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Cropping Intensity in a Developing Economy : Flow, Spatial Disparity and Determinants

G. S. Kainth* and R. S. Bawa**

Introduction

Appreciation of the importance of agriculture in the process of development has been greatly enhanced by the green revolution that have begun to transform the economics of diverse countries such as Costa Rica, Israel, Nigeria, the Philippines, Thailand, Tanzania and Yogoslavia. Even for countries with high population densities such as India and Pakistan, the recent advances in agricultural output have raised new hopes.[1] These transformations provide a detailed source of evidence that enables us to enhance our understanding of economic development. Agricultural productivity and cropping intensity are the two important factors responsible for the growth of agriculture. Agricultural productivity , however, can increase only to a limited extent and the further growth of agricultural output has to be brought about through intensive cultivation. Therefore, the importance of the study of inter-district variations and dynamics of cropping intensity is obvious.

The objective of this paper is to evaluate the empirical basis for the assessment of past trends and future prospects. The principal sources of data of our study are the various issues of Statistical Abstract of Punjab— an annual publication of Economic and Statistical Organization, Government of Punjab. The time reference of the present study is ten years from 1970—71 to 1979—80,[2] a period of post green revolution. This data set provides the basis for a systematic time series analysis of trend in cropping intensity for Punjab as a whole as well as for individual districts.

* *Department of Economics and Sociology, Punjab Agricultural University, Ludhiana*–141 004 (*India*).
** *Punjab School of Economics, Guru Nanak Dev University, Amritsar*–143 005 (*India*).

The paper is organised as follows: Second Section presents results on trends in the extent of cropping intensity over the period 1970-71 through 1979-80 for Punjab as a whole as well as for the individual districts. Third Section attempts to relate observed changes in cropping intensity to productivity of land. Fourth Section deals briefly with the determinants of inter—district variations in cropping intensity. A summary view of the evidence on changes in cropping intensity and factors affecting these changes is presented in Section five.

Trends in Cropping Intensity : 1970-71 to 1979-80

The estimates of cropping intensity[3] in Punjab for the period under review are presented in Table 1. The results are discussed separately for Punjab as a whole and for the individual districts.

(a) The All Punjab Results

It will be seen from Table 1 that there exists fluctuations over time in the extent of cropping intensity. The extent of cropping intensity initially increases from 140.0 per cent in 1970-71 to 146.7 per cent in 1973-74, falls sharply in 1974-75 and rises reaching a peak in 1978-79. In 1979-80, the extent of cropping intensity falls to 156.4 per cent. The existence of fluctuations over time implies that we cannot generalise about the underlying trends on the basis of comparisons between the selected endpoints. This can only be done on the basis of time series analysis. Accordingly, a linear time trend was fitted to the extent of cropping intensity. The resulting estimates are reported in Table 2.

The results (Table 2) provide clear evidence of a significant positive time trend in the extent of cropping intensity. This means a clear visible success of the Green Revolution in raising the output.

(b) The results for Individual Districts

Our estimates of the extent of cropping intensity for the individual districts are reported in Table 1. In general, the time pattern of the extent of cropping intensity in individual districts follows the pattern of fluctuations described for Punjab as a whole (except Amritsar and Bhatinda).

The extent of cropping intensity in Amritsar district initially declines in 1971-72 to 149.4 per cent. In the subsequent two years, the extent of cropping intensity increased to 158.8 per cent. Again it declines through mid—seventies reaching the bottom in 1976-77 and then rises again. In case of Bhatinda, the extent of cropping intensity fluctuates up and down in the alternate years in general.

Once again, we have tested for the existence of fluctuations over time by fitting

a linear time trend to the extent of cropping intensity for the individual districts. Except for Hoshiarpur, Ropar and Bhatinda districts, all other districts show a significant positive trend in the extent of cropping intensity.

The main conclusions to be drawn from these results are that the extent of cropping intensity in Punjab showed a significant trend over the last decade and shows signs of continuing to grow. But this is not true for individual districts where for some districts it seems to have reached its peak and may start declining or become stationary.

Land Productivity and Cropping Intensity

Ideally, the ovserved changes in the extent of cropping intensity over different time periods should be explained in terms of some explicit model of the determinants of cropping intensity. In this context, it is obviously relevant to consider productivity of land, tenancy pattern, literacy rate, irrigation intensity and farm mechanization etc. A complete exploration of the impact of these factors is obviously beyond the scope of this paper. Instead, we shall confine ourselves to examine the relationship between the extent of cropping intensity and the productivity of land[4] - a proxy for income. Once again the analysis is presented separately for Punjab as a whole and for the individual districts.

