AN ANALYSIS ON SPATIAL PATTERNS AND GROWTH OF INDIAN AGRICULTURAL ACTIVITIES

A Study on the Spatial Variations in Agricultural Situation by District-groups : 1960-61 to 1980-81

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AN ANALYSIS ON SPATIAL PATTERNS AND GROWTH OF INDIAN AGRICULTURAL ACTIVITIES

A Study on the Spatial Variations in Agricultural Situation by District-groups : 1960-61 to 1980-81

Abstract

The main objective of this dissertation has been an empirical identification and evaluation of the regional variations in the pattern and growth of agricultural activities in India during the period 1960-61 to 1980-81, with appropriate use of some of the advanced quantitative methods and statistical tools developed recently in the field of Regional Science and Planning. During the period under consideration, the over-all national agricultural productions have greatly been improved, eliminating India's dependence on foodgrain imports, through certain intensification measures initiated at the beginning of the period. But the pursuance of over-all growth efforts has not been inter-woven with sound regional strategies and as such regional imbalances have become more pronounced in recent years. Thus the need for the study of this kind is felt for a detailed investigation towards diagnosis and evaluation of the spatial patterns on the nature and growth of agricultural activities, so that our vision for a proper perspective of regional plan formulations can be clarified. Our regional analysis has been attempted for the said period by about 151 areal units (district-groups) of India; it has been carried out mainly in the following four important aspects of agricultural production activities :

(i) The identification of broad characteristics and spatial concentration patterns for about 26 field crops of India

and the formulation of crop-combinations regions for the terminal year 1980-81;

(ii) Identification of spatial variations in the development of agricultural activities, with spatial reference to the measurement and evaluation of marketable surplus of food-grains, agricultural land productivity, labour productivity and over-all agricultural development in 1980-81;

(iii) Comparative spatial pattern analysis of agricultural development measures between time-points, 1960-61, 1970-71 and 1980-81 and also the agricultural production and productivity growth analysis by component factors for the period 1960-81 and its two sub-periods; and

(iv) Identification of the role of agriculture in the spatial pattern of economic development and the synthetic measurement of agricultural growth-retardedness cum backwardness by areal-units towards evaluating the dimension of growth task ahead.

Detailed investigations on all these aspects would be useful in providing not only an insight in the regional problems, short-falls, and the growth-efforts needed for agricultural activity development, but also the detailed background regional information for an incorporation of the much needed distributional objective more scientifically into our planned efforts for proper agricultural development, based on the objective of national optimisation with sectoral balance. Our study has been however limited to the diagnosis and evaluation of spatial patterns for broad parameters of agricultural activities; a full-fledged plan formulation for agricultural development with incorporation of necessary regional dimensions, that would require additionally much of spatial linkage, interaction and flow studies with detailed micro agro-economic parameters, is not however within the scope of the present study made by an individual research worker with his limited available resources. What has been aimed at here is to show a regional approach for understanding the present pattern and growth-trend so that a desirable spatial pattern of agricultural activities based on sound regional principles with special attention to less-progressive areas could easily be visualised for future. The present regional approach is essentially of interdisciplinary nature in which an integration of the economic principles of production and productivity analysis and the geographic principles of spatial variation analysis in the context of agricultural activities has been attempted through the use of statistical techniques and quantitative methods.

The statistical and quantitative tools that have been applied in our empirical investigations with success can be broadly summarised as follows :

> Although the geographic principle of superposing technique of mapping for identification of a "formal" regional configuration of several connected spatial variables could not be totally abandoned, particularly in the formulation of crop-combination regions, the limitation of the principle as experienced with tboo many variables has been considerably eliminated through the statistical formulation of a single index variable in lieu of many inter-related variables. When we are to deal with a multi-dimensional (in mathematical sense) composite economic characteristic of several inter-

related spatial variables, the said geographical principle is not of much help in an unidimensional ranking of spatial unit observations, here district-groups, for the composite economic characteristic. This limitation has been greatly overcome by the formulation of composite regional indices with the application of some multivariate statistical methods, developed already or recently in the field of Regional Science and Planning. Many such composite regional indices have been used for the depictions of diversified spatial patterns. Some of the main regional indices thus formulated are : (i) crop concentration indices, (ii) land productivity index and sub-indices (iii) over-all agricultural development index, (iv) over-all economic development index. These multivariate indices have been formulated by appropriate selections of available statistical procedures namely (1) Kendall's optimal formulation, (2) Pal's equity formulation, (3) Pal's equi-spaced optimal formulation.

(b) Economic principles and relations have been used in conjunction with the simple statistical measures of spatial concentration, like "location factors"; these have been used in formulating various foodgrain production surplus indices by different population categories and also in formulating initial sub-indices of land productivity and over-all agricultural development. Special statistical treatment has however been necessary to permit for both spatial and time-point comparability at a time; in the usual spatial index formulation the time-point comparability aspect is not involved.

(c) Various multivariate regression analyses have been widely used for identifying spatial associations, interactions and explanatory roles of different spatial variables considered. Usually OLS (Ordinary Least Squares) regressions are used in statistical literature. This has also been used here, only when we are not concerned with the problem of multicollinearity and the problem of mathematical reversibility of functional relation between variables. But often in our regional analysis, we are faced with situations of practical importance where these aspects of multicollinearity and mathematical reversibility must have to be considered. In such situations, we have not used the OLS regression technique. The basic theoretical requirement of multicollinearity-free explanatory variables and also the inbuilt axis-biased least-squaring, as implicit in the OLS procedure, limit the application of this procedure in our analysis, when we are concerned in identifying the true and distinct roles of explanatory variables through regression coefficients, and also when it is important that relationship between two variables has to be reversible for prediction purpose of one from other without any consideration for their dependent or independent role. To tackle these kinds of situation of practical importance the recently developed advanced regression technique, called the VLS (Vertical Least Squares) regression method (Pal and De 1979a) has been used very satisfactorily. We have used this advanced VLS regression technique in identifying the explanatory factors and their distinct contribution for explaining the spatial variation of many economic measures of importance in our context. Although we based our inferences on the VLS regression estimates, we have often given side by side the OLS regression estimates to show the extent of multicollinearity cum axis-biased least-squaring distortions present in the OLS estimates of parameters.

(d) It should be noted that the superiority of the VLS regression over the OLS regression is demonstrated not only in the evaluation of the role of highly multicollinear explanatory variables distinctly and truely (in the regression coefficients), but also in the elimination of a variable that does not explain directly the dependent variable; this has been possible by virtue of the discriminatory power of the VLS correlation coefficient : it does not always increase with each inclusion of an additional variable considered for explanation of the dependent variable, unlike the OLS correlation coefficient. It is this discriminatory power that helps us in identifying, for example, the proper role of relevant component-growth factors and also the redundancy of some others in explaining the spatial variation of agricultural production and productivity growth in the period and sub-periods under consideration.

(e) Agricultural growth analysis involves various forms of mathematical model split (due to Minhas-Vaidyanathan, Pal, Pal-De) into basic components, both for production and productivity growth. The above mentioned discriminatory power of VLS correlation coefficient has actually helped us in identifying the best fitting model-split with revevant explanatory basic components applicable in the Indian situation during the period. The productivity model split has however been empirically verified for the first time in this dissertation.

(f) Statistical and quantitative tools have been most integrated in our formulation of an index of growth-retardedness cum backwardness that has been devised here, not only by use of the statistical methods of index formulation referred to here in (a), but also by application of economic constraints and relations involving growth factors, labour-change, etc., and also the regression techniques. This index gains importance in our analysis, since it has helped us in evaluating the dimension of our growth task ahead with the objective of reducing regional disparities in agricultural progress.

By application of these statistical and quantative methods, selected or devised with the fitness of situations, the regional analyses -- mainly along the direction of formal regionalisation and interaction analysis -- have been attempted on various agricultural characteristics and also on the factors that influence them or get influenced by them. Apart from the diagnosis and evaluation of spatial patterns and problem areas, here our principle has been to take lessons from the favourable formal regional structures, and try to examine whether the conditions that led to favourable structure could be created in or transferred to an area where relatively less favourable formal structure is existing. Along these lines the present study on the spatial variations in agricultural situation in India has been designed in the following fashion :

Chapter 1 : Regional Analysis of Indian Agriculture : The Need for Present Study.

Chapter 2 : Spatial Concentration of Crops and the Identification of Cropping Patterns and Crop Regions : 1980-81.

Chapter 3 : Spatial Variation in the Development of Agricultural Activities : 1980-81.

Chapter 4 : Comparative Spatial Pattern Analysis of Agricultural Development and Growth Component Analysis for Agricultural Production and Productivity: 1960-61 to 1980-81.

Chapter 5 : Role of Agriculture in the Overall Spatial Pattern of Economic Development and Regional Synthesis of Agricultural Activities.

Chapter 1 : REGIONAL ANALYSIS OF INDIAN AGRICULTURE : THE NEED FOR PRESENT STUDY

1.1 The Problem and Objective

The main objective of this dissertation is to evaluate and identify empirically the regional variations in the pattern and growth of agricultural activities in India, with the appropriate uses of quantitative methods and statistical tools. Although India has been traditionally an agricultural country, some signs of achievements in agricultural production can be noticed only very recently, say, in the last two decades, under the planned efforts for growth by the national authorities. Under the planned efforts, the overall agricultural productions have definitely improved, eliminating India's dependence on food imports, but the achievements cannot be said to be balanced or, say, fully satisfactory from the distribution point of view. In fact, the pursuance of overall growth efforts has not been interwoven with sound regional strategies and as such regional imbalances have become more pronounced in recent years. Our growth achievements really come from very limited areas and without these limited areas India is still agriculturally backward. Thus there is a need for a detailed investigation towards diagnosis and evaluation of the spatial patterns as also the nature and growth of agricultural activities so that our vision for a proper perspective of regional plan formulations can be clarified.

India's overall agricultural performance can be briefly summarised as follows : During the first plan (1950-51 to 1955-56) increase in agricultural production, particularly of foodgrains, was nothing spectacular, although planning efforts were initiated with emphasis on agricultural growth for the predominantly agricultural country. The main reasons are given below :

(a) investible resources being limited, irrigational facilities were extended only to a limited extent; and

(b) agricultural activities, being confined within the traditional framework, were primarily primitive.

The result was that the level of foodgrains production was much below the domestic consumption requirement. In the second plan (1955-56 to 1960-61) development of basic and heavy industries duly received the prime attention; the same objective was continued during the third plan (1960-61 to 1965-66) maintaining a status-quo for agriculture. From the first plan period itself it was being comprehended that as long as yield rate remains low, irrigational facilities or favourable weather condition and increase in cropped acreage cannot bring much improvement in production of foodgrains. Thus from early sixties experiments for intensification of cultivation were initiated with main emphasis on improvements in yield rates through improved seeds and other basic inputs, like water, fertiliser, modernised agricultural implements etc. This programme, then called " New Agricultural Strategy" was launched in early sixties with the sole objective of making the country self-sufficient in foodgrains production. But initial effort in this direction was so limited in nature that India had to suffer a negative agricultural growth i.e., a deline, by the end of the third plan period as compared to the 1961 situation. Whatever had been the efforts, those turned out to be utterly fruitless on the event of a disastrous famine due to severe drought in two consecutive years (1964-66); huge quantities of foodgrains, mainly wheat and to a lesser extent rice, had to be imported. Due to limited availability, statutory rationing was introduced more effectively for the public distribution of cereals. Different austerity measures and restrictions were introduced to stop or reduce the undersirable wastage of foodgrains. It was then felt that the programmes under the " New Agricultural Strategy" as initiated mainly in the experimental fields, have to be mass-based. Thus serious action programmes followed to give top priority towards the much needed intensification of agricultural activities. In consequence of this new alertness, there was even a plan holiday (during 1966-67 to 1969-70) except for on-going non-agricultural projects. The farmers and cultivators were then encouraged and educated to work under the new programmes on agricultural intensification and government attentions were taken to remove some of their difficulties. Thus attempts were made to provide them with the three basic facilities as described below :

i) adequate irrigation facilities at the right time of requirement;
ii) ensured supply of fertiliser; and
iii) distribution of seeds of high yielding variety.

As a result of all the new alertness and attempts, the economy showed the first sign of boost-up in agricultural production in 1967-68. Then on, the trend of agricultural growth remained more or less unabated except for some years of stagnancy due to rain failure, say, for instance, in

1972-73. Thus from the late seventies the economy has not only become self-sufficient in domestic availability, but also maintains a stable and sufficient buffer stock of foodgrains in addition to some exports to other countries.

While this achievement in the production of foodgrains at the national level is highly impressive, the picture is very disturbing in terms of regional pattern of agricultural development as also in terms of inter-crop development within the agricultural economy. The revealed achievement in agricultural production, as had been possible through the extension of these basic input facilities, had not been widespread and always appropriate. Only a few selected areas, particularly those which are near to the capital, were brought under the purview of the said programme, while many remote areas, particularly the eastern region, were not given any balanced sort of attention. So much so that quite expensive irrigational facilities were extended around the areas near to the capital, while remote areas with assured water availability remained neglected for a proper implementation of the new strategy of intensification. In support of this point, findings from a statistical study made by Pal and De [1979a] may be referred to, in which they have shown that during 1963-72 the nearest dynamic areas of agricultural growth have been found in two contiguous patches in northern and western parts of India, e.g., Punjab, Haryana and narrow areas of U.P around the capital region of Delhi. With these leading agricultural areas, the overall agricultural growth rate for the decade was shown to be comparable to that of population growth rate in India; but without these areas, the agricultural growth for the rest of India falls miserably below - about a third of the corresponding population growth rate. So the socalled all-India self-sufficiency with respect to this vast residual part of India is really maintained through the regional imports from these leading areas, though replacing imports from international sources. Because of our overall food situation and buffer stock, it is true, any eventuality due to some natural calamities could be successfully combated in recent years. But as the intensification programme is limited to very selected areas, it appears that a vast majority of cultivators in different corners of the country do not always generate agricultural surplus for their non-food-grain items and even the prospect of surplus gets dwindled if there were a bad year with below normal rainfall. The condition of agricultural labourers is still worse there. Thus while majority of Indian cultivating class did not get much benefit from the selected way of the programme implementation, there grew a priviledged class of cultivators at selected areas who have been fortunate enough to receive these facilities under the scheme with the result of an ever-increasing disparity in the level of living among cultivators and agricultural workers residing in different regions of India. Thus the maladies as cropped up from the lopsided implementation of the new agricultural intensification programme have to be thoroughly investigated and hence there is a pressing need for making detailed regional analysis of agricultural situation to be attempted in this dissertation.

1.2 Choices of Time-horizon, Data-base and the Unit Crop-areas

As the "new agricultural strategy" was initiated in early sixties, we have restricted the time-period of our study over two decades with selected points of time at 1960-61, 1970-71 and 1980-81. Our study for regional variation has been attempted generally for the terminal year 1980-81, although for the comparative and the growth analyses we have considered the other time points as well.

Again in this fact finding regional study, our primary attempt has been a proper and systematic analysis of statistical data and information as are already available in the official and published sources and also in some past research studies. As such all our raw data are compiled from the secondary sources(govt. publications for secondary data, used for this study are listed at end of the present section). The dimension of our data base with the temporal, the areal and the sectoral ramifications is so large that any further primary compilations would not have been possible for an individual research worker with his limited resources.

The agricultural data are mainly available by the state and the district breakdowns of India. In our federal administrative structure, where state governments are substantially responsible for plan implementations and taking decisions on many planning measures, the state estimates are necessary, but never sufficient for any kind of all-India regional variation analysis. On the other hand, the vast country of India has so many districts --- about 333 in number in 1970-71 --- ; the computational work load for advanced statistical analysis becomes very heavy, if the districts were taken as units of observations. Again over the period of time, the number of districts in India has been increasing with changes in district boundaries. For this, we felt the need of an aggregation of, say, two or three contiguous districts to define common unit areas of observations for all the three time points chosen for any comparative statistical analysis. This aggregation has also been useful to get agricultural character of areas in which haphazardly demarcated urban metropolitan districts like Bombay, Calcutta, Delhi and Madras are situated. Thus our unit crop-areas of study are contiguous district-groups with boundaries not cutting across the parent state boundaries. In deciding upon the districts to be included in each of the unit crop-areas, we have taken special care to get a similar or almost similar crop-combination pattern in each, apart from the consideration of forming possible common administrative boundary for all the time-points for which comparative data could reasonably be built up. To ascertain the similarity of crop association among districts within an areal unit, we have made the necessary background studies by districts along the line followed in chapter 2 later, but not reproduced here. After the initial exercise, we have altogether 151 unit crop areas or, in short, areal units, the detailed description of which, in terms of 1970-71 districts are recorded in appendix Table (A.1); their areal distribution is reported in Figure (1.1).

The data base of the present study has been developed primarily from the following Govt. of India publications :

a) Agricultural Situation in India;

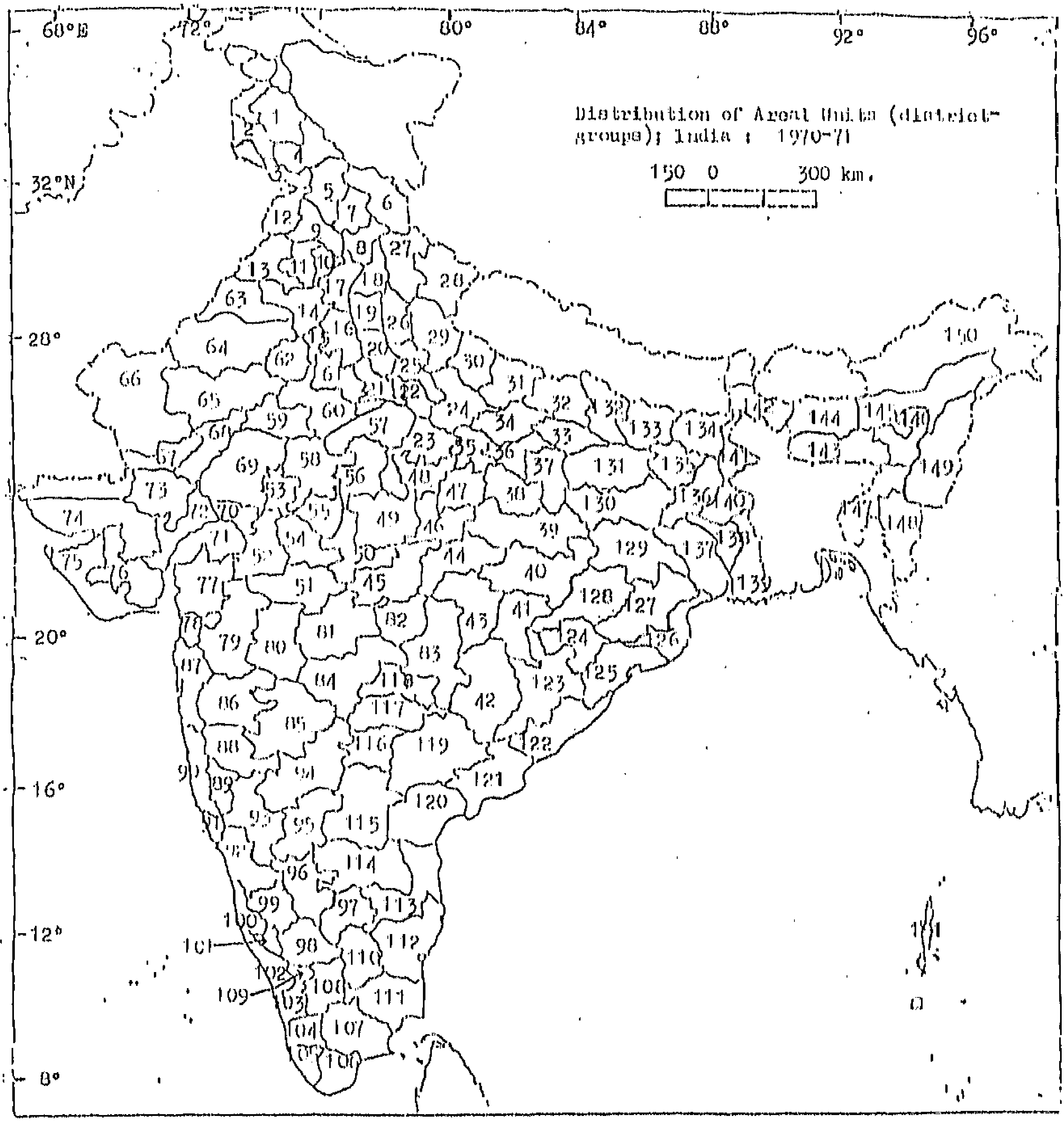
Distribution of Areal Units (district-groups): India : 1970-71
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
1
2
4
5
6
7
8
9
10
11
12
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Fig. 1.1

b) Estimates of Area and Production of Principal Crops in India;

c) General Population Tables, Census of India;

d) Tables with Notes on Consumer Expenditure;

e) Fertiliser Statistics;

f) Coffee Statistics;

g) Tea Statistics.

Details of these publications are reported in the bibliography.

1.3 The Need for Regional Analysis on Agricultural Activities

For a vast country like India, any comprehensive all-India regional analysis with the incorporations of all the three dimensions —— the temporal, the spatial or areal, and the sectoral —— has hardly been attempted earlier although there have been some partial analysis. Some such studies of importance are, for example,

1) K.S. Rao's (1960, Agricultural Situation in India) studies on the measurement of food surplus and deficit by districts of India;

2) Minhas and Vaidyanathan's (1965, Journal of Indian Statistical Association) study on the components of agricultural growth : 1952-60, by states of India;

3) Pal and De's (1979a, Sankhyā) comparative study on the statistical identification of contributory factors of agricultural growth : 1962-72, by districts of India;

4) Pal and De's (1979b, Indian Journal of Regional Science) study on the measurement of agricultural labour pressure on cropped land and production by districts of India;

5) Pal and Maity (1976, Indian Journal of Regional Science) and

6) Bhalla and Alagh (1979).

These studies are definitely path-setters from the methodological point of view and also instructive in understanding the problems of regional disparity empirically on those selected aspects of partial nature. As such the present author is greatly influenced by those important studies, yet those studies revealed problems -- both of methodological and empirical nature --- which should have follow-up regional analysis for clarifying our vision on a comprehensive basis. These studies, however, would be reviewed at appropriate places later. Again with dynamism in the overall agricultural growth particularly in the later half of our period of study, it is also necessary to update their findings for comparative regional analysis on recent changes, if any.

As already hinted at the beginning, our agricultural planning efforts had turned out to be global in nature with a view to gain all-India self-sufficiency. As such those planning efforts were basically non-spatial in nature, even though some of the favoured growth generating areas have been spatially distributed as a result of the persuasion or pressure from the more powerful state governments. But the formulation of agricultural activity planning was hardly based on appropriate regional principles supported by formal comprehensive regional studies with the explicit incorporation of the spatial dimension in them. The rationale behind this type of non-spatial national level agricultural plan formulation was to develop high yielding agricultural activities as quickly as possible in these locations where the receptivity of farmers and the infrastructural facilities for intensification already existed or could easily be attained, without making comparative regional studies to assess the problems and prospects of agricultural activities in different areas. It was thought that by this kind of quick switch-over to the intensification programmes, much of India's foreign exchange money that was being drained out on the essential food-imports could be saved and thereby the financial resource position would be better, which could be used later in the future planning with a greater attention on the distributional aspects. In a country where there is shortage of financial resources, the initial non-spatial approach followed in the agricultural activity planning could not be said to be grossly inappropriate. But now, after two decades of planning with the new agricultural strategy of intensification, we cannot avoid subscribing to the common place view that regional disparities in comprehensive agricultural situation have greatly enhanced, not to the benefit of a proper growth of agricultural activities themselves.

The agricultural growth of now-favoured locations can hardly be sustained if the demand for agricultural products do not grow in the same or accelerated pace. The demand is highly influenced by peoples' purchasing power which can be made possible if all people could be kept engaged in gainful activities. Unfortunately enough non-agricultural occupations have not been created despite our continued national planning efforts and day by day our unemployment situation is aggravating. This means that more and more of our people are to depend excessively on the limited agricultural land and thereby the agricultural labour productivity is geting more and more deteriorated with the passage of time. Thus if agricultural activities are created only in selected areas without a proper attention towards providing certain activity base for all other areas, certainly the domestic market of the agricultural products of those selected areas gets shrinked. This state of affairs is certainly not desirable at least in the long-run for a sustained agricultural growth. In fact in an agricultural country like India the opportunities for creating agricultural surpluses should be created in all feasible agricultural tracts with the existence of national locational advantages like fertile soil or assured water. Here comes the necessity for comprehensive study for a proper identification of regional variations, patterns and problems of agricultural activities with an explicit incorporation of the relevant spatial variables, so that we can understand the present pattern and the growth trend that would help in formulating the desirable spatial pattern of agricultural activities based on sound regional principles with special attention to less developed areas.

1.4 Scope and Approach of the Present Study

To analyse the problems and prospects of agricultural activities of any area, it is a prime requisite to have a prior knowledge of the cropping pattern of the area; also how it stands in relation to that of other neighbouring areas. The problems and prospects those are to be diagnosed must be based on the existing pattern. At any particular location, the cropping pattern that has emerged already must have been influenced by the nature of soil and climatic conditions, traditional habits of the cultivators, available basic input facilities etc. Soil and climatic conditions are not controllable variables, although by changing basic inputs, the cropping pattern can be conditioned for betterment. But if there is no sufficient incentive or if the cultivators are not sufficiently guaranteed of their changing risks, they do not generally prefer on their own to come out of their habits of traditional crop association practices in a large scale. Certain short-term fluctuating small scale changes may take place due to the cobweb theory of demand-supply and price mechanism [Wold, H & Jureen, L (1953)]. But this small scale change does not generally produce noticeable crop association changes. Thus one has to decide agricultural development programmes within the framework of existing crop association patterns as far as practicable. Here lies the importance of the study of cropping pattern and the follow-up identification of crop regions with common cropping patterns. Accordingly, our first attempt has been on the identification of cropping patterns and crop regions based on all important crops for the year 1980-81 by areal units as specified already.

We would next investigate, in chapter 3, whether or not the cropping pattern in an areal unit generates a viable or promising economy at least for the cultivators and agricultural workers who more or less entirely depend on it. In this respect we would first examine the marketable surplus out of their productions over and above their own consumption requirements on the basic necessity of foodgrains. This kind of surplus-deficit analysis would be attempted not only for cultivators and agricultural workers but also for extended group of rural and total population as well to classify the areas at different levels of economic viability on foodgrains economy. As all crops cannot and should not be brought under the purview of desirable regional self-sufficiency approach and also as there exists other crops as well over foodgrains --- though much less extensive in cropped acreages --- our viability study would not be comprehensive unless we have examined the totality of all agricultural production in relation to agricultural workers and cropped land. We shall do this through agricultural labour productivity and land productivity analyses. This will also throw light on the nature of surplus-deficit of foodgrains that exists in an areal unit. On the basis of all these studies we would design a comprehensive agricultural activity index to rank the areas on the present situation (1980-81) of its economic viability and relevant regional analysis with special attention towards identifying the regional disparities.

Next, in chapter 4, we would attempt a comparative analysis on the regional situations in agricultural activities for the three time points --- 1960-61, 1970-71 and 1980-81 --- spread over two decades and try to identify areas of stagnancy and growth over the period. Here we shall analyse the contributions to overall agricultural growth by different components like the acreage extension, the intensification of yields and the crop association. Here we would examine the growth of both agricultural production and agricultural labour productivity. We would also try to find out the distribution of some key input factors which might be responsible towards generating differentially manifested picture of growth, particularly that contributed by the intensification component. We shall also identify which of the growth components have been most responsible and which became not very effective in explaining the regional variation in overall agricultural growth. This would throw light on the future possibilities and limitations of agricultural growth in different regions.

Finally, in chapter 5, we would attempt for a comprehensive and systematic analysis, taking account of the aspects and findings already obtained in preceeding chapters and also some other aspects like the interactions of agricultural activities with other productive activity like industrial productions and the marketing and servicing activity like trade, transport and urban central place infrastructure for overall areas associations. We would also try to rank the different areal units on the basis of a comprehensive development index based on all these aspects and compare and constrast the role of agricultural activities in relation to the development pattern of different areas. This study would be designed with a view to examine the employment opportunity possibilities of huge labour force as kept bonded on limited agricultural land. This chapter would be concluded with a summary and conclusions on our main findings and observations.

The design of the chapters as briefly summarised above shows the main thrust area of our empirical study on getting a comprehensive picture of Indian agricultural situation. The tools those we would be using in our analysis are those which go in the name of Regional Science. It is essentially an inter-disciplinary field which makes use of various principles and methods of mainly three disciplines, namely, Statistics, Economics and Geography. The importance of the application of statistical and quantitative methods in the field of regional science can be well understood from the discussion offered by Preston E. James in connection with a seminar paper [Preston, J.E., 1958]. According to him the regional science has a "very promising application of statistical methods to problems those lie on the border between economics and geography". Our present attempt to identify the regional structure of agricultural activities, providing a background picture on variations in regional development patterns, is essentially an exercise that lies on the border between economics, geography and statistics. It should be noted that, while economic investigations aim to seek interpretations on the economic behaviour and processes of activities, the geographic investigations very often focus attention on the study of variations over the earth's surface in many spatial phenomena. In our present attempt for a diagnosis on the differential agricultural activity pattern on space and its causal factors, we are also aiming at analysing the spatial variations.

Thus economic principles as well as statistical tools and geographic approaches are to be integrated in the present study. In the applied regional science approach, the identifications of formal or regional configurations is the first stage of study. So our efforts will be first aimed at this direction. In any regional analysis, Geographers' approach with map analysis cannot be avoided, simply because the areal units of observation as involved in the spatial analysis are two dimensional in nature, unlike the unidimensional chronological sequence of a time series study and also because the configuration of areal units in relation to all neighbouring areal units cannot be comprehended in any kind of tabular presentation of the spatial data. Geographers' map analysis with classified data on a single spatial variable is quite helpful in understanding the spatial configuration of each areal unit in relation to all its neighbouring units at a glance for the single characteristic as depicted by the variable. But for a study of composite characteristic often several such single variable maps are to be examined in an integrated way. They have, however, evolved some technique like the superimposition of several single variable maps for evaluating a formal configuration of composite characteristic that is to be identified by several interacting variables (Schwartzberg, 1962; Learmonth and Pal 1959; Monkhouse and Wilkinson 1956). But such an identification with inter-acting spatial variables through superimposing technique of mapping often becomes difficult, when the variables to be considered are many in number. According to Preston James [1958], Keeble [1967] and Pal [1974] the geographic approach is to be improved through the needed analytical skills as available in the econometric approaches and the statistical tools, with a view to make a comprehensive formulation of any regional structure of activities (or characteristics). In the light of demands for operational regional development plan formulation in India, the Geographers have initiated studies on spatial variation particularly with physical aspects; very often regional mapping on the distribution of crops or crop yields or the related agricultural activity variables. But they have hardly gone into details of agricultural output and growth components of production and productivity and factors explaining them in a comprehensive manner in their map analysis. On the other hand, economists have focussed their attention more on causal relations affecting output growth, but without much verification on their spatial variation and behaviour on a global basis for a country. Here we shall make use of statistical and quantitative techniques to integrate both the partial approaches.

The inter-disciplinary regional science approach is of very recent origin. Isard's group of regional scientists working in USA is pioneer in developing theoretical concepts and definitions in the field [Isard, W. 1956, Isard, W. et. al. 1960]. But many theoretical methods developed by this group could not yet be made operational in the regional plan formulations of many developing countries. For example, Steven's [1959] theoretical formulation of regional programming model based on linear programming framework is hardly applicable for various practical reasons, including the problem of detailed data base visualised in his model framework. Similarly, the regional input-output technique, generally used for consistency checking between activities, has hardly been useful in a developing country like India. The plan formulations on the basis of past input-output norms have often gone off the mark in future in a developing economy like that of India. In fact, the scope of applications of many saphisticated techniques has been very limited, unless they are used in modified forms depending upon the situations and data base prevalent in a country. On applied side, Learmonth's group made the pioneering regional studies in the Mysore (Karnataka) State of India during 1956-58 [Learmonth, A.T.A, et.al. 1960 and 1962]. However, in this applied work, the principles and techniques of geography were mainly used, while the possibilities of applications of statistical methods and techniques were not fully explored or exploited. Our task here is to make an attempt for such explorations and exploitations of statistical tools for regional analysis of agricultural activities in an integrated way. In this respect, certain multivariate statistical methods as developed by Pal (1963a & b, 1971, 1974, 1979a & b, 1985) in the Indian regional planning context as a follow-up of the said regional studies in Mysore (Karnataka) State (in fact, Pal was an associate of Learmonth in the Mysore Project) could be of great use. By use of these statistical methods, the composite formal regional structure could be identified without the use of cumbrous superimposing techniques of mapping. A critical review of various methods of composite formal regionalisation under geographical, economic and statistical considerations is also available in the study made by Pal [1973]. The methods, particularly those relevant to our studies would be reviewed and summarised at appropriate places while proceeding with the actual empirical applications in subsequent chapters. The identification of formal regional structures on various activity characteristics is particularly useful in such situations where our objective would be to reduce the regional disparities in such activity characteristics. Here our prime aim would be to diagnose the variations in spatial patterns of agricultural activities and growth which would be useful for clarifying our visions on possible tasks ahead for a proper kind of planning attention. The planning approach would, however, be to draw lessons from the favourable formal structures and try to examine whether the conditions that led to favourable structure could be created in or transformed to an area where relatively less favourable formal structure is existing. To identify the interactions between characteristics or causal relations we have also used in many instances the advanced regression techniques of statistics, besides other methods.

Apart from this approach of deciding through formal regional structure analysis, there is also another important approach, of functional regionalisation approach which is more suitable for micro-locational analysis. The type of study we have indicated for all-India, does not have much scope to make use of that approach right now, mainly because it involves the consideration of a huge collection of micro-level flow data to establish inter-locational interactions for all-India, which is not within the plausible capacity of an individual research worker with his limited financial capacity. Moreover data and information gap are quite serious to get any dependable findings on the basis of such function regional approach in its proper form of application. For example, the study of flow to urban market centres from their rural producing hinterland and the related aspects of agricultural economy could be a topic that is usually tackled through functional regionalisation approach. We have, however, tried to incorporate some essential spatial interaction studies of agricultural activities with locational forces like the levels of industrialisation, trading, transportation, urbanisation etc., through regression analysis, even though detailed micro-level functional interaction studies could not be explicitly incorporated within the scope of present thesis. Granting the limited scope of present study, we would try to investigate the different regional aspects of agricultural activities in the best possible way and findings will be comprehensive only to that extent and not all-pervading. With the stated scope and approach, we proceed to make attempts for detecting regional problems and patterns of agricultural activities in India in the subsequent chapters enlisted below :

Chapter 2 : Spatial Concentration of Crops and the Identification of Cropping Patterns and Crop Regions : 1980-81.

Chapter 3 : Spatial Variation in the Development of Agricultural Activities : 1980-81.

Chapter 4 : Comparative Spatial Pattern Analysis of Agricultural Development and Growth Component Analysis for Agricultural Production & Productivity : 1960-61 to 1980-81.

Chapter 5 : Role of Agriculture in the Overall Spatial Pattern of Economic Development and Regional Synthesis of Agricultural Activities.

Chapter 2 : SPATIAL CONCENTRATION OF CROPS AND IDENTIFICATION OF CROPPING PATTERN AND CROP-REGIONS : 1980-81

2.1 Introduction

The agricultural activities, centering around various types of crop productions, do not get manifested uniformly over the entire territory of any country. The distributions of crops and crop-combinations are bound to vary on space and we are to admit the existence of uneven presence of locational forces or advantages that tend to create crop concentrations with various intensities in different areas. In fact crop-specific locational forces tend to create agglomeration of some crops in certain areas, while some other in different areas. Such areas of agglomeration can be termed as the core areas of specific cropping activities. In these crop-specific core areas, it is generally noticed that the growth of production activities is much more rapid than in other areas for the same crop or crop-combination. Thus it is necessary for us to identify the core areas of crop-production activities and find out the location factors of facilities those are responsible for their creations and continuations. In this chapter we would however limit our investigation on finding out the core areas of crop-concentrations for all important field crops of India, about twentysix in number. The identification of cropping patterns and crop-regions would then be taken up in this chapter itself. This needs a complex kind of integration of individual configurations of crop-concentrations. Here the geographical approach of mapping and super-imposed mapping is of great help, although we would have to moderate this with relevant statistical tools for simplifying the extent of cumbrous super-imposition method which cannot be eliminated altogether in the present case of regionalisation for complex structures.

2.2 Regional Systems : A Brief Review of Concepts

We have already used the word formal and functional regionalisations —— i.e., delineation of formal and functional regions —— without however explaining what we mean by such terms. We would now briefly review the concepts as already available in regional science literature on the term "region", that is often used in any "regional decision problem" involving the spatial variation of certain characteristics related to a context of study. Productive activities located in different areas grow or decline with the passage of time by the on-going momentum of processes related to the activities. A decision problem is characterised by the gap between a present state of activities and a desired state on a future date in a chosen time horizon, which is obtained as a by product of preassigned goals and objectives. If the processes, as they exist presently, are allowed to govern the activities, the state that we would obtain on the future date can be called the "usual state". The desired state and the usual state on the same future date are not likely to be identical. If they are identical, there is no problem really, because the existing processes can take care of the desired state. But generally the presence of departure between them pose problem that is to be sorted out through ways and means that would be capable of conditioning the processes in such a away that the desired state can be achieved on the specified future date. When the decision problems involve the study of spatial variations, also, we have to compare the present regional system with the desired regional system through an evaluation of the usual regional system first on a specified future date. This involves the identification of the present state of the structure of the system and the behavioural processes that would determine the usual state on the future state. To identify the state and behaviour of a regional system, geographers usually delineate regions on various characteristics related to a context of study (for details, see Pal, 1974).

In any type of decision making regional variation study, "system approach" has been preferred by pioneer regional analysts like Isard, Stevens, Alonso and Bramhall (1958). According to them " a system approach consists of defining the structural units of a system and the relations which bind them as a system". According to David Harvey (1969), a "system" is characterised by the attributes of objects related to a context of study and the various interactions of objects related to a context of study and the various interactions between the objects. Details of system concept are discussed by Pal (1974). But before going into certain relevant details, we would define now "regions" following Hartshorne (1958). According to him, geographers use the term 'region' to express any of the following three concepts (also quoted in Pal, 1971, 1973 and 1974) :

Adhoc region : or a region in the general sense, is simply a particular piece of area which may be in some way distinctive from other areas;

Formal region :	or a homogeneous or uniform region is an area within which the variations of one or more selected features fall within a certain narrow range; and
Functional region :	or a region of coherent organisation or a model region, is an area in which one or more selected phenomena of movement connect the diverse localities within it into a functionally organised unit.

Thus the delineation of formal regions, i.e., formal regionalisation, is nothing but an identification of similar areas on space with respect to some objects and their attributes in a regional system and the choice of the objects and their attributes depend on the context of the study. Functional regionalisation, on the other hand, are to be based on certain spatial linkage or flow or movement variables, showing the interactions among established formal structures. Thus the formal and functional regionalisations help in identifying structural units on space and their spatial interactions, although in our present study we would make attempts to identify the spatial interactions, not through spatial flow analysis, but through indirect evidence to be brought out through spatial association and correlation analysis through comparative map analysis and statistical regression analysis. We have also to make comparative studies at different time points in a part time period for the identified structural units on space towards an evaluation of the existing on-going processes implicit in the system. The totality of all such studies help us in knowing the state and behaviour of a regional system with reference to the context of the study. Adhoc regions are often taken for granted and not delineated with reference to the context.

As such these regions have none of the defining features of a regional system. However adhoc regions can be accepted some times to form regional subsystems when we have identified their role, characteristics and linkages in relation to the main purpose of analysis in a particular regional system. For example, in our national planning system in India, Indian states which control much of our planning investments can be regarded as adhoc regions (not the formal or functional planning system). In fact, these adhoc regions are broad linguistic formal regions and also the broad functional regions for administrative purpose in our federal set-up. However, these adhoc regions used for certain planning purposes can be regarded as the controlling sub-systems (see Hermansen, 1969, for definition) in our national planning system. In our all-India analysis, states would also be accepted as adhoc regions because agricultural planning actions are largely controlled by state governments. It is for this reason, the areal units of our study have not been allowed to cut across any state boundaries, so that our estimates to be recorded by areal units might be of some use in clarifying the visions on agricultural planning decisions within any state.

2.3 Review of Some Basic Quantitative Tools

Spatial configurations or distributions of certain characteristics are to be necessarily identified or measured before proceeding towards corresponding formal regionalisation analysis. In such studies, the configuration of spatial units, whether districts, district-groups, settlements or even point-locations, are implicitly related to the characteristics. These areal units are not of same size in terms of geographical area. As such, spatial characteristics or variables are to be neutralised for the variations in geographical area of the spatial units chosen. A characteristic, measured by its total magnitudes as concentrated in spatial units, is usually converted in a spatial variable by taking it in the form of what is usually called a <u>location factor</u> or <u>location quotient</u>. Thus the location factor of a characteristic u, denoted by L_u, can be written as in equation (2.1)

$$L_{u_i} = \frac{u_i \Big/ \sum\limits_{j=1}^{N} u_j}{a_i \Big/ \sum\limits_{j=1}^{N} a_j} = \frac{u_i/a_i}{\sum\limits_{j=1}^{N} u_j \Big/ \sum\limits_{j=1}^{N} a_j}, \qquad \ldots (2.1)$$

where u_i is the magnitude of characteristic u for the ith areal unit of observation, with $i = 1, 2, \ldots\ldots, N$ in the universe of study (here India), and a_i is the geographical area of the ith areal unit. The mode of construction of L_u indicates that its critical value is unity, which is the value for the universe of study as a whole. The values of L_u above unity represent a higher level of concentration and those below unity refer to a lower level of concentration as compared to the average concentration of the characteristic in the universe of study as a whole. If there were no variation in the geographical areas of the areal units, absolute concentration of u would have been measured by L_u and as such it is at times called the <u>absolute location factor</u>. But we would often refer it to simplify by location factor or location quotient.

