrigation water' is explained in the light of the unique experience drawn from the Sardar Sarovar Project (SSP) in Gujarat. Section four (chapters 10 and 11) underscores the impact of irrigation development on food grains production and employment generation. Section five (chapters 12 and 13) unfolds the scope of alternative modes of irrigation like the sprinkler and drip irrigation methods in economising water use and also the new dimension in Indian irrigated agriculture, i.e., the emergence of 'ground water markets'. Section six (chapter 14) summarises the various issues discussed in the book.

The author makes a strong case for a fresh and thorough empirical investigation into the impact of irrigation on intensity of cropping. The existing methodology is found to be handicapped by poor definition/ specification of variables like irrigation and intensity of cropping in the empirical model. Accordingly, the conventional regression analysis has been improved by him by the addition of another irrigation variable, viz., Intensity of irrigation, attempted earlier by Dharm Narain and Roy [1980], which gives a better representation of the quality aspect of the basic irrigation variable, net irrigated area.

Cross sectional and time series data have been used for the intensity of cropping analysis both at the national and state levels for the period 1950-51 to 1987-88. Though the time series model had a higher impact value of irrigation, i.e., 0.65 (cross sectional value being 0.46), it has been found to be biased upward because of the omission of variables like tractorisation from the regression model. The state-wise time series analysis has shown larger variation in the level of irrigation impact on intensity of cropping due to the problem of high multicollinearity among various types of irrigation sources in some of the states and the infirmities in irrigation data base (in terms of stickiness over time) in some others.

II

In a water scarce economy like India the choice between irrigation and dry land technology assumes significance. A major thrust on the development of dry land technology in India is necessitated by the large area going out of cultivation due to problems of waterlogging, salinity and alkalinity on the one hand and the limited prospects of irrigated regions in meeting future food requirements on the other [Ramanna, 1991]. The author does not prefer a shift in policy towards dry land technology as it will not result in self-sufficiency in the production of food grains; it should be an option only when no further irrigation capacity can be exploited. But, this seems to be a wrong contention as it does not foresee the sustainability of the resource base and the existence of water scarce regions of the country which have to go for dry land technology to provide sustenance.

The reliability of Indian irrigation data base as provided by the Planning Commission has been

subjected to cross-examination. The rosy picture of full utilisation of irrigation potential should be taken with circumspection, because, i) the downward trend in the rate of irrigation capacity utilisation is not well founded and ii) the evidence of full capacity utilisation in minor irrigation segment is suspect. He points to the divergence in the Planning Commission's estimates with those of the Directorate of Economics and Statistics in the Ministry of Agriculture.

With the advent of the HYV technology, there has taken place a rise in ground water based irrigation in terms of investment on tubewells, dugwells, borewells and dug-cum-borewells. This is supported by the feeling that big dams are no longer a viable proposition due to their overhead cost component and environmental damages. Ground water ensures increased agricultural production, has short gestation period in establishment and timeliness in irrigation operation.

But, due to their indivisible nature of investment, the ground water irrigation proves to be cost ineffective when compared to major irrigation works. Energy consumption is also much more in ground water irrigation. The pump-set combined with advances in boring technology for ground water conservation seems to be a non-viable option as it leads to over-exploitation of ground water resource base. The rapid diffusion of pump-set technology have made the state governments enact suitable legislation for ground water regulation. The author is highly critical about the so called anti dam groups, including the Central Ground Water Board (CGWB) who underestimate the 'hidden costs' of well irrigation and over-state the ground water potential.

The question of sustainability of water resources arises due to excessive withdrawals of water for irrigation, industrial and civic uses and siltation of the reservoirs. Also, there is considerable wastage of water at the farm level due to lack of necessary land development works, which is a serious constraint in achieving efficacy in water management. The author's feeling that this wastage has been eliminated through the on-going Command Area Development Authority (CADA) programmes is questionable in the light of the empirical evidence which prove the failure of CADA in fulfilling the proposed objectives. CADA is supposed to be responsible for water utilization and integrated area development in the irrigation command, including modernisation of the distribution system, the provision of drainage and the maintenance and operation of both the distribution and drainage systems [Government of India, December 1984, p. 20; Reddy, 1990].

III

The idea of conjunctive use of irrigation water is yet to receive wider attention. In India, Sardar Sarovar Project (SSP) in Gujarat is the only project to have incorporated the idea of conjunctive use of irrigation water in its project planning. The whole theme of conjunctive use of irrigation water signify the joint utilisation of both surface and ground water resources for irrigation. This will avoid over exploitation of the resource base. Though empirical studies indicate higher level of productivity under conjunctive irrigation, the additional productivity as a result of the added costs of conjunctive irrigation needs further probing.