(a) The All Punjab Evidence

We begin by postulating that an important determinant of the extent of cropping intensity is the level of productivity of land. If there is any break through machanism at work in the rural economy, we should expect increase in output per unit of land to increase the extent of cropping intensity. Does the available evidence support this view ?

The Punjab experience of the past decade is that the growth of production per unit of land leads to increase in the extent of cropping intensity. This is evident from the result reporting linear time trend fitted to the gross value productivity (Table 3).

The relationship between the extent of cropping intensity and the productivity of land over the period under review can be more systematically examined through regression analysis. When this done, we find that improved productivity of land is definitely associated with increase in cropping intensity. Table 4 presents results of regression analysis[5] along these lines. Initially, we hypothesise that the extent of cropping intensity depends upon the level of production per unit of land. As shown in Table 4 the coefficient on this variable is positive and highly significant. An alternative hypothesis is that the extent of cropping intensity depends not only on the

current year level of TVPPH but also on the level in the previous years.[6] This is tested by using the average value of TVPPH for the current and previous years as the independent variables in the regressions. As shown in Table 4, the explanatory power of the equations improves and the regression coefficient is again positive and very highly significant.

It can be argued that TVPPH is positively related to the extent of cropping intensity, there may be other factors operating in the rural economy affecting the extent of cropping intensity over time. This hypothesis can be crudely tested by including time as an additional explanatory variable (Equation 3). We find that the coefficient on this variable is not significant, suggesting that there is no underlying time trend in the extent of cropping intensity after allowing for changes in cropping intensity associated with changes in TVPPH.

What can we legitimately infer from these results ? There is clear evidence of positive relationship between productivity of land and cropping intensity. The fluctuation in cropping intensity simply coincide with the movements in production per unit of land and this relationship is even more firmly identifiable when account is taken of the lags involved.

(b) The Evidence For Individual Districts

Does the available evidence also support the positive relationship between the cropping intensity and the productivity of land ? There is support for the hypothesis that the extent of cropping intensity is positively associated with the productivity of land, but the corroboration is not complete. Indeed, there are some differences between all - Punjab and district level results, which call for further investigtion.

Table 3 presents the estimates of linear time trends for the productivity of land for the individual district. Three districts (Hoshiarpur,Ropar and Bhatinda) show significant growth in output per unit of land, yet (Table 2), none of these districts shows significant trend increase in the extent of cropping intensity. The absence of any trend in the extent of cropping intensity in districts that have experienced growth in output per unit of land is clearly disturbing and call for further investigation.

Following the approach adopted for the all - Punjab analysis, we have estimated regression equations for individual districts testing the hypothesis that the extent of cropping intensity depends on the level of output per unit of land. Table 4 presents the results of the regression analysis for individual districts. Our results can be summarised as follows:

(i) There is clear evidence of a significant relationship between output per unit

of land and the extent of cropping intensity in seven districts, namely, Amritsar, Jullundur, Ludhiana, Ferozepore, Sangrur, Kapurthala and Patiala. Although only seven districts of the twelve confirm to this pattern, it is important to note that these districts account for more than 60 per cent of the gross cropped area of Punjab. Of the other districts it is worth noting that Bhatinda has positive coefficient on productivity of land variable with t-ratios that are fairly high, although not high enough to ensure significance even at ten per cent level for a two tail test.

(ii) The district level results differ substantially from the all - Punjab results in the estimated coefficient on the time term. At the all Punjab level, we found no significant time trend in the extent of cropping intensity operating independently of the effect of productivity of land. The results for individual districts show that the coefficient on time is positively significant in a number of districts. If we accept the argument that the time term picks up the net impact of variables excluded from our analysis, these results suggest that in these districts- Gurdaspur, Kapurthala, Ferozepore and Patiala-there may be factors at work in the agrarian economy which by themselves tend to increase the extent of cropping intensity. Identifying these factors is clearly crucial for understanding the causal machanisms determining cropping intensity. Unfortunately, our data provides no basis for developing and testing specific hypotheses along these lines. However, it is interesting to note that this group includes those districts where conditions of tenancy are most adverse.[7]

(iii) For most of the districts for which the coefficient on the time term is positively significant, there is also a significantly positive coefficient on the productivity of land variable. This suggests that while—there were factors operating in agrarian economy which tended to increase the extent of cropping intensity, productivity of land tended to stimulate the impact of these factors.

(iv) Finally, the most disquieting feature of our analysis is the evidence from Bhatinda which does not support the hypothesis that improved productivity of land will help to increase the extent of cropping intensity.[8] This region has experienced a dramatic growth in productivity of land but there is no evidence of upward trend in the extent of cropping intensity.