In the location factor L_u, the two spatial distributions of u and a have really been contrasted. At times it will be necessary to contrast and compare the spatial distribution of u relative to certain other characteristics i.e. associated with the same areal units. In such a situation we often use another kind of location factor, called the relative location factor, which can be derived from the location factors L_u and L_v. Thus the relative location factor, denoted by L_{uv}, can be written as in equation (2.2) :

$$L_{uv} = \frac{u_i \Big/ \sum_{j=1}^{N} u_j}{v_i \Big/ \sum_{j=1}^{N} v_j} = L_u / L_v \qquad \ldots (2.2)$$

Here also the critical value of L_{uv}, that corresponds to the value for the entire universe of study, is unity [for discussions on location factors see Pal, 1971]. As for example, a specific crop production activity can be measured by, say, its total magnitude of cropped acreage or output u. The concentration of this characteristic can be measured by a contrast with the total magnitudes v by areal units of observation for variables like geographical area, total cultivated area, total population or total agricultural workers etc. As such the crop concentration can be measured in different forms of location factors, L_u or L_{uv}, depending upon the choices for u and v. The mapping of a simple location factor L_u or L_{uv} under uniformity criterion leads towards evaluation of what would be called the simple formal regionalisation. But as in our previous illustration, the special distribution of a single characteristic u is to be examined very often in relation to many other relevant characteristics v's, including the fact that the characteristic itself may have to be measured by different u variables. In such a situation one has to examine the spatial variations of the characteristic by many inter-related or inter-dependent spatial variables. A formal regionalisation made on the basis of many such interdependent spatial variables is called a composite formal regionalisation. Before reviewing the basic quantitative methods, now in use for composite formal regionalisation, we would complete our discussion on location factors with a kind of their spatial aggregation, called coefficient of localisation, which gives an overall measure of spatial concentration of the characteristic for the universe of study as a whole.

The coefficient of localisation, C, [as used by Sergant Florence, 1954, in the Economic Survey of Europe : 1954] can essentially be expressed as in formula (2.3)

$$C = \frac{1}{2} \sum_{j=1}^{N} p_j \left| L_{uv_j} - 1 \right| ; \qquad \ldots (2.3)$$

where $p_j = v_j \Big/ \sum_{i=1}^{N} v_i$

and L_{uv_j} = the value of location factor L_{uv} for, jth areal unit of observation.

It is an weighted aggregation of absolute deviations of L_{uv}'s from the critical value of unity and totals of positive and negative deviations are same but not identified in absolute deviations; this aggregation needed the coefficient 1/2 as attached to the formula. The coefficient of localisation can again be absolute or relative depending upon the variable used as v. While the measure L_{uv} gives the measure of spatial concentration of a characteristic for each point areal unit, the measure C gives a single overall measure of spatial concentration for the characteristic. As such C's are used to compare the nature of overall concentration among different characteristics. The usual Lorenz [1905] measure of concentration [ref to Wright, 1936, for its spatial use]; is a measure of this variety, but is more complex in its algebraic formulation..

In these overall measures, coefficient of localisation or Lor measure, distributions of two variables are explicitly involved in thei computation.. However, there is still simpler measure used in the Ph.D dissertation of Bishnu Dev Pant [1982] which we could call <u>Spatial Concentration Ratio</u> and denote by S. In this measure only the characteristic variable

$$s_j = u_j \Big/ \sum_{i=1}^{N} u_i \qquad \ldots (2.4)$$

occurs explicitly and not the denominator variable p_j of the corresponding location factor. In this, certain critical norm, say, $\overline{s}$, or some such similar measure, is used to classify all areal units into top and bottom classes and their respective class means $\overline{s}(t)$ and $\overline{s}(b)$ are computed.

Finally the spatial concentration ratio S ("localisation ratio" as per the nomenclature used by Pant) is given by :

$$S = \overline{s}(t) / \overline{s}(b) \qquad \ldots \quad (2.5)$$

We shall use this kind of measure to ascertain and compare the localised or the diversified nature of different crops.

2.4 Review of Quantitative Methods for Composite Index Formulations

The composite index formulation for a group of inter-related location factors or variables, those are supposed to measure a composite characteristic jointly, is really to be used in connection with the composite formal regionalisation analysis. The composite formal regionalisation is often attempted in geographic literature by the super-posing technique of mapping of interrelated spatial variables, [ref. to Learmonth, et al. 1960, 1962, in which many such maps were used by Learmonth and his associate M.N. Pal; also ref. to Schwartzberg 1962 and Spate and Learmonth 1967]. While the use of this super-posing technique cannot be altogether avoided [for details, see Pal 1973 and 1974], its dimension can be simplified by use of statistical tools. If the dimension of super-impositions is large with the use of many variables, it leads to the practical problem of multiplicity of classification for mapping. For example, if each variable is classified into three classes of value ranges (say, high, medium and low), the total number of classes to be dealt with in a superposing mapping with two variables will be nine and that with three variables will be twentyseven which is certainly a very big number for mapable classes. The classification problem however gets a bit simplified if there exist strong intercorrelations among variables. But for not so strongly related spatial variables, the classification problem remains acute if the number of variables is not reduced. Again, some kind of classification of areal units may be possible by the composite formal regionalisation analysis done through sequential super imposition for a limited number of variables. But by this method we are not in a position to rank the areal units on the basis of the composite characteristic that is under consideration. However, it is hopeful that certain quantitative and statistical methods [ref to Kendall, 1939 and Pal, 1963, 1971, 1973, 1974 and 1985] are available to solve this rather difficult situation of composite formal regionalisation, some details of which would be summarised shortly afterwards. Some of these techniques would be used along with the technique of sequential super-imposition in this chapter for identifying crop-concentrations and composite crop regions.

Regarding this practical need for a formulation of composite index related to an over-all characteristic, Pal's classical illustration [1971, 1973 & 1974] summarised below is illuminating. According to Pal, the absolute and relative location factors, for example, discussed earlier are generally concomitant in magnitudes over different areal units of observation and only in a limited number of observations, there may be discordance in the magnitudes because of certain locational peculiarities. Thus, for example, in an area where opportunities of agricultural practices are not much, the people residing therein may have to depend primarily on non-agricultural activities. Now if one is interested to see whether an area is more industrialised or not as compared with other areas on the basis of absolute or relative location factors of industrial acticity, measured by labour participation, it would be found that absolute location factor of the area without having the possibilities of agricultural production will be comparably much lower than the corresponding value of the relative location factor which may be comparable to some of the really industrialised area having high values in both the location factors. One could be easily misguided about the relative positions between two areas if one judges by a single location factor only and not by both the location factors simultaneously. This illustrates the need for a formulation of a composite index moderating the values of both relative and absolute location factors, particularly for the areas with discordant values. This principle can easily be generalised with any number of interrelated spatial variables to be considered simultaneously for an evaluation of the influencing or influenced composite characteristic under formal criterion. Pal has further emphasised that before going for aggregation of variables under consideration, the statistical distributions of variables are to be checked for a right depiction of inter-relations, measured by linear correlation coefficients, among variables under consideration. Unless the statistical distributions of two variables are made almost similar through suitable mathematical transformations, one cannot hope to properly identify the inter-relation that exists between any pair of variables by a "product moment linear correlation coefficient". In our subsequent analysis we would, however, make attempts to obtain improved linear correlation coefficient between a pair of variables in transformed forms with certain known mathematical transformations, when necessary and we would accept that transformation which would give the highest value of the correlation coefficient.

We would now discuss the existing methods for a composite index formulation. Certain terminologies as standardised in Pal's [1985] most generalised recent work, are discussed first for convenience. The location factors after the suitable mathematical transformations will be called the initial spatial indices, or simply, the indices (including the cases for which there is no need for any transformation). Let us suppose that the indices $x_1, x_2, \ldots\ldots, x_n$ constitute the composite index, designated by I. The correlation coefficient $r_{x_i I} = r_i$, say between the ith constituent variable x_i and the composite index I is called the <u>specific representation</u> of the ith constituent index in the composite index. So for n indices we have n such specific representations. The <u>aggregate representation</u> (or the average representation) by the composite index is defined as the squared root of the average of all squared specific representations. Thus, if ρ denotes the aggregate representation, the algebraic relation between the specific representations and ρ is given by

$$\rho = \sqrt{\frac{1}{n} \sum_{i}^{N} \rho_i^2} \qquad \ldots (2.6)$$

Prior to Pal's most generalised formulation [1985], the construction of a composite index statistically from a group of spatial indices have been usually based on the following two principles :

i) the aggregate representation maximising principle; and

ii) the specific representations equalising principle.

Pal [1985] has shown that the composite index as formed by the above two principles, are special cases of his most generalised formulation. Yet the classical interest in the above two principles cannot be ignored and one has still to judge which kind of index formulation would be suitable in a particular situation of composite index formulation. The generalised index formulation of Pal [1985] has however widened our horizon of expanding other classes of index formulation apart from the two based on the above mentioned classical principles. We would also use a subclass of Pal's generalised formulation later in Chapter 5 of this dissertation and there we would discuss the necessary details of his generalised formulation.

Turning to the two composite index formulation principles, it should be noted that while the maximising principle was used by Kendall [1939] in a regional analysis in England, Pal [1963, 1971] formulated the composite index by use of equalising principle to overcome certain practical difficulties those crop up if the maximising principle yields a composite index with widely diverse values of specific representations [for a comparative study, reference is made to Pal and Chattopadhyay, 1972]. The logic behind the formulation of a composite index, depicting certain composite or common characteristic is as follows : If the common characteristic that is not measurable directly are to be measured through a number of spatial indices or variables, it is expected that the characteristic is either influencing the variables or being influenced by the variables. As such the variables are likely to be strongly inter-related. Thus the mathematical transformations at the initial stage appear to be essential for a proper identification of those inter-relationships through the linear correlation coefficients. Again this possibility of the presence of strong inter-relations among the constituent variables also help us to make a final selection of the group of variables with strong inter-correlations for the construction of composite index representing an overall characteristic that is not directly measurable; if a certain variable selected initially does not have much relations with other variables chosen, one does not expect it to belong to the group of variables relevant for the common or over-all characteristic to be depicted by the composite index, and as such, it is eliminated from the final group. Now the question arises whether or not the constituent variables with strong inter-relations would influence the composite characteristic or be influenced by it equally. If the inter-correlations are all equally high, both the principles of construction would yield practically the same index, for in that case, the specific representations of the composite index, whether constructed by maximising or equalising principle, would be same or almost similar. In fact, in Pal's generalised formulation [1985] he has shown the condition on the correlation matrix for which two formulations would be identical or near identical and our contention is in line with the theorem proved by Pal in this connection. Yet, often for observational or sampling errors, diverse values in the inter-correlations are possible. It is also possible that the importance of all variables in the final group need not necessarily be equal with reference to the common characteristic. On the other hand, the composite index constructed by the maximising principle is solely formed by the mathematical maximisation and in that the specific representations obtained are purely dictated by this mathematical aspect. These specific representations need not reflect the (unknown) importances of variables with reference to the common characteristic. Thus when the specific representations are widely diverse, it is possible that the most important constituent variable has got the very low specific representation in the composite index. In such a situation, if equalising principle is used to construct the composite index, the specific representations are less anomalous compared with the importance of variables with reference to the common or over-all characteristic, on which we have no knowledge apriori. However, between the two principles, the maximising principle yields a higher value of the aggregate representation (because ρ is maximised in it). For this reason, if the specific representations are within certain narrow range of high values, the maximising principle is preferred in the composite index construction. In such a case, the aggregate representations obtained in both the principles are likely to be not significantly different and the two composite indices formed would be almost perfectly related. In such a situation, there is all the justifications for use of the composite index formed by the maximising principle. If, however, the composite index formed by maximising principle does yield wide variations in the values of specific representations, one may have to apply the equalising principle. In that, if the aggregate representation is significantly lower compared to that of maximising index, one may have to identify the sub-groups of strongly inter-related variables from the group of selected variables and apply the construction principles in phases. It is to be emphasized that both the principles would yield the same composite index when it is constituted of only two constituent variables. This property can be desirably used when one constructs the index from sub-groups in sequential stages and, in fact, we have faced such a situation in connection with our study on spatial crop concentrations, where we have used this unified principle quite fruitfully. Whenever we shall use the global maximising principle, we refer to the index as Kendall's optimal index or simply optimal index. On the other hand, if the equalising principle is followed, we refer to this index by Pal's equity index or, simply, equity index.

When there is a strong inter-correlation between constituent variables, say, n in number, a particular areal unit of observation can be considered as a point in the n-dimensional space of the variables. All areal units of observation form a scatter of points in the n-dimensional space. When the inter-correlations are very strong, the scatter will occur around a certain central line (through the mean-point of the variables). Kendall [1939] attempted to fit this line by the least square principle which will be the line of closest fit satisfying our maximising principle of aggregate representation. In Kendall's study of crop-productivity in England by countries by several crop-yield variables [1939], the line of closest fit is termed as the "productivity axis" which we shall refer to here as the "central axis". The determination of this central axis is algebraically equivalent to that of determination of "first principal component" as formulated by Hotelling [1933]. It should be noted that the first principal component maximises ($n\rho^2$) and hence ρ^2, the squared aggregate representation. Hotelling's principal component analysis was, however, not restricted to the determination of the first principal component alone. Rather this involves the computation of a series of "principal components" out of the same set of variables, which are taken to be mutually independent by assumption. This process of computation of subsequent principal component is based on the principle of maximisation residual variation which remains unexplained by the preceding components. Some regional studies did, however, use [ref. to Berry, 1960, Berry and Rao, 1968 and Dasgupta, 1971] more than one principal component those are taken as mutually independent for mathematical convenience in Hotelling's principal components formulation. But this property of mutual independence is hardly acceptable in regional literature since the regional indices are often oblique than orthogonal [ref. to Pal, 1968]. If the correlation matrix of the variables are such that more than one principal component are necessary for accounting a significantly major part of total variation of the variables, one should form rather sub-groups of variables, each with strong intercorrelations, construct the composite indices for each such sub-group and examine the correlation between the two sub-group indices for identifying their obliqueness [ref. to Pal, 1968, 1973 for further details]. Thus it is clear that the choice, transformation and final inclusion of variables relevant for a composite index and done on the basis of the supporting logic of strong intercorrelation is quite important in the composite formal regionalisation of a common characteristic.

2.5 Computational Procedures for Different Composite Index Formulations

2.5.1 Two-variable Composite Index Formulation :

Most of the composite indices to be formulated in this chapter would be of this category where equity and optimal formulations converge to a single formulation. It is for this property, we would be often using this formulation with two constituent variables although such two-variable indices would again be combined by pairs, where theoretical justification exists. The generalised formulations with more than two constituent variables would generally differ for the equity and the optimal formulations and we would discuss them in the later parts of this section. According to Pal's [1963] original equity formulation with two variables as shown below in equation (2.7), arithmetic averages of the variables have been used in the formulation as the central values of the constituent variables. But our spatial variables are often location factors. The critical value or the national value of these spatial variables (even for suitably power-transformed location factors, if used) is always unity. As such, the formula used here, shown below in equation (2.7) is obtained by using a constant multiplier, so that the critical values of the constituent variables, and not their averages, correspond to the same value of unity for the constituent index. Thus we have :

$$I_j^* = \left(\frac{\sigma_2}{\sigma_2\bar{x}_1 + \sigma_1\bar{x}_2}\right) x_{1j} + \left(\frac{\sigma_1}{\sigma_2\bar{x}_1 + \sigma_1\bar{x}_2}\right) x_{2j} \qquad \dots (2.7)$$

where $\bar{x}_1$ and $\bar{x}_2$ are averages of variables x_1 and x_2 respectively, varying over different areal units, $j = 1, 2, \dots\dots, N$; and σ_1 and σ_2 are the corresponding standard deviations. Clearly the averages $(\bar{x}_1, \bar{x}_2)$ correspond to the central value of unity for the index I^*. The changed formula to be used in our study is given by [often used by Pal himself in his recent studies] :

$$\left.\begin{aligned} I_j &= \left(\frac{\sigma_2}{\sigma_1+\sigma_2}\right) x_{1j} + \left(\frac{\sigma_1}{\sigma_1+\sigma_2}\right) x_{2j} \\ &= G\, I_j^*, \text{ with } G = \frac{\sigma_2\bar{x}_1 + \sigma_1\bar{x}_2}{\sigma_1+\sigma_2} \end{aligned}\right\} \qquad \ldots (2.7a)$$

Clearly the mean value of index I : $\bar{I} = G$. If the spatial variables x_1 and x_2 are location factors (or their power transformations), the critical values of x_1 and x_2 would remain as unity, while their averages could be different from unity. As the critical values are the meaningful national values (universe of observations as a whole), it is desirable that those critical values correspond to the central value of I which could be treated as the critical value of the constituted index. As shown above, the index I is proportional to index I^* and as such I retains all the properties of I^* in terms of equal specific representations and the maximum aggregate representations. In general, the constant of proportionality G is different from unity. The specific representations and the aggregate representation for either of formulations (2.7) or (2.7a) are identical and the common value is given in relation (2.7b) below :

$$\rho = \sqrt{\frac{1}{2}(1 + r_{12})} \qquad \ldots (2.7b)$$

where r_{12} is the correlation coefficient between the variables x_1 and x_2. (Here r_{12} is taken to be as positive; if it is negative, r_{12} is to be replaced by $- r_{12}$ in the formula). The standard deviation of the index I is given by

$$\sigma_I = \frac{2\rho\,\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

It should be noted, however, that the variables x_1 and x_2 can be in transformed forms, so that it is within our control to get the values of r_{12} in the positive interval (0, 1) and not in the negative interval (-1, 0). From the relation (2.7b) it is clear that the value of ρ will always exceed $\sqrt{0.5} = 0.71$. So the representation of the constituent variables of this index will always be considerable, between 0.71 and 1. This also shows the high level of dependebility of the index constructed out of two spatial variables only. It is because of this reason, we have tried to avoid a direct construction of a composite index (unless absolutely necessary) by use of generalised formulation for a group with more than two spatial variables, provided meaningful sub-group indices could be formed by the above formula (2.7a) and then the sub-group indices are combined, possibly again by the same formula, for the composite index. The correlation coefficient between two double-variable indices that we need in this connection can be estimated as follows : Suppose index I is constituted of variables x_1 and x_2 and I' of variables x_3 and x_4; then the correlation between I and I' is given by

$$\left.\begin{aligned} r_{I\,I'} &= (r_{13} + r_{14} + r_{23} + r_{24})/(4\rho\rho') \\ \text{where} \quad \rho &= \sqrt{\tfrac{1}{2}(1 + r_{12})} \text{ and } \quad \rho' = \sqrt{\tfrac{1}{2}(1 + r_{34})} \end{aligned}\right\} \quad \ldots (2.8)$$

2.5.2 Pal's n-variable Equity Index :

The equity index formulation with more than two variables has also been used in the following Chapter 3. As such we will briefly summarise below the computational procedures for this kind of formulations. According to Pal's [1971] formulation for n constituent variables, the formula for a composite index, denoted by I_e^*, characterised by its equal correlation with all the constituent variables (in transformed forms, if necessary) x_i; $i = 1, 2, \ldots, n$, can be written as follows :

$$I_{ej}^* = \frac{a_1x_{1j} + a_2x_{2j} + \ldots\ldots + a_nx_{nj}}{a_1\bar{x}_1 + a_2\bar{x}_2 + \ldots\ldots\ldots + a_n\bar{x}_n} \qquad \ldots (2.9)$$

where $(\bar{x}_i, \sigma_i)$ denote the mean and standard deviation respectively of ith variable, r_{ij} is the correlation coefficient between ith and jth variables, $a_i = w_i/\sigma_i$ and w_i's as also the common specific representation ρ_e are to be solved from the following simultaneous equation system of (n+1) equations given in (2.10) below :

$$\left.\begin{array}{l} w_1 + w_2 + \ldots\ldots\ldots\ldots + w_n = 1 \\ w_1 + w_2r_{12} + \ldots\ldots\ldots + w_nr_{1n} = \rho_e^2 \\ w_1r_{21} + w_2 + \ldots\ldots\ldots + w_nr_{2n} = \rho_e^2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ w_1r_{n1} + w_2r_{n2} + \ldots\ldots + w_n = \rho_e^2 \end{array}\right\} \qquad \ldots (2.10)$$

In this formulation, the point of averages of variables, $(\bar{x}_1, \bar{x}_2, \ldots\ldots \ldots, \bar{x}_n)$, is taken to correspond to the central value of unity for the index I_e^*. But for reasons stated earlier it is convenient to replace the point of averages by the point of critical values of constituent variables, so that this point of unit critical values correspond to the critical value of unity for the index. Such a revised index, denoted by I_e, is proportional to I_e^* and is given by equation (2.11) :

$$I_{ej} = \frac{a_1 x_{1j} + a_2 x_{2j} + \ldots\ldots + a_n x_{nj}}{a_1 + a_2 + \ldots\ldots + a_n} \qquad \ldots (2.11)$$

$$= G_e \; I_{ej}^* , \quad \text{with}$$

$$G_e = \sum_i a_i \bar{x}_i / \sum_i a_i$$

For this index, clearly we have

$$\left. \begin{array}{l} \text{the mean value } \bar{I} = G_e \\ \text{and the corresponding standard deviation } \sigma_I = g/(\sum_i a_i) \end{array} \right\} \qquad \ldots (2.12)$$

2.5.3 Kendall's n-variable Optimal Index :

Finally we discuss this index formulation made by the maximising principle as used by Kendall [1939]. As per this formulation, the formulas for the composite index, denoted by I_g^* and I_g, comparable to I_e^* and I_e respectively, can be written as in equations (2.13) and (2.14); this kind of formulation has also been used in some subsequent chapters.

$$I_{gj}^* = \frac{b_1 x_{1j} + b_2 x_{2j} + \ldots\ldots\ldots + b_n x_{nj}}{b_1 \bar{x}_1 + b_2 \bar{x}_2 + \ldots\ldots\ldots + b_n \bar{x}_n} ; \qquad (2.13)$$

$$\left.\begin{aligned} \text{and} \quad I_{gj} &= \frac{b_1 x_{1j} + b_2 x_{2j} + \ldots\ldots + b_n x_{nj}}{b_1 + b_2 + \ldots\ldots + b_n} \\ &= G_g \cdot I^*_{gj}, \quad \text{with} \\ G_g &= \sum_i b_i \bar{x}_i \Big/ \sum_i b_i \end{aligned}\right\} \quad \ldots (2.14),$$

For this index, clearly

$$\left.\begin{aligned} &\text{the mean value } \bar{I} = G_g \\ &\text{and the corresponding standard deviation } \sigma_I = \frac{(n\rho_g^2)}{(\sum_i b_i)} \end{aligned}\right\} \quad \ldots\ldots (2.15)$$

In these formulations, we have

$$b_i = r_i / \sigma_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.16)$$

where r_i is the ith specific representation. The specific representations r_i's and the corresponding aggregate representation ρ_g are solvable from the <u>matrix equation</u> (2.17) given below :

$$R.r = n\,\rho_g^2 \cdot r, \qquad \ldots\ldots (2.17)$$

where $R = ((r_{ij}))$, the known correlation matrix of the variables, r is the column vector of specific representations r_i's, and $n\rho_g^2 = r' \cdot r$, where r' is the transposed vector of r. For solving the matrix equation (2.17) we use an iterative procedure of computation after Hotelling [1933]. In this iterative procedure at the ith stage of iteration with the knowledge of ith weight vector W_i, we go for the calculation of the next weight vector as follows :

$$R . W_i = \Sigma_{i+1}; \quad \text{and}$$

$$W_{i+1} = \Sigma_{i+1} / M_{i+1}$$

where M_{i+1} is the maximum element in the calculated vector Σ_{i+1}. Combining the above computational steps, we can write

$$R . W_i = M_{i+1} . W_{i+1} \qquad \dots (2.18)$$

The initial vector of our choice Σ_0 is that one with elements as the column sums of the correlation matrix R. The iteration stops when we get the stable weight vector W_S with the condition that

$$W_{S-1} = W_S \qquad \dots (2.19)$$

Any subsequent iteration will not change the weight vector further. As W_{S-1} satisfies the relation (2.18) and also as we have relation (2.19), we can write the relation (2.20) which is comparable to relation (2.17) in structural form

$$R . W_S = M_S . W_S \qquad \dots (2.20)$$

As such, we can take the vector r as proportional to the vector W_S and write

$$W_S = G\, r \, , \qquad \dots (2.21)$$

Where G is the constant of proportionality. Multiplying the relation (2.17) by G and using relations (2.20) and (2.21), we can deduce

$$M_S = n \, \rho_g^2 = r' . r \qquad \dots (2.22)$$

Using relations (2.21) and (2.22), we can further deduce

$$G^2 = W_S' \cdot W_S/M_S$$

and hence our solution vector r is given by

$$r = W_S \sqrt{M_S/(W_S' \cdot W_S)} \qquad \ldots \quad (2.23)$$

2.6 Empirical Evaluations of Over-all Crop Characteristics

2.6.1 Coverage of Field Crops :

For all the three time points 1960-61, 1970-71 and 1980-81 we had to choose a common coverage of crops, although the official publications [ref : Agricultural Situation in India and Estimates of Area and Production of Principal Crops in India] from which data were compiled, had a somewhat extended coverage. But those crops were not at all important and our common coverage accounted for almost cent percent of national cultivation practices. The crops covered in our study are 26 in number which are recorded in column (1) of Table (2.1). At times, we would be interested in certain sub-aggregates of crops, which are also titled and shown in the same Table. Data of these crops were initially compiled for all districts for nine time-points; (1959-60, 1960-61, 1961-62), (1969-70, 1970-71, 1971-72) and (1979-80, 1980-81, 1981-82). To account for crop rotation practices in the same field over years, the data were averaged over three consecutive time-points as shown above, centering the time-points under our consideration, namely 1960-61, 1970-71 and 1980-81. Then the average data for the three time-points are aggregated for the common areal units which are contiguous district-groups with similar or almost similar kind of crop association pattern within each unit. In ascertaining these areal units, common for all three time points, we have made detailed relevant studies regarding the comparability of district boundaries* and also the similarity of crop association besides other related things but are not reproducing those here for the sake of brevity. We have however recorded the important crops by each areal unit in our appendix Table (A.1). Our starting point is thus with three time-points, twenty six crops and one hundred fifty one areal units.

2.6.2 Empirical Estimations :

But before entering into our main investigations with areal breakdowns for different time-points selected, we would like to record here a few back-ground informations on certain over-all crop characteristics for the latest time-point chosen. Relative national importance of different crops are shown by cropped acreage share and also by output value share by crops in columns (2) and (3) of Table (2.1). As we would be interested in comparative studies later by time-points, all crops are valued at constant 1970-71 wholesale prices [for price data, refer to Estimes of Area and Production of Principal Crops in India, 1971-72] to get crop-output values for all the three time-points. As the effects of relative price-mechanism and differential yield rates per acre of crops are exhibited in the output value, the ranking of crops by the two modes, one in physical term and the other in value term, would differ. The ratio of value output share to the cropped acreage share gives the index of <u>land productivity</u> of different crops relative to that

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* Relevant informations have been collected from the year book <u>India</u> (see bibliography).

of all crops (comparable to our definition of relative location factors with a change for sectoral breakdowns instead of areal breakdowns). These data are recorded in column (4) of Table (2.1). When the entries under column (4) is divided by the index value of foodgrains, shown in the same column, we get the estimates of the index of land productivity of different crops relative to that of foodgrains, which are recorded in column (5) of the same Table.

After making estimations of productivity rates and ranks, we go for the details of calculations for the overall spatial concentration ratios along the same line as discussed earlier in section 2.3. In B.D. Pant's [1982] calculation the percentage share demarcating the top and bottom classes of areal units was taken as 1.0 percent (and not the average $\bar{s}$ = 100/75 = 1.33). In our case we have objectively selected a demarcating figure of 0.8 percent (and not the average $\bar{s}$ = 100/151 = 0.66). Yet there is a common point in both the studies; the top class in both accomodates about a third of total number of areal units for the most wide spread aggregate all cropped acreage (in our case it is also true for other wide spread aggregates like foodgrains). In fact, our demarcation figure is done with a thorough study by varying the demarcating points at regular interval of 0.05 percent between 0.55 and 1.00 percents and calculating the values of spatial concentration ratio corresponding to each demarcating point (for several aggregates like (1) all cropped acreage, (2) foodgrains acreage, (3) foodgrains and oilseeds acreage etc.). It is noticed that the values of spatial concentration ratio decrease with the increase in demarcating values to start with and then stabilise over a considerable range (refer to the graphs shown in Figures g_1 and g_2). The demaracting point at which the spatial concentration ratio starts stabilising, is finally selected which is 0.08 percent. The demarcating point for the value of all cropped output became the same 0.8 per cent in a similar exercise done for spatial concentration ratio estimates in output value term. But here the top class accomodates a little less than a third of total number of areal units. Anyway, a common demarcating point should better be chosen for both in order to achieve comparability and in the event of any difference, we should go by that demarcating point done by the pure physical variable of cropped acreage. Once the common demarcating point is decided, not only for the two types but also for all crops, the remaining calculations are simple, details of which are shown in the two Tables (2.2) and (2.3) for (i) cropped acreages and (ii) cropped output values. The spatial concentration ratios are finally expressed in a changed scale of (1/36) part of initial ratio estimates. The choice of scale at 36 is such that about one third of all initial ratio estimates is just above 36. This has been done to facilitate classification of crops by the estimated final spatial concentration ratios; for the final estimates, the middle one third of crops are in the range of 0.4 and 1.0. Thus the classification for values will be as follows :

Type of Spatial Concentration	Class Symbols	Value Range of the Spatial Concentration Ratio
least concentration	LC	0.4 and below
moderate concentration	MC	above 0.4 upto 1.0
high concentration	HC	above 1.0 upto 2.0
extreme concentration	EC	above 2.0

Fig. 3.1 Behaviour Pattern of Spatial Concentration Ratio for Gross Cropped Area by Crops/Categories India : 1980-81

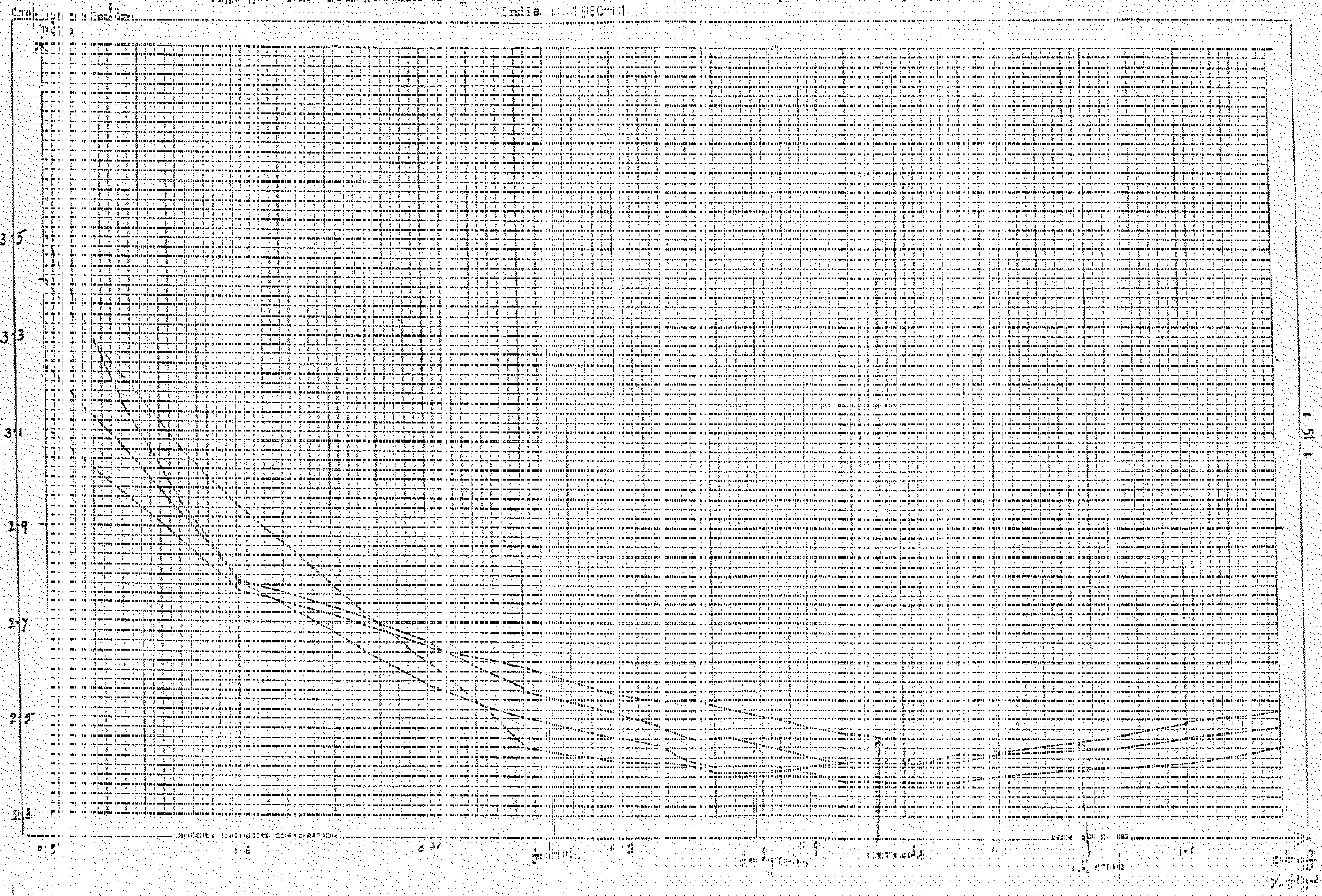


Fig. [illegible] Behaviour Pattern of Spatial Concentration Ratio for value of Crop Output by Crop-aggregates, India : 1980-83

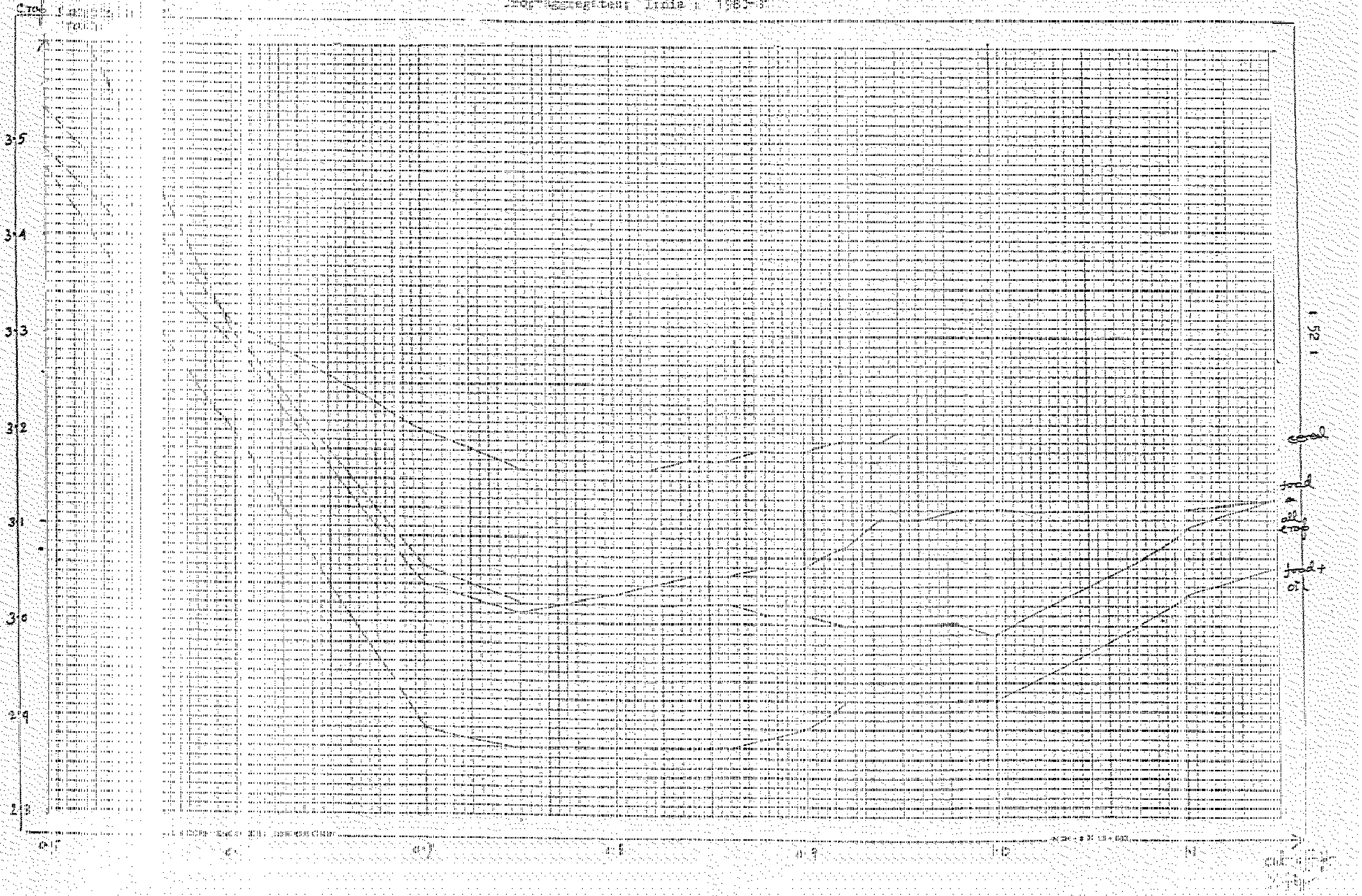


Table (2.1) : Shares of National Cropped Acreages and Output Values and the Land Productivity of Crops in India : 1980-81

	Crops	percent of national total		land productivity of crops relative to	
		cropped acreage	output value	all crops	foodgrains
	(1)	(2)	(3)	(4)	(5)
	major foodgrains	44.335	52.291	1.1795	1.3645
1	Rice	28.743	35.792	1.2453	1.4407
2	Wheat	15.592	16.499	1.0582	1.2242
	minor foodgrains	22.767	9.866	0.4333	0.5013
3	Jowar	11.936	5.215	0.4369	0.5054
4	Bajra	8.910	3.346	0.3755	0.4344
5	Ragi	1.921	1.305	0.6795	0.7861
	Other foodgrains	13.532	7.547	0.5577	0.6452
6	Maize	4.365	2.986	0.6841	0.7914
7	Barley	1.495	0.896	0.5991	0.6931
8	Gram	5.783	2.626	0.4541	0.5253
9	Tur	1.889	1.039	0.5501	0.6364
	Oilseeds	8.799	6.824	0.7756	0.8973
10	Groundnut	5.097	4.939	0.9691	1.1211
11	Mustard (including Repeseed)	1.201	0.827	0.6889	0.7966
12	Sesamum	1.157	0.539	0.4657	0.5388
13	Linseed	1.002	0.343	0.3421	0.3958
14	Castorseed	0.342	0.176	0.5158	0.5967

Table (2.1) Concluded

Crops		percent of national total		land productivity of crops relative to	
		cropped acreage	output value	all crops	foodgrains
(1)		(2)	(3)	(4)	(5)
	Fiber crops	6.229	4.756	0.7635	0.8833
15	Cotton	5.378	3.428	0.6374	0.7374
16	Jute	0.588	1.067	1.8151	2.0998
17	Mesta	0.263	0.261	0.9923	1.1480
18	Sugarcane	2.280	8.945	3.9234	4.5389
19	Potato	0.498	2.569	5.1577	5.9668
	Spices	0.851	2.261	2.6568	3.0736
20	Chillies (dry)	0.669	1.816	2.7141	3.1399
21	Pepper (black)	0.096	0.136	1.4171	1.6394
22	Turmeric	0.062	0.227	3.6680	4.2434
23	Ginger (dry)	0.024	0.082	3.4084	3.9431
24	Tobacco	0.336	1.419	4.2235	4.8860
	Plantation crops	0.373	3.522	9.4426	10.9239
25	Tea	0.260	3.078	11.8397	13.6970
26	Coffee	0.113	0.444	3.9275	4.5436
	All foodgrains	80.634	69.704	0.8644	1.0000
	All non-foodgrains	19.366	30.296	1.5644	1.8098
	Non-foodgrains excluding oilseeds	10.567	23.472	2.2213	2.5697
	All crops	100.000	100.000	1.0000	1.1569

Table (2.2) : Cropped Acreage Ranks and the Spatial Concentration Ratio by Crops in India : 1980-81

Crops		Cropped acreage ranks	Top class of areal units		Bottom class of areal units		Ratio of top to bottom shares per unit : $\frac{\text{col (4)}}{\text{col (6)}}$	Concentration ratio S: $= \frac{1}{36}$ of col.(7) (scale altered)
			number of areal units	average % share per areal unit	number of areal units	average % share per areal unit		
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Rice	1	42	1.768	109	.236	7.486	0.208
2	Wheat	2	47	1.655	104	.214	7.743	0.215
3	Jowar	3	40	2.190	111	.111	19.638	0.546
4	Bajra	4	30	2.776	121	.138	20.100	0.558
5	Ragi	10	33	2.749	118	.079	34.938	0.971
6	Maize	8	44	1.836	107	.180	10.213	0.284
7	Barley	12	34	2.520	117	.122	20.577	0.572
8	Gram	5	38	2.083	113	.184	11.294	0.314
9	Tur	11	39	1.952	112	.213	9.163	0.255
10	Groundnut	7	35	2.437	116	.127	19.211	0.534
11	Mustard + Repeseed	13	32	2.497	119	.169	14.795	0.411
12	Sesamum	14	44	1.729	107	.224	7.728	0.218
13	Linseed	15	32	2.717	119	.110	24.781	0.688
14	Castorseed	19	15	5.842	136	.091	64.237	1.784
15	Cotton	6	27	3.347	124	.078	43.141	1.198
16	Jute	17	11	8.742	140	.027	318.669	8.852
17	Mesta	21	19	4.791	132	.068	70.556	1.960

Table (2.2) Concluded

Crops	Cropped acreage ranks	Top class of areal units		Bottom class of areal units		Ratio of top to bottom shares per unit : $\frac{\text{col (4)}}{\text{col (6)}}$	Concentration ratio S: = $\frac{1}{36}$ of col.(7) (scale altered)
		number of areal units	average % share per areal unit	number of areal units	average % share per areal unit		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
18 Sugarcane	9	30	2.561	121	.191	13.381	0.371
19 Potato	18	35	2.388	116	.141	16.891	0.469
20 Dry chillies	16	39	1.908	112	.229	8.344	0.232
21 Black Pepper	24	4	24.470	147	.014	1696.321	47.120
22 Turmeric	25	28	3.146	123	.097	32.476	0.920
23 Dry Ginger	26	24	3.737	127	.081	46.222	1.284
24 Tobacco	20	19	4.576	132	.099	46.238	1.284
25 Tea	22	11	8.953	140	.011	826.007	22.945
26 Coffee	23	9	10.952	142	.010	1086.842	30.190
All foodgrains	-	52	1.093	99	.436	2.508	0.070
All crops	-	48	1.103	103	.457	2.415	0.067

NB : Each of areal units in top and bottom classes has respectively above or below 0.8% of national acreage by crop.