The author is concerned about the consequences of intensive irrigated farming in the SSP command area. If the farmer opts for more water-intensive crops (as happened in Punjab and Haryana) like paddy, sugarcane, fruits, etc., it will lead to overdraw of the ground water, thereby causing strain on the ground water resource of the SSP command. This phenomenon can be contained through policies, like, restricting the allocation of licenses in the case of sugar mills.

Though the lift mode of irrigation is an alternative to big dams, its high cost makes it less dependable as it cannot serve the beneficiary farmers meaningfully during years of rainfall failure. Very often, the scale economies of lift irrigation tend to be offset by the diseconomies experienced in water distribution segment. The author gives a brief account of lift irrigation in India, their nature of enterprise, cost structure, irrigation coverage, etc. He also examines the salient economic features of the studies by Sharan and Kayastha [1990], NABARD [1988] and Acharya [1991] on lift irrigation.

IV

It is obvious that irrigation development has its impact on the economy at large in terms of employment generation and food grains production. The author blames Indian water planners for being least concerned about the impact of irrigation development on employment generation.

In terms of labour absorption, the irrigated segment has a better claim over the rainfed segment due to a rise in individual crop yield, rise in intensity of cropping and a shift in cropping pattern in favour of high yielding, remunerative and water intensive crops, all demanding an increased labour input. But, the author comes up with the finding (as experienced in the Ghod command in Western Maharashtra) that the employment effect of irrigation decreases as crop yields on irrigated lands rise over time, due to input intensification.

In contrast Diwakar [1989], who studied 40 traditional wells and 60 modern wells, found that the modern wells provided employment for 140 person days per hectare as compared to 121 person days per hectare in the case of traditional well irrigation, thus ruling out the labour displacement effect of input intensification. The irrigation ratio under modern wells was 0.79 as against 0.37 under traditional wells.

The author examines the impact of irrigation on food grains production in a regression analysis framework, whereby, time series of food grains production over the post- HYV/ Green Revolution period (1964-65 to 1985-86) is regressed on the time series of irrigated area of a given region. For analytical simplicity, the states have been grouped into regions, viz. Northern, Southern, Eastern, Western and Central. The region-wise movements in food grains production and irrigation development showed a higher rate of growth in food grains production in the Northern region and a higher growth in irrigation development in the Central region. In the Southern region, despite its low position in the expansion of irrigation facilities, the rate of growth in food grains production was impressive. The better performance in production as shown by the Northern region has been due to the strict follow up of 'warabandi' and the 'localisation pattern'.

V

In recent years, there is an awakening among the ground water scarce economies towards developing technologies that will help in economising water use. Sprinklers and drippers are considered to be effective modes in achieving economy in irrigation water use, 25-40 per cent in the case of sprinklers and 45-60 per cent in the case of drippers. But the investment in sprinklers or drippers is not a solution to the problem of over exploitation of capacity, as these modes are not suitable for all the crop varieties. In USA, the investment is motivated by horticulture. Whereas, in India, the situation is altogether different as our cropping pattern is dominated by paddy with a low share for the horticultural segment in the total agricultural sector. Again, due to the preponderance of small and marginal land holdings, and lack of consolidation of these holdings, the investment on these modes proves to be highly indivisible.

The emergence of 'ground water markets' is a new trend in Indian irrigated agriculture. Such ground water markets are, at present, benefiting 5 to 7 million hectares of cropped area in the country [Shah, Tushaar *et. al*, 1989]. This estimate reveals that about 15 to 20 per cent of our ground water based agriculture is sustained by these markets. Since the availability of surplus irrigation capacity generated out of a modern well (over and above one's own use) enables one to trade in such a resource, there is enough scope for further investment on well irrigation, especially tubewells. The seller of water is fortunate enough to have potential demand from different sections of the farming community.

Despite the benefits that ground water markets can claim, they are not without reservations. A major limitation is the emergence of a class of 'water lords', who go on extracting monopoly rents from the small and marginal farmers for sale of water. The author's fear that the emergence of 'water lordism' may bring back the feudal lord/ zamindar and the tenancy evils, is misplaced in the event of the initiative of the 'water buyers' to instal wells on their own. This calls for necessary credit support from the lending agencies,

demanding a drastic restructuring in the functioning of our financial institutions, who over the year have developed a 'rich farmer bias' in their lending policies.

VI

The author brings out certain disquieting features of our hitherto experience with planned economic development strategy in the irrigation sector. The financial status of most of the public irrigation works is found to be dismal. These projects are unable to meet their working expenses, due mainly to the gross under- pricing of irrigation water by the state governments. It is unfortunate that over the years, we had been misled by the steeply accelerated emphasis on major irrigation development over time. But, when compared to the totality of investments made in Indian agriculture, the investment made on irrigation is not at all significant.