Inter-District Variations

A study into the factors influencing the changes in the pattern cropping intensity has to be necessarily preceded by an examination of occurrence of any change. Further, we can distinguish two types of changes, viz. (i) shifts, and (ii) devi-

ations.

When two or more patterns of cropping intensity are compared on arranging them on an increasing or decreasing order and if they do not exhibit similarity between them, shift is said to occur. On the other hand, when difference occur on account of changes within the pattern of cropping intensity, then these are taken as deviations.

It can be observed from Table 1, there is not much variation or shift in the pattern of cropping intensity between the years 1970-71 and 1979-80. However, some deviations do occur as the farmers respond to changes is seasonal conditions, price differentials and other influencing variables. To test whether there is a shift in the cropping intensity over different districts, Kendall's Rank Correlation Coefficient (T = tau) was worked out for each pair of years.[9] The resulting estimates alongwith Z-value are reported in Table 5.

It is evident (Table 5) that all the correlation coefficients are highly significant which indicate that there is no shift in the cropping intensity over different districts in Punjab. Further the total change over the period under review, that is, from 1970-71 to 1979-80 was examined by the test of concordance.[10] The data and the calculations are presented in Annex 1. The coefficient of concordance was worked out to be 0.8103 and was highly significant. Hence it can be definitely concluded that there has been no shift in the cropping intensity over different districts between the years or over a period of ten years.

From a study of Table 1, it can be argued that Ludhiana district maintained its top rank throughout the period under review with the only exception of 1970-71. On the other hand Kapurthala remained at the lowest ladder of the scale. In order to examine the evidence of relative inequality of cropping intensity over different districts of Punjab, we have worked out coefficient of variations for the individual years. We have tested for the existence of a linear time trend.[11] Far from finding an increase in relative inequality, we find that the evidence points in the opposite direction. There is a significant decline in the relative inequality in cropping intensity over different districts of Punjab. This suggests that the gap in the extent of cropping intensity between the top (Ludhiana) and the bottom (Kapurthala) district has narrowed down significantly over the periods. Unfortunately these variations are still of a very high order.

This persistent presence of the inter-district variation in cropping intensity points that agriculture in Punjab is still dependent upon agro-climatic conditions. This fact is further supported by some random declines in cropping intensity during

the bad year of natural conditions. This also confirms the belief of some agricultural economists that there still exists potential for further increase in agricultural production by decreasing the dependence upon nature and by creating more uniformity over different districts in cropping intensity and other resource use. No doubt the results observed pertains to Punjab, but have a great potentiality / applicability to other states/countries still striving for development.

Determinants Of Inter-District Variations

In part (a) of this section, we have noticed that there was a considerable variation in the extent of cropping intensity. It is now worth-while to explore the factors which might explain the considerable inter-district variations in the extent of cropping intensity. This part is a step in that direction. We approached the problem in a sequential manner. The agricultural development of an area considered in terms of cropping intensity of the area is a function, other things remaining the same, of a paraphernalia of institutional variables like tractor intensity, productivity of land, irrigation, infrastructure rural literacy, average size of operational holdings and average rainfall etc. The data on some of the variables are not available, hence kept out of the scope of the study.

Column 2 of Table 6 gives the extent of cropping intensity in various districts. Column 3 presents total value productivity per hectare. These two columns clearly establish the fact that "the districts with higher productivity of land are also generally the districts with large cropping intensity." Similarly column 4 of Table 6 represents average rainfall in various districts of Punjab. The comparison of column 2 with column 4 reveals that area with higher degree of average rainfall are generally the districts with higher extent of cropping intensity. This means that Punjab agriculture is still nature oriented.

Further more, the relative literacy rate of the rural population is an indicator of their managerial efficiency. In column 5 of Table 6 we have the percentage of rural literate to total rural population. The close relationship between column 2 and 5 is striking. In other words, the extent of cropping intensity has a positive correlation with the percentage of rural literate to total rural population. Similarly, the comparison of column 6 and 7 with column 2 also reveals that gross area irrigated as a percentage of cropped area and the tractor per thousand hectare of gross cropped area is positively related with the extent of cropping intensity.

Again, one would theoretically speaking expect that the area with higher area under high yielding varieties are also the area with higher extent of cropping intensity. The comparison of column 2 with column 8 clearly confirms this

hypothesis. Table 6 is not a random sample, nor does it satisfy the essential assumption of correlation analysis. Nevertheless, without imputing any probabilistic connotation, we present in Table 7, the correlation coefficient (Spearman Rank) simply as a succint statement of the observed relationship between the extent of cropping intensity on one hand and the institutional variables on the other.