Table (2.3) : Cropped Output Value Ranks and the Spatial Concentration Ratio by Crops in India : 1980-81

Crops	Cropped output value ranks	Top class of areal units		Bottom class of areal units		Ratio of top to bottom shares per unit : col (4) / col (6)	Concentration ratio S: = $\frac{1}{36}$ of col (7) (scale altered)
		number of areal units	average % share per areal unit	number of areal units	average % share per areal unit		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Rice	1	43	1.697	108	.250	6.787	0.189
2 Wheat	2	39	1.999	112	.197	10.150	0.282
3 Jowar	4	35	2.395	116	.139	17.176	0.477
4 Bajra	7	39	2.248	112	.110	20.409	0.567
5 Ragi	14	29	3.112	122	.080	38.952	1.082
6 Maize	9	42	1.904	109	.184	10.371	0.288
7 Barley	17	34	2.591	117	.102	25.454	0.707
8 Gram	10	39	2.124	112	.153	13.873	0.385
9 Tur	16	36	2.159	115	.194	11.158	0.310
10 Groundnut	5	32	2.597	119	.142	18.290	0.508
11 Mustard + Repeseed	18	31	2.632	120	.153	17.153	0.476
12 Sesamum	19	45	1.713	106	.216	7.932	0.220
13 Linseed	21	36	2.457	115	.100	24.502	0.681
14 Castorseed	24	19	4.776	132	.070	68.052	1.890

Table (2.3) Concluded

Crops	Cropped output value ranks	Top class of areal units		Bottom class of areal units		Ratio of top to bottom shares per unit : $\frac{\text{col (4)}}{\text{col (6)}}$	Concentration ratio S: $= \frac{1}{36}$ of col (7) (scale altered)
		number of areal units	average % share per areal unit	number of areal units	average % share per areal unit		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
15 Cotton	6	24	3.718	127	.085	43.824	1.217
16 Jute	15	11	8.740	140	.028	316.889	8.802
17 Mesta	22	17	5.428	134	.058	94.199	2.617
18 Sugarcane	3	35	2.323	116	.161	14.400	0.400
19 Potato	11	32	2.648	119	.128	20.630	0.573
20 Dry Chillies	12	34	2.212	117	.212	10.445	0.290
21 Black Pepper	25	5	19.741	146	.009	2230.471	61.958
22 Turmeric	23	27	3.269	124	.095	34.534	0.959
23 Dry Ginger	26	20	4.550	131	.069	66.233	1.840
24 Tobacco	13	19	4.686	132	.083	56.436	1.568
25 Tea	8	9	10.817	142	.019	579.889	16.108
26 Coffee	20	9	10.905	142	.013	832.969	23.138
All foodgrains	-	40	1.304	111	.431	3.027	0.084
All crops	-	43	1.270	108	.420	3.024	0.084

2.6.3 Findings :

On the basis of our analysis of estimates presented in these three Tables, certain comparative crop characteristics emerge which can be briefly stated as follows :

(i) Our arable cropping is mostly devoted to production of foodgrains; more than 80 per cent of total gross cropped area are utilised in this aggregate sector. The relative price advantage of non-foodgrain crops is responsible to bring down the foodgrains output value to a little lower level of about 70 per cent of all outputs. This relative price advantage is, however, not exhibited for all non-foodgrain crops. In fact, the behaviour of oilseeds as considered here (note that coconut is not included in our coverage of oilseeds on which there is no official record, particularly for the early years) is very much like that of foodgrains --- acreages devoted to oilseeds production is about 8.8 per cent of national total cropping with a lower output value of about 6.8 per cent. Together, foodgrains and oilseeds account for about 89.4 per cent of total cropped acreage and 76.5 per cent of total crop output value;

(ii) Among foodgrain crops, even among foodgrains and oilseed crops, it is only the two important cereals, namely, rice and wheat, for which the output value share has exceeded the corresponding acreage share and for no other foodgrain and oilseed crops it is so. As a result, it is only these two crops among foodgrains and oilseeds, where land productively relative to that of all crops have shown above unity values (1.25 for rice and 1.06 for wheat). When the land productivity is seen relative to that of aggregate of foodgrains, the estimates become higher to 1.44 for rice and 1.22 for wheat. In this comparative measure only groundnut has above unity productivity relative to foodgrains ---- about 1.12 in magnitude, exhibiting that it is the most important oilseed among those considered in this category;

(iii) Highest single-crop acreage share is also noticed only for rice and wheat --- about 28.7 per cent and 15.6 per cent respectively. This fact together with the exhibited fact of highest productivity ratings of these two crops among all foodgrain and oilseed crops, can be taken to support the view that these two crops receive highest attention in the Indian agricultural scene. It is possible that the "new agricultural strategy" might have been most successful with these two crops as a result of which the national foodgrains imports are no longer there. But the question arises : why not the agricultural planning attention be extended to other serious deficit sectors as well, for example, to the production of oilseeds for which we have not been able to eliminate national imports yet;

(iv) The non-foodgrain and non-oilseed crops generally have quite high productivity ratings (about 2.22 relative to all crops for this group as a whole), except for cotton which has much below unity relative land productivity. In this group of, say, cash crops, cotton is most important in acreage share and sugarcane is most important in value share. The productivity rating of sugarcane is, however, is quite high with a magnitude of above 3.9 when measured relative to that of all crops and about 1.8 when measured relative to that of all cash crops. But the low productivity of an important cash crop like cotton (over half of cash crop acreages is devoted to this crop) is not very encouraging;

(v) In a vast country like India, although there is a variation in the degree of spatial concentration or localisation among crops, all crops are bound to be localised (it is to be noted that the values of concentration ratio S are much above those of most wide-spread aggregates of all crops or all foodgrains). As such a classification of crops on the basis of values of S is made below to identify their nature of localisation. We would classfy the crops in terms of S (acreage) and for each crop we give the ratio estimate r of S (output) to S (acreage). As we are dealing with a single crop in the estimation of r, it is not affected by the relative price differential of different crops. What the estimate of r gives is again a kind of pure land productivity rating for the top class of areal units (core areas for the crop) relative to that of the corresponding bottom class. Thus we have the following classification of crops along with their physical productivity rating estimates r, shown within parentheses next to the crops :

Least localised (or concentrated) crops (LC) : $S \leq 0.4$

1. rice (0.909), 2. wheat (1.312), 3. maize (1.014), 4. gram (1.226), 5. tur (1.216), 6. sesamum (1.023), 7. sugarcane (1.078), 8. dry chillies (1.250);

Moderately localised crops (MC) : $0.4 < S \leq 1.0$

1. jowar (0.874), 2. bajra (1.016), 3. ragi (1.114), 4. barley (1.236), 5. groundnut (0.951), 6. mustard & rapeseed (1.158), 7. linseed (0.990), 8. potato (1.222), 9. turmeric (1.063);

Highly localised crops (HC) : $1.0 < S \leq 2.0$

1. cotton (1.016), 2. castorseed (1.059), 3. mesta (1.335), 4. dry ginger (1.433), 5. tobacco (1.221);

Extremely localised crops (EC) : $S > 2.0$

1. jute (0.994), 2. black pepper (1.315), 3. tea (0.702) and 4. coffee (0.766).

Except for marginal changes with ragi and mesta (due to their bordering positions in their respective classes and also due to their above unity productivity ratings r), the above classification is retained, if done by S (output) values.

(vi) Among all crops considered, only four crops, namely, tea, coffee, jowar and rice, have values of productivity ratings r, considerably below unity (say, below 0.91). On the other hand, another four crops, namely, dry ginger, mesta, black pepper and wheat have very high productivity ratings with values of r above 1.31. The productivity ratings of eight crops : ragi, barley, gram, tur, mustard & rapeseed, potato, dry chillies and tobacco can be considered as high with values of r between, say 1.09 and 1.31. The remaining ten crops have moderate productivity ratings with values of r between 0.91 and 1.09.

(vii) Contrasting the relative land productivity index values (ref. to Table (2.1)) of the two major cereal crops, rice and wheat, and also the values of the between-class productivity ratings r, we infer that the core wheat producing areas are in much more advantageous position in respect of physical yield rates than the core rice producing areas in the country. If rice had shown better land productivity relative to that of wheat (1.2453/1.0582 = 1.1768), it is because it had the benefit of relative price advantage. In fact, the 1970-71 relative price used for rice to wheat was 1.3642, a figure that supports our contention more than adequately. It is rather alarming that the most important crop of rice has not shown the deserving attention, that it would require for a betterment of physical yield rates in its wide-spread core areas, in line with the nation's second important crop of wheat.

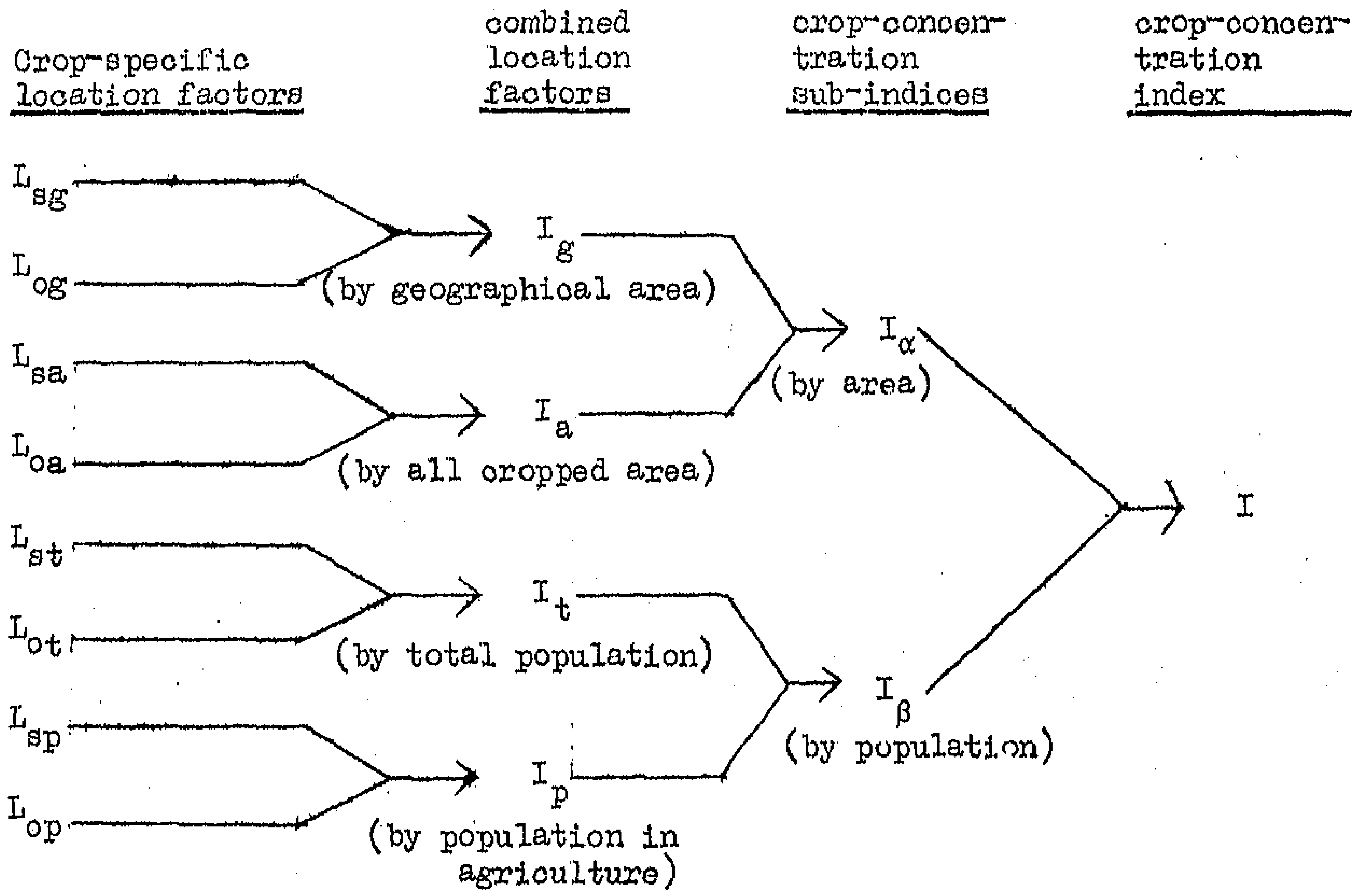
(viii) The attention to the nation's third important crop of jowar is also lacking in the core jowar producing areas, but here the crop itself, generally grown in low rainfall areas, is low productive as compared to wheat (ref. to Table (2.1)), which cannot be explained at all by jowar-wheat price relatives (the land productivity of jowar relative to that of wheat is 0.4129 (= 0.4369/1.0582), but the value of 1970-71 jowar-wheat price relative used has been 0.8878).

(ix) Unlike the foodgrain crops like rice, wheat and jowar, the cash crops like tea and coffee are extremely localised (the values of S (acreage) for these two crops are as extremely high as 23 and 30 respectively) and it cannot happen without the presence of tremendous locational advantage in the actual producing areas of these crops, whether they belong to top class or bottom class of areal units in our classification scheme. If the between-class productivity rating r has shown as low a value as 0.702 for tea and 0.766 for coffee, the actual producing areas in the bottom class, possibly lying in the fringe of core producing areas in the top class, has higher productivity either by the relatively increasing scale effect in the fringe areas or by the relatively diminishing scale effect in the core producing areas. This situation is in contrast to that of the most extremely localised crop of black pepper (with S (acreage) value = 47), showing very high between-class productivity rating (r = 1.315). Certainly the attention for yield rate improvements in the core producing areas of these two export-earning crops is called for. Another extremely localised crop is jute (value of its S (acreage) = 8.9), which does not practically show any difference in productivity rating between top and bottom classes of areal units, i.e., between the core and the fringe producing areas of jute (value of r = 0.99, i.e., almost unity) but the land productivity of jute relative to that of all cash crops (i.e., all non-foodgrain and non-oilseed crops) is somewhat low; lower than unity, about 0.817 (= 1.8151/2.2213). Again the two important cash crops, cotton and sugarcane, do not have much of difference in between-class productivity rating (value of r is 1.016 for cotton and 1.078 for sugarcane, both in the medium class of values around unity), although the land productivity of cotton relative to that of sugarcane has been seen to be much lower than unity (about 0.1625 = 0.6374/3.9234). Perhaps the price structure as was prevalent in 1970-71 was not that favourable to cotton as was to sugarcane. But pricing structure cannot be the sole cause; something must have been wrong with the physical productivity of cotton relative to that of sugarcane.

2.7 Formulation of Crop-Concentration Indices

2.7.1 Introduction

Having our analysis on the overall crop-characteristics of different crops we would now proceed for the explicit and distinct identifications of core producing areas by different crops. The size and intensity of a cropping activity can be measured in various ways. Here we would use "total acreage" as the crop-specific measure of size, or rather the major physical input, and "total output" as the corresponding intensity measure for the cropping activity. The size variable of 'acreage' is designated below by s and the 'output' variable by o. We have already argued that any 'total' variable cannot achieve comparability between areal units of varying geographical areas, unless they are examined in relation to some other variable as in the form of a location factor, already discussed in section 2.3. Such variables neutralising the size differentials of areal units, can be both "total geographical area" and "total population". Again for our present interest in agricultural activity, the area and population variables have also been restricted to "all cropped area" and "population in agricultural sector". These four variables would be designated as follows : g for "geographical area", a for "all cropped area", t for "total population" and p for "population in agricultural sector". The combination of two numerator variables, s and O, and four denominator variables, g, a, t and p, would generate eight location factors of both absolute and relative varieties (both would be designated below in the mode of relative variety for avoiding confusion of symbols). Thus we have eight crop-specific location factors, namely L_{sg}, L_{og}, L_{sa}, L_{oa}, L_{st}, L_{ot}, L_{sp} and L_{op}. All these location factors measure the size and intensity of cropping activity for the same crop; an integrated ranking of areal units for the level of crop-concentration requires the consideration of all these location factors simultaneously. So following our arguments given earlier, we would go for a construction of composite crop-concentration index out of these eight location factors for a crop or a crop-aggregate. As we have here three 'pair' variables, namely a pair of numerator variables, a pair of population variables and also a pair of area variables in the denominator, we would go for the double variable index formulations in the sequence as presented below diagramatically : (we have already mentioned the merit of this mode of index construction in our preceeding discussions in section 2.5).



Following this scheme of index formulation, we have made the empirical estimations of all crops and some selected crop-aggregates and used them in our subsequent study for identifying the crop-regions of India. But the crop-concentration patterns for some of the minor crops are so limited in areal coverage that it is not worth while to take the trouble of mapping those crop-concentration indices individually. Moreover, for the sake of brevity, we have shown the computed results for some important crops and crop-aggregates without showing those for all crops individually. We have, however, used the computed results for all crops individually, when necessary, in our later evaluations for synthetic crop-regions. Thus we would present our empirical estimations for only the following crops (or crop-aggregates, definitions of which are presented in Table (2.1)) :

(1) Rice, (2) Wheat, (3) Minor foodgrains, (4) Other foodgrains, (5) Oilseeds, (6) Groundnut, (7) Fibre crops, (8) Sugarcane, (9) Potato, (10) Spices, (11) Tobacco and (12) Plantation crops (Tea & Coffee).

We have recorded below the values of estimated parameters and the coefficients to be attached with location factors constituting the crop-concentration index I and sub-indices I_α and I_β in the Tables (2.4) to (2.8) for all the crops mentioned above. However, the details of computational steps would be shown for only the two most important crops, rice and wheat, after the presentation of Tables (2.4) to (2.8). These Tables are entitled as follows :

Table (2.4) : Representativeness ρ_e of Double-variable Crop-concentration Indices and Sub-indices by Crops; India, 1980-81;

Table (2.5) : Specific Representativeness (r_i's) and Corresponding Aggregate Representativeness (ρ) of the Crop-concentration Index I : India, 1980-81;

Table (2.6) : Coefficients with Location Factors Constituting Crop-concentration Index I by Crops and Mean and Standard Deviation of I;

Table (2.7) : Coefficients with Location Factors constituting Crop-concentration Sub-index I_α (by area) by Crops and the Aggregate Representativeness (ρ), Mean and Standard Deviation of I_α ; and

Table (2.8) : Coefficients with Location Factors Constituting Crop-concentration Sub-index I_{β} (by population) by Crops and the Aggregate Representativeness (ρ), Mean and Standard Deviation of I_{β} and also the Correlation Coefficients between I_{α} and I_{β}.

Table (2.4) : Representativeness (ρ_e) of Double variable Crop-concentration Indices and Sub-indices by Crops; India : 1980-81

Crop-and crop-aggregates	Combined location factors				Crop-concentration indices		
	I_g	I_a	I_t	I_p	I_{α} (area)	I_{β} (population)	I (composite)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Rice	.9800	.9900	.9755	.9746	.9026	.9735	.9636
2 Wheat	.9872	.9835	.9685	.9770	.9368	.9929	.9820
3 Minor foodgrains	.9781	.9796	.9587	.9572	.9452	.9526	.9663
4 Other foodgrains	.9865	.9873	.9833	.9844	.9017	.9893	.9771
5 Oilseeds	.9870	.9831	.9825	.9883	.9734	.9936	.9846
6 Groundnut	.9957	.9921	.9963	.9980	.9839	.9952	.9875
7 Fibre crops	.8919	.9418	.9271	.9367	.9515	.9899	.9773
8 Sugarcane	.9959	.9750	.9887	.9938	.9841	.9946	.9951
9 Potato	.9868	.9429	.9666	.9986	.9308	.9147	.9442
10 Spices	.9622	.9396	.9631	.9734	.9757	.9255	.9654
11 Tobacco	.9872	.9740	.9866	.9859	.9902	.9971	.9981
12 Tea & Coffee	.9926	.9873	.9974	.9947	.9882	.9945	.9835

Table (2.5) : Specific Representativeness (r_i's) and the Corresponding Aggregate Representativeness (ρ) of the Crop-concentration Index I; India : 1980-81

Crops and crop aggregates	Specific representation (r_i) of constituent location factors								Aggregate representation (ρ) of index I
	L_{sg}	L_{og}	L_{sa}	L_{oa}	L_{st}	L_{ot}	L_{sp}	L_{op}	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Rice	.8243	.8034	.9124	.8876	.8756	.9245	.9503	.9081	.8870
2 Wheat	.9359	.8966	.8895	.9039	.9313	.9582	.9685	.9361	.9279
3 Minor foodgrains	.8933	.8232	.9435	.9162	.8796	.9500	.8721	.8256	.8891
4 Other foodgrains	.8707	.8408	.9134	.8931	.9329	.9706	.9371	.9637	.9115
5 Oilseeds	.9575	.9246	.9367	.9578	.9528	.9829	.9585	.9618	.9542
6 Groundnut	.9791	.9575	.9589	.9671	.9822	.9918	.9738	.9718	.9728
7 Fibre crops	.9000	.7175	.9055	.8897	.8606	.9378	.8942	.9140	.8797
8 Sugarcane	.9669	.9826	.9848	.9260	.9841	.9742	.9802	.9858	.9734
9 Potato	.9035	.7842	.8885	.8136	.9125	.9615	.7390	.7748	.8505
10 Spices	.9042	.9015	.8699	.9071	.8809	.8512	.8782	.8504	.8807
11 Tobacco	.9898	.9522	.9635	.9709	.9633	.9953	.9868	.9810	.9755
12 Tea & Coffee	.9442	.9720	.9388	.9928	.9747	.9419	.9982	.9823	.9684

Table (2.6) : Coefficients with Location Factors Constituting Crop-concentration Index I by Crops and the Mean and Standard Deviation of I

Crops and crop-aggregates	Index I	Coefficients of location factors							
		L_{sg}	L_{og}	L_{sa}	L_{oa}	L_{st}	L_{ot}	L_{sp}	L_{op}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rice	I_1	.10396	.09545	.11887	.15483	.12490	.13457	.13848	.12894
Wheat	I_2	.10205	.06957	.19490	.19737	.13544	.10791	.11204	.08071
Minor foodgrains	I_3	.15720	.15894	.17890	.10682	.08681	.12700	.08263	.10170
Other foodgrains	I_4	.13605	.11823	.18980	.11743	.11728	.11237	.10718	.10166
Oilseeds	I_5	.16257	.11815	.19111	.13116	.11850	.09512	.10352	.07987
Groundnut	I_6	.14294	.13403	.16655	.14953	.11043	.10891	.09536	.09225
Fibre crops	I_7	.14120	.09185	.17959	.12805	.10190	.13587	.10354	.11800
Sugarcane	I_8	.06100	.07010	.12339	.21129	.14457	.15750	.10951	.12264
Potato	I_9	.11128	.08987	.10440	.23814	.17183	.22169	.02614	.03665
Spices	I_{10}	.10702	.11839	.06982	.13909	.16820	.15841	.11710	.12197
Tobacco	I_{11}	.11199	.09121	.11523	.13732	.12815	.12078	.15775	.13757
Tea & Coffee	I_{12}	.12265	.12487	.08474	.16023	.14536	.12788	.12142	.11285

Indices	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}
Mean	1.0023	1.1542	1.0825	1.2870	0.9878	0.9081	0.9513	0.9293	1.1107	1.0683	0.8175	1.4051
Standard deviation	0.8755	1.4032	1.2297	1.3525	1.2996	1.9774	1.6749	1.8272	2.3975	1.5057	2.8404	3.5422

Table (2.7) : Coefficients with Location Factors Constituting Crop-concentration Sub-index I_α (area) by Crops and the Aggregate Representativeness (ρ) Mean and Standard Deviation of I_α

	Crops	Coefficients with location factors (for I_α)				Characteristics of I_α		
		L_{sg}	L_{og}	L_{sa}	L_{oa}	ρ	mean	standard deviation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Rice	.21975	.20175	.25125	.32725	.8892	1.0737	0.9603
2	Wheat	.18098	.12336	.34563	.35003	.9234	1.1085	1.2670
3	Minor foodgrains	.26120	.26408	.29724	.17748	.9253	0.9957	1.0572
4	Other foodgrains	.24229	.21055	.33802	.20914	.8903	1.2461	1.2325
5	Oilseeds	.26961	.19594	.31693	.21752	.9590	0.9364	1.0945
6	Groundnut	.24103	.22601	.28083	.25213	.9779	0.8691	1.6883
7	Fibre crops	.26115	.16988	.33214	.23683	.8736	0.9143	1.5848
8	Sugarcane	.13096	.15049	.26492	.45363	.9701	0.9697	1.9711
9	Potato	.20467	.16530	.19202	.43801	.8994	1.1737	2.3351
10	Spices	.24641	.27258	.16076	.32025	.9280	1.1222	1.7954
11	Tobacco	.24572	.20014	.25284	.30130	.9710	0.8860	3.1220
12	Tea & Coffee	.24904	.25355	.17206	.32535	.9783	1.4921	3.6566

Table (2.8) : Coefficients with Location Factors Constituting Crop-concentration Sub-index I_β (population) by Crops and the Aggregate Representativeness (ρ), Mean and Standard Deviation of I_β and also the Correlation Coefficient between I_α and I_β

Crops	Coefficients with location factors (for I_β)				Characteristics of I_β			Correlation coefficient
	L_{st}	L_{ot}	L_{sp}	L_{op}	ρ	mean	standard deviation	$r_{I_\alpha I_\beta}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 Rice	.23705	.25540	.26283	.24472	.9494	0.9382	0.8623	.8570
2 Wheat	.31057	.24745	.25691	.18507	.9660	1.2132	1.6383	.9288
3 Minor foodgrains	.21805	.31898	.20753	.25544	.9130	1.2138	1.5981	.8075
4 Other foodgrains	.26747	.25627	.24442	.23184	.9733	1.3394	1.5783	.9095
5 Oilseeds	.29847	.23960	.26075	.20118	.9791	1.0658	1.6623	.9390
6 Groundnut	.27136	.26763	.23432	.22669	.9923	0.9650	2.4604	.9503
7 Fibre crops	.22185	.29581	.22543	.25691	.9227	0.9948	1.8656	.9103
8 Sugarcane	.27062	.29481	.20500	.22957	.9859	0.8940	1.7186	.9805
9 Potato	.37656	.48584	.05728	.08032	.8990	1.0356	2.7824	.7831
10 Spices	.29735	.28003	.20701	.21561	.8962	1.0270	1.3785	.8641
11 Tobacco	.23547	.22192	.28984	.25277	.9835	0.7601	2.6143	.9926
12 Tea & Coffee	.28641	.25197	.23925	.22237	.9907	1.3207	3.5484	.9345

2.7.2 Details of Computational Steps for Rice

The double-variable index formulation of Pal [1968] as presented in modified form earlier in equations (2.7a) and (2.7b) is followed here. The starting point of present index formulation in pairs of variables sequentially is to get the correlation matrix of all variables, here eight location factors for rice, along with their means and standard deviations. These data are shown in Table (2.9) below :

Table (2.9) : Correlation Matrix, Means and Standard Deviations for Location Factors : Rice

	L_{sg}	L_{og}	L_{sa}	L_{oa}	L_{st}	L_{ot}	L_{sp}	L_{op}
	1.0000							
	0.9207	1.0000						
	0.6716	0.5987	1.0000					
	0.6087	0.5637	0.9603	1.0000				
	0.6029	0.4981	0.8063	0.7962	1.0000			
	0.6332	0.6746	0.7826	0.7922	0.9032	1.0000		
	0.7106	0.6492	0.8768	0.8269	0.8972	0.8877	1.0000	
	0.6633	0.7610	0.7646	0.7386	0.7224	0.8975	0.8998	1.0000
Mean	1.1082	1.1537	1.1386	0.9514	0.9396	0.9300	0.9258	0.9587
Standard deviation	1.2351	1.3452	1.0692	0.8209	0.9576	0.8888	0.8645	0.9284

From the data of Table (2.9) we can easily compute the following combined location factors by use of formulations and equations given earlier in (2.7a) and (2.7b) :

$I_g = 0.521352\ L_{sg} + 0.478648\ L_{og}\ ;\ \rho_e = 0.97997;$

$I_a = 0.434323\ L_{sa} + 0.565688\ L_{oa}\ ;\ \rho_e = 0.99003;$

$I_t = 0.48137\ L_{st} + 0.51863\ L_{ot}\ ;\ \rho_e = 0.97550;$ and

$I_p = 0.51784\ L_{sp} + 0.48216\ L_{op}\ ;\ \rho_e = 0.97463$

The correlation matrix of these four combined location factors, as can be computed by use of formula (2.8), and also their means and standard deviations, as can be computed by the formulas (2.7a) and (2.7b) are shown below in Table (2.10) :

Table (2.10) : Correlation Matrix, Mean and Standard Deviations of the four combined Location Factors : Rice

	I_g	I_a	I_t	I_p
	1.00000			
	0.62943	1.00000		
	0.62994	0.82250	1.00000	
	0.72873	0.83090	0.89536	1.00000
Mean	1.13000	1.03268	0.93459	0.94166
Standard deviation	1.26203	0.91952	0.89934	0.87259

On the basis of these estimates of Table (2.10), we can compute the two crop-concentration sub-indices I_α and I_β given below, with the relevant parameters shown below their algebric formulations :

$$I_\alpha = 0.42150\ I_g + 0.57850\ I_a\ ; \quad \rho_e = 0.90262$$

$$\bar{I}_\alpha = 1.07370 \text{ and } \sigma_\alpha = 0.96028;$$

$$I_\beta = 0.49245\ I_t + 0.50755\ I_p\ ; \quad \rho_e = 0.97349$$

$$\bar{I}_\beta = 0.93818 \text{ and } \sigma_\beta = 0.86228; \text{ and}$$

the correlation coefficient between I_α and I_β : $r_{\alpha\beta} = 0.85698$. Finally we compute the crop-concentration index I for rice as given below :

$$I = 0.47311\ I_\alpha + 0.52689\ I_\beta\ ; \quad \rho_e = 0.96358,$$

$$\bar{I} = 1.00230 \text{ and } \sigma_I = 0.875557.$$

We have altogether seven double-variable index formulations and on the basis of preceding formulations, last three formulations for I_α, I_β and for I can be expressed in terms of relevant original location factors. In Tables (2.6) to (2.8) we have given the coefficients of relevant location factors for such equations respectively for I, I_α and I_β. The correlation coefficients of I with all the eight location factors can also be estimated, which are really specific representations for the final formulation of I with all eight location factors. These specific representations, together with the corresponding aggregate representation ρ of I have been recorded in Table (2.5). The representativeness ρ_e of all seven double-variable formulations are recorded in Table (2.4). The four-variable aggregate representations (ρ), means and standard deviations for I_α and I_β are recorded in Tables (2.7) and Table (2.8) respectively. The means and standard deviations of I by crops are recorded in Table (2.6). Finally, although the correlation coefficient between I_α and I_β is deducible from the values of corresponding ρ_e s given in the last column of Table (2.4), we have recorded the values of $r_{\alpha\beta}$ in Table (2.8).

2.7.3 Detailed Estimations for Wheat :

We would show below the estimations for wheat, following the same steps as described for rice.

Table (2.11) : Correlation Matrix, Means and Standard Deviations for Location Factors : Wheat

	L_{sg}	L_{og}	L_{sa}	L_{oa}	L_{st}	L_{ot}	L_{sp}	L_{op}
	1.0000							
	0.9490	1.0000						
	0.8144	0.6771	1.0000					
	0.7743	0.6668	0.9345	1.0000				
	0.7850	0.6955	0.8779	0.9102	1.0000			
	0.8778	0.9137	0.7422	0.7978	0.8761	1.0000		
	0.8573	0.8068	0.8508	0.8804	0.9597	0.9273	1.0000	
	0.8810	0.9436	0.6922	0.7367	0.8094	0.9817	0.9089	1.0000
Mean	1.3715	1.5084	0.9583	0.9799	1.1718	1.1348	1.2706	1.3079
Standard deviation	1.8925	2.7763	0.9947	0.9822	1.3713	1.7211	1.6434	2.2814

From the data of Table (2.11) we compute the following combined location factors :

$I_g = 0.594642\, L_{sg} + 0.405358\, L_{og}$; $\rho_e = 0.987178$;

$I_a = 0.496843\, L_{sa} + 0.503157\, L_{oa}$; $\rho_e = 0.983481$;

$I_t = 0.556561\, L_{st} + 0.443439\, L_{ot}$; $\rho_e = 0.968540$; and

$I_p = 0.581278\, L_{sp} + 0.418722\, L_{op}$; $\rho_e = 0.976967$

Table (2.12) : Correlation Matrix, Mean and Standard Deviations of the four combined Location Factors : Wheat

	I_g	I_a	I_t	I_p
	1.0000			
	0.7551	1.0000		
	0.8555	0.8735	1.0000	
	0.9043	0.8222	0.9718	1.0000
Mean	1.4270	0.9692	1.1554	1.2862
Standard deviation	2.2219	0.9721	1.4784	1.3665

From the estimates of Table (2.12), we compute for I_α and I_β the following associated relevant estimated parameters :

$I_\alpha = 0.30434\, I_g + 0.69566\, I_a$; $\rho_e = 0.93679$,

$\bar{I}_\alpha = 1.10852$ and $\sigma_\alpha = 1.26695$ and

$I_\beta = 0.55802\, I_t + 0.44198\, I_p$; $\rho_e = 0.99292$,

$\bar{I}_\beta = 1.21322$, $\sigma_\beta = 1.63823$ and $r_{\alpha\beta} = 0.92878$

We then get crop-concentration index I for wheat as

$$I = 0.56390\ I_{\alpha} + 0.436100\ I_{\beta}\ ;\ \rho_e = 0.98203$$

2.7.4 Some Brief Comments on Crop-concentration Indices :

For other crops or crop-aggregates such details of computational estimates have been followed, but not presented here. As the correlation coefficient r_{12} between any pair of variables, say, x_1 and x_2, is connected with the aggregate representation ρ_e of the corresponding double-variable index by the following relation :

$$r_{12} = 2\rho_e^2 - 1,$$

the relation between any pair of constituent variables of seven indices, shown in Table (2.4) can be inferred. Moreover, since the values of ρ_e are same as the corresponding constituent specific representations of the double-variable indices, we have sufficient summary information in the values of ρ_e in Table (2.4). As these values are sufficiently high, we can infer that the measurements of crop-concentration in various forms of location factors have very close agreement, apart from certain minor variations from crop to crop. For example, the least value of ρ_e (about 0.892) has occurred for the index I_g (absolute index) for the aggregate of fibre crops; the overwhelmingly major constituent of which is cotton. This corresponds to a value of about 0.591 for the correlation coefficient between the corresponding constituent variables, namely, the absolute location factors L_{sg} and L_{og} by acreage and by output of the crop. So this is also the least such value compared to any other crops or any other double-variable, paired for index construction. Thus we notice that the acreage size and the output intensity are in least agreement for this crop-aggregate. Earlier also we have detected this fact in our overall crop-productivity analysis for all the crops. In Table (2.5) we note the differential roles of all initial location factors constituting the final crop-concentration index I. Here also we notice that all specific representations for all crops are sufficiently high, showing the general agreements among the location factors in reflecting the crop-concentrations on space. Of course, there will be minor variations in fringe areas (around the cores), since specific representation values are below unity (the value for perfect unity). For unifying our decisions on the ranking of the areal units by crop-concentration, we have depended on index I, and not on a single location factor. After all, things are to be judged from all angles to make a correct decision and it is with this motive we will bank on this index I rather than on a single location factor. Yet a single location factor, at times, does reveal some picture of its own. Again, for example, for the representation of L_{og} (absolute crop output location factor) for the fibre crops (mainly reflecting cotton) in the index I, the fibre crop (cotton) output variable is in least agreement with final index I, which must have been caused by certain local peculiarities those are in existence with the output pattern of this crop. It is quite possible that the core fibre crop producing areas do not have concomitantly high output pattern. It is also possible for jute, that constitutes the aggregate of fibre crops. The aggregate representation (ρ) of the index I, when seen in terms of all eight constituent location factors, is also seen to be quite high, varying between the minimum of 0.85 for potato and the maximum of 0.978 for tobacco (ref. to Table (2.5)). The least value has occurred for potato, because the location factor of crop-acreage relative to agricultural population, L_{sp}, has not enough agreement with the final index I (specific representation here is 0.739, which is just above the minimum value of 0.718 as referred to already for fibre crops, (ref. to estimates of Table (2.5))).

The values of crop-concentration index I for the crops like tobacco, sugarcane, groundnut, plantation crops (tea & coffee) and oilseeds, with very high aggregate representation (values of ρ above 0.95, ref. to Table (2.5)) show highest agreement among constituent location factors, without practically any local peculiarity compared with the general crop-concentration pattern as brought out by the corresponding crop-specific final index I. However, for other crops, like potato, fibre crops, spices, rice and minor foodgrains, with relatively lower ρ values (between 0.85 and 0.90), the agreement among constituent location factors and hence with the index I, is relatively lower with the incidences of local peculiarities. Hence the consideration for composite index I of different location factors is more needed for proper identifications of crop-concentration patterns for these crops. In the Tables (2.6) to (2.8) we have recorded simply the necessary statistical details for arriving at the point estimates (i.e., estimates by areal units) of the index I and its two constituent sub-indices I_α (relative to area variables) and I_β (relative to population variable) and also certain characteristic measures of these indices. We have recorded here, among other things, the aggregate representation ρ of I_α

and I_β and also the correlation coefficient $r_{\alpha\beta}$ between these sub-indices suffixed by α and β. The estimates of $r_{\alpha\beta}$ as recorded in the last column of Table (2.8), generally show that the agreement between the two sub-indices I_α and I_β of I is generally high, with values of $r_{\alpha\beta}$ lying between 0.857 (for rice) and 0.993 (for tobacco) except for potato where the stated agreement is a little lower with its $r_{\alpha\beta}$ being equal to 0.783. Apart from potato and rice, other crops like spices and minor foodgrains also show relatively low agreements between I_α and I_β (values of $r_{\alpha\beta}$ are 0.864 and 0.868 respectively). As I_α is an extension of absolute location factors (i.e., relative to areas) and I_β is an extension of relative location factors (i.e., relative to population), the relatively less agreements between these two sub-indices among crops (as shown by lower $r_{\alpha\beta}$) are possibly suggestive of a more population pressure on land in the core producing areas of these crops. However, I_α and I_β are only intermediate sub-indices towards the computation of our main crop-concentration index I. At times we would use them in our evaluations of crop regions to be undertaken later, but our subsequent work and analysis will mainly be attempted with the index I for different crops. The estimated values of I for different areal units are presented in the appendix table (A.2) for selected foodgrains, oilseed crops, crop-aggregates and cash crops (non-foodgrains and non-oilseeds). We have also presented the estimated values of I_α and I_β, only for the two most important crops, rice and wheat, by areal units in the appendix-table (A.3). All these estimates are presented for the latest time-point under our consideration (i.e., 1980-81). These computations have been made not only for these twelve crops or crop-aggregates but also for all 26 individual crops, which would be used in some subsequent analysis, when necessary, but not presented here for the sake of brevity. The estimates of these values of I for different crops are then drawn for selected important and wide-spread crops/crop-aggregates) classified for mapping (ref. to Figures (2.2) to (2.9)[into six classes, to be termed as classes of (i) Extremely High (EH) values, (ii) Very High (VH) values, (iii) High (H) values, (iv) Medium (M) values, (v) Low (L) values and (vi) Very Low (VL) values. As the critical value (signifying the national value) is unity, the demarcating boundary values between consecutive classes (equi-interval) has been uniformly taken as : 2.25, 1.75, 1.25, 0.75 and 0.25 respectively. There are altogether 151 areal units and the frequency classification of the values of I for different crops are given in the following Table (2.13) :

Table (2.13) : Frequency Classification of Areal Units for the Crop-concentration Index I by Crops (or Crop-aggregates)

Crops (or, crop-aggregates)	Frequency of areal units by classes of crop-concentration index I value					
	EH	VH	H	M	L	VL
	[2.25≤I)	[1.75, 2.25)	[1.25, 1.75)	[0.75, 1.25)	[0.50, 0.75)	(I<0.25)
1. Rice	14	21	19	26	26	45
2. Wheat	26	13	19	11	27	55
3. Minor foodgrains	25	13	12	22	22	57
4. Other foodgrains	34	14	10	20	34	39
5. Oilseeds	11	11	18	32	44	35
6. Groundnut	21	7	5	14	23	81
7. Fibre crops	21	7	6	8	21	88
8. Sugarcane	16	2	14	12	42	65
9. Potato	21	7	10	12	26	75
10. Spices	18	9	11	28	35	50
11. Tobacco	12	1	6	7	17	108
12. Plantation crops (tea & coffee)	10	1	3	2	3	132

In this Table (2.13) the skewed nature of frequency distribution is revealed, with more-peakedness at the lower tail-end for extremely localised crops and with a tendency of formation of another peak at the upper tail-end by the presence of core-producing areal units. In that, rice as an individual crop and oilseeds as a crop-aggregate are exceptions without the formation of second peak at the upper-tail-end. Of the two most important crops, rice and wheat, much more areal units are in extremely high (EH) group for wheat than rice (26 against 14). Such difference is also perceptible between the oilseeds (as aggregate of mustard & rapeseed, sesamum, linseed, castorseed and groundnut) and groundnut (as an individual crop) with higher number of areal units for groundnut than oilseeds -- a difference which is caused by the presence of other oilseeds in the oilseeds aggregate.