There are certain issues left unaddressed by the author (he himself mentions it elsewhere), like the emergence of Pani Panchayats and the decline in local institutional arrangement for tank irrigation. Similarly, the issue of water management in the canal commands requires serious attention. It is widely reported that due to over appropriation of canal water and unauthorised use of heavily irrigated crops by the farmers at the head and middle reaches, the farmers at the tail end always stand to lose. This could be prevented through imposing localisation pattern and irrigation discipline in the canal commands. Facilities like agricultural extension services should be made available to the farmers, so that they will equip themselves for scientific water management by economising the use of water.

The problem of conveyance losses is not taken care of in terms of adequate land development works like lining of canals, levelling the land, etc., in many of the major irrigation works.

The over exploitation of the surface and ground water resources could be avoided if the farmers at large opt for the conjunctive use of irrigation water. This is perhaps one of the viable options to make our water resource base a sustainable one.

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Dennis Kux, *Estranged Democracies - India and the United States, 1941-1991*, Sage Publications, New Delhi, 1994, Pp. xxiv+514, Price Rs. 375/-.

Dennis Kux, the author of this book, was an American diplomat for about thirty years and then became Executive Director of the Association for Diplomatic Studies, Arlington, Virginia, and a Visiting Fellow at the National Defense University, where he researched and wrote this history of the Indo-US relations. How extensive the research was is shown by the fact that the first chapter of thirty-eight pages of narrative is followed by eight pages of 133 notes and comments.

With that amount of research, the book has turned out to be a very even-handed narration. Each country's actions and reactions have been faithfully recorded. Three important areas of

relations can be chosen to illustrate this. One is that of security, the second of US aid and the third of each country's position over global events. India's strong reactions to the US arms aid to Pakistan, and India's gratitude for food aid and for the defence aid against the Chinese aggression have been well recorded. So have the two countries' differing perceptions and reactions to the developments in Hungary, Czechoslovakia, Suez, Formosa, Indo-China, Afghanistan, etc.

The study set out to enquire as to 'what caused these two countries to have such volatile relations, occasionally friendly, sometimes hostile, more often that not estranged?' (p. xi). What the study found out was that Washington and New Delhi fell out because they disagreed on national security issues of fundamental importance to each. Moynihan, who has been US ambassador to India, has in his introduction to the book said the same thing. 'The United States and India', says he, 'are estranged democracies not because we have failed to understand each other but because of conflicting policies we and they have pursued with regard to the most elemental of national interests, military security' (p. xvii).

The book however does not go into the merits of each country's perceptions about its security. Kux tries to let the story largely tell itself without much attempt at theorising (p. xiii). Moynihan contents himself by saying: 'Indian fear of Pakistan may have been irrational as Ambassador Kux suggests. It was no less real' (p. xix). With this deliberate staying away from evaluation, the book does not give the readers a key to the understanding of what lay behind each country's reactions and positions.

Since military security is seen as the main determinant of these relations, it would be worthwhile to say something more about it. The author says 'India was lined up with America's principal foe, while, at the same time, Washington was itself aligned with India's major enemy. Not a recipe for amicable relations' (p. xxi). In these enmities, Russia has more to complain against the USA and India has more to complain against Pakistan, rather than the other way around.

It is necessary to recall that at the birth of the communist regime in Russia, it was the west-European capitalist powers which supplied men and material to the anti-communist forces within Russia. The exploiting systems that these western powers were, looked at the communist ideology itself as their enemy. The US was a natural ally of these powers and came to have its own global interests. Anti-communism became a cardinal principle of its policy. (Nehru has recorded the foreign intervention in Russia in his *Glimpses of World History*. Eisenhower's mention of Russians as 'a non-European people who also suffered from the West' (p. 143) - is too mild a statement). Communism began as a movement to free the masses from economic exploitation and to establish a just economic order. Stalin's important contribution to communist practice was to limit the use of Russian power to the establishment of communism in that single country. He made communism national rather than international. Communist ideology was of course spreading elsewhere, but not through Russian arms, though Russia helped its spread. Moynihan says 'We never got it clear in our heads whether by (Russian) expansion we referred to the Red Army or the Communist Party' (p. xix). That is not really true. America had seen China 'go' communist without the help of the Russian Army. Other people were also 'going' communist. Their struggle against colonial powers was two-fold. It was for freedom from foreign domination as well as from economic exploitation. In this process a national movement itself became a communist movement. If Truman or Dulles, Nixon and Kissinger did not see this clearly, Eisenhower certainly did. 'Eisenhower was less antagonist toward India and more concerned about relations with former colonial states, than his Secretary of State (Dulles). He worried that if the West failed to support decolonization and economic development, the countries of Asia and Africa would become independent anyway *and find communism attractive*' (p. 184, emphasis added). So, there is no reason to believe that, as Moynihan has said, the Americans were not clear in their heads on this issue. What seems to have happened, and this needs further study, is that the Americans had no clue as to how to deal with the ideological threat. They were too tied up with the colonial powers and ended up with opposing freedom struggles simply because these struggles had communist influence.