Complementarity Of Institutional Variables

It was hypothesized that those districts which had lower cropping intensity were also having all the institutional variables at a lower rank and those where cropping intensity was higher all the institutional variables had higher ranks. This means that institutional variables were complementary. The coefficient of complementarity was measured by rank correlation between all possible pairs of ranks of different institutional variables. There were six institutional variables, namely, productivity of land, rainfall, rural literacy, irrigation intensity, tractor intensity and area under high yielding varieties. Thus there were 15 possible pairs. The coefficient of complementarity between different institutional variables for different districts were computed.[12]

The coefficient of complementarity between different institutional variables for the four districts which had the lowest cropping intensity viz. Bhatinda. Kapurthala, Ferozepore, and Faridkot was 0.84; 0.67; 0.45 and 0.24 Respectively; and for the top four districts in cropping intensity viz. Ludhiana, Sangrur, Patiala and Gurdaspur was 0.73; 0.51; 0.33 and 0.43 respectively. Among other districts, viz. Amritsar and Jullundur, the coefficient of complementarity was worked out at 0.67 and 0.66 respectively.

These findings confirmed our view that the institutional variables moved in complementary fashion. This showed that in order to bring improvements in agricultural production (cropping intensity) vis institutional variables, all the institutions in the lowest cropping intensity regions have to be tackled; for those in the middle range, the lagged institutions have to be identified and given the priority; and again for those already in the top gear, all the institutional variables have to be further improved.

Conclusions

The twin objectives of this paper were to document trends in cropping intensity in Punjab, to examine the relationship between cropping intensity and productivity of land and the determinants of inter-district variations in cropping intensity. Our principal empirical findings and the caveats accompanying them can be summarised as follows:

(i) The evidence reviewed provides a fairly firm basis for documenting trends in cropping intensity in Punjab. We find that Punjab experience over the last decade can be characterised as showing a trend increase in the extent of cropping intensity in Punjab as a whole. The same conclusion holds for all the individual districts except Hoshiarpur, Ropar and Bhatinda Some of the agriculturally advanced districts like Ludhiana, Patiala and Jullundur etc. have started experiencing a fall in cropping intensity. This needs a thorough investigation and remedies.

(ii) The evidence on the relationship between cropping intensity and productivity of land is more difficult to evaluate for two reasons. In first place, the evidence itself is somewhat mixed. Much depends upon the level of aggregation at which the analysis is conducted with the all-Punjab results presenting a somewhat different picture from that obtained at the level of individual districts. Furthermore, the evidence necessarily is difficult to interpret since we are implicitly searching for causal relationships in what are at best observed correlation. The All Punjab evidence is entirely consistent with the hypothesis that the extent of cropping intensity is positively related to productivity of land measured as total value productivity per hectare.

(iii) The district level analysis presents a somewhat different picture. On the one hand we find a significant positive relationship in at least seven districts accounting for three quarters of the area. On the other hand the district level analysis also shows that there may be processes at work in the rural economy which tended to increase the extent of cropping intensity.

(iv) There has not been any significant shift in the pattern of cropping intensity over districts during the period under review, suggesting that the relative positions of districts over period remains more or less unchanged. Moreover, the gap between the top and bottom districts in the extent of cropping intensity has considerably declined, but these are still at a very high level.

(v) The factors which positively affects cropping intensity were found as productivity, rainfall, literacy rate, gross area irrigated as a percentage of total cropped area number of tractor per 1000 hectares of cropped area, and the area under high yielding varieties. The coefficient of complementarity between different institutional variables was found to be high for the top four and the four bottom districts in cropping intensity. This showed that institutional variables moved in a complementary order particularly at two extremes Thus in order to bring improvement in cropping intensity via institutional variab-

les, all the institutions in the lowest region have to be tackled; for those in the middle range, the lagged institutions have to be identified and given the top priority; and again, for those already in the top gear, all the institutional variables have to be further improved.

The policy implication of the analysis is very clear. Punjab, agriculturally advanced economy, is striving hard for industrial revolution. Moreover, rapid urbanization is in process. Both these process will reduce the area under plough. No doubt, this problem is not very serious at present, but will put heavy pressure on land to keep the tempo of agricultural production. Therefore, to maintain the tempo of agricultural growth, productivity of land and hence the cropping intensity will have to play an important role. Inter district variations in the cropping intensity have to be reduced to a considerable extent, by having more uniform resources over different districts of the state to meet the challenge imposed by industrialization and rapid urbanization Moreover, the extension services of the state in respect of agriculture has to be strengthened to enlightened the farmers about the recent improvements in the farm technology. The short duration hybrid varieties suitable for the particular region have to be evolved. The breeders have to shoulder this responsibility with utmost care.