2.8 Identification of Crop-regions and the Nature of Crop-association :

Our next task would be to go for the identification of crop regions by grouping the areal units with similarity in crop-associations (i.e., crop combinations), for import crops. The crop-concentration indicates that we have now at our disposal, ranks of the areas with respect to national importance by crops. We have also identified the locally important crops for each areal unit by the percentage share of total cropped area devoted to different crops by areal units. The important crops cultivated in each areal unit are recorded in the appendix Table (A.1) in decreasing order of their local importance (percentage of cropped area are also shown within parenthesis to the right of these locally important crops). It should be noted that, rice being the most important among crops nationally, may show a locally important crop, even if its I value (crop-concentration index value for the crop) is below unity. This kind of situation may arise even for some other nationally important crops (ranks of crops and related measures are shown in Tables (2.1) to (2.3). For identification of crop regions with similarity in crop-associations, we have first used the crop-concentration index values for different crops (i.e., values of crop-specific I's considered in a sequence in descending order of the national ranks of crops) for possible grouping of areal units, then finalised the grouping for crop-regions by examining the local importance of the crops for all the areal units in each such possible group and finally decided on the actual general pattern of crop-associations and the corresponding crop-regions. The general crop-association pattern of a region is valid for almost all constituent areal units in the region, although there may be a few areal units within the region, where some additional crops may also be important, occuring as a sort of transitional areas from a neighbouring crop-region. Such incidences are also recorded in our detailed tabular analysis of crop-regions given below at the end of this sub-section. The general crop-associations in different regions are shown below (preceding to the said tabular analysis) by naming the crops in their descending order of local importance. Any crop in such a crop-association for a crop-region is certainly locally important (in fact, more important than any other crop, if cultivated there), while all crops with high local importance need not necessarily show always high national importance, as compared with another crop in the sequence of crop-association, showing possibly lower local importance but quite high crop-specific national importance /‾for example, important local crop of rice is sometimes not so high in crop-specific national importance in some major ragi or jowar producing region (ref. to region code no. H1 and H2)_7.

In deciding upon preliminary grouping of areal units on the basis of crop-specific concentration index values (I-values) prior to the checking of local importance of crops, the super-imposition technique of mapping has been used. But this technique has not been used for all individual crops simultaneously; rather, we have considered the technique sequentially by relative national importance of crops. Thus by the first consideration of three important foodgrain crops : rice, wheat and minor foodgrains (constituents of this crop-aggregate have been examined later to identify the exact crop), we are in a position to have a kind of broad regionalisation by the first important cereal crop. It should be noted that by a comparison of the crop-concentration maps for wheat and other foodgrains, it becomes evident that other foodgrains are mostly concentrated in the core wheat producing areas. As such, it was not necessary to consider the other foodgrains to start with for broad regionalisation. While doing the broad regionalisation, one or two small regions have also emerged in special areas, which could not be merged with any of the neighbouring broad-regions and they are retained as such and also shown as regions in our final regionalisation schemes, without any further breakdown for them. Thus the broad regions with their territorial positions in India could be named as follows :

Most important cereal based broad regions

broad-region code	the name to be used
A	Northern Wheat Region
B	Eastern Rice-Wheat Region
C	Far-Eastern Rice Region
D	Eastern Rice Region
E	East-Coastal Rice Region
F	Far-South Rice-mixed crop Region
G	West-Coastal Rice Region
H	Southern Jowar/Ragi Region
I	Western Bajra/Maize Region

These broad regions are then sub divided, if it has been necessary, by examining both the national and the local importances of crops produced within each broad-region. The task of all-India level super-imposition for all crops has thus been simplified to a great extent. The final crop-regions thus identified are thirty in number, and these regions have the following types of general crop-associations with crops shown in order of decending local importances :

contd.........

General crop-association regions

(with crops shown in order of descending local importance)

Region number	Region code	Crop-association
1	A1	Maize - Wheat
2	A2	Wheat - Ragi
3	A3	Wheat - Gram - Cotton - Mustard
4	A4	Wheat - Sugarcane - Maize
5	A5	Wheat - Sugarcane - Mustard - Potato
6	A6	Wheat - Gram - Barley - Linseed
7	A7	Wheat - Gram - Linseed
8	A8	Wheat - Jowar - Gram
9	B1	Rice - Wheat - Sugarcane - Potato
10	B2	Rice - Wheat
11	C1	Rice - Tea - Mustard
12	C2	Rice - Potato - Ginger
13	C3	Rice - Maize
14	C4	Rice - Ginger
15	D1	Rice - Jute - Potato
16	D2	Rice
17	D3	Rice - Linseed
18	D4	Rice - Sesamum - Mesta
19	D5	Rice - Jowar
20	E1	Rice - Groundnut - Chillie
21	F1	Rice - Cotton - Groundnut - Chillies
22	G1	Rice - Pepper - Coffee - Ginger
23	G2	Rice
24	H1	Ragi - Rice - Jowar - Castorseed
25	H2	Jowar - Cotton - Groundnut - Rice
26	H3	Jowar - Cotton - Tur
27	H4	Jowar - Bajra - Groundnut - Sugarcane
28	I1	Cotton - Maize - Jowar - Wheat
29	I2	Groundnut - Bajra - Cotton - Jowar
30	I3	Bajra - Sesamum

These crop-association regions, or in short, crop-regions have been mapped in Figure (2.1) from which the localisations and crop combinations of the regions and also the cropping patterns of individual crops, those are important both nationally and locally, can be identified and studied. The detailed values of crop-specific concentration indices, I's for all crops and crop-aggregates are shown by these thirty regions in appendix Table (A.4). Finally a tabular-analysis has been made for each of these regions, summarising their characteristics, nature and other details, both for general cropping pattern and local peculiarities, if any, with the necessary supporting data (ref. to Table (2.14)). Statewise estimates of the crop concentration index for different crops are reported in Table (2.15).

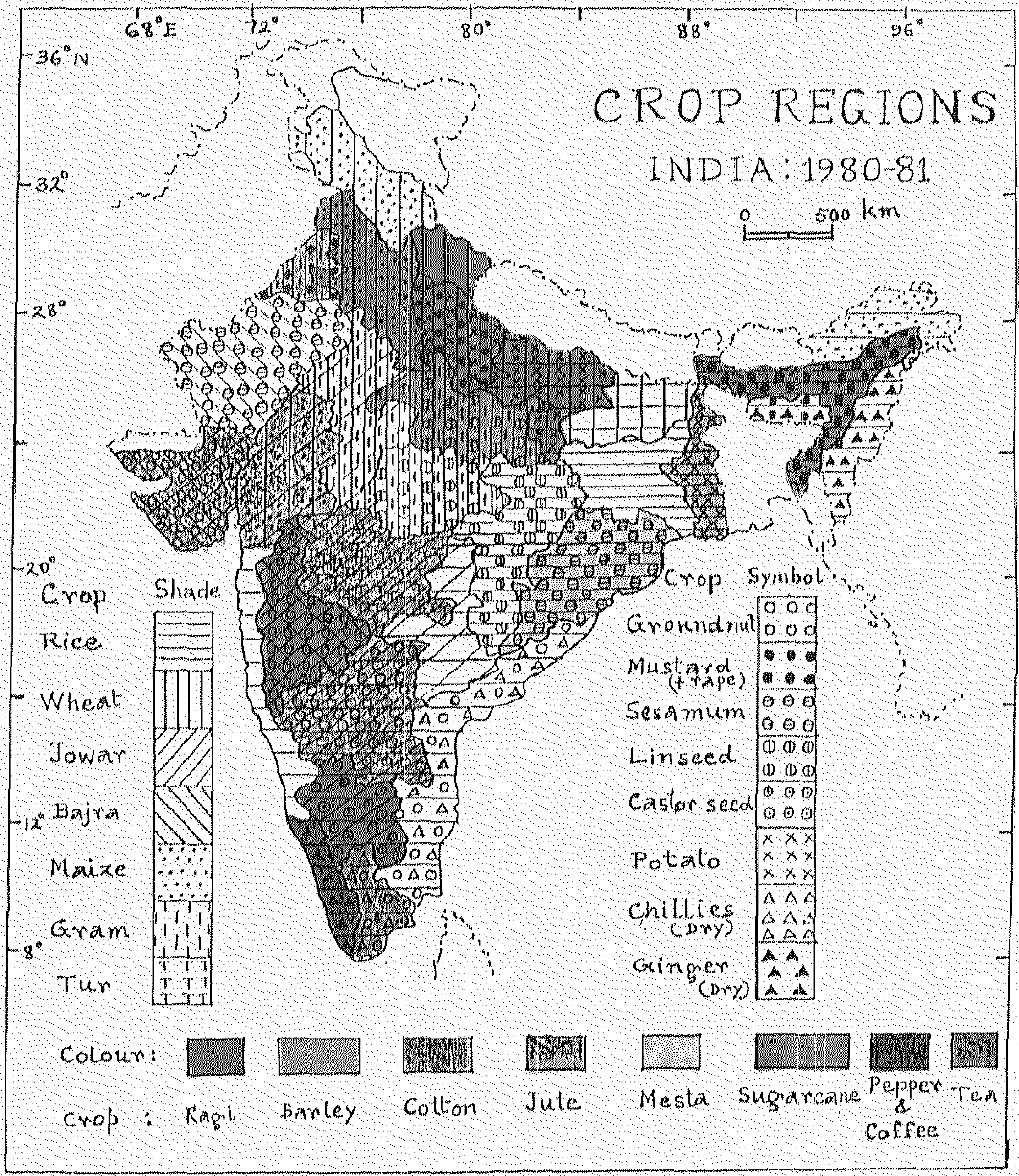

CROP REGIONS
INDIA : 1980-81
0
500 km
68°E
72°
80°
88°
96°
36°N
32°
28°
20°
12°
8°
Crop
Shade
Rice
Wheat
Jowar
Bajra
Maize
Gram
Tur
Crop
Symbol
Groundnut
Mustard (+ rape)
Sesamum
Linseed
Castor seed
Potato
Chillies (Dry)
Ginger (Dry)
Colour:
Crop :
Ragi
Barley
Cotton
Jute
Mesta
Sugarcane
Pepper & Coffee
Tea

Fig.2.1

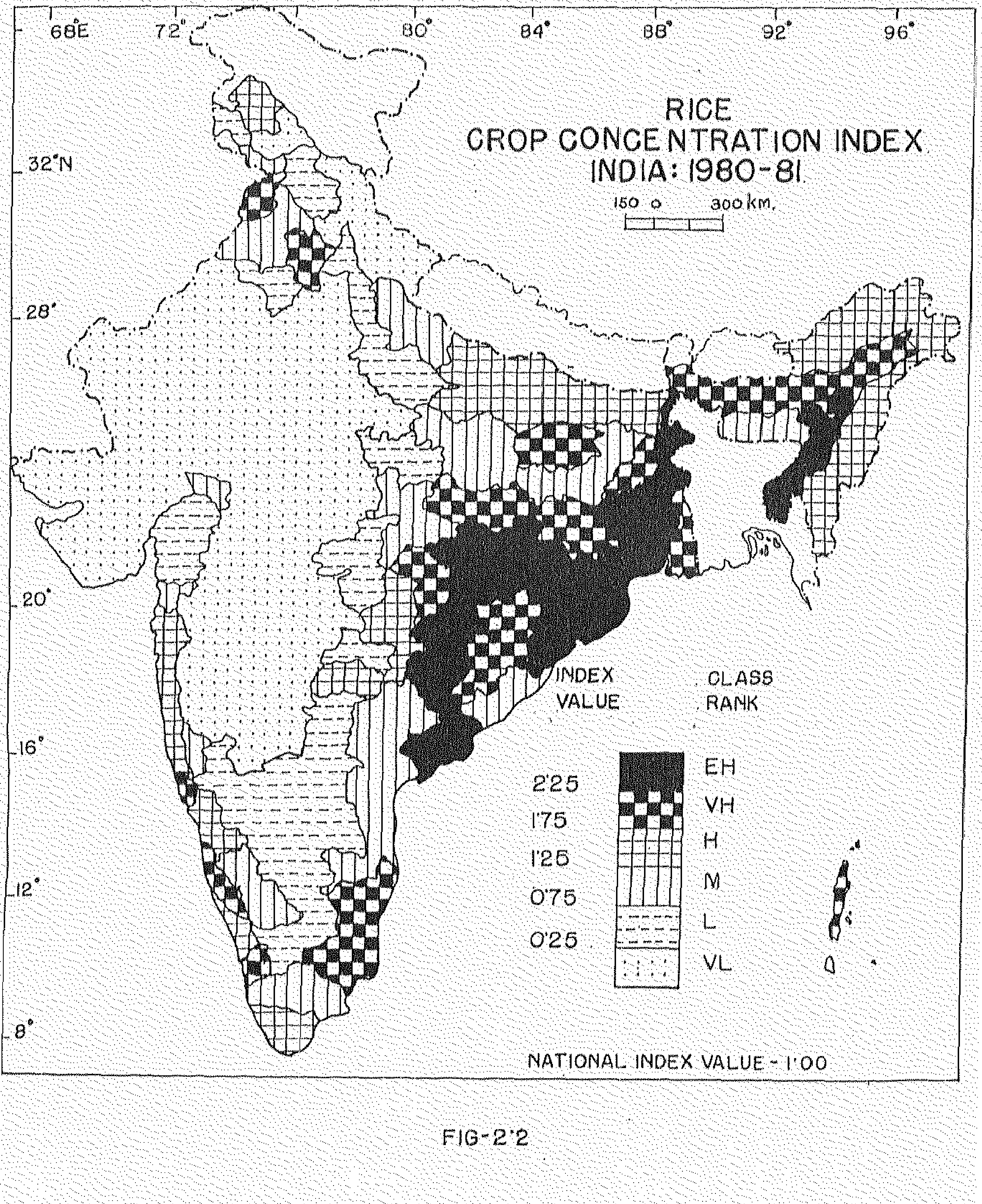

68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
RICE
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'2

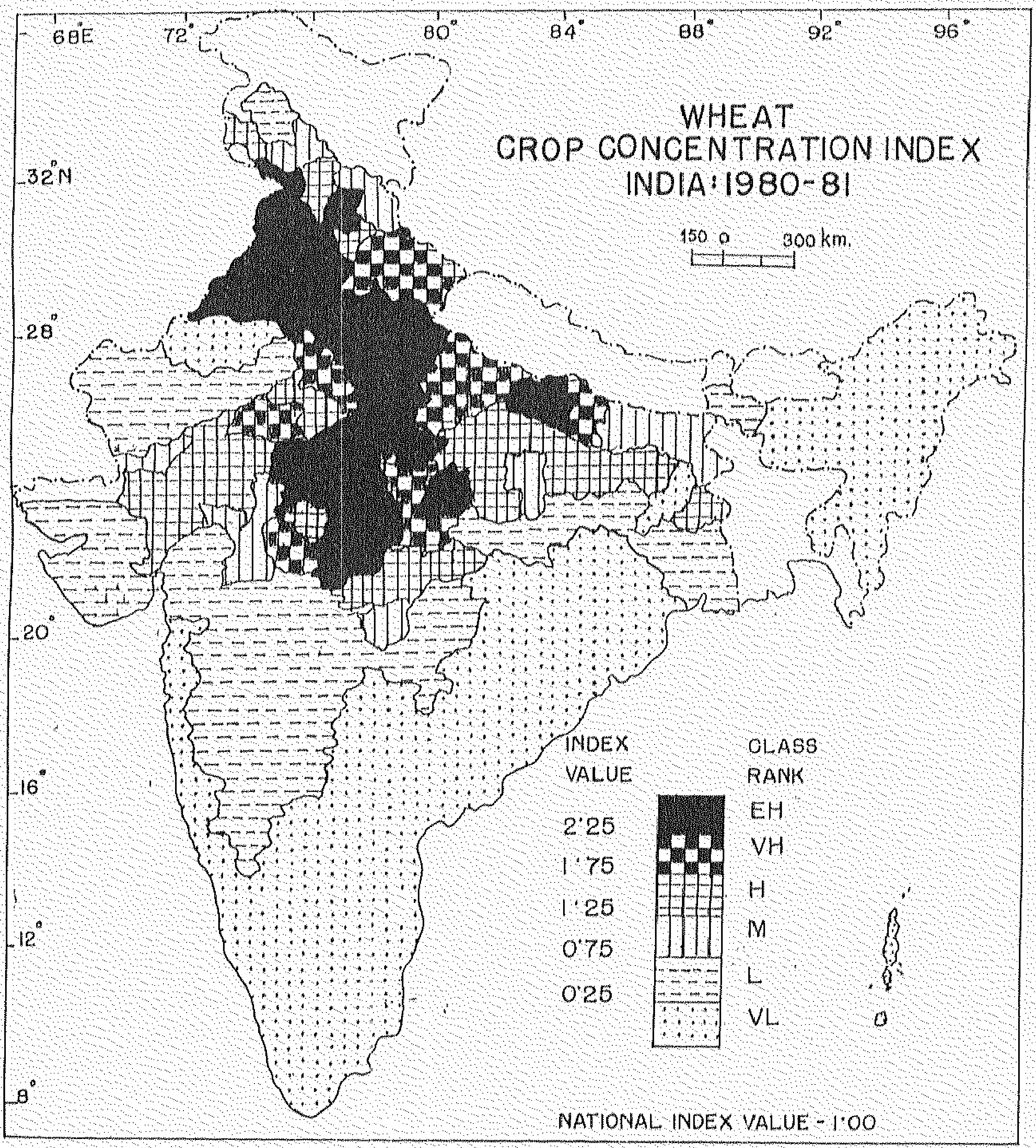

68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
WHEAT
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'3

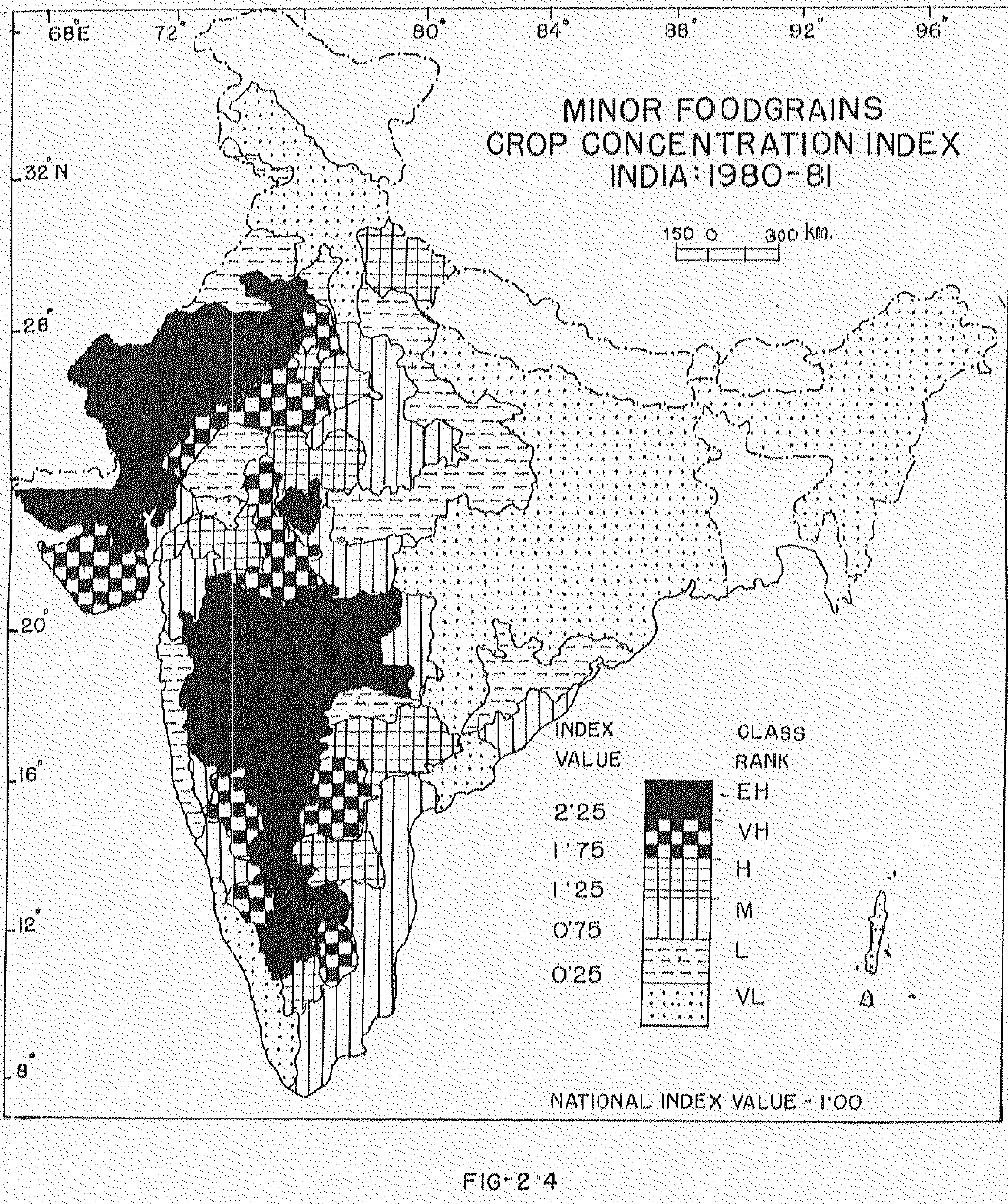

MINOR FOODGRAINS
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32° N
28°
20°
16°
12°
8°
INDEX VALUE
2'25
1'75
1'25
0'75
0'25
CLASS RANK
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2·4

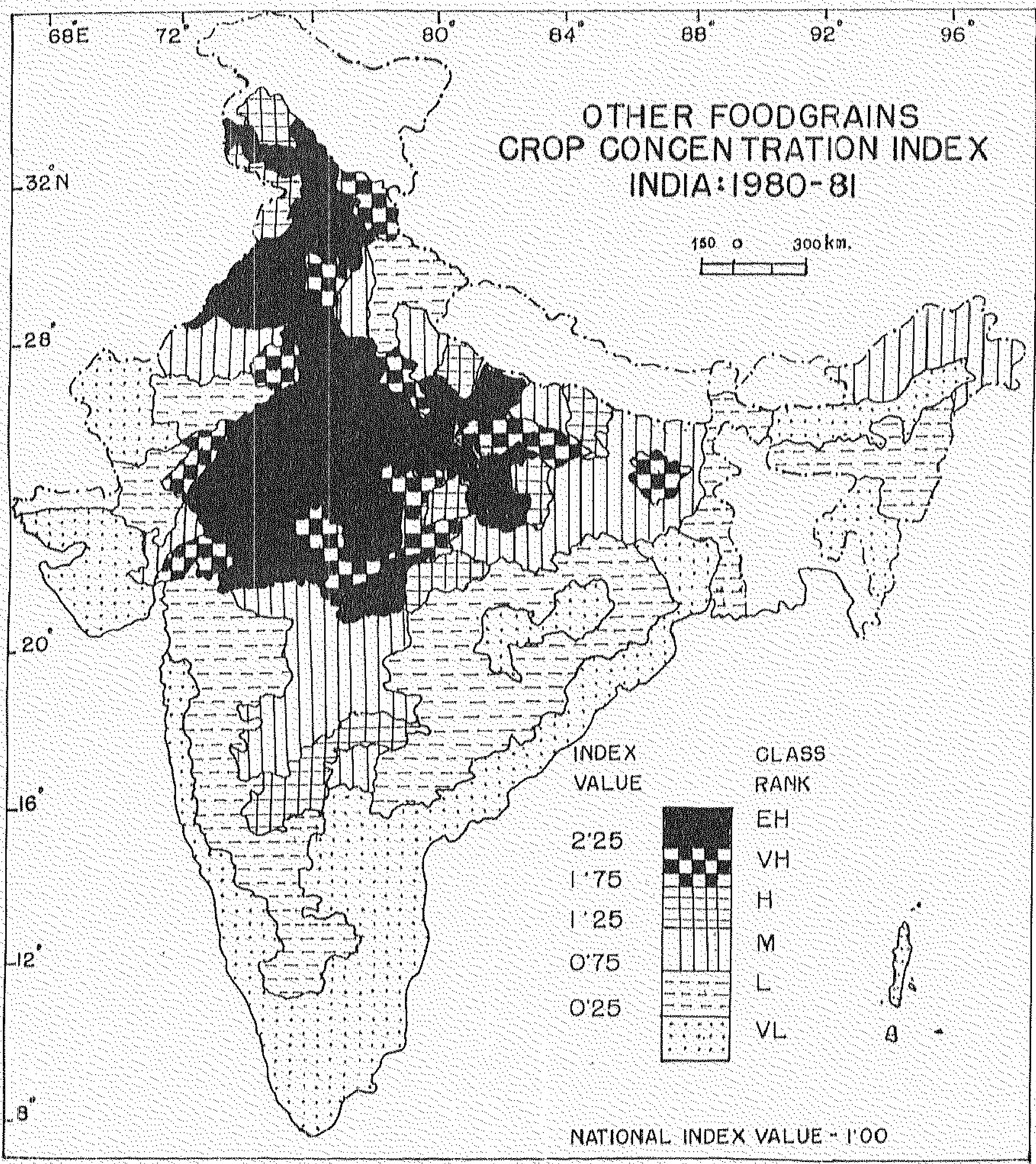

OTHER FOODGRAINS
CROP CONCENTRATION INDEX
INDIA : 1980-81
150 0 300 km.
68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'5

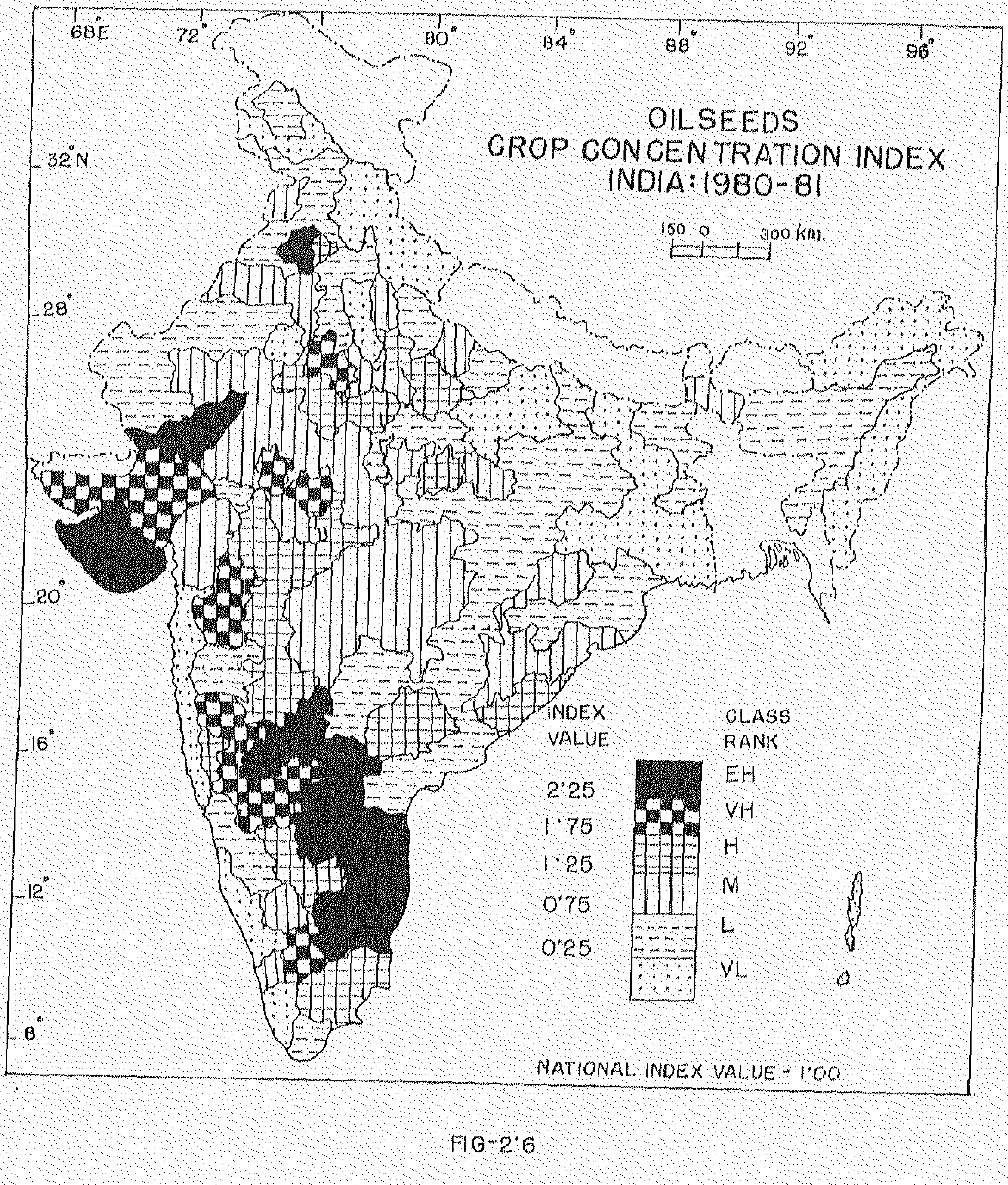

68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
OILSEEDS
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'6

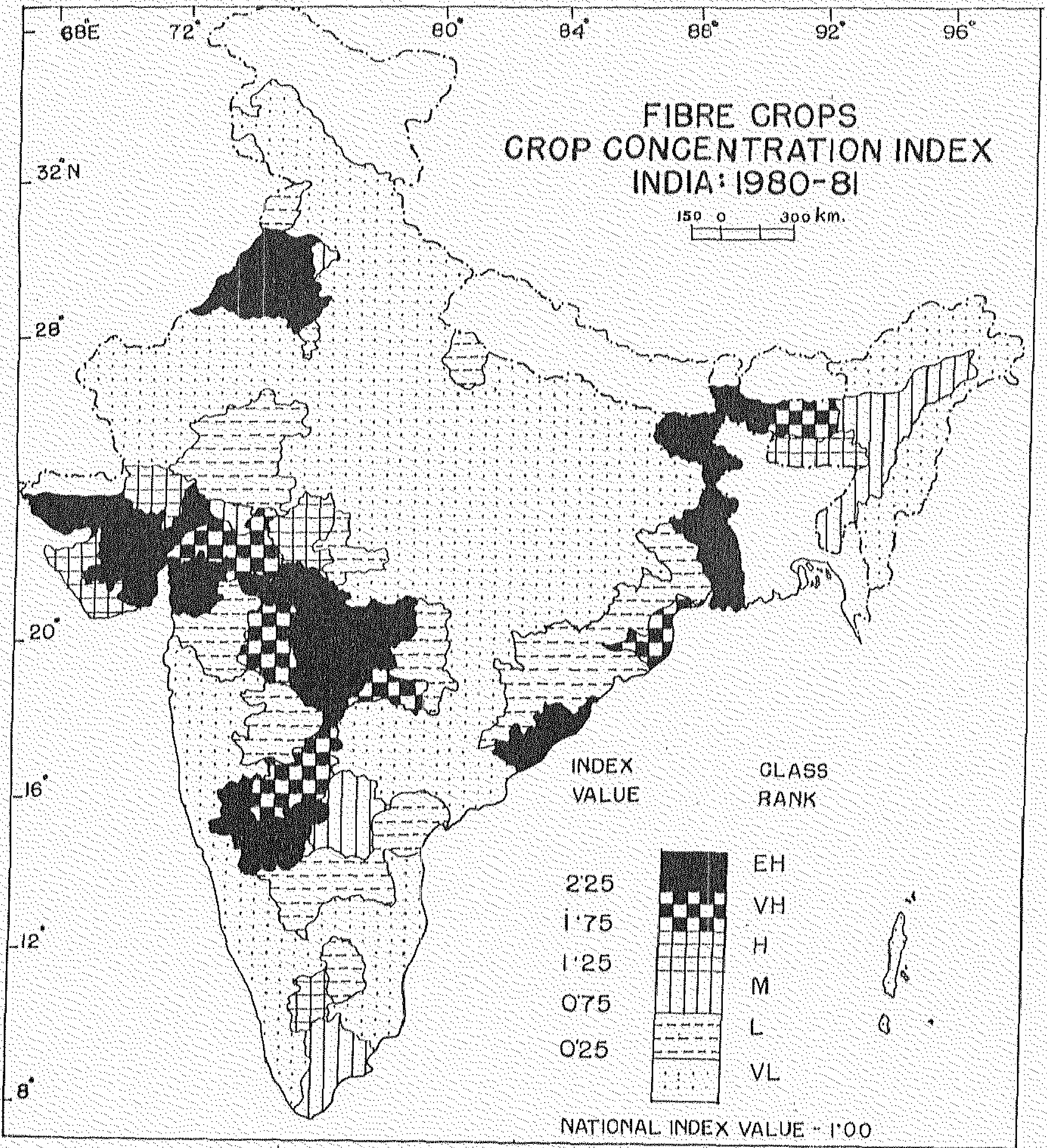

FIBRE CROPS
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-27.

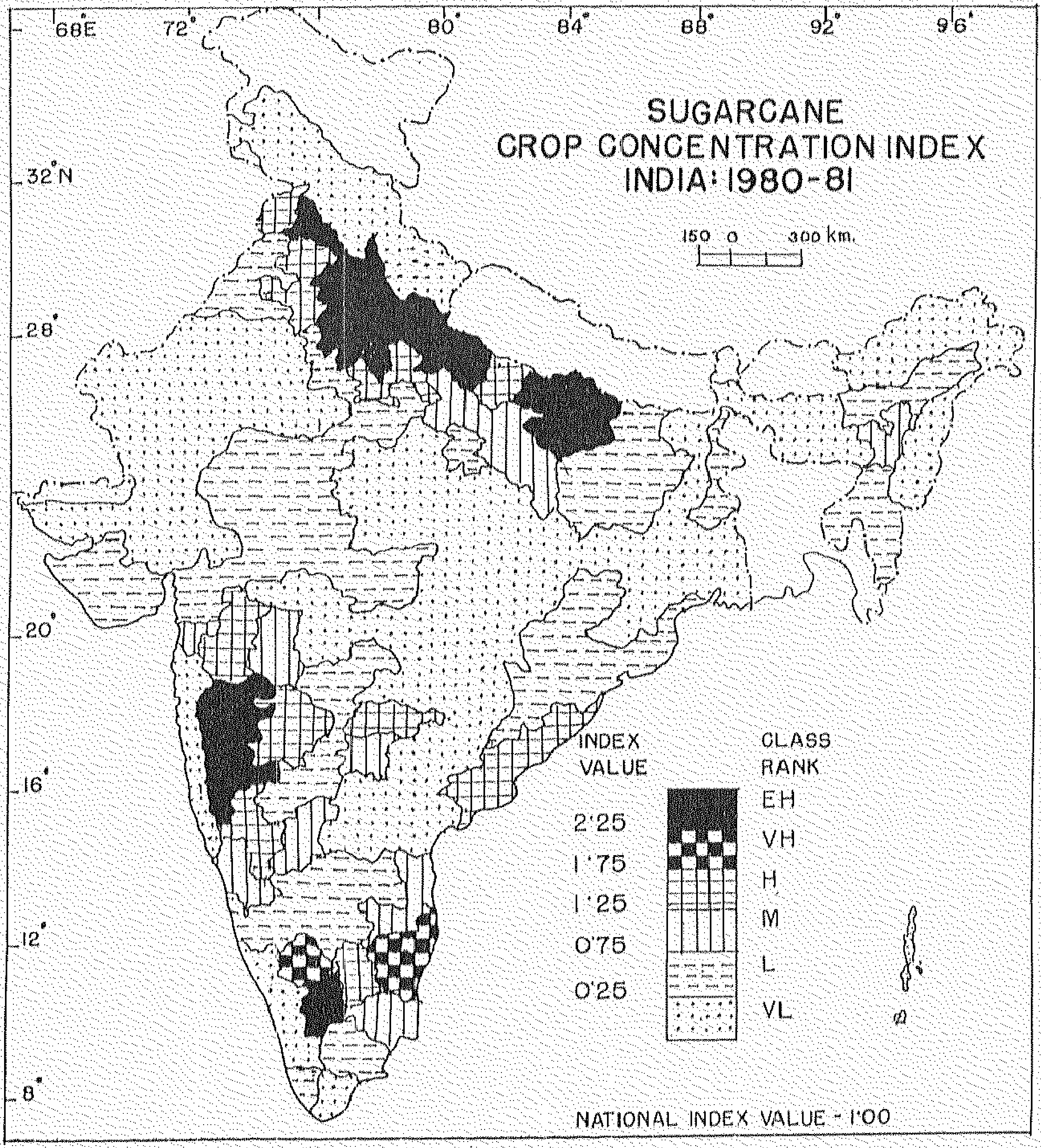

SUGARCANE
CROP CONCENTRATION INDEX
INDIA: 1980-81
150 0 300 km.
68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
2'25
1'75
1'25
0'75
0'25
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'8

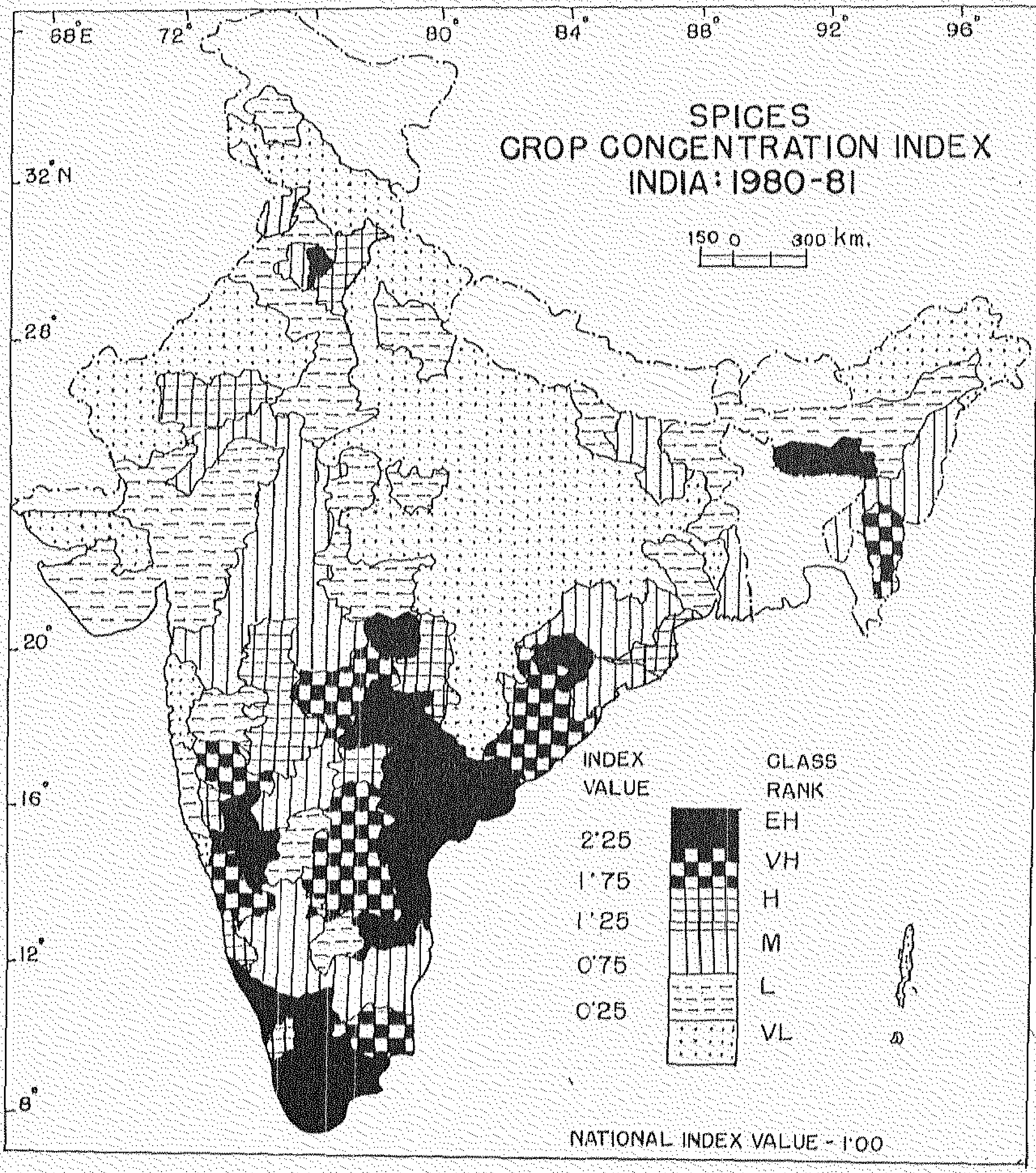

SPICES
CROP CONCENTRATION INDEX
INDIA : 1980-81
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
EH
2'25
VH
1'75
H
1'25
M
0'75
L
0'25
VL
NATIONAL INDEX VALUE - 1'00

FIG-2'9

Table (2.14) : Characteristics and the Nature of Cropping Patterns and Crop-combinations by Crop-regions; India: 1980-81

areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α(relative to area), I_β(relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2	A 1	.1 Poonch-Rajuri	Crops — I — I_α — I_β Maize 6.1 5.5 6.9 Wheat 1.4 1.3 1.4 Ginger 3.5 2.8 4.3 Mustard 1.6 1.5 1.7 Potato 1.1 1.0 1.2	% share of total cereals — by cropped area — by quantity of production Maize 37 42 Wheat 34 27 Rice 24 28 % share of all crops — by cropped area — by value of production Maize 34 29 Wheat 31 25 Rice 22 35 Mustard 2.1 2.1 Potato 1.2 2.5 Ginger 0.1 0.4	Maize & wheat are most wide spread crops of the region with the following national share by quantity of production : general crops — % national share Maize 11.0 Wheat 1.7	Other important crops of the region are rice, ginger, mustard & potato, which are localised as revealed from below : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Rice — A1.2(1.4), A1.4(1.1) — 73 — 0.8 Ginger — A1.7(29.1) — 96 — 4.9 Mustard — A1.2(5.2) — 83 — 2.4 Potato — A1.7(5.5), A1.8(5.7) — 57 — 0.6	It is a hilly region with the universal crops of maize-wheat. The variations in topographic features have, however, been responsible for the concentration of highly localised crops e.g.; rice, jowar, mustard & potato. Rice is mainly localised in the valley areas of the region where it is the first or the second important crop.
1	(1)	.2 Srinagar + Anantanag + Baramulla					
4		.3 Doda+Udhampur					
3		.4 Jammu+Kathua					
5		.5 Chamba+Kangra					
7		.6 Bilaspur + Kulu + Mandi					
8		.7 Mahasu + Simla + Sirmur					
6		.8 Kinnaur + Lahul & Spiti					
		% national share of the region w.r.t Geo. area = 3.1790 Agri. area = 1.1823 Total pop^n = 1.4546 Agri. pop^n = 1.4682					

Table (2.14) Continued

areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite); I_α (relative to area); I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments; if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
27	A 2 (2)	.1 Uttar Kashi + Tehri Garhwal + Garhwal	Crops I I_α I_β Wheat 1.7 2.0 1.3 Ragi 11.2 11.5 11.1	% share of total cereals by cropped area / by quantity of production Wheat 45 44 Ragi 42 43 % share of all crops by cropped area / by value of production Wheat 44.7 47.5 Ragi 42.2 41.2	Important crops of the region are wheat & ragi; for which national share by quantity of production are as follows : general crops / % national share Wheat 0.5 Ragi 5.6	————	It is a hilly region with agricultural activities devoted almost entirely on cereal production (99.9% of the cropped area is devoted to production of cereal crops).
28		.2 Chamoli + Almora + Pithorgarh % national share of the region w.r.t Geo. area = 1.3390 Agri. area = 0.2802 Total pop^n = 0.4463 Agri. pop^n = 0.6134					

Table (2.14) Continued

areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13 63	A 3 (3)	.1 Ferozepur + Bhatinda .2 Ganganagar % national share of the region w.r.t Geo. area = 1.2272 Agri. area = 2.2931 Total pop^n = 0.9233 Agri. pop^n = 0.8417	Crops — I — I_α — I_β Wheat 5.0 3.3 6.8 Bajra 2.2 1.6 1.3 Cotton 9.8 7.3 13.6 Gram 7.9 5.8 11.0 Mustard 6.8 5.0 9.4	% share of total cereals — by cropped area — by quantity of production Wheat 68 73 Rice 12 17 Bajra 12 5 % share of all crops — by cropped area — by value of of production Wheat 55 44.3 Rice 6.3 13.9 Bajra 6.4 2.7 Gram 23.9 9.9 Cotton 19.3 21.8 Mustard 3.8 2.9	Important crops of this region are wheat, gram, cotton & mustard, for which national share by quantity of production are as follows : general crops — % national share Wheat 7 Gram 10 Mustard 9.5 Cotton 17	Rice is the only important localised crop, as is evident from figures below : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional, national Rice A3.1(1.0) 90 0.9	This is a wheat-gram-mustard-cotton growing area. As a transitional area to its southern bajra region, it grows some bajra but of not much significance. In fact, this region seems to be transitional to all its surrounding regions (including its western neighbour, now in Pakistan). Here cropped land relative to population seems to be favourable, as indicated by higher values of I_β than those of corresponding I_α.