The Indian side to the Indo-US relations was

largely shaped by the US's arming of Pakistan. In the face of repeated armed invasions by Pakistan, India's fears were certainly not irrational. India's fears were not that Pakistan would vanquish India, but an invasion certainly puts a strain on Indian defences and on the Indian economy. It is the US-Pakistan alliance that pushed India closer to the Soviet Union. Nehru had told the very first American ambassador that India disliked the undemocratic and totalitarian nature of the Soviet regime (p. 57) and it was only in 1955, when America had finally decided to arm Pakistan that 'Nehru was prepared to edge India closer to the Soviet Union, to offset US support for Pakistan' (p. 118). When under the Nixon-Kissinger regime, the US-Pakistan axis threatened to become a US-Pakistan China axis, India had naturally to be soft on Russian misdeeds. Even then, India did try to lead the non-aligned movement and, as Kissinger wrote in his memoirs, 'Mrs Gandhi (around 1975/76) gave indications of wanting to maintain a certain distance from the Soviets and to seek better relations with the US despite the scars left by 1971 (US role in the Bangladesh war) and the insistent US media criticism of the Emergency' (p. 337). This account by Kux does not bear out his statement that India was *tied up* with America's principal foe. In the case of global events India just couldn't go along with the US in looking at every communist-influenced movement as an extended arm of Russia, inimical to the US. That the US was displeased with India's attitude is another matter.

Many of the determinants of the Indo-US relations have now changed. With the decline of the Russian army as well as of the communist doctrine, the US is no longer obsessed with the Russian threat. It has practically given up its alliance with Pakistan. India has become a major power in Asia, militarily as well as economically and has no need to beg for aid. The time is ripe for 'more mature relationship' between the two countries. Kux gives the following prescriptions for good relations:

(1) If India makes US-bashing a national political pastime ... if Washington functionaries continue to have an almost knee-jerk negative attitude of distrust towards India, it will be difficult to advance relations (p. 451). (2) The United States needs to respect India's security sensitivities ... (p. 451) (3) In the economic area, the US should show more understanding of India's enormous problems and poverty, *especially in relations to trade policy questions* (emphasis added) (p. 451). (4) India has to open up her economy and give greater scope for market forces for inducing the US private sector to invest in and trade with India. (5) The most difficult issue is that of nuclear weapons. A nuclear Pakistan has in effect achieved strategic parity with India. How effectively and calmly Washington and New Delhi deal with this difficult and dangerous problem is certain to have a major impact on the Indo-US relations (p. 452).

One can whole-heartedly agree with Kux. Only that the nuclear issue is not just one between India and Pakistan. India wants to know what the major N-weapon powers are doing to destroy their own weapons and to submit their nuclear establishments to international inspection.

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Reddy K.N. and V. Selvaraju, *Health Care Expenditure by Government of India 1974-75 to 1990-91*, Seven Hills Publications, New Delhi, 1994, Pp. x+199, price Rs 275/-.

This study on expenditure on health care by the Central, State and Union Territory Governments has been undertaken by the authors with the objective of (i) to estimate the size and composition of health care expenditure (ii) to examine the trends in health care expenditure from 1974-75 to 1990-91; (iii) to present the interstate variations in health care expenditure; (iv) to examine the linkages between plan and non-plan expenditure and (v) to study the priorities in the allocation of resources among different health categories and programmes and by sectors. The study has been undertaken for the years 1974-75, 1978-79, 1982-83, 1986-87 and 1990-91. The health care expenditure studied pertains to (a) medical and public health, (b) family welfare, (c) water supply and sanitation, (d) nutrition and (e) child and handicapped welfare. The study is made up of the introduction, six chapters and over 130 pages of appendices and tables. Chapter 2 gives

a detailed account of how the health care expenditure of the governments in India has been estimated for this study. However, except for a break-up of the actuals and outlays on health, family welfare, water supply and sanitation for the different Plans given at table 3.1 (p. 9), and total health expenditure for the five years mentioned earlier at table 3.2 (p. 10), all other tables pertaining to the study have been given in per-capita terms. It would have been interesting if the break up of actual expenditure, state wise and department wise under the different heads of study and years had also been given for follow up studies by any other researcher.