TABLE 1

Estimates of Cropping Intensity over Different Districts of Punjab : 1970–71 To 1979–80

(in percent)

District	1970–71	1971–72	1972–73	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	1979–80
1	2	3	4	5	6	7	8	9	10	11
Gurdaspur	140.6	142 2	145.7	146 5	148 8	159.6	159.3	162.4	171.3	166.3
Amritsar	151.0	149.4	150.2	158.8	155.0	164.4	154.2	156.9	162.2	162.5
Kapurthala	117.4	117.4	116.7	122.7	124.8	128.5	130.0	132.8	136.0	141.2
Jullundur	138.7	146.4	146.7	149 6	150.6	152.9	154.9	153.5	160.7	159.5
Hoshiarpur	142.2	147.8	155.1	159.6	146.4	150.3	152.3	150.5	152.9	152.2
Ropar	165.8	151 8	152.4	154.4	158.5	159.6	155.6	158.8	155.2	155.2
Ludhiana	155.8	160.6	160.9	163.4	164.3	167.4	164.4	166.6	176.1	172.4
Ferozepur	127 5	129.0	130.2	134 3	133 0	146.5	146.8	146.2	164.4	150.9
Faridkot	133.0	134.2	141.2	139.5	134.4	137.4	141.2	140.4	147.5	147.2
Bhatinda	136 7	125.1	139.1	135.6	118 6	140.9	138.3	149 1	136.5	157.4
Sangrur	141.4	148 0	150 2	152.0	155.7	158.3	156.2	159.6	163 3	163.5
Patiala	142.3	141 8	151 4	149.4	155.8	157.3	159.8	163.4	173.5	171 3
Punjab	140.0	140.4	145.1	146.7	144.2	150 4	150.8	153.2	157.2	156.4

TABLE 2

Estimates of Linear Time Trend for Cropping Intensity by District

District	Intercept	Estimated Coefficient on Time	Standard Error	R^2
Gurdaspur	134 2917	3.7283***	0.3652	0.9371
Amritsar	148 7694	1.1817*	0.3670	0 5969
Kapurthala	112.3944	2.5500***	0.2098	0.9547
Jullundur	139.6944	2.1500***	0.2764	0.8963
Hoshiarpur	147.7889	0 6000	0.6613	0.1052
Ropar	157.6444	0.1533	0.5985	0.0093
Ludhiana	155.2055	1.8367**	0.3449	0.8019
Ferozepur	121 6056	3.4100***	0.4229	0.9028
Faridkot	132.5472	1.2417*	0.4193	0.5560
Bhatinda	129.3028	1.2483	1.1312	0.1481
Sangrur	142 1306	2.3450***	0 2542	0.9239
Patiala	137.1083	3 5717***	0.3658	0.9316
Punjab	137.3639	2 0383***	0 2210	0 9239

Note: *** Indicates that the coefficient on Time is significant at 0.001 level.

** Indicates significant at 0 01 level for a two tail test.

* Indicates significant at 0.05 level for a two tail test.

@ Indicates significant at 0.10 level for a two tail test

TABLE 3

Estimates of Linear Time Trends For Productivity of Land by District

District	Intercept	Estimated Coefficient on Time	Standard Error	R^2
Gurdasput	1155.400	147.582**	33.7233	0.7054
Amritsar	1138.133	143.994	28.2091	0.7651
Kapurthala	1052.200	169.054***	38.6217	0.7055
Jullundur	1026.470	222.479***	35.3147	0.8322
Hoshiarpur	788.733	141.739**	30.1903	0.7337
Ropar	777.533	171.849**	44.3023	0.6529
Ludhiana	1236.400	183.091***	23.3045	0.8854
Ferozepur	1126.330	142.867**	30.2396	0.7362
Faridkot	1467.360	75.476*	33.0310	0.4653
Bhatinda	—25.000	258.400***	47.5005	0.7872
Sangrur	996.412	151.646***	21.6278	0.8602
Patiala	908.533	193.576***	29.7603	0.8408
Punjab	935.670	169.915***	27.4661	0.8271

*** Indicates that the coefficient on Time is significant with the sign indicated at 0.001 level for a two tail test.

** Indicates significance at 0.01 level for a two tail test.

* Indicates singificance at 0.05 level for a two tail test.