Table (2.14) Continued

<table>
<tr><th>areal unit no.</th><th>Crop region code</th><th colspan="2">District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite);
I_α (relative to area);
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><th>(1)</th><th>(2)</th><th colspan="2">(3)</th><th>(4)</th><th>(5)</th><th>(6)</th><th>(7)</th><th>(8)</th></tr>
<tr><td>12</td><td rowspan="12">A 4
(4)*</td><td>.1</td><td>Kapurthala + Amritsar + Gurdaspur</td>
<td rowspan="12">
<table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Wheat</td><td>4.5</td><td>4.1</td><td>4.5</td></tr>
<tr><td>Maize</td><td>3.2</td><td>3.3</td><td>3.0</td></tr>
<tr><td>Barley</td><td>2.5</td><td>2.6</td><td>2.5</td></tr>
<tr><td>Bajra</td><td>2.4</td><td>2.5</td><td>2.1</td></tr>
<tr><td>Sugarcane</td><td>4.6</td><td>4.3</td><td>4.9</td></tr>
<tr><td>Gram</td><td>2.9</td><td>2.9</td><td>3.0</td></tr>
<tr><td>Mustard</td><td>2.7</td><td>2.7</td><td>2.7</td></tr>
<tr><td>Potato</td><td>1.9</td><td>1.9</td><td>2.0</td></tr>
</table>
</td>
<td rowspan="12">
% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Wheat</td><td>53</td><td>64</td></tr>
<tr><td>Rice</td><td>15</td><td>18</td></tr>
<tr><td>Maize</td><td>11</td><td>9</td></tr>
<tr><td>Bajra</td><td>14</td><td>5</td></tr>
<tr><td>Barley</td><td>3</td><td>2</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Wheat</td><td>39</td><td>41.9</td></tr>
<tr><td>Rice</td><td>10.8</td><td>16.1</td></tr>
<tr><td>Bajra</td><td>10.5</td><td>3.7</td></tr>
<tr><td>Maize</td><td>8</td><td>4.5</td></tr>
<tr><td>Barley</td><td>2.3</td><td>1.1</td></tr>
<tr><td>Gram</td><td>10.4</td><td>4.0</td></tr>
<tr><td>Sugarcane</td><td>8.2</td><td>19.2</td></tr>
<tr><td>Mustard</td><td>2.1</td><td>1.1</td></tr>
<tr><td>Potato</td><td>0.5</td><td>2.6</td></tr>
</table>
</td>
<td rowspan="12">
Important crops of the region are wheat, maize & sugarcane; whose national share by quantity of production are as follows :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Wheat</td><td>31</td></tr>
<tr><td>Maize</td><td>18</td></tr>
<tr><td>Sugarcane</td><td>26</td></tr>
</table>
</td>
<td rowspan="12">
Other crops important in certain areas of the region are rice; bajra, barley; gram, mustard & potato; localised characteristics of which are as follows :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Rice</td><td>A4.6(2.2)
A4.1(2.0)
A4.5(2.2)</td><td>65</td><td>3.6</td></tr>
<tr><td>Bajra</td><td>A4.5(6.5)
A4.9(4.9)
A4.10(3.0)
A4.11(4.2)</td><td>86</td><td>12</td></tr>
<tr><td>Barley</td><td>A4.9(5.4)
A4.10(8.4)
A4.11(8.0)</td><td>79</td><td>12</td></tr>
<tr><td>Gram</td><td>A4.5(12.5)
A4.9(5.0)</td><td>60</td><td>7</td></tr>
<tr><td>Mustard</td><td>A4.5(7.1)
A4.9(4.0)
A4.11(8.8)
A4.1(3.0)</td><td>84</td><td>14</td></tr>
<tr><td>Potato</td><td>A4.2(3.5)
A4.6(3.0)
A4.8(2.2)
A4.10(2.9)</td><td>76</td><td>9</td></tr>
</table>
</td>
<td rowspan="12">This is a wheat - maize - sugarcane growing region. It being one of the most flourishing agricultural region in India; a diversification of cropping pattern has been established. Most of the areas of this region; especially those around the capital region of Delhi are rich in quite a number of crops.</td>
</tr>
<tr><td>9</td><td>.2</td><td>Hashiarpur + Jullandur + Ropar</td></tr>
<tr><td>10</td><td>.3</td><td>Patiala</td></tr>
<tr><td>11</td><td>.4</td><td>Ludhiana + Sangrur</td></tr>
<tr><td>14</td><td>.5</td><td>Hissar + Jind</td></tr>
<tr><td>17</td><td>.6</td><td>Karnal + Ambala</td></tr>
<tr><td>18</td><td>.7</td><td>Saharanpur + Dehradun</td></tr>
<tr><td>19</td><td>.8</td><td>Meerut + Muzaffarnagar</td></tr>
<tr><td>16</td><td>.9</td><td>Rohtak + Delhi + Gurgaon</td></tr>
<tr><td>20</td><td>.10</td><td>Bulandshahr + Aligarh</td></tr>
<tr><td>21</td><td>.11</td><td>Mathura + Agra</td></tr>
<tr><td></td><td colspan="2">% national share of the region w.r.t
Geo. area = 3.6658
Agri. area = 8.4298
Total pop^n = 6.7562
Agri. pop^n = 4.7867</td></tr>
</table>

Table (2.14) Continued

areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite); I_c (relative to area) I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments; if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
26	A 5 (5)	.1 Bijnor + Moradabad					This is a wheat - sugarcane - mustard - potato growing region. It is also another flourishing agricultural region in contiguity to the most advanced agricultural region of A4. Here also diversification of cropping pattern has been established.
29		.2 Nainital + Rampur + Bareilly + Pilibhit					
25		.3 Budaun + Etah + Farrukhabad					
24		.4 Kanpur + Hardoi + Lucknow + Unnao					
30		.5 Sitapur + Kheri					

(3)

% national share of the region w.r.t

Geo. area = 2.5561

Agri. area = 4.6798

Total pop^n = 4.9007

Agri. pop^n = 4.5722

(4)

Crops	I	I_c	I_β
Wheat	2.4	2.7	2.1
Barley	2.1	2.5	1.8
Maize	1.9	2.2	1.5
Bajra	1.0	1.1	0.7
Sugarcane	4.1	4.5	3.7
Potato	3.5	4.1	3.0
Mustard	2.2	2.4	1.8
Tur	3.4	3.3	3.4

(5)

% share of total cereals

	by cropped area	by quantity of production
Wheat	47	56
Rice	27	24
Maize	10	9
Bajra	8	5
Barley	4	4

% share of all crops

	by cropped area	by value of production
Wheat	34.4	29.7
Rice	20.2	17.1
Maize	7.3	3.7
Bajra	5.8	2.4
Barley	2.7	1.4
Sugarcane	9.9	25.5
Mustard	2.2	1.3
Potato	1.4	7.4

(6)

Important crops of the region are wheat; sugarcane; mustard & potato; whose national share by quantity of production are as follows :

general crops	% national share
Wheat	9.6
Sugarcane	15
Potato	15
Mustard	8.6

(7)

Other crops important in certain areas of the region are rice, bajra; maize & barley; whose localised characteristics are given below :

Localised crops	Areas of localisation (with I-value)	% share of crops by quantity of production	
		regional	national
Rice	A5.2(1.0) A5.5(1.0)	57	1.5
Bajra	A5.3(2.8)	56	2
Maize	A5.3(3.5) A5.4(1.8)	62	4
Barley	A5.4(4.7)	59	5

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region
(1)	(2)	(3)
22	A 6 (6)	.1 Mainpuri + Etawah
37		.2 Morena + Bhind + Gwalior + Datia
23		.3 Jalaun + Jhansi + Hamirpur
48		.4 Tickamgarh + Chattarpur
47		.5 Panna + Satna
38		.6 Rewa + Sidhi
35		.7 Fatehpur + Banda
36		.8 Allahabad + Jaunpur

% national share of the region w.r.t

Geo. area = 3.9628

Agri. area = 4.7724

Total pop^n = 3.9793

Agri. pop^n = 4.0317

Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population) (4)

Crops	I	I_α	I_β
Wheat	2.0	2.0	2.1
Barley	3.3	3.7	3.8
Jowar	1.0	0.9	1.0
Gram	3.8	3.8	3.9
Linseed	3.4	3.4	3.5
Tur	3.4	3.3	3.4
Mustard	2.4	2.3	2.4
Potato	1.8	1.8	1.8

Relative importance of different crops within the region (5)

% share of total cereals

	by cropped area	by quantity of production
Wheat	43	52
Barley	7	8
Rice	24	19
Jowar	14	10
Bajra	8	6
Maize	4	5

% share of all crops

	by cropped area	by value of production
Wheat	29.2	56.3
Barley	4.9	3.9
Rice	16	18.1
Jowar	9.2	6.2
Bajra	5.2	4.1
Maize	3.0	0.3
Gram	18.3	12.3
Tur	4.4	5.0
Linseed	3.1	1.3
Mustard	2.6	2.1
Potato	0.7	5.6

General crop characteristics (6)

Important crops of the region are wheat, gram, barley & linseed, whose national share by quantity of production are given below :

general crops	% national share
Wheat	7
Barley	15
Gram	16
Linseed	13

Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)

Jowar, bajra, maize, tur; mustard & potato are the other crops important in certain areas of the region; as is established from the following figures :

Localised crops	Area of localisation (with I-value)	% share of crops by quantity of production: regional	national
Jowar	A6.4(1.8) A6.3(1.9) A6.5(1.4)	62	2.5
Bajra	A6.2(1.6) A6.1(2.7)	60	2.5
Maize	A6.1(2.7) A6.8(1.8)	71	2
Tur	A6.3(4.3) A6.5(5.3) A6.8(4.0)	66	11
Mustard	A6.2(8.0) A6.1(6.9)	83	7
Potato	A6.1(5.3) A6.8(4.8)	79	6

Analytical comments, if any (6)

This is a wheat - barley - gram - linseed growing region*. Established diversification in the cropping pattern is an indication of the prosperity of the agricultural economy of the region.

* It being a neighbour to eastern rice region, rice is also grown in most of the areas in this region; but not of much significance.

Table (2.14) Continued

Areal unit no. (1)	Crop region code (2)	District groups included and the relative size of the region (3)	Crops with significant values of concentration index I (composite); I_α (relative to area), I_β (relative to population) (4)	Relative importance of different crops within the region (5)	General crop characteristics (6)	Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)	Analytical comments; if any (8)
44 45 50 49 46	A 7 (7)	.1 Mandla + Seoni .2 Chindwara + Betul + Narashimhapur .3 Hoshangabad + Sehore .4 Vidisa + Sagar + Raisen .5 Damoh + Jabalpur % national share of the region w.r.t Geo. area = 3.6351 Agri. area = 2.8664 Total pop^n = 1.9673 Agri. pop^n = 2.2062	Crops I I_α I_β Wheat 2.4 2.1 2.7 Jowar 1.2 1.0 1.4 Linseed 5.6 4.3 6.5 Gram 3.5 3.1 4.0 Tur 3.0 2.6 3.4 Sesamum 1.6 1.4 2.0	% share of total cereals by cropped area / by quantity of production Wheat 60 56 Rice 19 20 Jowar 16 17 % share of all crops by cropped area / by value of production Wheat 39.6 38.1 Rice 12.5 18.9 Jowar 10.7 10.1 Gram 18.5 12.6 Linseed 4.7 3.0 Tur 4.2 5.2 Sesamum 2.2 1.1 Mustard 0.8 0.9	Important crops of the region are wheat, gram & linseed; whose national share by quantity of production are as follows : general crops / % national share Wheat 3.7 Gram 7.6 Linseed 14	Rice, jowar; tur; sesamum & mustard are the other important crops in certain areas of the region, as revealed from the following figures : Localised crops / Area of localisation (with I-value) / % share of crops by quantity of production: regional, national Rice A7.1(1.1) 40 0.3 Jowar A7.2(1.9)} A7.3(1.9)} 65 2 Tur A7.2(6.1)} A7.3(4.1)} 72 5.7 Sesamum A7.3(4.8) 54 1.7 Mustard A7.1(2.3) 62 1.0	This is a wheat - gram - linseed growing region with a tendency towards diversification in the cropping pattern.

Table (2.14) Continued

Areal unit no. (1)	Crop region code (2)	District groups included and the relative size of the region (3)
15	A 8 (8)	.1 Mohindergarh
61		.2 Alwar + Bharatpur
60		.3 Jaipur + Swai Madhopur
59		.4 Tonk + Ajmer
58		.5 Bundi + Kota + Jhalawar
56		.6 Guna + Shivpuri
55		.7 Shajapur + Rajgarh
54		.8 Ujjain + Indore + Dewas

% national share of the region w.r.t

Geo. area = 4.3828

Agri. area = 5.2442

Total pop^n = 3.2525

Agri. pop^n = 2.9489

Crops with significant values of concentration index I (composite); I_c (relative to area); I_β (relative to population) (4)

Crops	I	I_c	I_β
Wheat	2.0	1.7	2.3
Jowar	2.4	2.0	2.8
Barley	4.7	3.9	5.4
Bajra	2.1	1.8	2.6
Maize	1.4	1.2	1.6
Gram	4.7	4.1	5.6
Mustard	3.0	2.7	3.6
Linseed	2.8	2.4	3.3
Sesamum	1.4	1.3	1.7

Relative importance of different crops within the region (5)

% share of total cereals

	by cropped area	by quantity of production
Wheat	33	47
Jowar	31	20
Bajra	19	13
Maize	7	7
Barley	6	10

% share of all crops

	by cropped area	by value of production
Wheat	23	34.0
Jowar	20.6	13.1
Bajra	12.7	9.0
Maize	4.6	4.2
Barley	4.2	5.3
Gram	18.6	15.1
Mustard	2.4	3.1
Linseed	1.8	1.2
Sesamum	1.4	0.8

General crop characteristics (6)

Wheat; jowar & gram are the most important crops of this region; national share by quantity of production for these crops being given below :

general crops	% national share
Wheat	6
Jowar	8
Gram	18

Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)

Barley; bajra; maize; mustard; linseed & sesamum are the other crops; important in certain areas of the region; as is evident from below :

Localised crops	Area of localisation (with I-value)	% share of crops by quantity of production	
		regional	national
Bajra	A8.1(11.1) A8.3 (4.7) A8.2 (4.4)	93	8
Barley	A8.1 (6.8) A8.3 (9.7) A8.2 (6.6) A8.4(10.2)	92	17
Maize	A8.7 (2.1) A8.6 (2.4) A8.4 (2.8) A8.5 (2.6)	84	3.7
Mustard	A8.1 (8.1) A8.2(14.7)	89	10
Linseed	A8.6 (5.1) A8.8 (5.3)	45	5
Sesamum	A8.2 (1.9) A8.4 (2.3) A8.6 (2.2)	58	2.7

Analytical comments; if any (8)

This is a wheat - jowar-gram growing region. Wide divergence in the cropping pattern of the region is the indication of prosperity of the agricultural economy.

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite);
I_α (relative to area);
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments; if any</th></tr>
<tr><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th><th>(5)</th><th>(6)</th><th>(7)</th><th>(8)</th></tr>
<tr><td>31</td><td>B 1
(9)</td><td>.1 Bahraich + Gonda + Bara Banki</td>
<td rowspan="7"><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Wheat</td><td>1.9</td><td>2.3</td><td>1.4</td></tr>
<tr><td>Rice</td><td>1.3</td><td>1.7</td><td>1.0</td></tr>
<tr><td>Barley</td><td>3.7</td><td>4.7</td><td>2.7</td></tr>
<tr><td>Maize</td><td>1.6</td><td>2.0</td><td>1.1</td></tr>
<tr><td>Potato</td><td>2.6</td><td>3.4</td><td>1.9</td></tr>
<tr><td>Sugarcane</td><td>2.0</td><td>2.4</td><td>1.5</td></tr>
</table></td>
<td rowspan="7">% share of total cereals<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Rice</td><td>49</td><td>43</td></tr>
<tr><td>Wheat</td><td>34</td><td>42</td></tr>
<tr><td>Barley</td><td>6</td><td>6</td></tr>
<tr><td>Maize</td><td>8</td><td>6</td></tr>
</table>
% share of all crops<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Rice</td><td>41</td><td>38</td></tr>
<tr><td>Wheat</td><td>28</td><td>26.9</td></tr>
<tr><td>Maize</td><td>7.0</td><td>3.1</td></tr>
<tr><td>Barley</td><td>5.3</td><td>2.8</td></tr>
<tr><td>Sugarcane</td><td>5.0</td><td>14.8</td></tr>
<tr><td>Potato</td><td>1.1</td><td>6.5</td></tr>
<tr><td>Turmeric</td><td>0.06</td><td>0.2</td></tr>
</table></td>
<td rowspan="7">Rice, wheat, sugarcane & potato are the important crops of the region. National share by quantity of production for these crops are as follows :<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Rice</td><td>6.5</td></tr>
<tr><td>Wheat</td><td>10.0</td></tr>
<tr><td>Sugarcane</td><td>10.1</td></tr>
<tr><td>Potato</td><td>15.4</td></tr>
</table></td>
<td rowspan="7">Maize, barley & turmeric are the other important crops in some limited areas of this region, as evident from below :<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Maize</td><td>B1.4(2.6)
B1.1(3.8)</td><td>75</td><td>5</td></tr>
<tr><td>Barley</td><td>B1.2(3.7)
B1.5(7.4)
B1.6(5.0)</td><td>71</td><td>13</td></tr>
<tr><td>Turmeric</td><td>B1.4(4.4)</td><td>75</td><td>3.4</td></tr>
</table></td>
<td rowspan="7">This is a rice – wheat – sugarcane-potato region. Cropping pattern is quite diversified. Yet the distribution of cropped land to agricultural workers seems to be not very favourable, as can be inferred from the higher values of I_α than those of corresponding I_β</td></tr>
<tr><td>34</td><td></td><td>.2 Pratapgarh + Rae-Barelli + Sultanpur + Faizabad</td></tr>
<tr><td>32</td><td></td><td>.3 Basti + Gorakhpur + Deoria</td></tr>
<tr><td>132</td><td></td><td>.4 Saran + Champaran</td></tr>
<tr><td>33</td><td></td><td>.5 Azamgarh + Gazhipur + Ballia</td></tr>
<tr><td>37</td><td></td><td>.6 Varanasi + Mirzapur</td></tr>
<tr><td></td><td></td><td>% national share of the region w.r.t
Geo. area = 3.2352
Agri. area = 6.1131
Total pop^n = 7.4178
Agri. pop^n = 7.7820</td></tr>
</table>

Table (2.14) Continued

Areal unit no. (1)	Crop region code (2)	District groups included and the relative size of the region (3)	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population (4)	Relative importance of different crops within the region (5)	General crop characteristics (6)	Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)	Analytical comments, if any (8)
131	B 2 (10)	.1 Patna + Gaya + Shahabad	Crops I I_α I_β Rice 1.5 2.1 1.0 Wheat 1.4 1.8 0.9 Maize 1.9 2.6 1.2 Jute 3.2 4.4 2.3 Potato 2.2 3.1 1.5 Mesta 2.1 3.0 1.4 Linseed 2.0 2.6 1.2	% share of total cereals by cropped area / by quantity of production Rice 58 55 Wheat 27 34 Maize 10 9 % share of all crops by cropped area / by value of production Rice 51 52 Wheat 23 23.5 Maize 1.5 4.9 Jute 2.4 3.2 Potato 1.3 5.6 Linseed 1.2 0.9 Mesta 0.5 0.6	Rice & wheat are the predominant crops of the region. National share by quantity of production for these two crops are as follows : general crops / % national share Rice 6 Wheat 6	Maize, potato, linseed, jute & mesta are the other important crops in certain areas of the region as evident from below : Localised crops / Area of localisation (with I-value) / % share of crops by quantity of production: regional, national Maize B2.2 (2.5), B2.3 (4.0) 68 5 Potato B2.1 (2.8), B2.2 (2.9) 78 7 Linseed B2.1 (2.4), B2.4 (2.3) 66 6 Jute B2.4(15.0) 98 13 Mesta B2.4 (8.7) 92 8.7	Although the predominant crops are rice & wheat, there are quite a number of crops those are locally important. Yet the distribution of cropped land to agricultural workers seems to be not very favourable, as can be inferred from the higher values of I_α than those of corresponding I_β.
133		.2 Muzaffarpur + Darbhanga					
135		.3 Moughyr + Bhagalpur					
134		.4 Saharsa + Purnea					
		% national share of the region w.r.t Geo. area = 2.5349 Agri. area = 4.3085 Total pop^n = 6.4841 Agri. pop^n = 6.8913					

Table (2.14) Continued

Areal unit no. (1)	Crop region code (2)	District groups included and the relative size of the region (3)	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population) (4)	Relative importance of different crops within the region (5)	General crop characteristics (6)	Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)	Analytical comments, if any (8)
142	C 1 (11)	.1 Cooch Behar + Jalpaiguri + Darjeeling			Rice, tea and mustard are the important crops of the region. National share by quantity of production for these crops are as follows :	Jute, ginger, mesta, tobacco & potato are the other important crops localised in some limited areas of the region, as is evident from the following :	This is a rice – tea – mustard growing region. Diversification of crop is more or less a general phenomenon of agricultural activities of this region, especially for C 1.1.
144		.2 Goalpara + Kamrup					
145		.3 Darrang + Nowgong + Lakhimpur + Sibsagar					
146		.4 Mikir + North Cachar Hills					
147		.5 Cachar + Tripura					

% national share of the region w.r.t

Geo. area = 3.3003

Agri. area = 3.0308

Total pop^n = 3.6421

Agri. pop^n = 3.2058

Crops	I	I_α	I_β
Rice	2.0	1.9	2.0
Tea	21.2	20.4	22.0
Jute	6.8	6.4	7.0
Mustard	3.6	3.5	3.6
Mesta	2.5	2.4	2.5
Ginger	1.5	1.4	1.5
Potato	1.4	1.4	1.4
Tobacco	1.4	1.3	1.4

% share of total cereals

	by cropped area	by quantity of production
Rice	94	92

% share of all crops

	by cropped area	by value of production
Rice	73.7	42
Tea	6.6	43.0
Mustard	5.5	1.7
Jute	4.7	4.8
Potato	1.2	1.5
Mesta	0.7	0.4
Tobacco	0.6	1.2
Ginger	0.04	0.07

general crops	% national share
Rice	6.3
Mustard	10.9
Tea	74.8

Localised crops	Area of localisation (with I-value)	% share of crops by quantity of production	
		regional	national
Potato	C1.1 (2.1)	33	1
Tobacco	C1.1 (4.1)	58	2.5
Mesta	C1.5 (6.6)	41	3.7
Ginger	C1.1 (6.3)	80	3.8
Jute	C1.2 (7.8) C1.3 (4.8) C1.1(15.0)	95	23

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_{α} (relative to area), I_{β} (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
143	C 2 (12)	.1 Garo Hills + United K & J Hills % national share of the region w.r.t Geo. area = 0.7282 Agri. area = 0.1175 Total pop^{n} = 0.2029 Agri. pop^{n} = 0.2856	Crops — I — I_{α} — I_{β} Rice — 1.0 — 1.1 — 1.0 Ginger — 44.2 — 37.2 — 52.1 Potato — 7.1 — 7.2 — 7.0	% share of total cereals (by cropped area — by quantity of production) Rice — 83 — 90 % share of all crops (by cropped area — by value of production) Rice — 56.7 — 55.6 Potato — 10.9 — 18.8 Ginger — 2.5 — 6.9	Rice, potato & ginger are the important crops of the region. National share by quantity of production for these crops are as follows : general crops — % national share Rice — 0.2 Potato — 1.1 Ginger — 13	——	It is an isolated hilly region with rice as the predominant cereal crop together with significant share of non-cereal crops (distribution of cereal to non-cereal = 2 : 1). Apart from major non-cereal crops of potato & ginger, some other crops like jute & mesta are also grown but not in significant quantity.

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
150	C 3 (13)	.1 Arunachal Pradesh % national share of the region w.r.t Geo. area = 2.7189 Agri. area = 0.0721 Total pop^n = 0.0960 Agri. pop^n = 0.1585	Crops / I / I_α / I_β Rice 1.4 1.4 1.3 Maize 2.5 2.2 2.3	% share of total cereals by cropped area / by quantity of production Rice 77 74 Maize 22 25 % share of all crops by cropped area / by value of production Rice 77 83 Maize 22 15.9	Practically rice & maize are the only crops grown in this region. National share by quantity of production for those two are as follows : general crops / % national share Rice 0.1 Maize 0.3	———	Highly isolated hilly region with primitive agricultural economy based on cereal production alone.

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
149 148	C 4 (14)	.1 Nagaland + Manipur .2 Mizoram	Crops — I — I_α — I_β Rice — 1.5 — 1.6 — 1.6 Ginger — 7.4 — 5.6 — 9.5	% share of total cereals (by cropped area — by quantity of production) Rice — 92 — 98	Rice & ginger are the important crops of the region. National share by quantity of production for these two are as follows : general crops — % national share Rice — 0.8 Ginger — 4.3	————	Mainly hilly region with primitive agricultural practices.
		% national share of the region w.r.t Geo. area = 1.9476 Agri. area = 0.2534 Total pop^n = 0.4086 Agri. pop^n = 0.5498		% share of all crops (by cropped area — by value of production) Rice — 85 — 86 Ginger — 0.4 — 1.1			

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr><td>141</td><td rowspan="5">D 1
(15)</td><td>.1 West Dinajpur + Malda</td>
<td rowspan="5"><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Rice</td><td>2.5</td><td>3.4</td><td>1.8</td></tr>
<tr><td>Jute</td><td>14.4</td><td>19.0</td><td>11.1</td></tr>
<tr><td>Potato</td><td>5.3</td><td>7.1</td><td>3.9</td></tr>
<tr><td>Mesta</td><td>2.8</td><td>3.7</td><td>1.9</td></tr>
<tr><td>Mustard</td><td>1.3</td><td>1.6</td><td>0.8</td></tr>
<tr><td>Linseed</td><td>1.1</td><td>1.4</td><td>0.7</td></tr>
<tr><td>Tea</td><td>1.0</td><td>1.3</td><td>0.7</td></tr>
</table></td>
<td rowspan="5">% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Rice</td><td>87</td><td>81</td></tr>
<tr><td>Wheat</td><td>12</td><td>18</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Rice</td><td>70</td><td>61</td></tr>
<tr><td>Wheat</td><td>9.4</td><td>9.8</td></tr>
<tr><td>Jute</td><td>9.0</td><td>11.4</td></tr>
<tr><td>Potato</td><td>2.3</td><td>9.9</td></tr>
<tr><td>Mustard</td><td>1.5</td><td>0.6</td></tr>
<tr><td>Linseed</td><td>0.9</td><td>0.2</td></tr>
<tr><td>Mesta</td><td>0.6</td><td>0.5</td></tr>
<tr><td>Sesamum</td><td>0.4</td><td>0.3</td></tr>
<tr><td>Tea</td><td>0.3</td><td>1.8</td></tr>
</table></td>
<td rowspan="5">Rice, jute & potato are the important crops of the region. National share by quantity of production for these crops are as follows :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Rice</td><td>8.1</td></tr>
<tr><td>Jute</td><td>50.6</td></tr>
<tr><td>Potato</td><td>18.2</td></tr>
</table></td>
<td rowspan="5">Other important crops of the region are wheat, mustard, sesamum, mesta, linseed & tea. Localised characteristics of which are as follows :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Wheat</td><td>D1.2(1.4)</td><td>41.3</td><td>1.2</td></tr>
<tr><td>Mustard</td><td>D1.1(3.8)</td><td>56</td><td>1.9</td></tr>
<tr><td>Sesamum</td><td>D1.3(2.2)</td><td>71</td><td>2</td></tr>
<tr><td>Mesta</td><td>D1.1(8.1)</td><td>54</td><td>4.7</td></tr>
<tr><td>Linseed</td><td>D1.2(2.4)</td><td>46.9</td><td>1.4</td></tr>
<tr><td>Tea</td><td>D1.1(5.2)</td><td>100</td><td>2.8</td></tr>
</table></td>
<td rowspan="5">Although rice cultivation is predominant (68% of cropped land devoted to it), there are some signs of advanced agricultural practices in this region resulting into a diversification in cropping pattern.</td></tr>
<tr><td>140</td><td>.2 Murshidabad + Birbhum</td></tr>
<tr><td>138</td><td>.3 Burdwan + Hooghly + Howrah + Calcutta</td></tr>
<tr><td>139</td><td>.4 Nadia + 24 Parganas</td></tr>
<tr><td></td><td>% national share of the region w.r.t
Geo. area = 1.5865
Agri. area = 3.0787
Total pop^n = 5.3620
Agri. pop^n = 3.5439</td></tr>
</table>

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
136	D 2 (16)	.1 Santhal Parganas + Dhanbad	Crops — I — I_α — I_β Rice — 2.0 — 2.3 — 1.8 Potato — 1.9 — 2.1 — 1.6	% share of total cereals — by cropped area — by quantity of production Rice — 87 — 86 % share of all crops — by cropped area — by value of production Rice — 81.6 — 81 Potato — 1.2 — 5.7	Rice is the most predominant crop of this region, whose % national share by quantity of production is 6.9.	Cultivation of any crop other than rice is practically very insignificant except for a little potato in limited areas as highlighted below : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Potato — D2.2(2.3), D2.4(3.0) — 85 — 5.7	Absence of any diversification of cropping pattern shows that the region's agricultural practices are at a primitive stage. [N.B : The island areal unit of Andaman and Nicobar (No. 149 in table A.1) is like this region in crop-association pattern, but not shown within this region (or anywhere else), because of its geographical non-contiguity].
130		.2 Hazaribag + Palamau					
129		.3 Ranchi + Singhbhum					
137		.4 Purulia + Bankura + Midnapore					
		% national share of the region w.r.t Geo. area = 3.4719 Agri. area = 2.9406 Total pop^n = 4.3426 Agri. pop^n = 4.1245					

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_{α} (relative to area), I_{β} (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments; if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
39 40 43 41 42	D 3 (17)	.1 Shurguja + Shahdol .2 Bilaspur + Raigarh .3 Durg + Balaghat .4 Raipur .5 Bastar % national share of the region w.r.t Geo. area = 5.1446 Agri. area = 3.2973 Total pop^{n} = 2.5073 Agri. pop^{n} = 3.9055	Crops I I_{α} I_{β} Rice 2.2 2.0 2.4 Linseed 4.3 3.9 4.9 Mustard 0.3 0.7 0.9	% share of total cereals by cropped area / by quantity of production Rice 91 91 % share of all crops by cropped area / by value of production Rice 78.7 86.8 Linseed 5.4 1.7 Mustard 1.2 0.7	Rice & linseed are the two important crops of the region. National share by quantity of production of these two crops are as follows : general crops / % national share Rice 6.2 Linseed 12.7	Mustard is grown in the very limited area of D3.1 in this region; localised characteristics of this crop being as follows : Localised crops / Area of localisation (with I-value) / % share of crops by quantity of production: regional, national Mustard D3.1(2.3) 45 0.9	This is a rice - linseed producing region. Absence of crop diversification is the indication of imbalanced agricultural activities.

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr><td>126</td><td>D 4
(13)</td><td>.1 Balasore + Cuttack</td>
<td rowspan="7"><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Rice</td><td>2.4</td><td>2.3</td><td>2.7</td></tr>
<tr><td>Ragi</td><td>2.1</td><td>1.9</td><td>2.2</td></tr>
<tr><td>Turmeric</td><td>4.9</td><td>4.5</td><td>5.2</td></tr>
<tr><td>Mesta</td><td>2.5</td><td>2.3</td><td>2.6</td></tr>
<tr><td>Sesamum</td><td>2.4</td><td>2.2</td><td>2.8</td></tr>
<tr><td>Castorseed</td><td>1.6</td><td>1.6</td><td>1.7</td></tr>
<tr><td>Jute</td><td>1.5</td><td>1.4</td><td>1.5</td></tr>
</table></td>
<td rowspan="7">% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Rice</td><td>90</td><td>91</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Rice</td><td>79</td><td>79</td></tr>
<tr><td>Ragi</td><td>4.7</td><td>2.5</td></tr>
<tr><td>Sesamum</td><td>2.2</td><td>1.7</td></tr>
<tr><td>Jute</td><td>0.8</td><td>1.6</td></tr>
<tr><td>Mesta</td><td>0.6</td><td>0.7</td></tr>
<tr><td>Castorseed</td><td>0.5</td><td>0.3</td></tr>
<tr><td>Turmeric</td><td>0.3</td><td>1.0</td></tr>
</table></td>
<td rowspan="7">Rice, sesamum & mesta are the most important crops of the region. National share by quantity of production for these crops are given below :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Rice</td><td>10</td></tr>
<tr><td>Sesamum</td><td>14</td></tr>
<tr><td>Mesta</td><td>12</td></tr>
</table></td>
<td rowspan="7">Ragi, castorseed, jute and turmeric are the other important crops grown in some limited locations as indicated below :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Ragi</td><td>D4.6 (6.1)</td><td>4.4</td><td>4</td></tr>
<tr><td>Castorseed</td><td>D4.6 (5.2)</td><td>5.5</td><td>5</td></tr>
<tr><td>Turmeric</td><td>D4.4(31.3)</td><td>12.3</td><td>12</td></tr>
<tr><td>Jute</td><td>D4.1 (6.8)</td><td>6.4</td><td>6</td></tr>
</table></td>
<td rowspan="7">This is a rice - sesamum - mesta growing region. Though rice is the most predominant crop, limited crop diversification is indicative of imbalanced agricultural activities.</td></tr>
<tr><td>127</td><td></td><td>.2 Mayurbhanj + Keonjhar + Dhenkanal</td></tr>
<tr><td>128</td><td></td><td>.3 Sundergarh + Sambalpur</td></tr>
<tr><td>124</td><td></td><td>.4 Bouth Khondmals + Bolangir</td></tr>
<tr><td>125</td><td></td><td>.5 Puri + Ganjam</td></tr>
<tr><td>123</td><td></td><td>.6 Kalahandi + Koraput</td></tr>
<tr><td></td><td></td><td>% national share of the region w.r.t
Geo. area = 5.0555
Agri. area = 4.1491
Total pop^n = 4.0064
Agri. pop^n = 4.3248</td></tr>
</table>

Table (2.14) Continued

Areal unit no. (1)	Crop region code (2)	District groups included and the relative size of the region (3)	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population) (4)	Relative importance of different crops within the region (5)	General crop characteristics (6)	Localised crop characteristics (value of I given within parenthesis beside the location code in this column) (7)	Analytical comments, if any (8)
117 119 83	D 5 (19)	.1 Nizamabad + Karimnagar .2 Warangal + Khammam + Nalgonda .3 Bhandara + Chanda % national share of the region w.r.t Geo. area = 3.1828 Agri. area = 2.3796 Total pop^n = 2.1788 Agri. pop^n = 3.1241	Crops — I — I_α — I_β Jowar 1.8 1.8 1.8 Rice 1.3 1.3 1.3 Maize 1.3 1.2 1.3 Castor-seed 8.0 7.6 8.6 Turmeric 2.5 2.5 2.5 Linseed 1.7 1.7 1.8 Sesamum 1.3 1.3 1.4	% share of total cereals — by cropped area — by quantity of production Rice 49 68 Jowar 34 17 Maize 7 10 % share of all crops — by cropped area — by value of production Rice 39 60 Jowar 27 9.9 Maize 5.9 5.1 Castor-seed 4.2 1.0 Linseed 2.1 0.7 Sesamum 2.0 0.8 Turmeric 0.2 0.7	Rice & jowar are the important crops of the region; national share by quantity of production for these crops at the region are given below : general crops — % national share Rice 3.5 Jowar 4.0	Maize, sesamum, linseed, castorseed & turmeric are important crops in some limited localities of this region. Localised characteristics of these crops are given below : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Maize D5.1 (3.7) 74 2.7 Sesamum D5.3 (3.1) 73 2.0 Linseed D5.3 (5.6) 97 4.0 Castor-seed D5.2(18.6) 96 12.0 Turmeric D5.1 (8.5) 89 6.0	This is a rice - jowar region, though quite a number of other crops are grown which are localised in nature.

