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DETERMINANTS OF AGRICULTURAL PRODUCTIVITY IN TAMIL NADU - INDIA

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ABSTRACT : Research effort in agricultural geography in India has so far paid little attention to the geographic analysis of socio-economic indicators such as agricultural growth; productivity and new technology in the farming practices. This paper aims at studying agricultural productivity and its spatial variations in the light of environmental, technological and Institutional factors. In order to probe into the dynamics of agricultural development of Tamil Nadu, districtwise patterns in agricultural productivity measured in monetary value per unit area at the constant price-level for the state were taken into account for three points of time . . . 1954-55, 1964-65, and 1970-71. A number of variables viz. soil rating index, amount of rainfall, irrigated area, fertilizer consumption, mechanization, agricultural labourers and scheduled caste and scheduled tribes population are hypothesized to explain the areal differentiation in the agricultural productivity. The explanatory model built up in this paper has been tested with a stepwise multiple regression procedure. The R^2 reveal that the environmental and the institutional variables emerge out as the more associative factors whereas the technological factors have dominating effect on agricultural productivity only at the later point of time.

Indian agriculture continues to be an area of vigorous research interest for the social and the natural scientists alike. This is understandably so as agriculture absorbs an overwhelmingly large section of the work force and is the single productive sector which sustains the national economy. However, a disturbing feature which emerges from a casual survey of this mounting body of research in the agricultural geography of India is that little attention has yet been paid to the geographical analysis of more substantive economic indicators, such as agricultural growth, productivity and the role of new technologies in the farming practices and the factor underlying the spatial variations in these phenomena. Barring a few notable exceptions the geographical research in India has remained by and large aloof to these problems. On the contrary, the research effort has been mainly directed to areas such as agricultural land use, association pattern of crops, combination regions and the efficiency patterns in the crop yields. Measurement and evaluation of agricultural productivity, however, continues to be the exclusive field of the economist.

Conceptual Framework

The primary concern in this paper is to focus attention on this research gap in the agricultural geography of India. An attempt has been made to apply a stepwise regression model to measure the role of a number of determinants in the spatial variations in agricultural productivity in Tamil Nadu, one of the states of the Indian Union, in order to probe into the network of relationships between productivity and the factors

which explain these variations. The choice of these variables flows from the conceptual premise stated below.

Speaking theoretically, all development is a function of a complex interplay between the environment, technology and social institutions, each acquiring its specificities as components in an interacting system over time. To begin with, the environment lays down the very basis for, and points up, the direction which the developmental process would eventually take. At the same time, the environment imposes constraints on human activity which man attempts to remove to the extent of his competence by adopting a package of technology. Whether a certain package will be employed by a social group will largely depend on the social institutional frame. Social institutions may thus decelerate the development process by being merely inhibitive to the adoption of technology; they may accelerate this process by inducing adoption of a viable technological package. The level of development attained by a certain region will, therefore, be a function of the harmony or otherwise between the triple components in the development. In the process of development the lagging regions indicate the need for striking a balance in the network of multiple relationships between environment and social institutions and technology, and technology and enviroment.

The performance of a social group in agriculture as reflected in the output, described here as agricultural productivity, is an outcome of and is largely contingent upon these multiple linkages. Guided by this analytical frame, a set of variables has been chosen which provide an explanatory framework for the spatial variations in agricultural productivity selecting one of the states of the Indian Union, namely Tamil Nadu, as a case of study.

Study Area

Tamil Nadu, the southernmost of the states of the Indian Union on the Bay of Bengal sea-front, extends over an area of 130,000 square kilometres and supports, according to 1971 census, over forty-one million people. The average density of 317 persons per square kilometre, however, compares unfavourably with the other littoral states of Andhra Pradesh and Kerala-the latter being particularly overcrowded.

The major determinants of Tamil Nadu's geographical regionalism stem from its maritime location on a pre-Cambrian peninsular plateau dominated by the two flanking mountain ranges called the Eastern and the Western Ghats. The narrow coastal plain, apart from being a gift of the sea, is also a monument to the ageless work of the east-flowing peninsular rivers particularly the Cauvery and its affluents. The topographic impact of the general latitudinal alignment of the two flanking mountain ranges is immense. It weighs heavily against the territory's prospects in sharing the rains from the main thrust of the southwest monsoon. The Arabian Sea current is arrested by the more imposing Western Ghats while the Bay of Bengal current lashes more or less parallel to its coast, sending it dry at a time when the rest of India experiences wet weather. This climatic anomaly is of fundamental importance in the understanding of the geographical reality of the Tamil territory.