Chapter 4 deals with the inter-state variations in health care expenditure for 1974-75 to 1990-91. Among the major states, Kerala had the highest per-capita expenditure on health care in 1974-75 dropped fourth place in 1978-79, but stayed in the second place during 1982-83, 1986-87 and 1990-91. At the other extreme, Bihar ranked the lowest in per-capita expenditure for three of the five years, and only a rung higher for the other two years (p. 20). Expenditure on medical and public health was highest in 1974-75 and 1978-79 in West Bengal, but the State dropped to the second position in 1982-83 and 1990-91 and to the fifth position in 1986-87 (p. 21). The per-capita expenditure on family welfare was highest in Orissa during the period 1974-75 to 1986-87 but dropped to the last position in 1990-91, yielding place to Kerala as the first in ranking (p. 22). The per capita expenditure on water supply and sanitation, nutrition and child and handicapped welfare exhibited a mixed trend among the major states. The highest per-capita expenditure on health care was in Nagaland one of the special category states, throughout the period of study.

The linkages between Plan and non-Plan expenditures on health care are discussed in chapter 5. The study finds that per-capita Plan expenditure in real terms had increased three-fold during the period 1974-75 to 1990-91 while non-Plan expenditure rose by a little more than one and a half times. The largest increase in Plan and non Plan expenditure took place under Child and Handicapped welfare, which rose by 10.35 and 4.90 per cent, respectively between 1974-75 and 1990-91. The linkages of per capita Plan and non-Plan expenditure appeared to have been closest in the case of 'nutrition' which increased by 6.94 and 5.71 per cent, respectively, between 1974-75 and 1990-91. In all other cases Plan expenditure per-capita, rose much faster than non-plan expenditure between the same period.

As regards government priority in health care expenditure, the study was able to obtain details only for (i) medical and public health and (ii) family welfare (chapter 6). By combining the expenditure for the centre, state and union territory governments it was found that the proportion on medical expenditure declined from 68.89 per cent in 1974-75 to 64.66 per cent in 1990-91 and on public health expenditure from 18.18 per cent to 17.30 per cent, but increased perceptibly for family welfare expenditure from 12.93 per cent to 18.05 per cent, during the same period (Table 6.1). The study points out that these trends reveal 'little about the composition of each category and the purposes for which the items of expenditure are directed at - such as curative and preventive health care' (p. 46). An attempt was made to present the data in that form. Expenditure for purposes of curative treatment included medical relief, employees state insurance, central government health scheme, medical education training research, other systems of medicine, etc. Preventive measures included (a) prevention and control of diseases, prevention of food adulteration, drug control, minimum seeds programme under public health and (b) rural family planning service, maternity and child health, compensation and other services and supplies under family welfare. The data showed a decline in curative treatment expenditure from 64.46 per cent in 1974-75 to 60.25 per cent in 1990-91, while expenditure on preventive measures increased from 22.34 per cent to 26.33 per cent, respectively.

The study reveals that of the total health care expenditure of the government, barely 33.04 per cent was spent in the rural sector and 66.96 per cent continued to be spent in the urban area even in 1990-91 (p. 50). With 74.28 per cent of the population living in the rural areas in 1991, this is indeed a very sad commentary on the priorities of the health care programmes in the country.

This book will be of great use to researchers in public health with the fund of tables given.

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ANNOTATED INDEX OF BOOKS AND ARTICLES IN INDIA

EDITOR'S NOTE

These abstracts are prepared by the author of each book/article sent to us voluntarily in response to our invitation through the Economic and Political Weekly. These cover publications after 1st January 1986. Only abstracts of books/articles so received are published. The index, therefore, is not exhaustive and complete.

The limit of 250 words and 100 words for abstracts of books and articles, respectively, is strictly enforced. Only a minimum amount of copy editing is done in order to bring the abstracts within the prescribed limits. The readers should approach the author of the abstract, not this Journal, for any clarifications.

BOOKS

1994

Saini, Debi S. *Redressal of Labour Grievances, Claims and Disputes*, Oxford & IBH Publishing Company, New Delhi, 1994, Pp. xvi+203.

The Indian industrial relations model places heavy reliance on state regulation; and bilateralism is allowed to grow only under over-arching shadows of labour lawyers, quasi-judicial labour courts and tribunals, full-time labour law professionals including union leaders, and a labour bureaucracy saddled with substantial powers of intervention.

In such a framework, even individual labour issues have become very complex and juridified; the worker finds himself surrounded by a number of laws, lawyers, and quasi-judicial and administrative authorities.

In the above-mentioned perspective this book deals with the concepts of labour grievances, claims, and disputes and their interconnection. With a view to putting together substantive ad procedural knowledge relating to individual disputes and grievances, it discusses grievance procedure and grievance handling practices; substantive provisions in labour laws relating to worker's claims and claims procedure; the framework of industrial disputes resolution; and the administrative structure of Central and State labour departments for enforcing labour grievances, claims and disputes.

The book brings into focus legal and bilateral issues in dealing with individual worker's problems at the work place. It is based on fieldwork conducted, among others, at the Central and State labour departments and certain selected large-scale establishments at Ahmedabad. Apart from discussing the procedural aspects, it analyses why certain and not other grievance practices are followed. The author also makes suggestions for a more efficacious system of grievance redressal and disputes resolution.