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
122	E 1 (20)	.1 Srikakulam ÷ Vishakhapatnam	Crops I I_α I_β Rice 1.8 2.0 1.6 Mesta 5.4 6.2 4.7 Tobacco 5.2 5.9 4.5 Chillies 3.3 3.8 2.9 Groundnut 2.3 2.6 2.0 Turmeric 2.0 2.3 1.8 Sesamum 1.6 1.7 1.3 Sugarcane 1.3 1.4 1.2	% share of total cereals by cropped area · by quantity of production Rice 77 87 % share of all crops by cropped area · by value of production Rice 56 59.5 Groundnut 12.6 9.4 Sugarcane 2.8 11.3 Chillies 2.5 5.4 Tobacco 2.3 5.2 Sesamum 2.0 0.6 Mesta 1.5 1.3 Castorseed 0.4 0.05 Turmeric 0.1 0.4 Ginger 0.02 0.05	Rice is the predominant crop with groundnut & chillies as the associated widespread crops of the region. National percentage share by quantity of production for these crops are given below : general crops · % national share Rice 15 Groundnut 17.3 Chillies 27	Other important crops, e.g., sugarcane, tobacco, sesamum, mesta, castorseed, turmeric & ginger are localised in certain areas of the region as indicated below : Localised crops · Area of localisation (with I-value) · % share of crops by quantity of production: regional · national Sugarcane E1.1 (1.7), E1.2 (1.6), E1.5 (2.0) 79 9 Tobacco E1.2 (8.0), E1.3(22.8) 92 31 Sesamum E1.1 (2.6), E1.2 (2.2), E1.6 (2.1) 69 7 Mesta E1.1(40.2) 99 44 Castorseed E1.3 (4.4) 82 2 Turmeric E1.3 (5.9) 42 7 Ginger E1.1 (6.1) 97 5	This is a rice – groundnut – chillies growing region, though quite a number of crops of localised nature are grown in this region, especially in the part that lie across the path of south-west monsoonic wind.
121		.2 E. Godavari ÷ W. Godavari ÷ Krishna					
120		.3 Guntur ÷ Ongole					
113		.4 Nellore ÷ Chittoor					
112		.5 Chingleput + S. Arcot + N. Arcot ÷ Pondicherry + Madras					
111		.6 Tiruchirapalli + Tanjavur					
		% national share of the region w.r.t. Geo. area = 5.3121 Agri. area = 5.3981 Total pop^n = 7.2235 Agri. pop^n = 8.7018					

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
$I_α$ (relative to area),
$I_β$ (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I give within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>108
107

106</td>
<td>F 1
(21)</td>
<td>.1 Coimbatore
.2 Ramanathapuram + Madurai
.3 Tirunelveli + Kanyakumari

<u>% national share of the region w.r.t</u>
Geo. area = 1.7534
Agri. area = 1.4972
Total pop^n = 2.7342
Agri. pop^n = 2.8021</td>
<td><table>
<tr><th>Crops</th><th>I</th><th>$I_α$</th><th>$I_β$</th></tr>
<tr><td>Rice</td><td>1.0</td><td>1.2</td><td>0.8</td></tr>
<tr><td>Jowar</td><td>1.2</td><td>1.4</td><td>0.9</td></tr>
<tr><td>Chillies</td><td>3.6</td><td>4.5</td><td>3.0</td></tr>
<tr><td>Cotton</td><td>1.8</td><td>2.0</td><td>1.3</td></tr>
<tr><td>Groundnut</td><td>1.7</td><td>2.0</td><td>1.3</td></tr>
<tr><td>Turmeric</td><td>4.3</td><td>5.2</td><td>3.6</td></tr>
<tr><td>Coffee</td><td>3.1</td><td>4.0</td><td>2.7</td></tr>
<tr><td>Tea</td><td>1.9</td><td>2.2</td><td>1.5</td></tr>
<tr><td>Tobacco</td><td>1.6</td><td>2.0</td><td>1.3</td></tr>
<tr><td>Sugarcane</td><td>1.0</td><td>1.2</td><td>0.8</td></tr>
</table></td>
<td><u>% share of total cereals</u>
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Rice</td><td>52</td><td>68</td></tr>
<tr><td>Jowar</td><td>25</td><td>16</td></tr>
</table>
<u>% share of all crops</u>
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Rice</td><td>34.8</td><td>43</td></tr>
<tr><td>Jowar</td><td>17.0</td><td>6.6</td></tr>
<tr><td>Cotton</td><td>11.2</td><td>6.5</td></tr>
<tr><td>Groundnut</td><td>10.6</td><td>9.0</td></tr>
<tr><td>Chillies</td><td>2.5</td><td>9.5</td></tr>
<tr><td>Sugarcane</td><td>2.3</td><td>1.0</td></tr>
<tr><td>Coffee</td><td>0.7</td><td>1.1</td></tr>
<tr><td>Tobacco</td><td>0.7</td><td>2.8</td></tr>
<tr><td>Tea</td><td>0.6</td><td>6.6</td></tr>
<tr><td>Turmeric</td><td>0.3</td><td>0.5</td></tr>
</table></td>
<td>Important crops of this region are rice, cotton, groundnut & chillies. National share by quantity of production for these crops of this region are given below:
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Rice</td><td>2.7</td></tr>
<tr><td>Cotton</td><td>4.3</td></tr>
<tr><td>Groundnut</td><td>4.1</td></tr>
<tr><td>Chillies</td><td>11.8</td></tr>
</table></td>
<td>Other important crops localised in some particular areas of the region are jowar, sugarcane, coffee, tobacco, tea & turmeric as pointed out below :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Jowar</td><td>F1.1 (2.0)</td><td>45</td><td>1.3</td></tr>
<tr><td>Turmeric</td><td>F1.1(14.5)</td><td>99</td><td>13.0</td></tr>
<tr><td>Tea</td><td>F1.1 (5.1)</td><td>84</td><td>4.0</td></tr>
<tr><td>Coffee</td><td>F1.2 (6.4)</td><td>74</td><td>4.0</td></tr>
<tr><td>Tobacco</td><td>F1.1 (4.6)</td><td>88</td><td>4.0</td></tr>
<tr><td>Sugarcane</td><td>F1.1 (2.4)</td><td>75</td><td>2.0</td></tr>
</table></td>
<td>This is a black soil region producing primarily rice, cotton, groundnut & chillies. Considerable diversification in the cropping pattern is noticed in this region, particularly in F1.1.</td>
</tr>
</table>

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th><th>(5)</th><th>(6)</th><th>(7)</th><th>(8)</th></tr>
<tr>
<td>101
102
103
104
105</td>
<td>G 1
(22)</td>
<td>.1 Coorg
.2 Cannanore + Kozhikode + Mallapuram
.3 Palghat + Trichur
.4 Ernakulam + Kottayam
.5 Alleppey + Quilon + Trivandrum

% national share of the region w.r.t

Geo. area = 1.3950
Agri. area = 0.9061
Total popⁿ = 3.9373
Agri. popⁿ = 1.8908</td>
<td><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Rice</td><td>1.4</td><td>1.9</td><td>1.0</td></tr>
<tr><td>Pepper</td><td>46.5</td><td>71.2</td><td>34.2</td></tr>
<tr><td>Ginger</td><td>23.6</td><td>29.7</td><td>16.7</td></tr>
<tr><td>Coffee</td><td>25.5</td><td>38.7</td><td>18.7</td></tr>
<tr><td>Tea</td><td>5.1</td><td>6.6</td><td>3.5</td></tr>
<tr><td>Turmeric</td><td>3.6</td><td>4.8</td><td>2.5</td></tr>
</table></td>
<td>% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Rice</td><td>98</td><td>99</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Rice</td><td>72.7</td><td>56.5</td></tr>
<tr><td>Pepper</td><td>10.4</td><td>7.5</td></tr>
<tr><td>Coffee</td><td>6.5</td><td>13.2</td></tr>
<tr><td>Tea</td><td>2.7</td><td>15.2</td></tr>
<tr><td>Ginger</td><td>0.9</td><td>2.2</td></tr>
<tr><td>Turmeric</td><td>0.5</td><td>0.6</td></tr>
</table></td>
<td>Rice is the predominant cereal crop while pepper, ginger & coffee are the important non-cereal crops of the region. National shares of these crops in the region by quantity of production are as follows :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Rice</td><td>2.8</td></tr>
<tr><td>Pepper</td><td>98.0</td></tr>
<tr><td>Coffee</td><td>53.0</td></tr>
<tr><td>Ginger</td><td>47.0</td></tr>
</table></td>
<td>Tea & turmeric are the other important non-cereal crops localised in limited areas of the region as described below :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Tea</td><td>G1.4(15.1)</td><td>65</td><td>5.7</td></tr>
<tr><td>Turmeric</td><td>G1.2 (4.8)
G1.3 (4.0)
G1.4 (6.9)</td><td>95</td><td>4.6</td></tr>
</table></td>
<td>This region extends from coastal plain to mountaineous western ghats with the predominant crop of rice in the plane and the non-cereal crops of pepper, ginger & coffee extending in the uplands quite extensively. Problem of labour pressure on land can be suspected in view of $I_\alpha > I_\beta$.</td>
</tr>
</table>

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant value of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
78 87 90 91 92 100	G 2 (23)	.1 Dangs + Valsad + Dadra + Nagar Haveli .2 Thana + Kolaba + G. Bombay .3 Ratnagiri .4 Goa .5 North Kanara + Shimoga .6 South Kanara % national share of the region w.r.t Geo. area = 2.2880 Agri. area = 1.0270 Total pop^n = 2.2834 Agri. pop^n = 1.9913	Crops — I — I_α — I_β Rice — 1.6 — 1.9 — 1.4 Ragi — 3.0 — 3.3 — 2.7 Ginger — 1.8 — 1.9 — 1.7 Chillis — 1.1 — 1.3 — 0.9	% share of total cereals — by cropped area — by quantity of production Rice — 80 — 88 Ragi — 13 — 8 % share of all crops — by cropped area — by value of production Rice — 73 — 83 Ragi — 12 — 4.9 Chillies — 1.5 — 2.0 Ginger — 0.1 — 0.2	Rice is the only predominant crop of this region with the following national shares by quantity of production : general crops — % national share Rice — 3.3	Ragi, chillies and ginger are the other crops localised in limited areas of the region as follows : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Ragi — G2.1(5.3) G2.6(5.5) — 44 — 2.4 Chillies — G2.3(2.4) — 42 — 0.7 Ginger — G2.3(4.5) G2.4(4.9) — 98 — 3.6	This is predominantly a rice region.

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>109
98
99
96
97
110</td>
<td>H 1
(24)</td>
<td>.1 Nilgiris
.2 Mandya + Mysore
.3 Chickmagalur + Hassan
.4 Chitradurga + Tumkur
.5 Kolar + Bangalore
.6 Salem + Dharampuri

% national share of the region w.r.t

Geo. area = 2.9035
Agri. area = 2.1885
Total popⁿ = 3.4883
Agri. popⁿ = 3.5297</td>
<td><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Ragi</td><td>13.2</td><td>14.8</td><td>11.8</td></tr>
<tr><td>Jowar</td><td>1.2</td><td>1.3</td><td>1.1</td></tr>
<tr><td>Coffee</td><td>12.4</td><td>14.2</td><td>12.2</td></tr>
<tr><td>Tea</td><td>2.5</td><td>2.8</td><td>2.2</td></tr>
<tr><td>Castorseed</td><td>2.3</td><td>2.5</td><td>1.9</td></tr>
<tr><td>Groundnut</td><td>2.0</td><td>2.2</td><td>1.8</td></tr>
<tr><td>Sugarcane</td><td>1.0</td><td>1.1</td><td>0.9</td></tr>
</table></td>
<td>% share of total cereals<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Ragi</td><td>48</td><td>39</td></tr>
<tr><td>Rice</td><td>23</td><td>34</td></tr>
<tr><td>Jowar</td><td>20</td><td>18</td></tr>
</table>
% share of all crops<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Ragi</td><td>36</td><td>18.8</td></tr>
<tr><td>Rice</td><td>17</td><td>24.6</td></tr>
<tr><td>Jowar</td><td>15</td><td>8.3</td></tr>
<tr><td>Groundnut</td><td>12</td><td>11.6</td></tr>
<tr><td>Sugarcane</td><td>2.7</td><td>10.6</td></tr>
<tr><td>Coffee</td><td>2.0</td><td>5.9</td></tr>
<tr><td>Castorseed</td><td>1.0</td><td>0.4</td></tr>
<tr><td>Tea</td><td>0.9</td><td>8.6</td></tr>
<tr><td>Potato</td><td>0.6</td><td>1.8</td></tr>
<tr><td>Ginger</td><td>0.08</td><td>0.05</td></tr>
<tr><td>Pepper</td><td>0.01</td><td>0.008</td></tr>
</table></td>
<td>Ragi is the dominant crop associated with rice, jowar & castorseed, which are regionally quite widespread but nationally not significant. National quantity of production share for these crops are as follows :<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Ragi</td><td>44</td></tr>
<tr><td>Rice</td><td>2</td></tr>
<tr><td>Jowar</td><td>48</td></tr>
<tr><td>Castorseed</td><td>7</td></tr>
</table></td>
<td>Groundnut, sugarcane, coffee, tea, potato, ginger (dry) & pepper are other important crops of the region which are highly localised in very limited areas of the region as shown below :<table>
<tr><th>Localised crops</th><th>Area of localisation (with I-value</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th></th><th></th><th>regional</th><th>national</th></tr>
<tr><td>Groundnut</td><td>H1.4 (2.3)
H1.5 (2.2)
H1.6 (3.8)</td><td>87</td><td>6.3</td></tr>
<tr><td>Sugarcane</td><td>H1.2 (1.9)
H1.6 (1.3)</td><td>69</td><td>2.0</td></tr>
<tr><td>Coffee</td><td>H1.3(32.8)
H1.1(91.8)</td><td>91.5</td><td>37</td></tr>
<tr><td>Tea</td><td>H1.1(89.3)</td><td>93</td><td>8</td></tr>
<tr><td>Potato</td><td>H1.1(20.5)</td><td>50</td><td>1</td></tr>
<tr><td>Pepper</td><td>H1.1 (4.9)</td><td>87</td><td>0.2</td></tr>
<tr><td>Ginger</td><td>H1.1(52.3)</td><td>93</td><td>1.6</td></tr>
</table></td>
<td>This is a Ragi-Rice-Jowar-Groundnut producing region. It has a tendency to flourish towards diversification of crops.</td>
</tr>
</table>

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>114
115
116
94
93
95</td>
<td>E 2
(25)</td>
<td>.1 Cuddapah + Anantapur
.2 Kurnool + Mahbubnagar
.3 Hyderabad + Medak
.4 Bidar + Gulbarga + Bijapur
.5 Belgaum + Dharwar
.6 Raichur + Bellary

% national share of the region w.r.t
Geo. area = 5.7722
Agri. area = 6.1840
Total pop^n = 4.5062
Agri. pop^n = 5.3102</td>
<td>
<table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Jowar</td><td>3.2</td><td>3.0</td><td>3.3</td></tr>
<tr><td>Bajra</td><td>1.1</td><td>1.1</td><td>1.2</td></tr>
<tr><td>Castor-seed</td><td>4.1</td><td>3.8</td><td>4.6</td></tr>
<tr><td>Cotton</td><td>2.9</td><td>2.7</td><td>3.1</td></tr>
<tr><td>Groundnut</td><td>2.9</td><td>2.8</td><td>3.1</td></tr>
<tr><td>Tur</td><td>2.0</td><td>1.9</td><td>2.1</td></tr>
<tr><td>Chillies</td><td>2.1</td><td>2.0</td><td>2.2</td></tr>
<tr><td>Tobacco</td><td>2.0</td><td>1.9</td><td>2.1</td></tr>
<tr><td>Turmeric</td><td>1.5</td><td>1.4</td><td>1.5</td></tr>
<tr><td>Mesta</td><td>1.3</td><td>1.2</td><td>1.3</td></tr>
<tr><td>Linseed</td><td>1.0</td><td>0.9</td><td>1.0</td></tr>
<tr><td>Sesamum</td><td>1.0</td><td>0.9</td><td>1.0</td></tr>
</table>
</td>
<td>
% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Jowar</td><td>54</td><td>43</td></tr>
<tr><td>Rice</td><td>16</td><td>32</td></tr>
<tr><td>Bajra</td><td>15</td><td>9</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Jowar</td><td>32</td><td>20</td></tr>
<tr><td>Rice</td><td>9.5</td><td>22</td></tr>
<tr><td>Bajra</td><td>8.8</td><td>4.6</td></tr>
<tr><td>Groundnut</td><td>14</td><td>15</td></tr>
<tr><td>Cotton</td><td>14</td><td>9.9</td></tr>
<tr><td>Tur</td><td>3.8</td><td>2.0</td></tr>
<tr><td>Castor-seed</td><td>1.6</td><td>0.6</td></tr>
<tr><td>Chillies</td><td>1.4</td><td>3.4</td></tr>
<tr><td>Sugarcane</td><td>1.1</td><td>9.2</td></tr>
<tr><td>Linseed</td><td>0.9</td><td>0.4</td></tr>
<tr><td>Sesamum</td><td>0.9</td><td>0.7</td></tr>
<tr><td>Tobacco</td><td>0.6</td><td>2.9</td></tr>
<tr><td>Mesta</td><td>0.4</td><td>0.3</td></tr>
<tr><td>Turmeric</td><td>0.1</td><td>0.4</td></tr>
</table>
</td>
<td>
The predominant crops of the region are jowar, cotton & groundnut associated with rice, which is regionally widespread but nationally not significant (I = 0.5). The national quantity share of production for these crops are as follows :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Jowar</td><td>16</td></tr>
<tr><td>Groundnut</td><td>13</td></tr>
<tr><td>Cotton</td><td>12</td></tr>
<tr><td>Rice</td><td>2.7</td></tr>
</table>
</td>
<td>
There are a number of highly localised crops, e.g., bajra, tur, castorseed, linseed, chillies (dry), sesamum, tobacco, mesta & turmeric, localised characteristics of which are given below :
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Bajra</td><td>E2.4 (2.7)
E2.6 (1.4)</td><td>68</td><td>4.0</td></tr>
<tr><td>Tur</td><td>E2.4 (5.6)</td><td>59</td><td>4.8</td></tr>
<tr><td>Castor-seed</td><td>E2.2(13.2)
E2.3 (8.7)</td><td>85</td><td>12.0</td></tr>
<tr><td>Linseed</td><td>E2.4 (3.9)</td><td>81</td><td>4.0</td></tr>
<tr><td>Sugar-cane</td><td>E2.5 (1.6)</td><td>41</td><td>1.8</td></tr>
<tr><td>Sesamum</td><td>E2.4 (2.3)</td><td>53</td><td>2.7</td></tr>
<tr><td>Tobacco</td><td>E2.2 (5.0)
E2.5 (5.0)</td><td>90</td><td>8.0</td></tr>
<tr><td>Turmeric</td><td>E2.1 (5.6)</td><td>65</td><td>5.5</td></tr>
<tr><td>Mesta</td><td>E2.4 (5.8)</td><td>86</td><td>4.0</td></tr>
<tr><td>Chillies</td><td>E2.2 (2.2)
E2.3 (2.1)
E2.5 (4.5)</td><td>68</td><td>5.5</td></tr>
</table>
</td>
<td>It is a black soil region, generally dry but with irrigation facilities in many areas. As such besides jowar - cotton - groundnut, rice has become quite widespread crop in this region. Many localised crops are present in this region, particularly in E2.4. Over-all impression is that of a diversified cropping pattern.</td>
</tr>
</table>

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
118 84 82 81 80 51	H 3 (26)	.1 Adilabad .2 Yeotmal + Nanded + Parbhani .3 Wardha + Nagpur .4 Buldana + Akola + Amravati .5 Jalgaon + Aurangabad .6 East Nimar + West Nimar % national share of the region w.r.t Geo. area = 4.6295 Agri. area = 5.8126 Total pop^{n} = 3.4686 Agri. pop^{n} = 4.5804	Crops — I — I_α — I_β Jowar 5.0 4.8 5.2 Cotton 5.5 5.2 6.0 Tur 3.5 3.4 3.7 Linseed 2.2 2.2 2.3 Chillies 2.1 2.0 2.1 Turmeric 1.4 1.4 1.4 Groundnut 1.0 1.0 1.1	% share of total cereals — by cropped area — by quantity of production Jowar 69 69 % share of all crops — by cropped area — by value of production Jowar 39 39 Cotton 27 17 Tur 5 4.7 Groundnut 4.4 5.4 Linseed 1.8 1.0 Chillies 1 4 Turmeric 0.1 0.3	Jowar is the only important cereal crop while cotton & tur are the associated widespread crops of the region. The national quantity of production share of respective crops of this region are as follows : general crops — % national share Jowar 22 Cotton 14 Tur 14	Other important crops of the region are groundnut, linseed, turmeric & chillies, localised characteristics of which are given below : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Groundnut — H3.5 (1.7), H3.6 (2.5) — 72 — 2.0 Linseed — H3.2 (2.8), H3.3 (6.1), H3.5 (1.9) — 84 — 7.0 Turmeric — H3.1 (4.0), H3.2 (3.9) — 95 — 4.4 Chillies — H3.1 (3.4), H3.2 (2.0), H3.3 (4.2) — 55 — 3.6	This is a black soil region producing extensively Jowar - Cotton - Tur, with crops like groundnut, linseed, turmeric & chillies (dry) localised in limited areas of the region. H3.2 is an important area of crop diversification.

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>79
86

85

88

89</td>
<td>H 4
(27)</td>
<td>.1 Dhulia + Nasik
.2 Poona + Ahmedabad
.3 Bhir + Osmanabad + Sholhapur
.4 Satara + Sangli
.5 Kolhapur

% national share of the region w.r.t

Geo. area = 4.1813
Agri. area = 5.3656
Total pop^n = 3.7401
Agri. pop^n = 4.2075</td>
<td>
<table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Jowar</td><td>4.8</td><td>4.5</td><td>5.0</td></tr>
<tr><td>Bajra</td><td>2.3</td><td>2.2</td><td>2.4</td></tr>
<tr><td>Sugarcane</td><td>2.2</td><td>2.2</td><td>2.3</td></tr>
<tr><td>Tur</td><td>2.0</td><td>1.9</td><td>2.1</td></tr>
<tr><td>Groundnut</td><td>1.8</td><td>1.8</td><td>1.9</td></tr>
<tr><td>Mesta</td><td>1.8</td><td>1.7</td><td>1.9</td></tr>
<tr><td>Turmeric</td><td>1.2</td><td>1.2</td><td>1.3</td></tr>
<tr><td>Linseed</td><td>1.1</td><td>1.0</td><td>1.1</td></tr>
<tr><td>Tobacco</td><td>0.5</td><td>0.4</td><td>0.5</td></tr>
</table>
</td>
<td>
% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Jowar</td><td>57</td><td>58</td></tr>
<tr><td>Bajra</td><td>25</td><td>13</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Jowar</td><td>44</td><td>28</td></tr>
<tr><td>Bajra</td><td>19</td><td>7</td></tr>
<tr><td>Ragi</td><td>2</td><td>1.4</td></tr>
<tr><td>Groundnut</td><td>7.5</td><td>10</td></tr>
<tr><td>Sugarcane</td><td>2.8</td><td>27</td></tr>
<tr><td>Tur</td><td>3.4</td><td>2</td></tr>
<tr><td>Linseed</td><td>0.9</td><td>0.3</td></tr>
<tr><td>Mesta</td><td>0.6</td><td>0.3</td></tr>
<tr><td>Turmeric</td><td>0.1</td><td>0.3</td></tr>
<tr><td>Tobacco</td><td>0.1</td><td>0.5</td></tr>
</table>
</td>
<td>
Jowar, bajra, groundnut & sugarcane are the widespread crops of the region. The national quantity of production share of respective crops of this region are as follows :
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Jowar</td><td>20</td></tr>
<tr><td>Bajra</td><td>8</td></tr>
<tr><td>Groundnut</td><td>7</td></tr>
<tr><td>Sugarcane</td><td>11</td></tr>
</table>
</td>
<td>
There are a number of localised crops in this region, e.g., ragi, tur, linseed, turmeric, mesta and tobacco, details of their localised characteristics are given below :
<table>
<tr><th>Localised crops</th><th>Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th></th><th></th><th>regional</th><th>national</th></tr>
<tr><td>Ragi</td><td>H4.5 (4.5)</td><td>32</td><td>1.3</td></tr>
<tr><td>Tur</td><td>H4.3 (4.6)</td><td>64</td><td>4.2</td></tr>
<tr><td>Linseed</td><td>H4.3 (3.4)</td><td>93</td><td>3.6</td></tr>
<tr><td>Tobacco</td><td>H4.5 (2.8)</td><td>47</td><td>0.6</td></tr>
<tr><td>Turmeric</td><td>H4.4 (6.6)</td><td>81</td><td>3.9</td></tr>
<tr><td>Mesta</td><td>H4.3 (6.5)</td><td>97</td><td>3.3</td></tr>
</table>
</td>
<td>It is a Jowar - Bajra - Groundnut - Sugarcane producing region. It has a number of localised crops, many of which are concentrated in H4.3 & H4.4.</td>
</tr>
</table>

Table (2.14) Continued

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index
I (composite),
I_α (relative to area),
I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>52
53
69
70
72
71
77</td>
<td>I 1
(28)</td>
<td>.1 Dhar + Jhabua + Ratlam
.2 Mandsaur
.3 Udaipur + Bhilwara + Chitorgarh
.4 Banswara + Dungarpur
.5 Ahmedabad + Sabarkantha + Gandhinagar
.6 Panchmalals + Kaira
.7 Surat + Bharuch + Baroda

% national share of the region w.r.t
Geo. area = 4.3597
Agri. area = 4.5052
Total pop^n = 4.2114
Agri. pop^n = 4.1083</td>
<td><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Maize</td><td>4.3</td><td>4.4</td><td>4.3</td></tr>
<tr><td>Jowar</td><td>1.2</td><td>1.2</td><td>1.2</td></tr>
<tr><td>Barley</td><td>1.5</td><td>1.5</td><td>1.5</td></tr>
<tr><td>Bajra</td><td>1.0</td><td>1.0</td><td>1.0</td></tr>
<tr><td>Cotton</td><td>4.0</td><td>4.0</td><td>4.0</td></tr>
<tr><td>Groundnut</td><td>1.4</td><td>1.4</td><td>1.4</td></tr>
<tr><td>Sesamum</td><td>1.4</td><td>1.4</td><td>1.4</td></tr>
<tr><td>Castorseed</td><td>1.4</td><td>1.4</td><td>1.3</td></tr>
<tr><td>Gram</td><td>1.2</td><td>1.2</td><td>1.2</td></tr>
<tr><td>Tur</td><td>1.1</td><td>1.1</td><td>1.1</td></tr>
</table></td>
<td>% share of total cereals<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Maize</td><td>28</td><td>33</td></tr>
<tr><td>Jowar</td><td>22</td><td>12</td></tr>
<tr><td>Wheat</td><td>21</td><td>28</td></tr>
<tr><td>Bajra</td><td>10</td><td>8</td></tr>
<tr><td>Barley</td><td>3</td><td>4</td></tr>
</table>
% share of all crops<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Maize</td><td>16.9</td><td>14.8</td></tr>
<tr><td>Jowar</td><td>13.7</td><td>6.5</td></tr>
<tr><td>Wheat</td><td>13.1</td><td>15.9</td></tr>
<tr><td>Bajra</td><td>6.4</td><td>4.6</td></tr>
<tr><td>Barley</td><td>1.8</td><td>1.6</td></tr>
<tr><td>Cotton</td><td>17.3</td><td>17.2</td></tr>
<tr><td>Groundnut</td><td>7.2</td><td>6.7</td></tr>
<tr><td>Gram</td><td>7.0</td><td>3.1</td></tr>
<tr><td>Tur</td><td>2.2</td><td>1.1</td></tr>
<tr><td>Sesamum</td><td>1.6</td><td>0.8</td></tr>
<tr><td>Tobacck</td><td>1.4</td><td>11.0</td></tr>
<tr><td>Linseed</td><td>0.6</td><td>0.3</td></tr>
<tr><td>Castorseed</td><td>0.3</td><td>0.3</td></tr>
<tr><td>Ginger</td><td>0.02</td><td>0.03</td></tr>
</table></td>
<td>The dominant crops are cotton and maize together with associated cereal crops of jowar & wheat. The national shares by quantity of production for these crops of this region are as follows :<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Maize</td><td>19</td></tr>
<tr><td>Jowar</td><td>4.7</td></tr>
<tr><td>Wheat</td><td>3.6</td></tr>
<tr><td>Cotton</td><td>19</td></tr>
</table></td>
<td>Other important crops of this region are bajra, barley, groundnut, sesamum, linseed, castorseed, gram, tur & ginger whose localised characteristics are given below :<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Bajra</td><td>I1.6 (3.2)
I1.5 (2.4)</td><td>88</td><td>4.5</td></tr>
<tr><td>Barley</td><td>I1.3 (6.2)</td><td>89</td><td>6</td></tr>
<tr><td>Groundnut</td><td>I1.5 (2.4)
I1.1 (2.2)
I1.2 (2.7)</td><td>57</td><td>3</td></tr>
<tr><td>Sesamum</td><td>I1.3 (2.4)</td><td>33</td><td>1.3</td></tr>
<tr><td>Linseed</td><td>I1.1 (2.4)
I1.2 (3.0)</td><td>76</td><td>2</td></tr>
<tr><td>Castorseed</td><td>I1.5 (6.2)</td><td>68</td><td>5</td></tr>
<tr><td>Gram</td><td>I1.1 (2.8)
I1.2 (3.3)
I1.4 (2.9)</td><td>59</td><td>2.6</td></tr>
<tr><td>Tur</td><td>I1.7 (2.2)</td><td>37</td><td>14</td></tr>
<tr><td>Ginger</td><td>I1.6 (2.2)</td><td>60</td><td>0.8</td></tr>
<tr><td>Tobacco</td><td>I1.7 (6.9)
I1.6(23.2)</td><td>95</td><td>28</td></tr>
</table></td>
<td>It is a mixed cereal growing region (mainly maize - jowar - wheat) maize taking the leading role. Cotton is the associated non-cereal crop in the region. Diversification of crops is maximum here, especially for the non-cereal crops. Bajra & barley, though localised, are the 3rd crop in their areas of localisation.</td>
</tr>
</table>

Table (2.14) Continued

Areal unit no.	Crop region code	District groups included and the relative size of the region	Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)	Relative importance of different crops within the region	General crop characteristics	Localised crop characteristics (value of I given within parenthesis beside the location code in this column)	Analytical comments, if any
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
73 74 76 75	I 2 (29)	.1 Mehsana + Banaskantha .2 Surendranagar + Kutch .3 Rajkot + Bhavnagar .4 Jamnagar + Junagadh + Amreli **% national share of the region w.r.t** Geo. area = 4.2767 Agri. area = 3.8632 Total pop^n = 2.2556 Agri. pop^n = 1.8718	Crops — I — I_α — I_β Bajra 4.8 3.6 7.1 Jowar 1.5 1.0 1.9 Groundnut 8.6 6.5 11.9 Cotton 4.6 3.5 6.3 Castorseed 9.5 7.4 12.5 Sesamum 1.6 1.2 2.3 Mustard 1.2 0.9 1.7	% share of total cereals — by cropped area — by quantity of production Bajra 53 50 Jowar 30 15 Wheat 15 32 **% share of all crops** — by cropped area — by value of production Bajra 25.3 18.1 Jowar 14.5 5.0 Wheat 7.1 12.1 Groundnut 31.7 38.7 Cotton 15.3 16.3 Castorseed 1.3 2.3 Sesamum 1.3 0.9 Mustard 1.1 0.9	Groundnut, Bajra, jowar & cotton are the most widespread crops of the region. The national quantity share of production of these crops are as follows general crops — % national share Bajra 17 Jowar 3 Cotton 15 Groundnut 25	Other important crops of the region are wheat, mustard, castorseed & sesamum, whose localised characteristics are as follows : Localised crops — Area of localisation (with I-value) — % share of crops by quantity of production: regional — national Wheat I2.1 (1.2) 43 1 Mustard I2.1 (5.0) 99 3 Castorseed I2.1(33.0), I2.2 (5.2) 96 39 Sesamum I2.2 (2.3), I2.3 (1.7), I2.4 (1.7) 77 3.9	It is really Bajra – Cotton – Groundnut growing region with associated cereal crop jowar which is relatively less important. Wheat, castorseed, mustard & sesamum are localised crops, many of which are in I2.1. Wheat is the 2nd crop in I2.1. Cropped area relative to population seems to be favourable as wetnessed by higher values of I_β than those of I_α.

Table (2.14) Concluded

<table>
<tr><th>Areal unit no.</th><th>Crop region code</th><th>District groups included and the relative size of the region</th><th>Crops with significant values of concentration index I (composite), I_α (relative to area), I_β (relative to population)</th><th>Relative importance of different crops within the region</th><th>General crop characteristics</th><th>Localised crop characteristics (value of I given within parenthesis beside the location code in this column)</th><th>Analytical comments, if any</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td></tr>
<tr>
<td>64
62
65
66
67
68</td>
<td>I 3
(30)</td>
<td>-1 Bikaner + Churu
-2 Jhunjhunu + Sikar
-3 Nagaur + Jodhpur
-4 Jaisalmer + Barmer
-5 Jalore
-6 Pali + Sirohi

% national share of the region w.r.t
Geo. area = 6.2744
Agri. area = 3.7618
Total pop^n = 1.8224
Agri. pop^n = 1.6415</td>
<td><table>
<tr><th>Crops</th><th>I</th><th>I_α</th><th>I_β</th></tr>
<tr><td>Bajra</td><td>8.7</td><td>6.5</td><td>13.2</td></tr>
<tr><td>Wheat</td><td>0.7</td><td>0.6</td><td>0.8</td></tr>
<tr><td>Barley</td><td>2.3</td><td>1.8</td><td>2.9</td></tr>
<tr><td>Sesamum</td><td>5.7</td><td>4.1</td><td>8.8</td></tr>
<tr><td>Mustard</td><td>2.7</td><td>2.3</td><td>3.2</td></tr>
<tr><td>Gram</td><td>1.4</td><td>1.2</td><td>1.9</td></tr>
</table></td>
<td>% share of total cereals
<table>
<tr><th></th><th>by cropped area</th><th>by quantity of production</th></tr>
<tr><td>Bajra</td><td>87</td><td>68</td></tr>
<tr><td>Wheat</td><td>7</td><td>23</td></tr>
<tr><td>Barley</td><td>2</td><td>7</td></tr>
</table>
% share of all crops
<table>
<tr><th></th><th>by cropped area</th><th>by value of production</th></tr>
<tr><td>Bajra</td><td>75.3</td><td>50.2</td></tr>
<tr><td>Wheat</td><td>6.3</td><td>19.4</td></tr>
<tr><td>Barley</td><td>1.8</td><td>4.4</td></tr>
<tr><td>Sesamum</td><td>5.6</td><td>6.2</td></tr>
<tr><td>Gram</td><td>5.4</td><td>7.0</td></tr>
<tr><td>Mustard</td><td>1.5</td><td>4.8</td></tr>
</table></td>
<td>Bajra & sesamum are the predominant crops of the region with the following % of national quantity share of production.
<table>
<tr><th>general crops</th><th>% national share</th></tr>
<tr><td>Bajra</td><td>17</td></tr>
<tr><td>Sesamum</td><td>13</td></tr>
</table></td>
<td>Other important crops of the region are wheat, barley, gram & mustard which are localised according to following description.
<table>
<tr><th rowspan="2">Localised crops</th><th rowspan="2">Area of localisation (with I-value)</th><th colspan="2">% share of crops by quantity of production</th></tr>
<tr><th>regional</th><th>national</th></tr>
<tr><td>Wheat</td><td>I3.5 (1.1)
I3.6 (1.7)</td><td>55</td><td>0.7</td></tr>
<tr><td>Barley</td><td>I3.2 (4.8)
I3.6 (6.7)</td><td>76</td><td>4.0</td></tr>
<tr><td>Gram</td><td>I3.1 (2.8)
I3.2 (4.0)</td><td>74</td><td>2.0</td></tr>
<tr><td>Mustard</td><td>I3.5(13.3)
I3.6 (5.1)</td><td>78</td><td>5.0</td></tr>
</table></td>
<td>Substantial desert (Thar) areas are included in this region. As such inferior crops like bajra & sesamum are mainly produced in this region. Again cropped land relative to population seems to be favourable; as indicated by the higher values of I_β than those I_α.
Less dry areas, e.g., J2.5 & J 2.6 have some localised crops like wheat & mustard and also barley (in I3.6). Barley & gram are other localised crops of the region.</td>
</tr>
</table>

Table (2.15) : Estimated Values of the Crop-concentration Index I by Crops and by States : India 1980-81

States	Rice	Wheat	Jowar	Bajra	Ragi	Maize	Barley	Gram	Tur
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Jammu & Kashmir	0.988	1.059	0.001	0.170	0.0	5.877	0.536	0.053	0.0
Himachal Pradesh	0.316	1.810	0.0	0.001	0.628	6.637	1.948	0.489	0.011
Punjab	1.301	5.902	0.012	0.829	0.0	4.851	1.242	1.931	0.086
Haryana & Delhi	0.748	3.828	0.457	4.660	0.0	0.931	2.777	7.122	0.126
Uttar Pradesh	0.773	2.128	0.312	0.814	0.505	1.549	3.360	1.607	1.873
Madhya Pradesh	0.988	1.335	1.311	0.155	0.048	1.061	0.804	2.244	1.974
Rajasthan	0.081	1.411	0.730	4.558	0.0	2.055	4.307	3.615	0.214
Gujarat & Dadra	0.235	0.684	1.133	3.300	0.416	1.021	0.054	0.178	0.725
Maharastra	0.432	0.462	4.206	1.243	0.840	0.116	0.038	0.459	2.422
Karnataka (+ Goa)	0.665	0.216	2.260	0.809	6.674	0.676	0.011	0.276	1.630
Kerala	1.447	0.0	0.008	0.0	0.220	0.0	0.0	0.0	0.077
Tamil Nadu & Pondicherry	1.461	0.001	0.883	0.976	2.628	0.060	0.001	0.021	0.550
Andhra Pradesh	1.919	0.010	1.452	0.588	1.417	0.565	0.0	0.088	0.674
Orissa	2.454	0.070	0.041	0.011	2.159	0.413	0.0	0.092	0.480
Bihar	1.486	1.130	0.012	0.018	0.764	1.724	0.928	0.384	0.476
West Bengal	2.517	0.563	0.001	0.001	0.090	0.155	0.363	0.254	0.202
Assam (+ Far Eastern areas)	1.666	0.056	0.0	0.0	0.0	1.095	0.0	0.006	0.033
INDIA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table (2.15) Continued

States	Ground-nut	Mustard & Rapeseed	Sesamum	Linseed	Castor-seed	Cotton	Jute	Mesta
(1)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Jammu & Kashmir	0.0	2.825	0.447	0.781	0.0	0.015	0.0	0.0
Himachal Pradesh	0.035	0.305	0.519	0.655	0.0	0.011	0.0	0.0
Punjab	1.056	2.762	0.574	0.085	0.0	4.775	0.0	0.0
Haryana & Delhi	0.071	4.601	0.157	0.016	0.0	2.463	0.0	0.0
Uttar Pradesh	0.391	1.426	0.238	0.495	0.014	0.028	0.115	0.0
Madhya Pradesh	0.602	1.040	1.279	4.422	0.073	0.678	0.0	0.244
Rajasthan	0.459	3.141	3.264	0.948	0.081	0.778	0.0	0.012
Gujarat & Dadra	5.103	0.678	1.356	0.0	5.802	4.872	0.0	0.0
Maharastra	1.246	0.021	1.103	1.898	0.099	2.436	0.0	1.366
Karnataka (+ Goa)	1.933	0.021	1.050	0.803	1.152	2.276	0.0	1.101
Kerala	0.262	0.0	0.564	0.0	0.0	0.078	0.0	0.0
Tamil Nadu & Pondicherry	2.754	0.007	1.507	0.0	0.414	0.781	0.0	0.010
ndhra Pradesh	1.758	0.004	0.968	0.100	5.678	0.449	0.0	4.214
Orissa	0.385	1.151	2.496	0.485	1.621	0.020	1.488	2.501
Bihar	0.016	0.748	0.243	1.439	0.230	0.010	1.870	1.186
est Bengal	0.0	1.560	0.637	0.729	0.0	0.001	11.017	2.377
ssam (+ Far Eastern areas)	0.0	1.470	0.253	0.051	0.053	0.057	2.158	1.523
INDIA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table (2.15) Concluded

States	Sugar-cane	Potato	Dry Chillies	Black Pepper	Turmeric	Dry Ginger	Tobacco	Tea	Coffee
(1)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
Jammu & Kashmir	0.053	0.299	0.196	0.0	0.0	0.0	0.095	0.0	0.0
Himachal Pradesh	0.126	2.156	0.076	0.0	0.037	7.700	0.188	0.784	0.0
Punjab	1.467	1.566	1.357	0.0	0.0	0.0	0.016	0.0	0.0
Haryana & Delhi	2.821	1.019	0.979	0.0	0.0	0.046	0.116	0.0	0.0
Uttar Pradesh	3.087	2.517	0.131	0.0	0.102	0.175	0.146	0.0	0.0
Madhya Pradesh	0.184	0.319	0.415	0.0	0.031	0.330	0.058	0.0	0.002
Rajasthan	0.217	0.035	0.697	0.0	0.030	0.049	0.161	0.0	0.0
Gujarat & Dadra	0.306	0.266	0.605	0.0	0.0	0.333	4.782	0.0	0.0
Maharastra	1.220	0.168	1.569	0.0	1.091	0.132	0.226	0.0	0.003
Karnataka (+ Goa)	0.940	0.254	1.614	0.319	0.378	0.707	1.408	0.102	10.177
Kerala	0.153	0.0	0.379	47.717	4.097	23.588	0.134	5.405	17.648
Tamil Nadu & Pondicherry	1.243	0.260	2.285	0.047	2.554	0.445	0.692	1.956	2.542
Andhra Pradesh	0.771	0.008	3.501	0.0	2.764	0.732	5.106	0.0	0.026
Orissa	0.347	0.540	1.316	0.0	4.872	1.091	0.786	0.0	0.003
Bihar	0.548	2.061	0.322	0.0	1.255	0.179	0.425	0.0	0.0
West Bengal	0.235	4.027	0.492	0.0	0.425	1.347	0.589	4.582	0.007
Assam (+ Far Eastern areas)	0.243	1.403	0.493	0.0	1.196	6.694	0.387	17.490	0.011
INDIA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Chapter 3 : SPATIAL VARIATION IN THE DEVELOPMENT OF AGRICULTURAL ACTIVITIES : 1980-81

3.1 Introduction

Since the economic returns for different crops cannot be uniform, the levels of development of agricultural activities as generated by varying crop-association patterns in different areas cannot be the same. The prevalent conditions as available in different areas with varying degrees of advantages are certainly responsible for changing crop-association patterns on space. With a change in the conditions, the crop-association pattern could also be altered, and if suitable conditions are provided, a more economic crop combination could be practised for betterment. For example, in some relatively dry areas, where facilities of irrigation have been provided, people have gone for the cultivation of more economic cereal like rice than the tranditional crop of, say, jowar or ragi. This may be a factor to be considered for planning attentions to the more economic crops like major cereals (rice and wheat) or some suitable cash crops than, say, minor cereals in those areas where supply of water and other relevant facilities could be assured. Thus the present crop-association patterns have certainly influenced the economic viability of agricultural activities in specific areas. But that is not all; the economies of agricultural production in an area are also dependent on the people involved in the activities and also on the amount of surplus that they could generate over and above their own consumption. It has been found to be true in India (and also in many other agricultural countries) that the more capable the cultivators are in generating a greater amount of agricultural surplus, the more progressive would be their agricultural tracts. Thus in this chapter we would investigate on the nature of surplus generation and also on the over-all land and labour productivities in order to assess the levels of development in agricultural activities by different areal units of India, for the year 1980-81.

3.2 Measurements of Marketable Surplus of Foodgrains and Food-Surplus and Deficit Areas

3.2.1 Preamble

In India as more than 80 per cent of cropped land is utilised by cultivators for only foodgrain-productions, their economic conditions are first assessed through a measurement of their capacity for generating the marketable surplus production over and above their own requirements of family consumption and the allowance for use as seeds, animal feed and related marginal stocks including wastages. It is a fundamental planning requisite that, before going for surplus generation, the cultivators, under whose control the cropped land is, must have their own foodgrain-requirements fulfilled from their own land. For a viable economic condition, they must necessarily have enough surplus generating capacity, in order to meet the expenses for other unavoidable requirements of human life. So the degree of surplus generation is really an indicator of cultivating population's economic condition. This we would measure through an appropriate index. Next to the cultivating population, we would have to look for this aspect of surplus generation for all agricultural population.

The total cropped land of an area is supposed to provide not only for cultivators but also for the relatively poorer counterpart of agricultural labourers. The aim here is to examine whether the totality of cropped land under foodgrains in an areal unit is good enough to meet the requirement of food for the total agricultural population. Even if an areal unit is good enough, the question of distribution between the two counterparts of agricultural production still remains, the study of which is not within the scope of present research. So this part of study remains a variety of food-surplus and deficit study for agricultural population by areal units.

In fifties, when India had the severe food-shortage problem, K.S. Rao [1960] made similar studies to identify the food surplus and deficit areas by districts of India. That was really a significant areal study of this kind, made for total population on the basis of possibly crude consumption norms as is generally inherent in any pioneering applied study. With certain improved norms, now available from the government survey sources, we would examine the food surplus and deficit areas not only for the agricultural population, but also for the rural and total population. In order to have a compatible definition with the official survey sources, we would refer to foodgrains as defined in Chapter 2 without the crop of tur. This definition of foodgrains, as we modify in this Chapter is really used for "cereals and cereal-substitutes"; the only cereal-substitute included here being the crop of "gram".