	129.871		0.0092***		0.8494
			(0.0015)		
	136.0751		0.0031	1.5014	0.9092
			(0.0033)	(0.8548)	
Hoshiarpur	147.073	0.0024			0.0681
		(0.0032)			
	141.726		0.0053		0.2242
			(0.0041)		
	139.5541		0.0089	−0.5626	0.2489
			(0.0083)	(1.2671)	
Ropar	157.547	−0.0005			0.0054
		(0.0023)			
	158.36		−0.0009		0.0101
			(0.0032)		
	158.1024		−0.0004	−0.0996	0.0114
			(0.0062)	(1.1457)	
Ludhiana	146.38	0.0084***			0.7081
		(0.0019)			
	141.857		0.0102***		0.8292
			(0.0017)		
	145.3291		0.0074	0.5246	0.8339
			(0.0069)	(1.2682)	
Ferozepur	114.279	0.0137*			0.5549
		(0.0043)			
	106.193		0.0177**		0.6439
			(0.0049)		
	129.2515		−0.0043	3.6205*	0.8502
			(0.0084)	(1.2586)	
Faridkot	137.614	0.0019			0.0136
		(0.0067)			
	130.136		0.0055		0.0384
			(0.0124)		

TABLE 5

Estimated Value of Co-relation coefficient, Z-value and the Probability associated

Between the year	Kendall Rank Co-relation Co-efficient	Z-Value	Probability Associated
1970-71 and 1971-72	0.7273	3.2924	0.0005
1971-72 and 1972-73	0.7273	3.2924	0.0005
1972-73 and 1973-74	0.9848	4.4581	0.0003
1973-74 and 1974-75	0.6061	2.7437	0.0031
1974-75 and 1975-76	0.7576	3.4296	0.0003
1975-76 and 1976-77	0.9091	4.1154	0.00003
1976-77 and 1977-78	0.9091	4.1154	0.00003
1977-78 and 1978-79	0.8485	3.8411	0.00007
1978-79 and 1979-80	0 8485	3.8411	0.00007

TABLE 6

Basic Data Relating to Determinants of Inter - District Variation In Cropping Intensity In Punjab

District	Cropping Intensity	Total Value Productivity per hectare	Average Rainfall	Rural Literacy	Gross area Irrigated as a percentage to Gross Cropped Area.	Tractor per Thousand hectare of gross cropped area	Percentage area Under high Yielding Varieties.
1	2	3	4	5	6	7	8
Gurdaspur	166.7	2377	107.82	29.92	72.2	5.82	8.49
Amritsar	160.5	2375	71.36	26.89	97.6	6.64	12.29
Kapurthala	136.7	2462	60.63	29.66	91 6	7.42	3.82
Jullundur	157.9	2996	66.86	35·11	93.6	11.34	7.57
Hoshiarpur	151.9	1948	90.03	38.47	50 9	5.51	5.04
Ropar	157.0	2191	71.24	33.85	49.4	3.48	2.16
Ludhiana	171.7	2854	66.11	35.30	95.5	9 32	8.60
Ferozepur	150.5	2391	46.49	20.85	92.4	5.96	12.61
Faridkot	145.0	1941	44.40	23.81	92.3	9.69	10.08
Bhatinda	147.6	2288	39.17	17.47	88.87	4.51	6.33
Sangrur	162.1	2341	54 54	20.38	94.2	6.42	10.58
Patiala	169.4	2615	72.48	23.66	85 3	8.11	12.43

TABLE 7

Rank Correlation Matrix of Selected Variables

	Total Value Productivity Per Hectare	Averge Rainfall	Rural Literacy	Gross Area Irrigated as a gross Cropped area.	Tractor per thousand hectare of gross cropped area.	Percentage area under High yield ing Varieties.
Cropping Intensity	+0.4545	+0.5524	+0.2168	+0.2168	+0.1608	+0.3986
Productivity		+0.1538	+0.2273	+0.3986	+0.5385	+0.2867
Rainfall			+0.6014	−0.4266	−0.1259	−0.0909
Literacy				−0.1748	+0.1154	−0.4755
Irrigation					+0.4581	+0.5594
Tractor						+0.4476

ANNEX 1

Test of Concordance Data and Calculations

(Ranks of District)