Redressal of Labour Grievances, Claims and Disputes will be of interest to labour scholars and teachers and students of labour laws, industrial relations and business management. It will specially interest trade union leaders, labour law consultants, and labour administrators.

The Journal will publish in each issue Annotated Bibliography of Books and Articles on Indian Economy, Polity and Society, published after January 1, 1986. Authors are requested to send their entries with full details of publication and annotation not exceeding 250 words for books and not exceeding 100 words for articles. Use separate sheet for each entry.

BOOKS RECEIVED

Currently, a large number of books are being published on Indian economic, political and social problems and developments. We give below a list of books we have received with a request for a review. For want of editorial resources, it is not possible to review all of them though many deserve a critical review. Interested readers are requested to write to the editor indicating which of the following books he would like to review or write a full review article on. We shall be glad to do the needful. Readers are also welcome to review books recently published, but not appearing in the following list. As the contributors to this Journal are aware, all contributions published here are adequately remunerated.

Acharya, S.S. and Agarwal, N.L., *Agricultural Prices- Analysis and Policy*, Oxford and IBH Publishing Company, Pvt. Ltd., New Delhi, 1994.

This monograph furnishes an incisive analysis of the role, characteristics and determinants of agricultural prices and their economic and political implications for a developing and low-income country like India, where agriculture provides employment and income for about two-thirds of the work force.

The book is divided into three parts. The first part is an introductory one which acquaints the reader with the meaning and concept of agricultural prices, and of other important related terms. It also delineates on their role, functions and characteristics, general price level and inflation, the need for price analysis, and sources of price data and price statistics. Price analysis is the theme of the second part which studies in detail inter-temporal behaviour of prices, fluctuations and stability in prices, measures for price stabilisation, and agricultural price index numbers. In addition, it examines approaches to assess the pricing efficiency of the marketing system, demand for and supply of agricultural products, and their price determination under different market situations. The third part is devoted to state intervention in pricing- agricultural price policy, its objectives, and instruments, administered prices of agricultural products, food management policy, PDS, etc.

The book could be used as a textbook for a course on agricultural price analysis.

Apte, Pradeep, *Dunkel Draft: Myth and Reality*, Centre for Development Research and Documentation, Pune, 1994.

This is a non-technical yet rigorous and impartial inquiry into all the main issues in GATT, especially such issues as have cast a cloud of controversy in India. The book provides the essential historical background on GATT as well as the relevant excerpts from the Dunkel Draft as approved at the Uruguay Round. It analyses its implications for the Indian economy.

While asserting that the developed countries, the US in particular, commands great hegemony, the author points out that the tenable way to counter it is through politico-economic diplomacy, not by opting out of international institutions and eventually isolating ourselves from the international community and scene. Old ideological prisms, which distort our vista of the world, require to be discarded and alternate ways of thinking adopted. Patents, especially in agriculture and pharmaceuticals, subsidies, tariffs, quantitative restrictions and market access in other countries to our goods, primarily textiles, are some of the issues dealt with in the monograph.

Patents are exclusive rights to benefit from commercialising an invention. Only new products or new processes are patentable. Patents belong to conventional intellectual property rights like trademarks, copyrights, plant breeder's rights (PBRs), trade secrets, etc. The author presents an overview of the patent system, PBRs and copyrights. He comments on India's Research and Development (R&D) policy in general, highlighting its significance in the light of the Dunkel proposals.

The economic theory of international trade recognises the equivalence of import tariffs and export subsidies. It follows automatically, that tariff reduction entails a reduction in subsidy, which is non-tariff barrier to trade. The Final Agreement (FA) at the Uruguay Round contains provisions to this effect, which are critically examined by the author. The author argues in favour of restructuring our trade policy, in view of liberalisation of world trade through FA. He

emphasizes the exigency of bringing about reforms in the institutional and legislative arrangements that affect trade. In his view, it is necessary to concentrate initially on the following three areas: (i) anti-dumping, (ii) temporary safeguard measures to protect domestic industry from 'import-triggered injury', and (iii) value-related problems, like environmental concerns and social concerns- child labour, prison labour, human rights, etc.

Finally, the author concludes that India's membership of the GATT and now of the WTO is definitely preferable to complex bilateral negotiations. He strongly recommends that India should strengthen her trading capacity through internal reforms and also develop a pressure group of like-minded countries.

Centre for Economic and Social Studies, Hyderabad, *Rural Employment Guarantee Scheme: Andhra Pradesh*, Panchayati Raj and Rural Development Department, Government of Andhra Pradesh, Hyderabad, 1994.