Physiographically the state lies divided into four regions: coastal plain, eastern hills, interior plateau and the mountain rim called the Western Ghats. The principal rainfall regions by and large correspond with this east-west zonation. The rainfall is high along the northern littoral and in the western hilly block; it is generally low over the rest of the state. As many as eight districts fall below the state average of 985 millimetres.

Nearly fifty per cent. of the total area is under cultivation, and a further extension of agricultural area is improbable (NCAER 1961). The intensification level is also low as only 20 per cent. of the net sown area is brought under the plough for the second time. The cropping pattern is dominated by

food crops –paddy, **cholan** and **cunbu** –which account for three–fourths of the gross cropped area. Among the commercial crops, groundnut is by far the most important, particularly in terms of acreage strength.

The state has a predominantly agrarian economy. The farming sector contributes nearly 43 per cent. of the state's income and and supports 73 per cent. of its rural population. The state used to be a deficit area in agricultural production until the late fifties. It, however, improved its lot by 1960, turning itself into a surplus state (Rupchand and Varma, 1964). The state registered an average annual increase of 4.91 per cent. during the period 1952-53 — 1964-65. This was higher than the all-India increase of 3.42 per cent. over the same period. The only other states which were ahead of Tamil Nadu in the rate of increase in agricultural production were Punjab (including Haryana) and Gujarat. Tamil Nadu, however, ranked first among the states in the growth rate of foodgrain output (Thamarajakshi, 1967 and University of Madras 1976). The U.S.A.I D. Report (1968) noted that much of the growth in crop production was achieved through yield increases.

The structure of the administrative units, i. e., the districts, has changed a lot over the period of this study—1954-55—1969-70. There were 14 district units in 1954-55. This number fell to 13 in 1964-65 and rose again to 14 in 1969-70. The Nilgiris and Madras districts are excluded from this study for the reason that the former is a hilly district with an entirely different cropping pattern and the latter is a metropolitan district.

The Variables and Data

In order to probe into the dynamics of agricultural development, districtwise patterns in agricultural productivity measured in monetary value per unit area at the constant price-level for the state were taken into account for three points of time 1954-55, 1964-65, and 1969-70. These years marked striking points in a semi-logarithmic

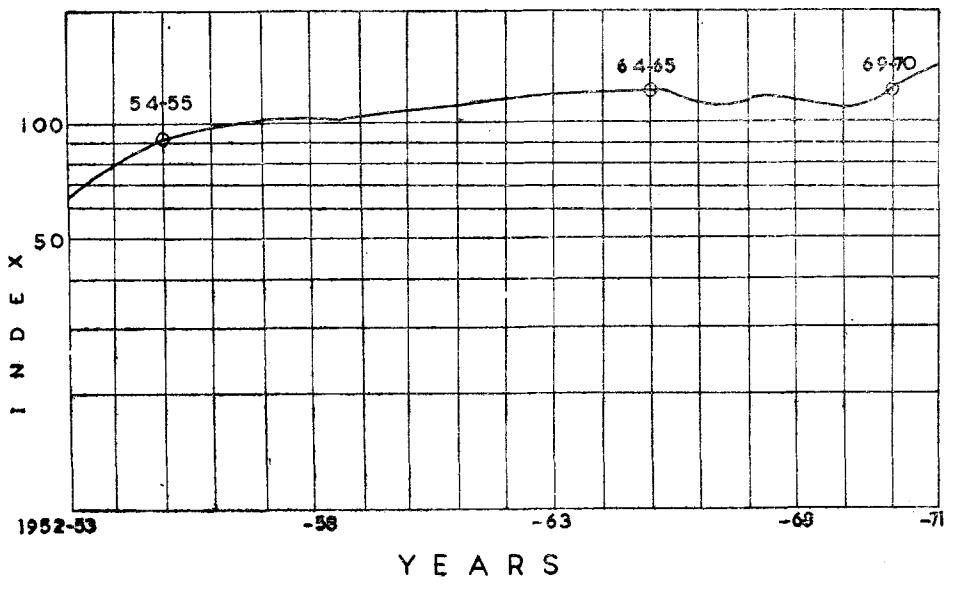

FIG.