District	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	Total	Difference X	Difference $X-\bar{X}$
Gurdaspur	7	7	8	8	1	3	3	3	3	3	52	13	169
Amritsar	3	3	6	3	5	6	7	6	5	5	49	16	256
Kapurthala	12	12	12	12	11	12	12	12	12	12	119	-54	2916
Jullundur	8	6	7	6	6	7	6	7	6	6	65	0	0
Hoshiarpur	5	5	2	3	8	8	8	8	9	9	64	1	1
Ropar	1	2	3	4	2	2	5	5	7	8	39	26	676
Ludhiana	2	1	1	1	1	1	1	1	1	1	11	54	2916
Ferozepur	11	10	11	11	10	9	9	10	8	10	99	-34	1156
Faridkot	10	9	9	9	9	11	10	11	10	11	99	-34	1156
Bhatinda	9	11	10	10	12	10	11	9	11	7	100	-35	1225
Sangrur	6	4	5	5	4	4	4	4	4	4	45	21	441
Patiala	4	8	4	7	3	5	2	2	2	2	39	26	676
													11588

$$X = \frac{m(n+1)}{2} = \frac{10(12+1)}{2} = 65$$

$$W = \frac{125}{m^2(n^3-n)} = \frac{12+11588}{100(1716)} = \frac{139056}{171600} = 0.8103$$

$$X^2 = m(n-1)w = 0.8101 \times 10 \times 11 = 89.1385$$

Foot notes

1. For a sampling of the dabate on this question see Hayami and Ruttan (1971); Ghosh (1977); Day and Singh (1977); Dantwala (1971, 1972); Ohkawa and Henry (1960); Dasgupta (1973); Kahlon (1972b); Kainth (1979a).

2. The figures for the year 1979-80 are provisional.

3. The cropping intensity in this paper is defined as the percentage of gross area sown to net area sown. An intensity of 100 per cent means one crop per year per acre.

4. The productivity of land is measured in terms of total value productivity per unit of land and is estimated as:

$$TVPPH = \frac{\Sigma Q_i \ P_i}{A}$$

Where Q_i is the production of the i-th crop, P_i the harvest price of the i-th crop and A is the gross area under the different crops. The major crops considered were: Wheat, Rice, Maize, Barley, Cotton Desi, Cotton American, Potato, Sugarcane and Rapeseed and Mustard. These crops covered more than 80 per cent of the crop area.

5. This approach to examine the relationship between cropping intensity and productivity of land is preferable to relating trends in the estimates of cropping intensity to trends in the productivity of land since it makes full use of the available information.

6. We used the average value of the current and the previous year rather than introduce both as independent variables solely because of the limited sample size.

7. The tenant cultivation in Ferozepore, Gurdaspur, Kapurthala and Patiala districts was 22.72; 12.27; 10.02 and 11.07 per cent. For detail see Kainth (1979b).

8. This region has experienced dramatic growth in total value productivity per unit of land but there is no evidence of upward trend in the cropping intensity. This phenomena is explainable solely in terms of production and prices of cotton which is the main kharif crop of the region. Moreover, the lack of suitability of the other crops explains it partially.

9. The coefficient of Kendall's Rank correlation (T) tau was computed by using the formula:

$$T = \frac{S}{1/2 \ N \ (N-1)}$$

Where N is the number of individuals ranked and S is defined as

$$S = \Sigma_i \Sigma_j \ S_{ij}$$

and S_{ij} is the value of a random variable X_{ij} defined as

$$X_{ij} = 1 \quad \text{if} \quad R_{xi} < R_{yj} \ \forall \ i \ \& \ j$$

$$= -1 \quad \text{if} \quad R_{xi} > R_{yj} \ \forall \ i \ \& \ j$$

The significance was tested by using Z-test. Since in our case N is greater than 10, may be considered as normally distributed with

$$\text{mean} = \mu_T = 0$$

$$\text{Standard Deviation} = \sigma_T = \frac{2(2N+5)}{9N(N-1)}$$

$$\text{That is } Z = \frac{T - \pi_T}{T}$$

is approximately normally distributed with Zero mean and unit variance. Thus, the probability associated with the occurrence under H_0 of any value as extreme as an observed T may be determined by computing the value of Z as defined above and there determining the significance of that Z-value.

For detail see kendall (1938, 1948a, 1948b and 1949) .

10. The coefficient pf concordance was worked out by using the formula :

$$W = \frac{12\ S}{m^2\ (n^3 - n)}$$

Where S stands for the sum of squares of the deviations of the total of the ranks assigned to each individuals from m (n+1) /2. To test the significance of W, the statistic X^2 was computed by the formula:

$$X^2 = m\ (n-1)\ W = \frac{12}{mn\,(n+1)}\ X^2 \sim n-1$$

For detail see Kendall and Smith (1939); add Kendall (1948).