This is a project report prepared by the Centre for Economic and Social Studies, Hyderabad, for the Government of Andhra Pradesh. The object of the project is to provide income security to the rural poor in areas with low, uncertain irrigation and without other schemes for income security/ employment guarantee. The fact that four-fifths of all the poor are dependent on agriculture and the apprehension about the Structural Adjustment Programme with the possibility of its adverse effects on the poor have accentuated the need for such security/guarantee.

The project proposes to benefit 13.48 lakh male and 14.72 lakh female agricultural labour in the selected areas, to generate additional employment for 250-260 person-days, to provide for unemployment compensation for 5 per cent of this, to raise the level of wages by 40 per cent and bring down the percentage of poor from 65 per cent to 20 per cent in these areas in five years.

Das, Keshabananda, *Peasant Economy and the Sugar Cooperative: A Study of the Aska Region in Orissa*, Occasional Paper Series, Centre for Development Studies, Trivandrum, 1993.

The book attempts to inquire into the dynamics of production relations within agriculture, and between agriculture and the processing cooperative in a traditionally sugarcane growing region in southern Orissa. This region is marked with a predominance of small peasants and high incidence of tenancy. Certain characteristic features of the market-oriented agro-industrial crop production in this socio-economically depressed region, like high self-exploitation of family labour, high rent, entrenched landlord- tenant power relations, discriminatory treatment by the cooperative management, etc., are distinguished by the author for analysis.

Institute for Social and Economic Change, *Industrial Potential in Karnataka*, sponsored by the Karnataka State Industrial Investment and Development Corporation, Bangalore, Institute for Social and Economic Change, Bangalore, 1994.

This study analyses Karnataka's industrial growth pattern across industries and regions, especially since the Five Year Plans. It examines various crucial parameters, such as finance, resources, infrastructure and policy, with a view to identify their relative advantages and disadvantages.

The study is divided into seven chapters- the first one presents a synoptic view of the industry in Karnataka *vis-a-vis* some selected states. The second and the third chapters discuss the growth and structure of the manufacturing sector, and the role of the institutional finance, respectively. Chapter 4 is devoted to the past, present and future availability of resources having a bearing on the industrial conformation in the state. The next two chapters delineate on the conduciveness of the infrastructure facilities and the government policy, while the last chapter comprises recommendations for further growth.

Nayyar, Deepak, *Economic Reforms in India: A Critical Assessment*, ILO-ARTEP Working Paper, International Labour Organisation and Asian Regional Team for Employment Promotion (ARTEP), New Delhi, 1993.

This is one of the background studies prepared under the project on 'Integrated Strategies of Employment Generation and Poverty Alleviation in India' implemented by ILO-ARTEP. It analyses the origins, the logic, the theoretical basis, and the nature of the economic liberalisation and structural reform programme in India. The contours of the programme included in this analysis are industrial policy reform, trade policy reform, foreign investment and foreign technology, public sector reform, and financial sector reform. The possible impact of the reform programme on growth, employment and poverty is evaluated as well as some critical gaps in it are outlined.

Parikh, Jyoti K., B. Sudhakara Reddy and Rangan Banerjee, *Planning for Demand Side Management in the Electricity Sector*, Indira Gandhi Institute of Development Research, Bombay and Tata McGraw-Hill Publishing Company, Ltd. New Delhi, 1994.

Planning for energy conservation and efficiency has so far been restricted to supply-side. This is a policy study on electric power, which is a demand-side management (DSM) study. It includes two implementable DSM plans (five year and twenty year) for Maharashtra, with specific targets and detailed cost-benefit analysis. DSM is defined as conservation and efficiency of use at the consumer/customer end. Customers themselves are to be involved in achieving efficiency of use with the help of equipment manufacturers.

Since the share of the high tension (HT) industries is the largest in Maharashtra with 33.4 per cent in the total electric consumption, the DSM in the HT industries sector is very crucial for overall energy conservation and the DSM strategies. An extensive survey of the end-use load structure of the HT industries was undertaken in 1989-90, It has shown that the share of motors was the highest with 49 per cent, followed by such major end-users as melting with 16 per cent, electric heating with 13 per cent, air-compressors 9 per cent and lighting and air-conditioning 4 per cent each. Accordingly twelve DSM options have been identified for evaluation and later for formulation of DSM programmes, such as energy efficient motors, variable speed drives, good housekeeping measures, waste heat driven vapour absorption refrigeration systems, time-of-day tariff, etc.

The study indicates that (i) through the adoption of DSM programmes, the customer reduces his energy bills, (ii) a number of DSM programmes are considerably cheaper than building new power plants, and (iii) they also bring in environmental benefits due to reduced burning of coal in power plants. But initial funding and/or technical assistance or services for adoption of such programmes as well as the involvement of equipment manufacturers are some of the important factors which need attention.

Parikh, Kirit S. and R. Sudarshan, *Eds., Human Development: And Structural Adjustment*, Macmillan India Ltd., Madras, 1993.