Fig. 1 Indices of Agricultural Production

graph showing index numbers of agricultural production during the period 1952-53 through 1970–71 (Figure 1). These years also represented critical stages in the process of agricultural modernization in the state. The year 1954–55 characterized a continuation of the older mode in the agrarian practices, while 1964-65 was transitional towards a growing trend of wider adoption of the emergent technological innovations in farming methods. The year 1969–70 was more characteristically representative of this new trend (Season and Crop Reports; Govt. of India 1971-72; Evanson and Jha 1975).

A number of variables drawn from a set of environmental, technological and institutional factors are hypothesized here to explain the areal differentiation in the dependent variable, i. e., the agricultural productivity. They are listed in Table I below.

Table I

The Variables

Category		
Environmental	x_1	Soil rating index of the district (SRI)
	x_2	Total amount of rainfall averaged for the district (TRA)
Technological	x_3	Irrigated area as % of the gross cropped area of the district (IRA)
	x_4	Quantity of fertilizer consumed per 100 hectares of irrigated area (FRC)
	x_5	Composite index of agricultural mechanization for the district (CIM)
Institutional	x_6	Census agricultural labor as % of the total agricultural workforce of the district (CAL)
	x_7	Rural population of the Scheduled Castes and the Scheduled Tribes as % of the total rural population of the district (SCT)

The data for these variables have been derived from a number of published sources particularly the official publications of the State of Tamil Nadu and the Census of India. The study also draws upon the earlier studies, mainly attempted by physical scientists and economists, in which one or the other of these variables has been employed. The soil rating index (SRI), as adopted here, is based on a modification of Storie's index by S. P. Raychaudhari and K. B. Shome (1960). It composites soil and terrain specificities, such as nature of profile, texture and slope as well as the modification brought by human agencies through soil management practices. Obviously it generalizes the soil productivity status of the district on the basis of marco-properties only. The composite index of machanization (CIM) has been developed by aggregating the numbr of tractors, oil engines and electrical pumping sets with the help of a simple statistical method (Kundu 1975). It is felt that the variables chosen to determine the role of institutional factors in the spatial variations of agricultural productivity are not as sensitive as otherwise desirable. They are in a way surrogates of the more sensitive variables such as pattern of land ownership and land tenancy, size of operational land holdings and the proportion of the landless laborers in the farming population. There