It is to be noted that the quantitative addition of the crops under foodgrains for production estimates is quite meaningful, unlike that for all crops, without the involvement of changable price weights due to demand-supply-price mechanism. Thus by our choice of foodgrains in all the surplus estimation studies, we are in a position to measure the economic viability in the pure physical terms, without any tampering influence of price mechanism.

3.2.2 Methods of Measurement of Marketable Surpluses

As referred to already, our estimates of human consumption requirements are arrived at by use of survey norms. The quantitative survey norms by states of India with rural and urban breakdowns have been taken from the National Sample Survey Organisation (NSSO) report for the thirty second round of survey (ref. period : July 1977 - June, 1978). This was the latest report available at the time of undertaking this part of study, in which quantitative norms are available in the form of physical indicators for differentiation in the magnitudes of foodgrain consumption habits among states of India by rural and urban sectors. The estimates of norms for per capita consumption of foodgrains, used actually by states with rural and urban breakdowns, are then arrived at by multiplying those physical indicators with the year-specific national consumption norms, as estimated directly by the following method :

We denote :

Q_t = total national production of foodgrains in t-th year (quantity);

m = proportionate allowance figure for seeds, animal feed, and related marginal stocks including wastages;

E_t = national export of foodgrains in t-th year (quantity);

M_t = national import of foodgrains in t-th year (quantity);

A_t = total national availability (quantity) of foodgrains for human consumption and trade (net export);

C_t = total national quantity of foodgrains for human consumption;

Then we have

$$A_t = (1 - m)\, Q_t \qquad \ldots (3.1)$$

and

$$\begin{aligned} C_t &= A_t - (E_t - M_t) \\ &= (1 - m)\, Q_t - (E_t - M_t) \qquad \ldots (3.2) \end{aligned}$$

Also let P_t = total national population in t-th year

$$= \sum_j (P_{trj} + P_{tuj}) \qquad \ldots (3.3)$$

where P_{trj} = rural population of j-th state in t-th year and

P_{tuj} = urban population of j-th state in t-th year.

Now f_t = estimated national norm of per capita consumption of foodgrains (quantity) in t-th year

$$= C_t/P_t \qquad \ldots (3.4)$$

The physical indicators used for incorporating the rural-urban and the areal (as far as the available sample survey data permit) differences in foodgrains consumption habits have been formulated as follows :

These physical indicators are really the following ratio estimates, designated by R_{tj} and U_{tj} for rural and urban sectors respectively of j-th state :

$$R_{tj} = f^*_{rj} / f^*_t \text{ and } U_{tj} = f^*_{uj} / f^*_t \quad \ldots \quad (3.5)$$

where

f^*_{rj} = given survey norm of per capita foodgrain-consumption for rural sector of j-th state;

f^*_{uj} = given survey norm of per capita foodgrain-consumption for urban sector of j-th state; and

f^*_t = derived survey norm of per capita foodgrain-consumption for the nation as weighted by t-th year population breakdowns

$$= \sum_j (P_{trj} f^*_{rj} + P_{tuj} f^*_{uj})/P_t \quad \ldots \quad (3.6)$$

Finally, we get our estimates of norms, to be used, as follows :

f_{trj} = estimated rural norm of per capita foodgrain consumption (quantity) for j-th state in t-th year

$$= f_t \cdot R_{tj} \quad \ldots \quad (3.7)$$

and f_{tuj} = estimated urban norm of per capita foodgrain consumption (quantity) for j-th state in t-th year

$$= f_t \cdot U_{tj} \quad \ldots \quad (3.8)$$

The values of these consumption norms, f_{trj} and f_{tuj}, would thus be different not only for the rural-urban and areal differences in consumption habits, but also for the temporal differences in national food-situation as prevalent at different time-points. For all areal units within j-th state, the same state norms f_{trj} or f_{tuj} would, however, be used. There exist data gaps for absence of survey norms (small sample problem) in some small union territories or hilly states; the corresponding gaps in estimated norms would be filled up in each, on the basis of relevant data of its geographical neighbour having the closest foodgrain crop-association patterns in the production front.

Again to get the quantity estimates of total consumption requirements of foodgrains for any of the population categories : (1) cultivating population (cultivators and family members), (2) agricultural population, and (3) rural population, the relevant norm taken is f_{trj}, while for the population category (4) total population, the norm of f_{tuj} is used for the sector urban population and the resulting urban estimates are added to the corresponding rural estimates to arrive at the total population estimates. Clearly the quantity estimates of total consumption requirements of foodgrains by areal units for different categories of population can be established by multiplying the relevant population figure with the corresponding estimated norm on per capita consumption of foodgrains as accepted above.

The rural, urban and total population estimates are available in different census reports*. To arrive at the population-estimates for cultivators and agricultural workers, from the corresponding estimates of workers, as could be established by areal units (from the published census reports), the corresponding ratio-estimates of "rural population to rural workers" have been used as multipliers with the relevant weaker-estimates. This

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* Padmanabha [1981] provides 1981 population estimates for Assam.

completes our discussion about the consumption estimates for the four population categories by areal units.

In all calculations of the availability of foodgrains from the corresponding quantity estimates of production of foodgrains, not only for the nation as a whole (ref. to formula (3.1)), but also for its any areal breakdown, the proportionate allowance figure m has been taken to be 0.125 uniformly, following the general official convention in this respect. Thus for any particular time-point (for the present chapter t refers to 1980-81), the quantity estimates of production, availability and consumption for different population categories, by areal units, would be designated as follows, after dropping the time-suffix t :

Q_j = the quantity of production of foodgrains in j-th areal unit at a time-point;

A_j = the quantity of availability of foodgrains for human consumption and trade in j-th areal unit at the same time-point; and

C_{ij} = the quantity of consumption requirements of foodgrains by i-th population category in j-th areal unit at the same time-point.

We now define

S_{ij} = the marketable surplus of foodgrains over and above the consumption requirements for i-th population category in j-th areal unit (at the same time point)

$$= A_j - C_{ij} \; ; \qquad \ldots (3.9a)$$

Σ_{ij} = the foodgrain availability to requirement ratio for i-th population category in j-th areal unit

$$= A_j/C_{ij} \; ; \qquad \ldots (3.9b)$$

M_{ij} = foodgrain surplus as ratio to total production for i-th population category in j-th areal unit

$$= S_{ij}/Q_j \; ; \qquad \ldots (3.10a)$$

L_{ij} = location factor of foodgrain surplus relative to total production for i-th population category in j-th areal unit (as m is constant, Q_j is proportionate A_j and hence this location factor can also be regarded as the same relative to total availability)

$$\left.\begin{aligned} &= M_{ij}/M_{i*} \\ &\text{with } M_{i*} = \sum_k S_{ik} \Big/ \sum_k Q_k \end{aligned}\right\} \qquad \ldots (3.10b)$$

and finally

M_j = index of monetization possibility on foodgrain crops with cultivators in j-th areal unit

$$\left.\begin{aligned} &= M_{1j} \; ; \text{ if } M_{1j} > 0 \\ &= 0 \; ; \text{ if } M_{1j} \leq 0 \end{aligned}\right\} \qquad \ldots (3.11)$$

Clearly, the monetization index M is same as M_1 for all areal units except for those where M_1 is negative (only in six cases out of total 151 areal units) and a seperate treatement of M is practically not necessary except to show the linkage with the commonplace concept on monetization with foodgrain crops.

It should be noted that M_i and corresponding Σ_i are connected by the relation

$$M_i = (1 - m)\,(\Sigma_i - 1)/\,\Sigma_i \qquad \ldots (3.12)$$

As m is a known constant, M_i can be treated as an algebrically transformed variable of Σ_i with positive covariation. Both the measures M_i and Σ_i are meaningful in different contexts. M_i is however more meaningful from production point of view. Again as L_i is proportional to M_i, they convey the same spatial differentiation. It is to be noted that the location factor L_i should better be not considered if the benchmark of national surplus ratio M_{i*} used in its formulation is very low. In the present case (for 1980-81) such benchmark national values are respectively 0.49895, 0.28602, 0.14986 and 0.00129 for the population categories of (1) cultivating population, (2) agricultural population, (3) rural population and (4) total population. In such a situation, the location factor L_4 should not be constructed at all, for an occurance of a near zero value in the denominator of its formulation. As the location factor L_1 is constituted of highest benchmark national value and also, as it is related to the concept of monetization of foodgrain crops, we have considered this location factor as the physical measure of areal differentiation in surplus economies of cultivators; after all it is more meaningful to consider the economic condition of cultivators under whose control the cropped land exists. The positions with respect to all agricultural population and also the other categories of population are however considered in ratios Σ_2, Σ_3 and Σ_4 (or, in ratios M_2, M_3 and M_4). As L_1 is proportional to M_1 (i.e., with non-negative monetization index M mostly) we would specially designate the location factor L_1 by x_m. Thus x_m (= L_1) is taken as the physical measure of economic conditions of cultivators.

In our subsequent analysis, when we would be interested in the actual estimates of foodgrain surplus or deficit, especially for certain areal aggregates, the values of S_{ij} could be used. But S_{ij} and Σ_{ij} would practically depict relatively the same spatial picture (mathematically speaking, they are really the additive and the multiplicative differences of the two values A_j and C_{ij}, with the respective benchmark values of 0 and 1). As such, we would use only the four indices, Σ_i's, instead of S_i's, for mapping purposes (by which we would avoid any dealing with possible negative figures of S_i's). Any way, one can always refer to the actual estimates of all these indices, recorded, among other things, in the Appendix Table (A.5). We have mapped the indices Σ_i's seperately and also in an integrated way for all the four indices together in figures (3.1) to (3.4). As the class boundary values of Σ_i's can be converted into those corresponding to M_i's by virtue of the algebric relations that exist between them, the maps of Σ_i's are shown by those of M_i's for i = 1, 2, 3, 4 and also of L_i's for i = 1, 2, 3. Again as the map for M_1 would practically be the same as that for M (except for a very limited number of Zero values of M), we have not mapped M seperately. The analysis with all these indices would be attempted in the concluding section of this chapter. Next we would formulate the over-all productivity measures which would be considered along with the presently formulated x_m towards the final assessment of the levels of development of agricultural activities by areal units.

3.3 Measurements of Overall Land and Labour Productivities

As cultivators could be considered as a part of entrepreneurs in agricultural productive activities, a measure of their economic condition, like the index x_m, is a prerequisite in any study on agricultural development. Yet, in the construction of x_m, neither all crops, nor all agricultural workers could be considered. To assess the areal differentiation in economic conditions, accomodating all agricultural workers, we would now formulate an overall labour productivity index. This has to be a crop-price dependent index (i.e., a value index), as we have no scope here to construct a physical index (i.e., independent of price) in the absence of breakdowns of agricultural workers in terms of utilised labour-hours by crops. Had these data been available, crop-specific physical labour productivities could have been computed and aggregated by some physical crop-weight for an overall physical labour productivity index. Opinions against a choice of value index as generally put forward by physical planners are based on the following fact : as the choices on prices could be changed with different varieties of prices (for example, wholesale, producer, retail and so on) and also on the different situations of price mechanism, the value index of overall labour productivity can be more changeable than an appropriate physical index. Yet the value concept is also important, because the economic conditions of agricultural workers are ultimately measured by the monetary power that the producers can fetch. In fact, it would help a better assessment if both the physical and the value indices of labour productivity could be prepared. But in the absence of a physical index, the value index could not be considered any less useful. The algebric formulation of this value index is also a variety of relative location factor as shown below :

x_{wj} = labour productivity index for j-th areal unit

$$= \frac{V_j/W_j}{\sum_k V_k / \sum_k W_k} = \frac{V_j/\sum_k V_k}{W_j/\sum_k W_k} \qquad \ldots \quad (3.13)$$

where V_j = total value of all crop-outputs in j-th areal unit and

W_j = total agricultural workers in j-th areal unit.

The situation for the construction of land productivity is different. Here we are in a position to construct both physical and value based land productivity indices, since we can construct crop-specific land productivity indices which are proportional to usual yield rates per unit area by crops. Kendall [1939] constructed such an index from yield rates with weights determined by the statistical consideration of maximising the aggregate representation. But in this case study, by "counties" of England, the implicit assumption was that the quality of cultivated land in a county in England was more or less suitable for all crops considered. But our evidence as revealed by different crop-concentrations and also the crop-association patterns (ref. to Figures (2.1) to (2.9) is against such a simplifying assumption for a vast country like India where there exist diversified locational forces for agricultural activities. Thus although Kendall could extract a physical crop-productivity index statistically for a small country like England, we are not in a position to apply the same statistical technique of optimisation to combine basic crop-yield rates to start with. Here a more appropriate procedure would be to assign the combining weights by following the economic or theory based method, such as the one followed by Pal [1963] in his South India case study. There weighting for crop-specific yield rate indices was assigned by the local importance of crops measured by cropped acreage share. It is a pure physical index. But weighting as well could be assigned by the local importance of crops measured by value shares of output. Both these indices, though weighted differently, however, belong to the same variety in the sense that crop-specific yield rate indices are involved explicitly in their constructions. But there can be yet another variety of land productivity measure, which is analogous to the overall labour productivity index with the replacement of variable of 'worker' by 'cropped land'. Thus we would consider three land productivity sub-indices first, which are to be combined later for the final index of land productivity. The sub-indices can be defined algebraically as follows :

U_{1j} = acreage weighted combined location factors of crop-yield rates

$$= \sum_i a_{ij} \, y_{ij} \qquad \ldots (3.14)$$

where Y_{ij} = location factor of crop-yield rate per acre for i-th crop in j-th areal unit; and

a_{ij} = acreage share of i-th crop in j-th areal unit,

with $\sum_i a_{ij} = 1$ for any j ;

U_{2j} = value of output weighted combined location factors of crop-yield rates

$$= \sum_i b_{ij} \, y_{ij} \qquad \ldots (3.15)$$

Where b_{ij} = share of value of output of i-th crop in j-th areal unit

with $\sum_i b_{ij} = 1$ for any j; and

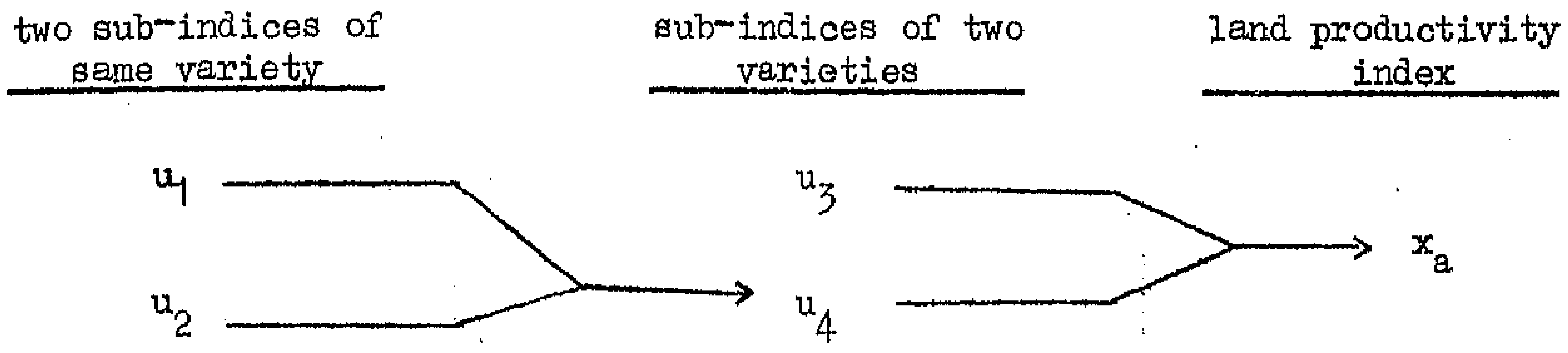
U_{3j} = location factor of value of total crop-output relative to total cropped land for j-th areal unit.

Our next attempt would be to combine these three sub-indices, u_1, u_2 and u_3, which measure the same overall land productivity. The correlation matrix of these three sub-indices is given below in Table (3.1) :

Table (3.1) : Correlation Matrix, Means and Standard Deviations of Land Productivity Sub-indices: India : 1980-81

	U_1	U_2	U_3
	1.0000		
	0.9623	1.0000	
	0.6525	0.6021	1.0000
Mean	1.0090	1.0529	1.0500
Standard deviation	0.2594	0.2804	0.4766

The entries in the correlation matrix reveal that the first two sub-indices of the same variety are very strongly interrelated (correlation coefficient as extremely high as to show a value of 0.9623) while the third sub-index of different variety is almost similarly related with the preceding two (but the correlation coefficients are not high). It shows that the two weighting schemes by acreage weights and value weights of output have almost equally affected the construction of u_1 and u_2. As such, it would be appropriate to combine them first, to have a unified sub-index of the same variety and then this unified sub-index could naturally be combined with the third sub-index at the second stage. Thus our scheme of combination could be described as shown in the following diagram :



This diagram clearly shows that the double-variable index formulation could appropriately be used in this case also as we did in previous Chapter by use of formula (2.7a) or (2.7). Thus the empirical evaluation of the sub-indices/indices at different stages as obtained could be written as :

$$u_4 = 0.519452\ u_1 + 0.480548\ u_2\ ;\ \rho_e = 0.9905,$$

mean : $\bar{u}_4 = 1.0301$, standard deviation : $\sigma_4 = 0.2669$ and the correlation coefficient $r_{34} = 0.6333$;

$$x_a = 0.358978\ u_3 + 0.641022\ u_4\ ;\ \rho_e = 0.9037,$$

mean $\bar{x}_a = 1.0372$ and standard deviation $\sigma_{x_a} = 0.3092$.

Eliminating the intermediate stage on the formulation of u_4, the land productivity index x_a can finally be expressed in terms of the three original sub-indices as follows :

$$x_a = 0.332980\ u_1 + 0.308042\ u_2 + 0.358978\ u_3 \qquad \ldots\ (3.16)$$

In this form, three specific representation values would be $r_1 = 0.9091$, $r_2 = 0.8812$ and $r_3 = 0.9037$ and hence the corresponding aggregate representation works out as $\rho = 0.8981$.

Had we constructed the optimal and equity indices directly for the three sub-indices (ref. to section 2.5), the corresponding aggregate representation would have been respectively 0.9111 and 0.8947 --- one is just above and the other just below the value of our index. Although our index x_a has slightly less value of aggregate representation as compared to that of the optimal index, it is more acceptable on the ground of better representation of the value sub-index u_3 in it, than in the optimal index. In our index formulation, all specific representations lie within a narrow margin, between 0.881 and 0.909 with the representation of the value index u_3 in the middle at 0.904. But the optimal index formulation, having been dictated by the sheer mathematical optimization consideration, has remained strongly inclined to the first two sub-indices of the same variety (specific representations $r_1 = 0.9671$ and $r_2 = 0.9505$), while it is quite away from the value sub-index u_3, which is of different variety (here $r_3 = 0.8073$). Thus the optimal index turns out to be almost an index of first variety. For reasons already stated in favour of the practical need of the value index representation, our index turns out to be more acceptable than the optimal index. Again, a direct three-variable equity index with the present correlation matrix structure turns out to be an inconsistent index, because of the presence of negative weight in its formulation for the first sub-index u_1. It should be noted that if the specific representations are positive (often these have to be, because the higher values of constituent variables and the index are often favoured in the same way similar to our mode of index formulation), we must have all its combining weights positive for a consistent interpretation of the index. As the three-variable equity index turns out to be inconsistent, our index formulation of land productivity x_a becomes most acceptable on all accounts.

3.4 Construction of Composite Development Index of Agricultural Activities

Finally, the construction of composite development index of agricultural activities would be attempted in this section on the basis of three indices, formulated in the just preceding sections, and to be called briefly as :

x_m = foodgrain surplus index;
x_w = labour productivity index; and
x_a = land productivity index.

The correlation matrix of these indices is presented below in Table (3.2):

Table (3.2) : Correlation Matrix of Agricultural Activity Indices, their Means and Standard Deviations; India : 1980-81

	x_m	x_w	x_a
	1.0000	0.4892	0.4074
	0.4892	1.0000	0.5640
	0.4074	0.5640	1.0000
Mean	0.8624	1.0823	1.0372
Standard deviation	0.4694	0.7141	0.3092

The inter-correlations between pairs of variables do not show great divergence in this Table (3.2) -- coefficients are between 0.407 and 0.564; all are moderate values and not a mixture of high and moderate values as in preceding Table (3.1). As such a direct three variable index formulation would be more appropriate than a two-stage double-variable formulations as done with reference to Table (3.1). While developing the mathematical properties of generalised index formulations, Pal [1985] has proved a theorem, which states :

> "The equity formulation becomes identical with the optimal formulation, if and only if the correlation matrix R is a symmetric circulant matrix".

The correlation matrix is always symmetric and it becomes a symmetric circulant matrix if all its column sums are a same positive quantity [Aitken, 1942]. In the present correlation matrix (ref. to Table (3.2)) the column sums are respectively 1.8966, 2.0532 and 1.9714. These values are not same, but they fall within a very narrow range. In such a situation, we can expect that the corresponding equity and optimal formulations would not be widely apart. We could have used any of the two index formulations here. However, following Pal's suggestion, we would go for an equity formulation, because the correlation coefficients between pairs of variables are all moderate here, not high. Had it been high, the optimal index formulation would have been more appropriate, because then the least represented constituent variable of the optimal index would have high specific representation value. Thus under the present circumstances, with all moderate inter correlations, the equity formulation would be more appropriate than the optimal formulation.

Although we apply here the more appropriate equity formulation, we have also computed the optimal formulation as well in order to have a comparative study. As expected, the aggregate representation of our equity index is very close to that of the corresponding optimal index (here $\rho_e = 0.8094$ as against $\rho_g = 0.8117$). While all the specific representations of the equity index would be the same 0.8094, the least represented constituent variable x_m of the optimal index has a lower specific representation of 0.7666. Had this least specific representation been around 0.8 or above, the optimal index could have been alright. But this has not been possible here for the presence of all moderate values in the correlation matrix of Table (3.2). The computation of weights and coefficients for the equity index could be done by the methods shown before in section (2.5). But it can as well be solved directly by the data of Table (3.2), since it is only a three-variable equity index. Thus we have the weights calculated as follows :

For a three-variable correlation matrix : $\begin{pmatrix} 1 & r_{12} & r_{13} \\ r_{21} & 1 & r_{23} \\ r_{31} & r_{32} & 1 \end{pmatrix}$

we have the weights :

$w_1 = D_1/(D_1 + D_2 + D_3)$;

$w_2 = D_2/(D_1 + D_2 + D_3)$; and

$w_3 = D_3/(D_1 + D_2 + D_3)$, where

$$D_1 = (1 - r_{23})(1 + r_{23} - r_{12} - r_{13})$$

$$D_2 = (1 - r_{13})(1 + r_{13} - r_{12} - r_{23})$$

$$D_3 = (1 - r_{12})(1 + r_{12} - r_{13} - r_{23})$$

We have calculated the weights by the above formulas and completed subsequent empirical estimations in the manner suggested in section (2.5) for the equity formulation. Thus we have the final empirical estimates of composite development index of agricultural activities, designated as D_A and given below in equation (3.17) :

$$D_A = 0.350364\ x_m + 0.166139\ x_w + 0.483497\ x_a\ ; \quad \rho_e = 0.809402 \qquad \ldots(3.17)$$

At times D_A would be redesignated as x_1, particularly in statistical analysis with other relevant variables.

3.5 Identification of Food-Surplus and Deficit areas : the Findings

We have constructed ratio or index measures of food-surplus and deficit for four categories of population, namely, (1) cultivators (including dependants), (2) agricultural population, (3) rural population and (4) total population. For each category of population, varieties of transformable measures are :

(a) availability - requirement ratio (Σ_1, Σ_2, Σ_3 and Σ_4),

(b) food-surplus - total production ratio (M_1, M_2, M_3 and M_4) and

(c) location factor of food-surplus to total production ($L_1 = x_m$, L_2 & L_3).

The location factor L_4 could not be constructed, since the all-India value M_{4*} is almost zero. Since L_1 $(=x_m)$ is treated as a constituent variable for the agricultural development index D_A, the spatial differentiation by Σ_1 or M_1 or L_1 $(= x_m)$ would not be attempted in full in this section, except for a composite spatial differentiation mapping by all four population categories. In fact, the six areal units which are deficit areas by even Σ_1 have been identified in the composite mapping (ref. to Fig. 3.4). The other three Σ_i's have been mapped in this section (ref. to Figs 3.1, 3.2 and 3.3). These maps stand also for corresponding M_i's and L_i's when calculated. The all-India values of Σ_2, Σ_3 and Σ_4 have been respectively 1.4856, 1.2067 and 1.0015 for 1980-81. In our classification for Σ_i's for mapping, the classes have been marked as extremely high (EH) surplus, very high (VH) surplus and high (H) surplus. The all-India value of Σ_2 has been marked as medium (M) surplus, while those of Σ_3 and Σ_4 as low (L) surplus because of their claseness to unity. The values below unity have been duly marked as low (l) deficit or high (h) deficit. In the classification schemes, the class-interval length (for Σ_i's) has been selected as 0.30 for all classes, except for the top two classes (EH and VH) where there exist skewed statistical distributions with extended right hand tails. The details of these classifications together with the frequency distribution of areal units are shown below in Table (3.3). While the classified data are recorded in Appendix Table (A.5) and mapped in Figures (3.1), (3.2) and (3.3), a composite food surplus-deficit mapping is attempted in Figure (3.4) according to following specifications :

.../-

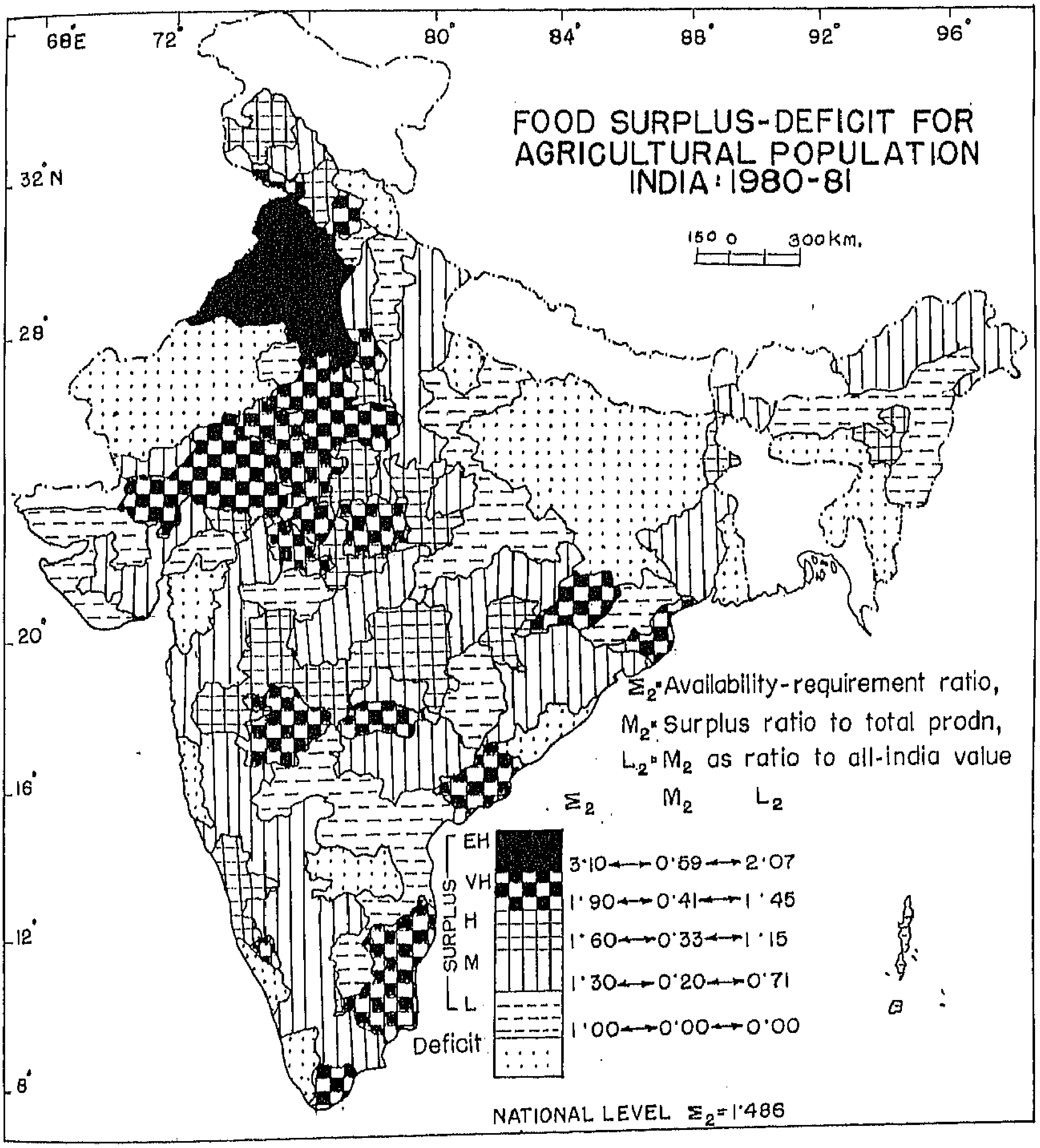

68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
FOOD SURPLUS-DEFICIT FOR AGRICULTURAL POPULATION INDIA : 1980-81
150 0 300km.
Σ_2 = Availability-requirement ratio,
M_2 = Surplus ratio to total prodn,
L_2 = M_2 as ratio to all-india value
Σ_2
M_2
L_2
SURPLUS
EH
VH
H
M
L
Deficit
3·10 ↔ 0·59 ↔ 2·07
1·90 ↔ 0·41 ↔ 1·45
1·60 ↔ 0·33 ↔ 1·15
1·30 ↔ 0·20 ↔ 0·71
1·00 ↔ 0·00 ↔ 0·00
NATIONAL LEVEL Σ_2 = 1·486

FIG-3·1

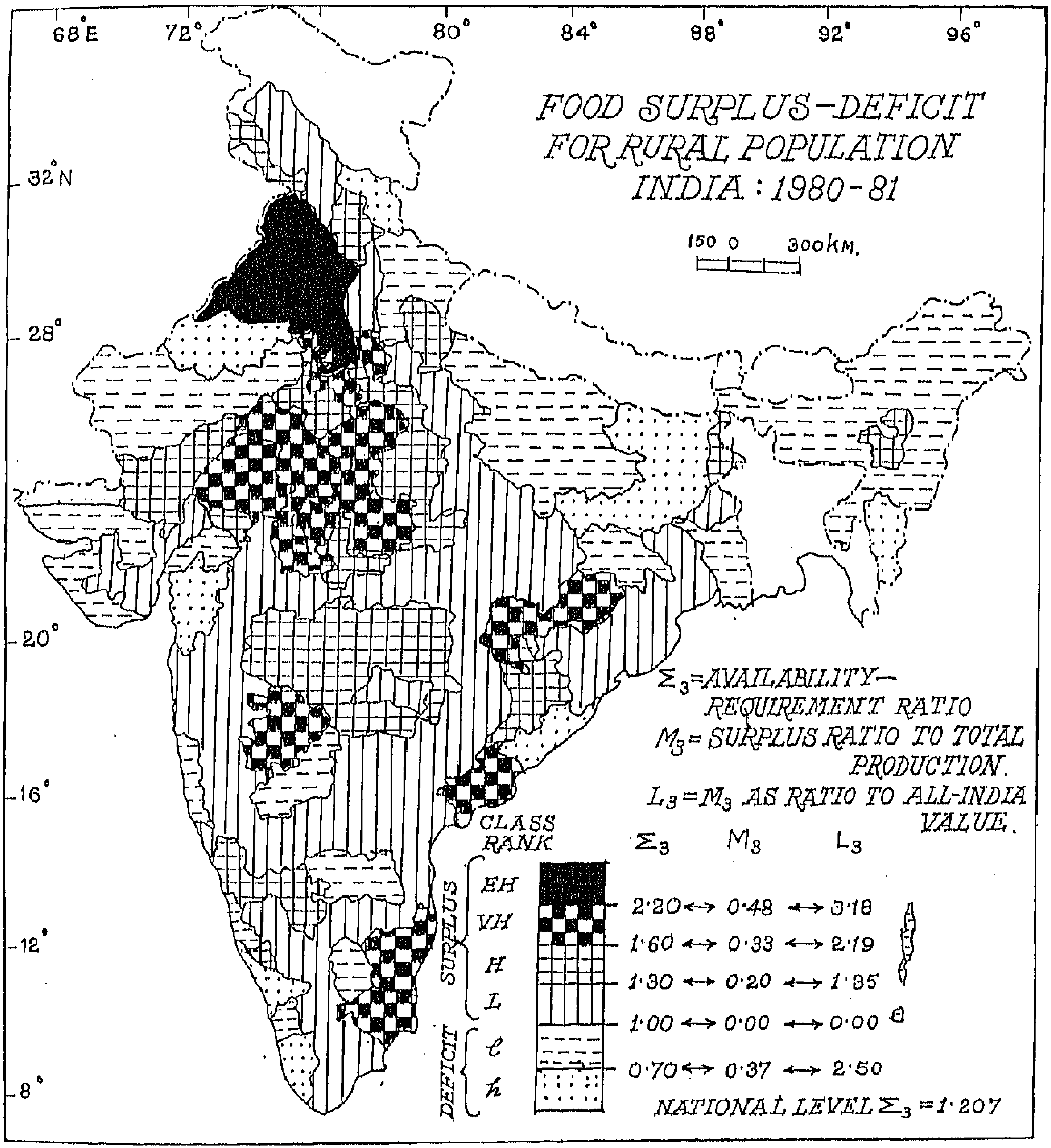

FOOD SURPLUS-DEFICIT
FOR RURAL POPULATION
INDIA : 1980-81
150 0 300 KM.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
Σ3=AVAILABILITY-REQUIREMENT RATIO
M3= SURPLUS RATIO TO TOTAL PRODUCTION.
L3=M3 AS RATIO TO ALL-INDIA VALUE.
CLASS RANK
Σ3
M3
L3
SURPLUS
EH
VH
H
L
DEFICIT
l
h
2·20 ↔ 0·48 ↔ 3·18
1·60 ↔ 0·33 ↔ 2·19
1·30 ↔ 0·20 ↔ 1·35
1·00 ↔ 0·00 ↔ 0·00
0·70 ↔ 0·37 ↔ 2·50
NATIONAL LEVEL Σ3 = 1·207

FIG - 3·2

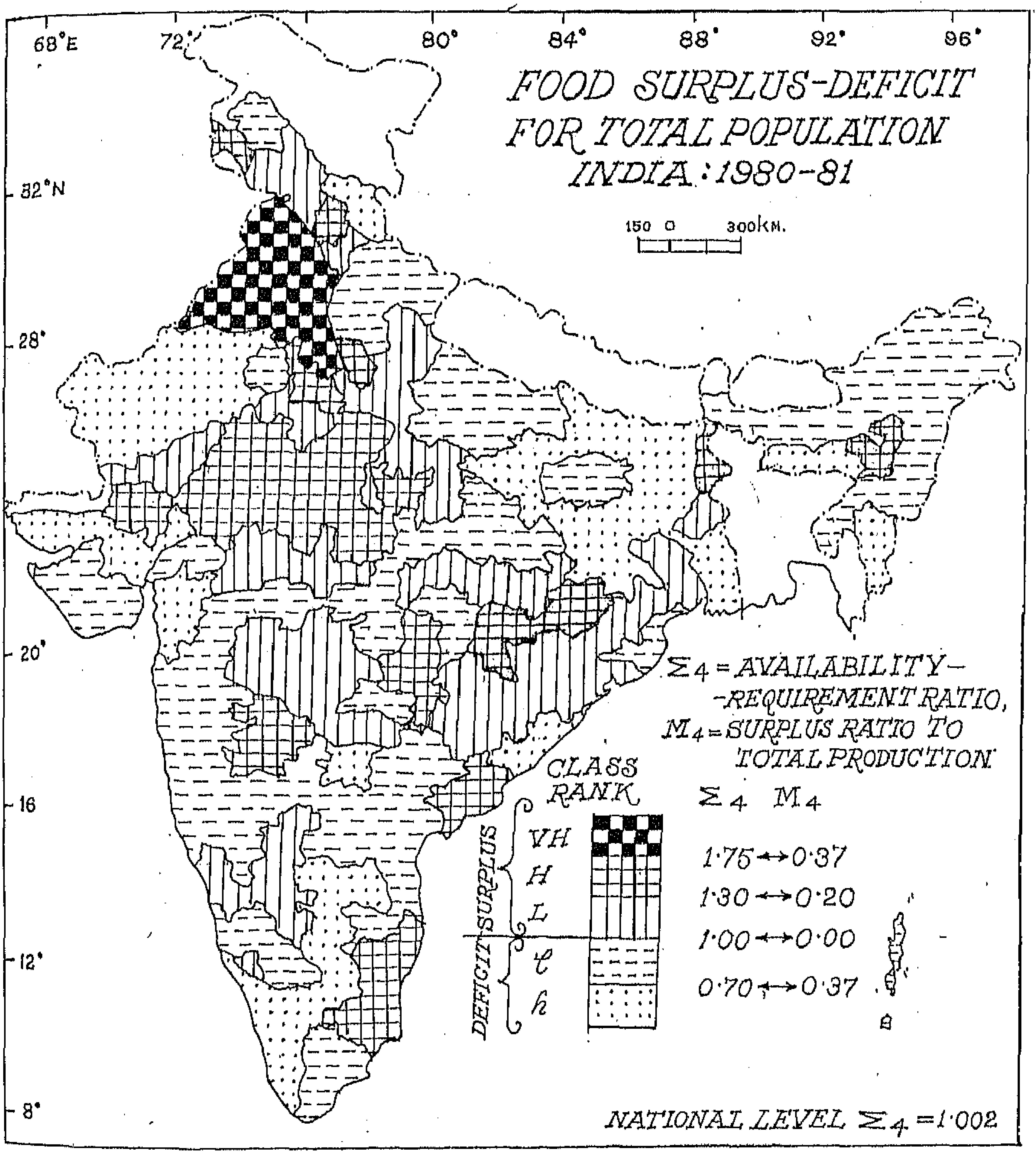

FOOD SURPLUS-DEFICIT
FOR TOTAL POPULATION
INDIA : 1980-81
150 0 300 KM.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16
12°
8°
Σ4 = AVAILABILITY-REQUIREMENT RATIO,
M4 = SURPLUS RATIO TO TOTAL PRODUCTION
CLASS RANK
Σ4 M4
SURPLUS
DEFICIT
VH
H
L
ℓ
h
1·75 ↔ 0·37
1·30 ↔ 0·20
1·00 ↔ 0·00
0·70 ↔ 0·37
NATIONAL LEVEL Σ4 = 1·002

FIG :- 3·3

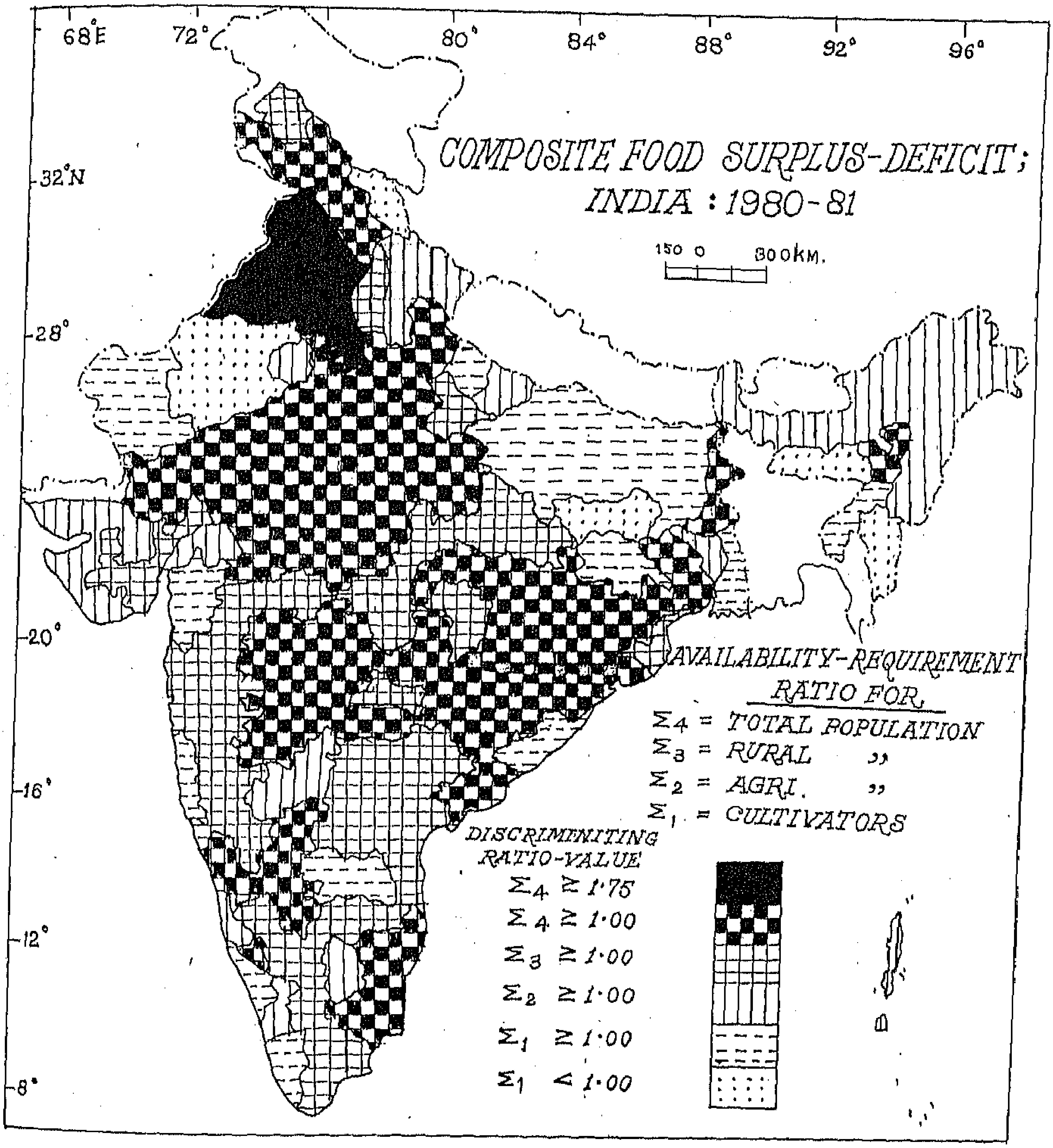

COMPOSITE FOOD SURPLUS-DEFICIT;
INDIA : 1980-81
150 0 300KM.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
AVAILABILITY-REQUIREMENT RATIO FOR,
Σ4 = TOTAL POPULATION
Σ3 = RURAL ,,
Σ2 = AGRI. ,,
Σ1 = CULTIVATORS
DISCRIMENITING RATIO-VALUE
Σ4 ≥ 1·75
Σ4 ≥ 1·00
Σ3 ≥ 1·00
Σ2 ≥ 1·00
Σ1 ≥ 1·00
Σ1 < 1·00

FIG-3·4.