This volume comprises papers and proceedings of the UNDP symposium, held in Bombay during Jan 3-6, 1992, on 'Economic Growth, Sustainable Human Development and Poverty Alleviation in India'.

Planning Commission, *A Study on the Performance of State Road Transport Undertakings*, Government of India, New Delhi, 1994.

The report presents a comparative appraisal of the strengths and weaknesses of 43 State Road Transport Undertakings (SRTUs). Despite steady improvement in the overall indices of physical performance of the SRTUs, their financial position has not improved during the period surveyed, i.e., from 1985-86 to 1993-94. Vehicle productivity has increased from 230 km per bus day to 267 km per bus day, and the staff productivity from 31.1 km to 37.5 km per worker day; bus-staff ratio has improved from 1:8.4 to 1:8.1. But the net loss of Rs 30,000 per bus per annum has not diminished.

Ramachandran, C.N., Jayagopal Uchil and T.N. Sreedhara, *Eds, Critical Spectrum: Lectures on Current Issues*, Mangalore University, Mangalagangothri, 1993.

As a part of the celebration of the Decennial year, the Mangalore University arranged a series of lectures by distinguished scholars from all over India. This volume presents fourteen of them. They are on different areas/issues of contemporary Indian society. Half of them in the first

section of the book are devoted to rural development and allied issues. While the remaining half lectures in the second section are delivered on varied themes, such as law, statistics, health Ayurveda and surgery.

Rao, V.M., *Dairy Farming: Socio-economic Analysis of Milk Production*, Reliance Publishing House, New Delhi, 1991.

This thesis examines the economics of milk production and its relevant aspects in Krishna District of Andhra Pradesh, where different species of milch animals are being reared by rural families. Economic performance of these species is analysed in terms of costs, returns and input-output relationship in milk production. A critical evaluation of the Intensive Cattle Development Project (ICDP) launched in the area by the state in 1965, a socio-economic profile of the sample households with an estimate of employment generated through dairy farming, a study of the animal feed and fodder situation, and suggestions for advancement of dairy farming and animal husbandry, like cattle insurance, scientific means of reducing the age at first calving and dry period, etc., are also included in this monograph.

Sreekumar, T.T., *Urban Process in Kerala: 1900-1981*, Occasional Paper Series, Centre for Development Studies, Trivandrum, 1993.

The monograph examines the characteristic features, of urbanisation in Kerala, their historical origins and their determinants or causes. The major differences from other third world regions, as pointed out by the author, comprise (a) a lesser degree of fluctuation in the urban growth, (b) very high spatial dispersion of towns, (c) slower rate of growth of towns over time, (d) insignificant role of rural to urban migration in overall growth of urban population, and (e) higher proportion of extensional (emergence of new towns) and decremental (declassification of erstwhile urban areas as rural) components in total urban growth. The factors responsible for such a unique spatial formation, which are analysed here, include (i) the ecology of the region which played a very significant role; (ii) absence of a primate city, because for all administrative purposes it was part of the Madras Presidency, with Madras as its central node; (iii) emergence of towns as a result of integration into the world system of modern capitalism through commercialised agriculture and processing and trading activity, not through industrialisation; and (iv) instability of the urban system, i.e., proliferation and disappearance of urban units in a given geographical area.

Tewari, Devi D. and V.M. Rao, *Castor Economy: A Profile and Analysis of Indian and International Market*, 1991.

Tewari, Devi D. and V.M. Rao, *International Castor Oil Market: An Econometric Analysis*, Pp. xvi+171, 1994.
Centre for Management in Agriculture (CMA) Monographs 150 and 167, Oxford and IBH Publishing Company, Pvt. Ltd., New Delhi.

These two studies provide a profile of castor in both Indian and international settings. Castor oil is one of the important foreign exchange earners. The first study brings to light that castor oil is the cheapest in the domestic market in India while it is the dearest in the international market. India, with her fine production potential, could raise her exports of castor oil to the tune of US$ 400 million per year by 2000 A.D., with proper investment in agricultural technology and market management.

The second study visualises the probable scenarios that may emerge in the future in the international castor oil market, based on an econometric simulation model. Using this model for policy experimentation and testing, the study suggests appropriate Indian strategic responses to these foreseeable events in the world castor economy.

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Extracts from (a) Report of the Indian Police Commission, 1905, Ch XII and (b) Report of the National Police Commission, 1981: Seventh, Eighth and Concluding Reports, Vol. VI, No. 3, Pp. 516-563.

Report of the Indian Irrigation Commission 1901-1903, Part I - General, Pp. 708-747.

Extracts from Report of the Royal Commission on Agriculture, 1928: Ch X, Irrigation, Vol. VI, No. 4, Pp. 748-779.

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