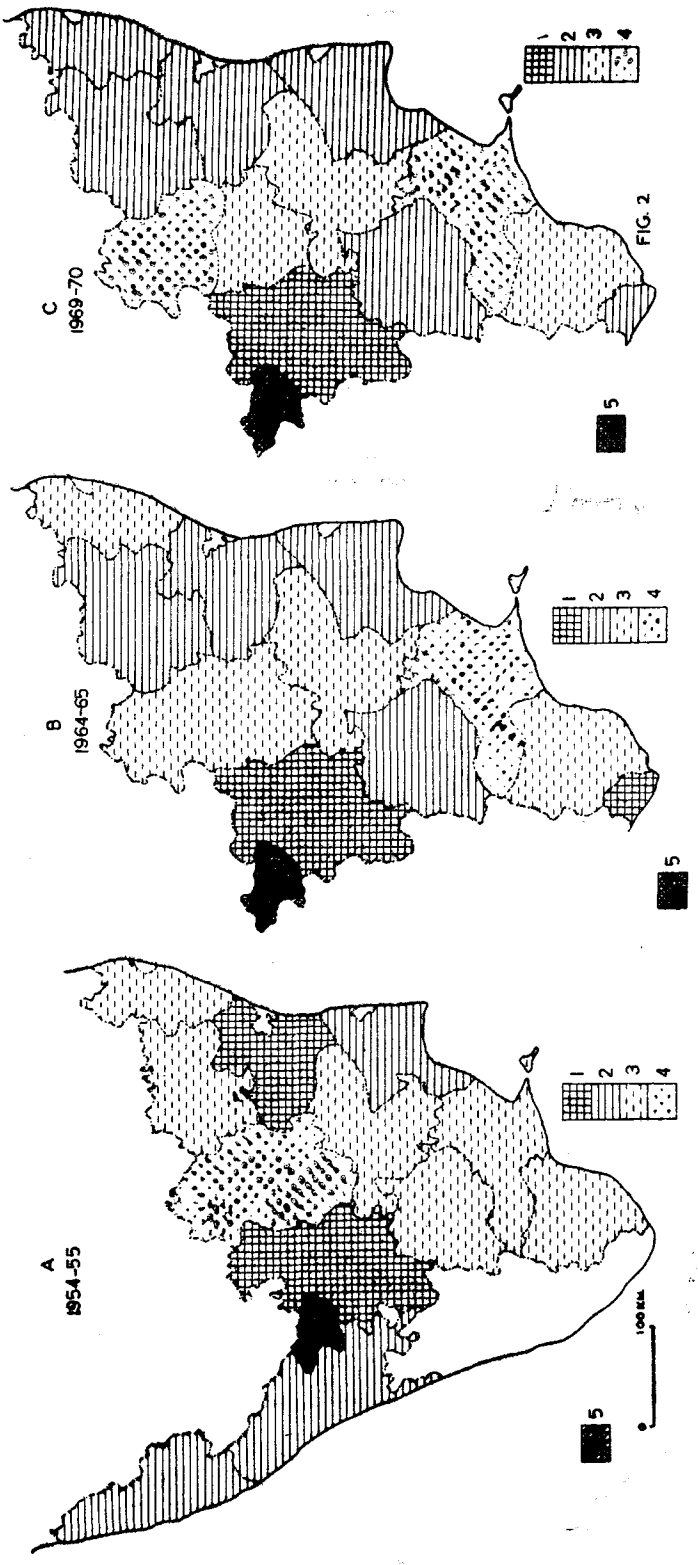

FIG. 2

Agricultural Productivity (Rs./Ha)

A – 1 : 600-900; 2 : 400-600; 3 : 300-400; 4 : 200-300; 5-Nilgiris
B – 1 : 500-600; 2 : 400-500; 3 : 300-400; 4 : 200-300; 5-Nilgiris
C – 1 : above 600; 2 : 400-600; 3 : 300-400; 4 : 200-300; 5-Nilgiris

is, however, no consistent data available for any point of time on these variables for the Tamil Nadu districts. This seems to be the only justification for their exclusion.

All variables, other than institutional, are assumed to be positively related with agricultuaral productivity. It is assumed that the preponderance of the census category of agricultural labor (CAL), which is usually landless, will weigh nagatively on agricultural productivity. This, however, may not hold good in a labor-intensive agriculture where a higher input of labor may lead to a higher level of agricultural productivity. In developing economies, such as India, a higher demand for labor has been noticed even in areas of green revolution characterized by a high level of mechanization in agriculture (Agarwal 1975; Aiyasamy et. al. 1975). Likewise the proportion of the scheduled castes and the scheduled tribes (SCT) is assumed as negatively related with agricultural productivity. The tribes are generally living in areas by and large negative to agriculture (Raza et. al. 1977) their agrarian mode being still largely primitive. The scheduled castes, on the other hand, have a tendency to converge on productive agricultural lands since the demand for labor in such areas is high. They are, however, the most deprived section of the farming population both socially and economically. In fact, the two variables—CAL and SCT—are in a big way mutually interpenetrative.

Levels of Agricultural Productivity

In a number of studies attempted in India and abroad, particularly those of Kendall (1939), Stamp (1960), Shafi (1960), Tambad (1965), Bhatia (1965), Sharma (1965), Sapre and Deshpande (1964), Shinde (1973), per acre / hectare yield of all, or selected, crops either by crude summation or by ranking method, or weighing with the acreage under the crops, has been generally adopted as a measure of agricultural productivity, The present authors were, however, convinced of inadequacy of these measures as indicators of the dynamic process of agricultural development. They found the per hectare agricultural produce expressed in monetary value—usually employed by the economists—as a more realistic and compre-