11. The trend equation fitted to the coefficient of variations for different years is:

$$CV = 0.0918 - 0.0023\ T, \quad R^2 = 0.3549$$
$$(0.00011)$$

12. The coefficient of complimentarity of the institutional variables was 0.43; 0.67; 0.66; -0.03; 0.25; 0.73; 0.45; 0.24; 0.84; 0.51 and 0.33 respectively for Gurdaspur, Amritsar, Kapurthala, Jullundur, Hoshiarpur, Ropar, Ludhiana, Ferozepore, Faridkot, Bhatinda, Sangrur and Patiala.

References

1. **Balogh, T.** (1961): "Agriculture and Economic Development" *Oxford Economic Papers*, Vol. 13, No. 1, February.
2. **Boserup, E.**, (1975): *The Condition of Agricultural Growth*, (London: Allen & Unwin).
3. **Dantwala, M. L.** (1972): "From Stagnation to Growth", *Indian Economic Journal*, Vol. 18.
4. ——— (ed) (1972): *Comparative Experience of Agricultural Development in Developing Countries of Asia and South East Since World War II*, (Bombay: Indian Society of Agricultural Economics).
5. **Dasgupta, A. K.** (1973): *Agricultural and Economic Development in India*, (New Delhi: Associated Publishing House).
6. **Day, Richard H. and Singh, Inderjit** (1977): *Economic Development as an Adaptive Process* (Cambridge: Cambridge University Press).
7. **Fei, John C.H. and Ranis, Gustav** (1964): *Development of the Labour Surplus Economy : Theory and Policy* (Homewood: Irwin).
8. **Ghosh, Rabindra Nath** (1977): *Agriculture in Economic Development* (New Delhi : Vikas Publishing House Pvt. Ltd.)
9. **Hayami, V. and Ruttan W. V.** (1971): *Agricultural Development : An International* Perspective (Baltimore: The Johns Hopkins Press).
10. **Johar, R. S.; Aulakh, H. S. and Kainth, G. S** (1979): "Dyanamics of Farm Mechanization in Punjab", *Journal of Business and Economics*, Vol.21, No. 1, October—Noveinber.
11. **Johnston, B. F.**, "Agriculture and Structural Transformation in Developing Countries : A Survey of Research', *Journal of Economic Literature*, Vol. 8, No.2,
12. **Kahlon, A. S. et. al.** (1972a); *The Dynamics of Punjab Agriculture* Ludhiana: Department of Economic and Sociology, Punjab Agriculture University).
13. **Kahlon, A. S.**, (1972): "The Green Revolution, Its Promise, Performance and Prospects in *Agricultural Development in Developing Countries Comparative Experience* (Bombay: The Indian Society of Agricultural Economics)
14. **Kainth, G. S.** (1980): "Impact of New Farm Technology on Farm Produce in Punjab", *Productivity*, Vol. 21, No. 3, October—December.
15. **Kainth, G. S.** (1979a) "Recent Trends in Sectoral Trade", *Indian Journal of Agricultural Economics*, Vol. 34, No. 4, October—December.

16. ———— (1979b): "Variation and Size of Holdings in Punjab", *Society and Culture*, Vol. 10, No. 1, January.

17. **Kendall M. G.**, (1938): "A New Measure of Rank Correlation", *Biometrika*, Vol, 30.

18. ———— (1945): "The Treatment of Ties in Ranking Problem", *Biometrika* Vol. 33

19. ———— (1947): "The Variance of T when both ranking contain Ties", *Biometrika*, Vol. 43.

20. ———— (1948 a.) *Rank Correlation Methods* (London: *Griffin*).

21. ———— (1948 b): *The Advanced Theory of Statistics*, Vol. 2, 4th Ed. (London: Griffin).

22. **Kendall, M. G. and Smith, B. B.** (1949): The Problem of m—ranking, *Ann. Math. Statist* Vol. 10,

24. **Rama Subban, T.V.** (1963): "Some Statistical Measures to Determine Changes in Cropping Pattern", *Agricultural Situation in India*, Vol. 17, No 11, February.

25. **Siegl, Sidney** (1956): *Nonparametric Statistics For the Behavioural Sciences*, (Tokyo: International Student Edition, McGraw–Hill Kogakusha, Ltd).

28. **Singh, K. and Sodhi. Rajinder** (1977): "Institutinal Growth and Disparities in a Growing Economy—the Punjab Case" *Agricultural Mechanization in Asia*, Vol 8No.2.

27. **Sridharan B and Radha Krishuan, S.A.** (1978): "A Study of the Factors Affecting Changes in the Cropping Pattern in Nilgiris District, Tamilnadu" *Indian Journal of Agricultural Economics*, Vol.33,No.4, Oct—Dec.