Table II

Agricultural Productivity as Measured in Rupees per Hectare of Cultivated Land

1954-55		1964-65		1969-70	
South Arcot	861.13	Kanyakumari	595.95	Coimbatore	626.76
Coimbatore	627.31	Coimbatore	536.17	Kanyakumari	481.29
Malabar	483.11	Tanjavur	448.65	South Arcot	467.89
Tanjavur	478.04	Madurai	420.47	Tanjavur	434 92
South Canara	442.18	North Arcot	416.08	Chingleput	421.38
North Arcot	384.65	South Arcot	402.15	Madurai	419.01
Chingleput	377.86	Tiruchirapalli	367.46	North Arcot	405.51
Tiruchirapalli	369.54	Tirunelveli	366.13	Tirunelveli	376.16
Madurai	368.99	Chingleput	364.57	Tiruchirapalli	366.28
Tirunelveli	356.00	Salem	310.58	Salem	346.36
Ramanathapuram	346.10	Ramanathapuram	287.71	Ramanathapuram	289.46
Salem	281.84			Dharmupari	228.96
State's Mean	448.06		410.54		405.33
Coefficient of Variation%	35.55		21.13		23.66

hensive indicator of the agricultural output (Murray 1969). The production of 22 major crops for the three years under consideration explaining more than 96 per cent. of the gross cropped area of the district was, therefore, converted into monetary value taking the constant state price level for the base year of 1954-55. The gross output was then divided by the hectarage under these crops in order to obtain per hectare output.

Table II shows agricultural productivity in Tamil Nadu districts arranged in a descending order at each of the three points of time. It is evident from Table II and Figure 3 that there are vast inter-district variations in agricultural productivity.

The year 1954-55 was characterized by the highest coefficient of variation—33.5 per cent. The inter-district variations at the later points of time were, however, less pronounced. Although temporal variations in productivity are significant in certain cases, the districts with the highest and the lowest levels of productivity generally maintained their position over the fifteen year period. Spatially, the agricultural productivity shows a declining trend towards the south with Salem and Kanyakumari districts being the only exceptions.

The Results

The explanatory model built up in this paper has been tested with a stepwise

Table III

Intercorrelation Matrices

1964—65

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y	1.00	.52	.69*	.31	.13	–.20	.46	–.52
X_1		1.00	.24	.11	.14	.08	.46	–.17
X_2			1.00	.34	–.03	–.09	.26	.33
X_3				1.00	–.49	.08	.79†	.45
X_4					1.00	.58*	–.29	–.14
X_5						1.00	.02	.65*
X_6							1.00	.31
X_7								1.00

1969—70

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y	1.00	.31	.18	.44	57*	.01	.72†	–.00
X_1		1.00	.03	–.02	.02	.07	.33	–.20
X_2			1.00	.83†	.19	–.03	.44	.32
X_3				1.00	.29	–.05	.70†	.50
X_4					1.00	.69*	.07	.52
X_5						1.00	–.37	.55
X_6							1.00	–.04
X_7								1.00

† Significant at 1% level.
* Significant at 5% level.

Table IV

Stepwise Regression Results

	Steps	Variable added	R	R^2	$R^2 \times 100$	Increase in R^2
1964-65						
	1	TRA	.690	.476*	47.6	—
	2	SRI	.779	.608*	60.8	13.2
	3	SCT	.825	.681*	68.1	7.3
	4	CAL	.896	.823*	82.3	14.2
	5	CIM	.930	.866*	86.6	4.3
	6	IRA	.941	.885	88.5	1.9
	7	FRC	.942	.888	88.8	0.3
1969-70						
	1	CAL	.724	.525†	52.5	—
	2	FRC	.891	.794†	79.4	26.9
	3	IRA	.922	.878†	87.8	8.4
	4	CIM	.946	.895†	89.5	1.7
	5	SCT	.949	.901†	90.1	0.6
	6	TRA	.954	.910*	91.0	0.9
	7	SRI	.956	.915*	91.5	0.5

† Significant at 1% level.
* Significant at 5% level.

multiple regression procedure at two points of time only, i.e., 1964-65 and 1969-70. The stepwise regression method has been purposely chosen as it is a search procedure and helps in the measurement of the relative influence of each explanatory variable on the explained variable (Hausar 1944, King 1969). The year 1954-55 was, however, dropped from this analysis as the technological variables were largely irrelevant for this point of time. The inter-correlation between the variables and the results of stepwise regression are shown in Tables III and IV.

It is observed that the "explanatory" variables account for as much as 88.8 per cent. of the total variation in the dependent variable in 1964-65. The R^2 reveals that the environmental and the institutional variables emerge out as the more associative or explanatory factor than others.

The first predictor alone accounts for 47.6 per cent. of the total variation in productivity. The first four variables put together raise this figure to 82.3 per cent. The remaining three variables, however, account for only 6.5 per cent. of the variation. The value of R^2 is highly significant up to the fifth step. The variables, such as rainfall, agricultural labor, mechanization index, irrigation and fertilizers are all positively related with agricultural productivity at all the steps, since their respective induction. It is obvious from the results that the first three variables, i.e., rainfall, soil rating index and the proportion of the

scheduled castes and the scheduled tribes turn out to be the most significant factors. The census agricultural labor, added at the fourth step, also emerges as a significant variable.

To test further, two additional equations were built up : first, by dropping x_7 from the equation at the fourth step; and second, by dropping x_6 but retaining x_7. The first equation thus reconstructed explained 63.2 per cent. of variation, while the second one explained 68.1 per cent. The distribution pattern of the residuals was then analysed for each of the three equations. This led to conclude that the equation constructed with x_2, x_1, x_7 and x_6 emerged as a " best-fit ". The selected model is given below :

$$y = a + b_2 x_2 + b_1 x_1 - b_7 x_7 + b_6 x_6 + e$$

Figure 3 (A) showing the residuals for this equation indicates the areas of positive and negative factors affecting the productivity in agriculture. The value of the residuals is negligible for Tanjavur and Kanyakumari districts, thus pointing out that productivity variations in these districts are mostly due to the combined effect of the four selected variables. Salem and Chingleput are on the other extreme where the role of the negative factors seems to be highly pronounced. The validity of this model may well be appreciated if one looked into the fact that the new technological methods made their breakthrough only after 1967 (Borns–1971).

The year 1969-70 marks a point of time when the technological breakthrough had already made its impact. All predictors together explain as much as 91 per cent. of the total variation. It is interesting to note that the technological inputs, expressed by x_4 and x_3 along with census agriculture labor (x_6), explain about 88 per cent. of the variation. The rest of the variables explain only 3.7 per cent. The value of the R^2, is highly significant at each of the steps. An evaluation of R^2. regression coefficients and the standard error of estimate clearly indicates that the first three variables x_6, x_4 and x_3— emerge as the most significant ones. As the technological factors seem to have a more pronounced role to play in explaining the variations in agricultural productivity in 1969-70, x_5 has also been added at the fourth step, the assumption being that the equation thus recontructed will be a best-fit.

It has been further tested by dropping one of the intercorrelated variables and thus building two other equations. The first, including x_6 and x_5, explains only 61.8 per cent. of the variation. The second equation, including x_4 and x_3, explains 40.8 per cent. An evaluation of these equations points up the validity of the model built up at the fourth step. The selected model is :

$$y = a + b_6 x_6 + b_4 x_4 - b_3 x_3 - b_5 x_5 + e$$

Figure 3 (B) shows that the positive factors seem to be more effective in the central and southern districts of the state, Tirunelveli with a very high negative deviation being an exception.

Conclusions

The empirical results of this research may not be interpreted as proving or disproving a thesis. It is felt that the explanatory framework developed in this paper primarily yields encouraging results. In fact, one of the aims of this study was to provide and test a methodology which can be more meaningfully employed at a lower level of reference, perhaps at the level of a subdivision of the district called **taluka** or the village level. The results well emphasize the need for such a closer scrutiny of the agricultural situation at the village-level with data generated through field work. The results further indicate that different variables exercise a dominant effect on the agricultural productivity at different points of time.

As expected, technological inputs, such as fertilizers, irrigation and mechanization have a dominating effect on agricultural productivity only at the later point of time. While their emergence as significant explanatory variables indicates the declining impact of the environmental determinants, such as rainfall and soil, on the agricultural performance, it does not mitigate the influence

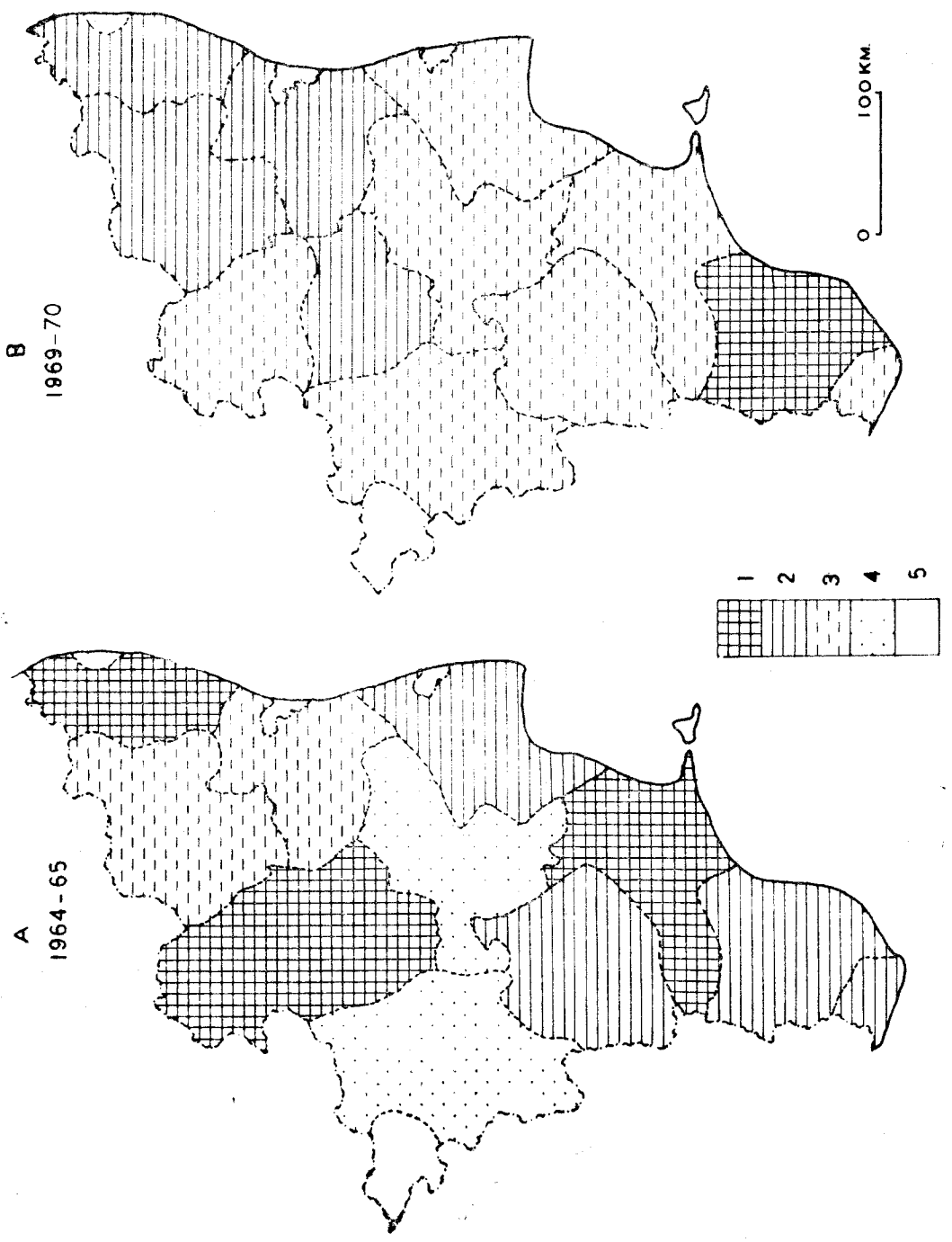

Fig. 3 Residuals of Regression
1 : – 10 to – 20; 2 : 0 to – 10; 3 : 0 to 10; 4 : 10 to 20; 5 – Excluded from study

of the institutional factors. The environmental factors, it may be noted, explained a fairly high amount of variation in agricultural productivity in the year 1964-65. The fact that the census category of agricultural labor also emerged as a significant variable, along with the technological inputs is contrary to our expectation and reveals a puzzling phenomenon. It is understood that the strong association between the agricultural labor and agricultural productivity implies a process of land accumulation in the hands of the big farmers involving squeezing out of the marginal farmer from the land concommitantly with the process of diffusion of new farm technologies. Recent studies of the agricultural situation in the prodominantly green revolution areas, such as Punjab and Haryana, have established such a phenomenon. That agricultural development aggravates the process of rural pauperization is a disturbing feature and emphasizes the need for a closer scrutiny.

The stepwise regression results also bring out the changing structure of Indian agriculture. In fact, the shifting emphasis from environmental factors to technological factors during the period 1964-65 through 1969-70 reveals the dynamics of agricultural transformation and points up the future course of development.

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