Composite Food Surplus-Deficit Classification and Frequency Distribution

Deficit for	Discriminating Ratio-Values	Surplus for	Frequency of areal units
no category of population	$\Sigma_4 \geq 1.75$	total population - VH	9
no category of population	$\Sigma_4 \geq 1.00$	total population - not VH	59
total population	$\Sigma_3 \geq 1.00$	rural population	33
rural population	$\Sigma_2 \geq 1.00$	agricultural population	20
agricultural population	$\Sigma_1 \geq 1.00$	cultivators	24
cultivators.	$\Sigma_1 < 1.00$	no category of population	6

On the basis of our spatial analysis through statistical and cartographic tools, we have the following observations :

i) There exists strong spatial association between the three population categories of food surplus-deficit measures, namely, Σ_2, Σ_3 and Σ_4. This could be noticed from the comparisons of three Figures (3.1), (3.2) and (3.3) and confirmed statistically from the following correlation matrix :

Availability requirement ratios	All-India value	Correlation coefficients		
		Σ_2	Σ_3	Σ_4
Σ_2	1.4856	1.0000		
Σ_3	1.2067	0.9824	1.0000	
Σ_4	1.0015	0.9624	0.9858	1.0000
	mean	1.7145	1.3524	1.1037
standard deviation		1.2830	0.9831	0.7571

Table (3.3) : Classifications for Food Surplus-Deficit Measures and the Frequency Distribution

Classes	Class intervals for measures			Frequency of areal units
	Σ_i	M_i	L_i	
(1)	(2)	(3)	(4)	(5)
i = 2 (agricultural population)				
EH Surplus	3.10 to 9.30	0.59 to 0.78	2.07 to 2.73	9
VH Surplus	1.90 to 3.10	0.41 to 0.59	1.45 to 2.07	25
H Surplus	1.60 to 1.90	0.33 to 0.41	1.15 to 1.45	19
M Surplus	1.30 to 1.60	0.20 to 0.33	0.71 to 1.15	43
L Surplus	1.00 to 1.30	0.00 to 0.20	0.00 to 0.71	25
Deficit	0.50 to 1.0	-0.87 to 0.00	-3.06 to 0.00	30
i = 3 (rural population)				
EH Surplus	2.20 to 7.20	0.48 to 0.75	3.18 to 5.03	9
VH Surplus	1.60 to 2.20	0.33 to 0.48	2.19 to 3.18	18
H Surplus	1.30 to 1.60	0.20 to 0.33	1.35 to 2.19	28
L Surplus	1.00 to 1.30	0.00 to 0.20	0.00 to 1.35	46
l Deficit	0.70 to 1.00	-0.37 to 0.00	-2.50 to 0.00	35
h Deficit	0.40 to 0.70	-1.31 to-0.37	-8.76 to-2.50	15
i = 4 (total population)				
VH Surplus	1.75 to 5.42	0.37 to 0.71	-	9
H Surplus	1.30 to 1.75	0.20 to 0.37	-	25
L Surplus	1.00 to 1.30	0.00 to 0.20	-	34
l Deficit	0.70 to 1.00	-0.37 to 0.00	-	50
h Deficit	0.05 to 0.70	-16.62 to -0.37	-	33

So the relative areal differentiation as revealed by the three population categories are similar, but there are differences in magnitudes of Σ_i's — values at a some areal unit likewise those with the all-India values. The presence of higher all-India means as compared with the corresponding direct all-India estimates for each of Σ_2, Σ_3 and Σ_4 has been due to their skewed nature of statistical distributions with very long right hand tails. As expected, all-India values, means and standard deviations are falling from Σ_2 to Σ_4 for increases in respective population sizes.

ii) The falling magnitudes of food surplus-deficit measures from Σ_1 to Σ_4 as synthesized in the Figure 3.4 reveal more or less distinct grouping of areal units in respect of degrees of food surplus-deficit levels. In this Figure, as also in all three other Figures, two extreme cases : (a) one of technology advancement together with least agricultural labour pressure on cropped land, and (b) the other of highest agricultural labour pressure on cropped land, could be very distinctly identified. The occurance of case (a) is in the nothern most advanced region comprising of Punjab state, Haryana state (excluding Mahendragarh district), Delhi and Ganganagar district of Rajasthan. The occurance of case (b) with food deficit even for agricultural population is in (1) an extensive region comprising of Bihar and eastern Uttar Pradesh, (2) all most entire Kerala state, (3) Rajasthan desert area, (4) in the far-eastern India in tribal areas bordering Bangladesh, (5) in south-eastern fringe of West Bengal, (6) in southern part of Gujarat and also in isolated single areal units in Orissa, Andhra Pradesh, Maharastra and Himachal Pradesh. In fact, generally speaking entire far-eastern and eastern regions, west-coastal belt and the Rajasthan desert area could be considered as extreme food deficit regions. Contrasting to this, the food surplus regions, accounting for total population, have extended transitionally in the north and quite extensively in the south from the Punjab - Haryana core, covering almost entire wheat region and also beyond in the further south.

iii) The food surplus generation is most strongly associated with the spatial concentration of wheat crop and shows practically no association with the spatial concentration of rice and minor foodgrains (i.e., jowar, bajra and ragi). It has also some relation with the spatial concentration of other foodgrains (i.e., maize, gram, barley, and tur), since these crops are associated generally in the core wheat-producing areas. The statistical support to these observations could be derived from the estimates of correlation coefficients as shown below :

Correlation Matrix

food availability requirement ratio			crop concentration indices			
agricultural population Σ_2	rural population Σ_3	total population Σ_4	rice C_1	wheat C_2	minor food-grains C_3	other food-grains C_4
0.046	0.011	0.040	1.000			
0.737	0.759	0.757	-0.245	1.000		
-0.039	-0.016	-0.064	-0.639	-0.107	1.000	
0.349	0.385	0.425	-0.456	0.604	-0.003	1.000

Clearly, for surplus generation in India, the most extensive rice crop did not play any important role comparable to wheat.

iv) The extensive cultivation of paddy is connected with high rainfall areas in India, while the cultivation of minor foodgrains is with low rainfall areas. As such the spatial concentration of rice is most negatively associated with that of minor foodgrain crops -- is revealed in the estimates of above mentioned correlation matrix. In fact, paddy shows negative association with most of foodgrain crops including even wheat. Wheat cultivation also needs water but receives more through assured irrigation, generally in winter, than from direct rainfall in the main monsoon period. Thus different water availability conditions were responsible for non-concomitant crop association patterns between rice, wheat and minor cereals. It is possible that the relative vulnerability to rainfall condition in India has not encouraged comparable attention to rice as one would expect for the most remunerative and wide spread foodgrain crop of India.

v) The estimates of food surplus-- deficit measures Σ_2, Σ_3 and Σ_4 are summarised by states and state-groups (excluding island) in Table (3.4). Conforming to our detailed spatial findings, only two states Punjab and Haryana (& Delhi) stand out uniquely in enormous food surplus generating capability (EH-S values for Σ_2 and Σ_3 and VH-S for Σ_4), without which India would not have been surely in the present happy state of getting rid of foodgrain imports from international markets. No other state of India comes any where near these two states in surplus generating capability.

vi) Judged by Σ_2 figures (related to agricultural population), Bihar and Kerala are not capable to feed even their own agricultural population. The labour pressure on cropped land is suspected to be most acute in Bihar and next in Kerala. When judged by Σ_3 figures (related to rural population), these two states become highly deficit in food situation and to them is added the state group of Assam (& Far Eastern areas) with its low-deficit food situation.

vii) Accounting by the foodgrain availability-requirement ratio Σ_4 for total population, India seems to be more or less balanced in food situation (in 1980-81) and states can be grouped by surplus-deficit status as shown below :

Very high surplus states	Low surplus states	Low deficit states	High deficit states
1. Punjab	1. Jammu & Kashmir	1. Uttar Pradesh	1. Kerala
2. Haryana (+ Delhi)	2. Himachal Pradesh	2. Gujarat (+ Dadra)	2. Bihar
	3. Madhya Pradesh	3. Karnataka (+ Goa)	3. Assam (+ Far Eastern areas)
	4. Rajasthan	4. Andhra Pradesh	
	5. Maharastra	5. West Bengal	
	6. Tamil Nadu (+ Pondicherry)		
	7. Orissa		

It should be noted that Rajasthan would have been ranked as a deficit state without its northern Ganganagar district which has the food surplus generating capacity as high as that of Punjab. Again the lower surplus status of Tamil Nadu is due to its highest urban population share. Otherwise Tamil Nadu would have been next to Haryana

Table (3.4) : Estimates and Rank-symbols of Food Surplus-Deficit Measures Σ_i and M_i for Different Population Categories by States: India : 1980-81

State or State-groups	agricultural population			rural population			total population		
	Σ_2 ratio	M_2 ratio	rank symbol	Σ_3 ratio	M_3 ratio	rank symbol	Σ_4 ratio	M_4 ratio	rank symbol
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. Jammu & Kashmir	1.776	0.382	H-S	1.291	0.197	L-S	1.051	0.043	L-S
2. Himachal Pradesh	1.570	0.318	M-S	1.295	0.200	L-S	1.241	0.170	L-S
3. Punjab	7.151	0.753	EH-S	5.453	0.715	EH-S	4.219	0.668	VH-S
4. Haryana (+Delhi)	3.826	0.646	EH-S	2.888	0.572	EH-S	2.356	0.504	VH-S
5. Uttar Pradesh	1.177	0.132	L-S	1.022	0.019	L-S	0.875	-0.125	l-D
6. Madhya Pradesh	1.614	0.333	H-S	1.411	0.255	H-S	1.173	0.129	L-S
7. Rajasthan	1.890	0.412	H-S	1.540	0.307	H-S	1.279	0.191	L-S
8. Gujarat (+ Dadra)	1.263	0.182	L-S	1.010	0.008	L-S	0.749	-0.294	l-D
9. Maharastra	1.620	0.335	H-S	1.345	0.224	H-S	1.073	0.060	L-S
10. Karnataka (+ Goa)	1.416	0.257	M-S	1.135	0.104	L-S	0.864	-0.115	l-D
11. Kerala	0.884	-0.115	D	0.422	-1.198	h-D	0.356	-1.586	h-D
12. Tamil Nadu (+ Pondicherry)	1.875	0.408	H-S	1.473	0.281	H-S	1.118	0.092	L-S
13. Andhra Pradesh	1.420	0.259	M-S	1.142	0.109	L-S	0.913	-0.083	l-D
14. Orissa	1.606	0.330	H-S	1.316	0.210	H-S	1.176	0.131	L-S
15. Bihar	0.758	-0.278	D	0.658	-0.456	h-D	0.583	-0.625	h-D
16. West Bengal	1.382	0.242	M-S	1.020	0.017	L-S	0.830	-0.179	l-D
17. Assam (+ Far Eastern areas)	1.045	0.038	L-S	0.764	-0.270	l-D	0.670	-0.431	h-D
All-India	1.486	0.286	M-S	1.207	0.150	L-S	1.002	0.001	L-S (balanced)

in food surplus generation capability through rice production mainly (ignoring the anomalous status of Rajasthan which accomodates a part of core wheat producing areas and also the desert areas with extreme foodgrain deficit situation therein); this is revealed for Tamil Nadu if judged by Σ_2 or Σ_3. Finally, it should be noted that highly deficit states are geographically quite remote from the capital of India and the food situation is more depressing in eastern India than in southern India.

3.6 Statistical Analysis for Explanatory Factors to Spatial Variation in Agricultural Development

3.6.1 Introduction

Agricultural development index D_A as constructed in section 3.4 has been taken as a linear function of three sub-indices, namely : (1) foodgrain surplus generating capacity x_m, (2) agricultural labour productivity x_w and (3) agricultural land productivity x_a, with equal representation which turned out to be as high as 0.8094. In this, however, land productivity is the most fundamental factor depicting geographical variations in revealed soil quality; the other two are the revealed response factors in relation to people involved in crop production activities with the use of varying soil quality and associated input conditions. Of the two response factors, the labour productivity x_w reflects the totality of agricultural activities in relation to all people involved in crop production. The other factor x_m is really partial, both in respect of the involvement of people and the coverage of crops. Yet its importance lies in the fact that it reflects the decision-making cultivators' achievement (or, entrepreneurial ability) in excess production (after satisfying their own requirement) for the society at large in respect of basic human requirements of foodgrains. As the "new agricultural strategy" practised in two decades prior to 1980-81 aimed at improvements in foodgrain production for getting rid of food imports, and also as most of our cropped land is utilised in foodgrain cropping, its surplus generation becomes an important factor in respect of the question : how far it has contributed to explain spatial variations in the other total response factor of labour productivity x_w. However, as x_w is related to all agricultural workers, including both cultivators and labourers, the surplus generation aspect should better be viewed in respect of the same coverage of population if it has to be an explanatory variable for x_w.

Thus, instead of x_m ($=L_1$ or M_1), we would consider M_2 or its transformed measure Σ_2 (whichever fits the statistical distribution of x_w) as an explanatory factor of x_w. The factor Σ_2 or M_2 can however be called "new strategic" response factor, since foodgrain crops received most of the intensification attention under the "new strategy". As we have already noticed the existence of very strong spatial association of Σ_2 with Σ_3 (related to rural population) and Σ_4 (related to total population) in section 3.5, Σ_2 alone could be taken as sufficient for any spatial variation analysis in respect of foodgrain surplus generation. Thus Σ_3 and Σ_4 have not been considered.

Thus, although x_m is a constituent variable of the agricultural development index D_A, we would not search for explanatory factors of x_m and try to find out what caused or contributed to the spatial variation of other two constituent variable x_a and x_w. It is quite logical that the search for explanatory factors to the spatial variation of D_A should follow only after we have explanations for x_a and x_w. There is, however, bilateral interaction between x_a and x_w. But as x_a is more fundamental for improvement by intensification programmes, we would treat x_a as an explanatory factor to x_w and not the other way round.

3.6.2 Explanatory Factor of the Spatial Variation of x_a

The most important single variable explaining the spatial variation of x_a (land productivity) has been found to be the fertiliser input variable (source of data : Fertiliser Statistics, Fertiliser Association of India, 1981). This variable is designated as F and defined as :

F_j = the location factor of total fertiliser input ($N_2 + P_2O_5 + K_2O$) relative to gross cropped area for j-th areal unit.

This variable is constructed for all the three time-points 1960-61, 1970-71 and 1980-81 (with 1980-81 national benchmark value common to all time points used as denominator in location factors, so that inter-temporal comparison is permitted). The fertiliser data were collected from the relevant annual publications of the same source. In this chapter, we are however concerned with the fertiliser input variable for 1980-81 only. The estimate of correlation coefficient between x_a and F has turned out to be as high as 0.811. The empirical relation (with highly significant regression and intercept parameters) is given below in equation (3.18) :

$$x_a = 0.77244 + 0.25951 F \qquad \text{... (3.18)}$$

As many important factors like assured water availability, high quality seed input, level of technology-use, etc. are positively related with the fertiliser input, above certain critical minimum level, the variable F has really taken care of those multicollinear variables, so as to depict the very high correlation with x_a.

In explaining x_a by F we did not have the problem of tackling multicollinear dependent variables. But for explaining x_w and D_A we have to deal with multicollinear explanatory variables. For multicollinear variables, the VLS (Vertical Least Squares) regression technique, as recently developed by Pal and De [1979a] is better suited than the usual OLS (Ordinary Least Squares) regression technique. In addition to the advantage of tackling the multicollinearity problem, the VLS regression technique is found to possess certain discriminatory powers which can be used to identify the best dependent variables with the appropriate combination of explanatory variables. The VLS regression technique has also certain other advantages which are discussed in detail by Pal [1986]. We would summarise below the salient features of the method, before proceeding for further search of explanatory variables for x_w and D_A.

3.6.3 Salient Features of VLS Regression Technique

The fitness of the VLS regression technique, in contrast to the OLS regression technique, with multicollinear explanatory variables can be readily comprehended from the following discussions. The inappropriate decision-making on the basis of the OLS regression coefficients often follows because of the overlooking of basic hypotheses implicit in the

OLS procedure. The basic hypotheses of the OLS procedure are that the dependent variable should have strong inter-correlation with each of the regressants included, while the regressants themselves should be mutually unrelated or independent. These hypotheses are hardly met in reality, especially in many multivariate regional analysis. But the basic hypotheses of the VLS regression procedure are such that, the stronger the intercorrelations among variables, the more powerful is the VLS regression analysis. As such in a multicollinear situation of regional analysis, the VLS regression technique provides with the discriminatory power to measure the roles of explanatory variables uniquely and disjointly by the corresponding regression coefficients in accounting for a regressor (or dependent variable).

It should be noted that the minimisation involved in the OLS regression is biased towards the axis of dependent variable, while that in the VLS regression treats all variable-axes equally. As such the correlation coefficient for the OLS regression gets over-estimated as compared with the VLS regression. Moreover, the OLS correlation coefficient does never decrease with the inclusion of an additional regressant (or, explanatory variable). If the inclusion of an unnecessary (or, insignificant) explanatory variable has not deteriorated the statistical fitness, we have no way to discriminate between multicollinear explanatory variables as regards their relative relevance to account for the dependent variable. It should be noted that a judgement by statistical tests for an insignificant role of an explanatory variable is not appropriate by the corresponding regression coefficient in a multicollinear situation; this point has been adequately established by Pal [1986]. Often in our regression analysis, we have to consider a large number of explanatory variables initially, without much knowledge of their causal relation with the dependent variable. There is always a possibility that the dependent variable could be adequately explained by a less number of relevant variables than those considered initially, particularly when we are dealing with multicollinear variables. This kind of discrimination which is not possible by the comparison of OLS correlation coefficients with and without an additional regressant, is quite possible by that of VLS correlation coefficients, since these coefficients do not necessarily become non-decreasing with the inclusion of an additional regressant. By this discriminatory power of the VLS correlation coefficient, it has been well established [Pal and De 1979a] that the best dependent variable with the best combination of relevant explanatory variables could be identified among several variables chosen initially. It is this property that we are going to use in our subsequent analyses.

The details of mathematical developments of the VLS regression technique, the statistical estimation procedure, the test procedure satisfying the maximum likelihood criterion, etc. have been fully discussed by Pal and De [1979a] which we are not going to discuss here. We would only be interested to know the details of computation procedure for the parameters involved in the VLS regression analysis. In this regard we would summarise from Pal and De's work in the following fashion :

If r_i denotes the specific representation of ith variable x_i ($i = 0, 1, 2, \ldots\ldots\ldots\ldots, m$), for the composite index constructed by the aggregate representation maximising principle (ref. to section 2.5), the VLS regression of o-th variable is given by

$$\hat{Z}_0 = \left(\frac{r_0}{\mu - r_0^2} \right) \sum_{i=1}^{m} r_i \, Z_i \qquad \ldots (3.19)$$

where Z_i = standardised variable corresponding to x_i,

$\hat{Z}_0$ = the VLS regression estimate of Z_0 and

$\mu = \sum_{i=0}^{m} r_i^2$.

The VLS correlation coefficient, $r_{Z_0 \hat{Z}_0}$ is expressed as

$$r^2_{Z_0 \hat{Z}_0} = 1 / \left[1 + \left(\frac{\mu}{\mu - 1}\right)^2 \left(\frac{1}{r_0^2} - 1\right) \right] \qquad \ldots (3.20)$$

The equation (3.19) can easily be changed to one involving $\hat{x}_o$ and x_i's; further $r_{x_o \hat{x}_o} = r_{Z_0 \hat{Z}_0}$. The relative importance of explanatory variables $x_1, x_2, \ldots\ldots\ldots\ldots, x_m$ in explaining the accounted variation (or, spatial variation, when dealing with spatial variables) of x_0 is given by the shares

$$g_{0i} = r_i^2 / (\mu - r_0^2), \quad i = 1, 2, \ldots\ldots\ldots, m \qquad \ldots (3.21)$$

so that $\sum_{i=1}^{m} g_{0i} = 1$.

3.6.4 Explanatory Factors of the Spatial Variation of x_w

We have already argued in favour of Σ_2 (or M_2) and x_a as possible explanatory variables. In addition we may also examine whether or not certain non-foodgrain crop concentrations have any explanatory role for labour productivity x_w. We have included all foodgrain crops in the calculation of Σ_2. Although we have noticed that wheat plays the dominant role in explaining the spatial variation of Σ_2, wheat alone could not have been able to improve upon the foodgrain surplus situation for the totality of all areas of India, simply because of the fact that wheat alone cannot be grown everywhere, replacing the traditional geographical distributions of other foodgrain crops. In fact, all foodgrain crops contributed towards building up the all-India total, so that foodgrain imports could be avoided in recent years. So we propose to consider the variable Σ_2 instead of dealing with detailed foodgrain crops. In fact, seperately, the different foodgrain crops have much inferior spatial relations with x_w to what we get for the total accounting through Σ_2, as is evident from below :

Correlation Coefficients

labour productivity	Σ_2	foodgrain crops			
		C_1 (rice)	C_2 (wheat)	C_3 (minor f.g)	C_4 (other f.g)
x_w	0.7837	0.0742	0.6235	-0.0252	0.2169

Again it is also noted that the statistical distribution of Σ_2 is more matching with x_w than that of M_2 with x_w (as evaluated by the relative magnitudes of the two linear correlation coefficient). As such the ratio form Σ_2 and not M_2 would be considered as a more appropriate explanatory variable of x_w.

The correlation coefficients of x_w with non-foodgrain crops are as given below :

Correlation coefficients with x_w			Correlation coefficients with x_w		
C_{12} .	plantation crops (tea & coffee)	0.3485	C_5 .	oilseeds	0.1536
C_8 .	sugarcane	0.2908	C_6 .	groundnut	0.1392
C_9 .	potato	0.2688	C_{10} .	spices	0.0450
C_7 .	fibre crops	0.2460	C_{11} .	tobacco	-0.0215

As the crop C_6 (groundnut) is within the coverage of C_5 (oilseeds), we do not have any need for its consideration. Moreover, an overwhelming proportion of oilseeds is comprised of groundnut (ref. to section 2.6). The crops C_{10} (spices) and C_{11} (tobacco) have almost no relation with x_w. As such these two crops also do not need any consideration. Thus we would consider only the remaining five crops along with Σ_2, x_a and x_w for finding out the groups of explanatory variables and the corresponding best explained variable through discrimination by VLS correlation coefficients reported in Table (3.5).

From an examination of the estimates recorded in Table (3.5), we infer that the spatial variable of labour productivity x_w has remained the best dependent variable in all variable-spaces shown in different columns. The estimates shown in the row against x_w reveal that the value of $r_{x_w \hat{x}_w}$

Table (3.5) : The VLS Correlation Coefficients in Different Variable-spaces for Spatial Variables related to Agricultural Labour Productivity; India. : 1980-81

Spatial variable y_i	VLS Correlation Coefficients $r_{y_i\hat{y}_i}$								
	7-space	6-space	6-space	7-space	5-space	5-space	4-space	3-space	2-space
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$y_0 = x_w$	0.8492	0.8255	0.8728	0.8807	0.8515	0.8596	0.8424	0.8167	0.7837
$y_1 = \Sigma_2$	0.5208	0.5057	0.6014	0.6042	0.5906	0.6166	0.6099	0.6903	0.7837
$y_2 = x_a$	0.5615	0.5662	0.5503	0.5430	0.5608	0.5261	0.5401	0.5105	—
$y_3 = C_{12}$	0.3062	0.3168	0.2163	0.2064	0.2234	0.2343	0.2470	—	—
$y_4 = C_8$	0.2049	0.2161	0.2091	0.2044	0.2255	—	—	—	—
$y_7 = C_9$	0.2712	0.2836	—	—	—	—	—	—	—
$y_5 = C_7$	0.1201	—	0.1429	0.1569	—	0.1657	—	—	—
$y_6 = C_5$	—	—	—	0.0907	—	—	—	—	—

N.B: The variables not included in the variable-space are shown by dashes '—'.

is the highest for the variable-space (x_w, Σ_2, x_a, C_{12}, C_8, C_7, C_5). In the multicollinear situation of the variables considered, the variable C_9 (potato) turns out to be redundant for explaining the best dependent variable x_w.

Denoting the variables as :

$y_0 = x_w$, $y_1 = \Sigma_2$, $y_2 = x_a$, $y_3 = C_{12}$, $y_4 = C_8$, $y_5 = C_7$, $y_6 = C_5$ and

Z_i = standardised y_i; i = 0, 1, 2, 3, 4, 5, 6, the best fitted VLS regression equation can be written as follows :

$$\hat{Z}_0 = 0.50430\ Z_1 + 0.47234\ Z_2 + 0.21615\ Z_3 + 0.21421\ Z_4 + 0.16694\ Z_5 + 0.09805\ Z_6 ; \qquad \ldots (3.22);$$

the VLS correlation coefficient $r_{Z_0\hat{Z}_0} = 0.88070$ and the total spatial variation explained $r^2_{Z_0\hat{Z}_0} = 0.77564$. Contributions of different regressants in explaining the spatial variation of x_w are given by :

$g_{01} = 0.41861$, $g_{02} = 0.36724$, $g_{03} = 0.07691$,

$g_{04} = 0.07553$, $g_{05} = 0.04588$ and $g_{06} = 0.01583$.

The VLS regression equation (3.22) can be written equivalently in unstandardised variables in the following fashion :

$$\hat{x}_w = -0.75679 + 0.28076\ \Sigma_2 + 1.08801\ x_a + 0.01718\ C_{12} + 0.08364\ C_8 + 0.07119\ C_7 + 0.05389\ C_5 ; \qquad \ldots (3.23)$$

VLS correlation coefficient $r_{x_w\hat{x}_w} = 0.88070$

Thus in terms of contributions to explain the spatial variation of x_w, two most important variables have been Σ_2 (food surplus generating capability factor) and x_a (land productivity factor). Contributions of individual non-foodgrain crops have come from only C_{12} (plantation crops), C_8 (sugarcane), C_7 (fibre crops) and C_5 (oilseeds). The crops C_{12} and C_8 show comparatively low magnitude of contribution, the crop C_7, very low and the crop C_5, extremely low. However, the contribution of these four significant non-foodgrain crops together is about 0.21415, which is about half of that by foodgrain crops (i.e., about half of g_{01}). This relative picture is obtained when examined for explanation of the spatial variation of x_w from the standardised regression equation (3.22). It should be noted that the contributory major g_{0i} is proportional to the corresponding squared regression coefficient of equation (3.22). However, as all our variables are location factors or indices derived from location factors with critical all-India value of unity for each, the regression coefficients of the unstandardised regression equation (3.23) are also quite meaningful in terms of marginal rate concept. Here these regression coefficients or the marginal rates are measurement unit-free (since the index-variables are unit-free numbers). These coefficients are also distinct, in the sense that these are not of mixed-up magnitudes due to multicollinearity among explanatory variables (unlike those estimated by OLS regression procedure). The relation between the forms of regression coefficients of equations (3.22) and (3.23) is as follows :

$$b_i = a_i (\sigma_0 / \sigma_i),$$

where a_i = regression coefficient in standardised VLS regression,

b_i = regression coefficient in corresponding unstandardised VLS regression,

σ_i = standard deviation of explanatory variable i and

σ_0 = standard deviation of the dependent variable.

As such, with increasing σ_i, the magnitude of b_i would be diminishing. As the plantation crop C_{12} is extremely localised, its standard deviation is tremendously high and so the magnitude of corresponding regression coefficient is greatly diminished in unstandardised form (3.23). On the other-hand, as the variability (squared standard deviation) of x_a is not high in India, the magnitude of corresponding regression coefficient of x_a is again greatly increased in unstandardised form (3.23). Clearly the variance of x_w is higher than that of x_a. Anyway, judging from the regression coefficients (or the marginal rates) of equation (3.23), the highest value is associated with x_a [i.e., $(\delta \hat{x}_w / \delta x_a) = 1.08801$ is highest] and the lowest with C_{12} [$(\delta \hat{x}_w / \delta C_{12}) = 0.01718$]. The second important marginal rate is associated with Σ_2 [$(\delta \hat{x}_w / \delta \Sigma_2) = 0.28076$]. For other three non-foodgrain crops, the marginal rates lie between 0.054 and 0.084 which could be considered as of low magnitudes.

To get a comparative assessment of how the multi-collinearity effect would have overestimated or underestimated the regression and correlation coefficients, we have also estimated the OLS regression in (3.24) in comparable form to VLS regression (3.23). Thus we have the OLS regression :

$$x_w = -0.13784 + 0.38125\ \Sigma_2 + 0.28460\ x_a + 0.02834\ C_{12} + 0.09729\ C_8 + 0.06720\ C_7 + 0.06666\ C_5; \qquad \ldots (3.24)$$

OLS multiple correlation coefficient R = 0.92758; and

spatial variation explained : $R^2 = 0.86041$.

The OLS regression has overestimated the explained variation by 11 percent, the correlation coefficient by 5.3 percent, the regression estimates of Σ_2 by 36 percent, C_{12} by 65 percent, C_8 by 16 percent and C_5 by 24 percent, whereas it has underestimated the regression estimates of x_a by 74 percent and also that of C_7 by 6 percent. The role of x_a in explaining x_w as depicted by the VLS regression coefficient is more acceptable not only on technical grounds related to multicollinearity but also because it is more fundamental in nature to impart relatively much higher marginal rate than the other important factor Σ_2. So a relatively higher marginal rate for x_a and a lower marginal rate for Σ_2 as obtained in the VLS regression seem to be more realistic.

3.6.5 Explanatory Factors of the Spatial Variation of D_A

Finally we would be finding the explanatory factors to spatial variation of the over-all agricultural development index D_A. As it is constituted of x_m, x_w and x_a, any of them cannot be considered for this purpose, although factors explaining these constituted indices could be considered. We make our search among the factors those have already explained substantially the variations of x_a and x_w. Thus the factors of interest are F (fertiliser), Σ_2 or M_2 or L_2 (foodgrain surplus generation capability) and the non-food crops : C_{12} (plantation crops), C_8 (sugarcane), C_7 (fibre crops) and C_5 (oilseeds). Both Σ_2 and L_2 (same as M_2) are almost similarly correlated to D_A but F shows greater multicollinearity with the form Σ_2 than with the form L_2. Infact, the VLS correlation coefficient of D_A as explained by Σ_2 and F is lower than that explained by L_2 and F (it is 0.813 against 0.865). So to get rid of the non-conformal multicollinearity effect, we would consider here L_2 form instead of Σ_2 form of the surplus-generating capability variable. We would apply a similar VLS regression discrimination procedure as we have done already for x_w^*. The results are recorded in Table (3.6).

Table (3.6) : The VLS Correlation Coefficients in Different Variable-spaces for Spatial Variables related to Agricultural Development; India 1980-81

Spatial variable y_i	VLS Correlation Coefficients $r_{y_i\hat{y}_i}$						
	7-space	6-space	6-space	5-space	4-space	3-space	2-space
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$y_0 = D_A$	0.8698	0.8681	0.8920	0.9041	0.8878	0.8651	0.6795
$y_1 = F$	0.5609	0.5709	0.4942	0.5040	0.5156	0.5143	0.6795
$y_2 = L_2$	0.4571	0.4453	0.4821	0.4716	0.4680	0.4974	-
$y_3 = C_{12}$	0.1608	0.1743	0.1790	0.1983	0.2060	-	-
$y_4 = C_7$	0.1143	0.0947	0.1455	0.1233	-	-	-
$y_5 = C_5$	0.1164	-	0.1327	-	-	-	-
$y_6 = C_8$	0.2294	0.2376	-	-	-	-	-

N.B. : The variables not included in the variable-space are shown by dashes '—'.

We can conclude from an examination of estimates given in Table (3.6) that the over-all agricultural development index D_A has remained the best dependent variable in all variable-spaces shown in different columns. The estimates shown in the row against D_A reveal that the value of $r_{D_A \hat{D}_A}$ is the highest for the variable-space (D_A; F; L_2; C_{12}; C_7). Although the variables C_5 and C_8 explain to some extent variation of labour productivity x_w (ref. to Table 3.5), these two variables turn out to be redundant for explaining the spatial variation of the best dependent variable D_A in the multicollinear situation of the variables considered. As $r_{D_A \hat{D}_A}$ is of higher magnitude than $r_{x_w \hat{x}_w}$, the statistical fitness for D_A is more acceptable. Thus our conclusion is that sugarcane and oilseeds are not needed for explaining the spatial variation of over-all agricultural development, though, however, these crops explain to some extent the spatial variation of labour productivity.

Again denoting afresh the variables as $y_0 = D_A$; $y_1 = F$; $y_2 = L_2$; $y_3 = C_{12}$; $y_4 = C_7$; and Z_i = standardised y_i; $i = 0, 1, 2, 3, 4$; the best fitted VIS regression equation can be written as follows :

$$\hat{Z}_0 = 0.58677\ Z_1 + 0.56275\ Z_2 + 0.28134\ Z_3 + 0.17983\ Z_4; \qquad \ldots (3.25)$$

VIS correlation coefficient $r_{Z_0 \hat{Z}_0} = 0.90407$; and the

total spatial variation explained $r^2_{Z_0 \hat{Z}_0} = 0.81735$.

Contributions of different regressants in explaining the spatial variation of D_A are given by $g_{01} = 0.44571$; $g_{02} = 0.40996$; $g_{03} = 0.10246$ and

g_{04} = 0.01187. The VLS regression equation (3.25) can be written equivalently in terms of unstandardised variables as

$$\hat{D}_A = 0.55971 + 0.21089\ F + 0.19970\ L_2 + 0.01091\ C_{12} + 0.03739\ C_7; \qquad \ldots (3.26)$$

VLS correlation coefficient $r_{D_A \hat{D}_A}$ = 0.90407

The variable L_2 is in the form of a location factor to make it comparable with other variables, so that for each of the variables the critical all-India value is unity. The conversion, if desired, can be obtained by use of the relation $L_2 = M_2/M_{2*}$, where M_{2*} = 0.28602. Here the two most important variables are fertiliser-input index F and the foodgrain surplus generating capability index L_2. From the point of view of variation explained, C_{12} is more important than C_7. But as C_{12} is extremely localised crop so as to have an extremely high magnitude of its variability, it is better to use its unstandardised form to take account of this fact. Thus from the point of view of marginal rates of agricultural development, the fibre crops C_7 has been more important than the plantation crops C_{12}.

Likewise the case with x_W, we have also estimated the OLS regression equation for D_A to make a contrast with the corresponding VLS regression equation (3.26). The OLS regression equation is given by

$$D_A = 0.59214 + 0.19450\ F + 0.18878\ L_2 + 0.00842\ C_{12} + 0.03423\ C_7; \qquad \ldots (3.27)$$

OLS multiple correlation : R = 0.90506.

Here all the OLS regression coefficients are a little underestimated as compared to the corresponding VLS regression coefficients. Further the problem of multicollinearity is not as great as it has been for the statistical fitness of x_w. This can be seen from the relatively closer estimates between the OLS and VLS correlation coefficients in the present case with D_A. Here by our choice of L_2, instead of Σ_2, the multicollinearity between variables has been reduced (for example, $r_{L_2F} = 0.1992$ as against $r_{\Sigma_2 x_a} = 0.3941$). Again if variables C_5 and C_8 are also included as additional explanatory variables to D_A, the VLS correlation coefficient falls from the present value of 0.9041 in 5-space to a lower value of 0.8698 in 7-space while the corresponding OLS correlation coefficient increases (in fact it can never fall) from the present value of 0.9051 in 5-space to a marginally higher value of 0.9058 in 7-space. All OLS regression coefficients in 7-space were found to be significant (at 5% level of significance) by the usual statistical tests. But this notion of significance does not truly bear much meaning in the event of multicollinearity distortions on the estimates of regression coefficients in the OLS regression; this increase in multicollinearity distortions (for incorporation of the two additional variables C_5 and C_8) could easily be appreciated by the greater fall in magnitude of OLS to VLS correlation coefficients in 7-space (from 0.9058 to 0.8698) than that in 5-space (from 0.9051 to 0.9041). This redundancy on the explanatory role of C_5 and C_8 for D_A could easily be assessed by the fall in the VLS correlation coefficient from 7-space to 5-space which would not have been possible otherwise by the corresponding OLS correlation coefficients.

3.7 Ranking of Areal Units by Agricultural Development Index and its Constituent Sub-indices

The position we have arrived at in our preceding statistical analysis is that :

i) the main causal variable for improvements in land productivity has been the fertiliser input;

ii) the land productivity and agricultural population's foodgrain surplus generating capacity have been mainly responsible for labour productivity; and naturally

iii) the over-all agricultural development (D_A), as estimated by a composition of land productivity (x_a), labour productivity (x_w) and cultivators' entreprenenrial ability (x_m), has been mainly influenced by the fertiliser input variable (F) and the agricultural population's foodgrain surplus generating capability index (L_2). The cultivation of non-foodgrain crops, like (a) plantation crops C_{12}, (b) fibre crops C_7, (c) sugarcane C_8 and (d) oilseeds C_5 have also influenced the agricultural development. But, of these crops, only C_{12} and C_7 have some direct explanatory role to D_A, while the role of the other two, C_8 and C_5, could be appreciated only indirectly through their influence on the labour productivity. It is also noted that the factor L_2 has been greatly improved by the intensification of attention bestowed mainly on wheat crop ; the most wide spread rice crop did not get yet its due attention that it ought to have received as the most important crop in the climatological environment of India.

Before proceeding with our attempts on regional analysis of agricultural development we would now classify the agricultural development index D_A and its constituent sub-indices x_m, x_w and x_a for the purpose of ranking the areal units in respect of agricultural development patterns.

Again, of the two most important explanatory factors F and L_2, we have already classified and analysed the areal data on L_2 (i.e., M_2 or Σ_2) in section 3.5. The other important factor, namely, the location factor of fertiliser input relative to gross cropped area, F, has not been analysed for areal variation. So we would also classify here the data on F and rank the areal units according to this classification.

We have noted already some six areal units stand out uniquely in all our preceding analysis on surplus indices in section 3.5. Keeping these observations aside, roughly the middle one-third of the remaining 145 observations (i.e., about 47) is accomodated with a range of 0.82 to 1.00 for the value of the over-all agricultural development index D_A. This leads us to take an interval length of 0.18 for D_A, which has been used for further equal interval classifications of D_A. We have noted a significant gap in the occurance of areal units just from and beyond 1.36. Thus the class of observations above the value of D_A = 1.36 is termed as the class of extremely high (EH) values and then in the sequence of downward values we have VH (1.18 - 1.36), H (1.00 - 1.18), M (0.82 - 1.00), L (0.64 - 0.82) and VL (below 0.64) classes.

As the correlation coefficient between D_A and each of its constituent sub-indices x_m, x_w and x_a, is the same very high value of about 0.81 and also as that between x_a and F is again has that very high value, we have drawn binary graphs for the pairs (D_A, x_m), (D_A, x_w), (D_A, x_a) and (x_a, F), with the respective regression lines on it. From an analysis of the scatter of points on these graphs and also the individual statistical distributions, an interval length of 0.20 fits for the equal interval classifications on both x_m and x_a; while because of higher variability, an interval length of about 0.24 fits for x_w and about 0.40 for F. For all sub-indices of D_A, the all-India critical value of unity fits for the boundary value between M and H classes. But for a very peculiar distribution of F with only an elongated right hand tail and for a predominance of low valued observations, we have put the all-India critical value of unity at the middle of M-class and not as its upper boundary. Moreover, the most advanced North Indian region has also some areal units in its southern fringe which could generate that high agricultural development with a value of F, just above 0.80. So the range of M-class for the fertiliser input index F has been (0.80 - 1.20). And for the existence of elongated right hand tail, the top two classes of F are formed by taking increased interval length. We summarise in Tables (3.7) and (3.8) the details of classification and frequency distribution for these indices and sub-indices.

On the basis of these classifications, we have recorded the class-ranks of all areal units for D_A, x_m, x_w, x_a and F in Table (3.9) and also prepared corresponding maps shown in Figures (3.5) to (3.9). In addition, the actual estimates of D_A and F by areal units have also been recorded in Table (3.9). The estimates of x_m, x_w and x_a are reported among other things in the Appendix Table (A.5). We would attempt regional analysis with these data in the next section.

Table (3.7) : Class-intervals for Agricultural Activity Indices and Sub-indices

class-rank code	Class-intervals for indices and sub-indices				
	D_A (= x_5)	x_m	x_w	x_a	F
(0)	(1)	(2)	(3)	(4)	(5)
EH (Extremely High)	1.36 to 2.23	1.40 to 1.66	1.48 to 4.15	1.40 to 1.81	2.40 to 3.80
VH (Very High)	1.18 to 1.36	1.20 to 1.40	1.24 to 1.48	1.20 to 1.40	1.60 to 2.40
H (High)	1.00 to 1.18	1.00 to 1.20	1.00 to 1.24	1.00 to 1.20	1.20 to 1.60
M (Medium)	0.82 to 1.00	0.80 to 1.00	0.76 to 1.00	0.80 to 1.00	0.80 to 1.20
L (Low)	0.64 to 0.82	0.60 to 0.80	0.52 to 0.76	0.60 to 0.80	0.40 to 0.80
VL (Very Low)	0.23 to 0.64	-1.66 to 0.60	0.15 to 0.52	0.31 to 0.60	0.01 to 0.40

Table (3.8) : Frequency Distribution for Agricultural Activity Indices and Sub-indices 1980-81

class-rank code	Frequency of areal units for				
	D_A(=x_5)	x_m	x_w	x_a	F
(0)	(1)	(2)	(3)	(4)	(5)
EH	17	10	22	19	18
VH	17	19	10	22	14
H	28	38	27	32	17
M	48	29	39	37	19
L	24	22	42	36	29
VL	17	33	11	5	54

Table (3.9) : Estimates of Agricultural Development Index D_A, Fertiliser Input Index F and Ranks of Indices and Related Sub-indices by Areal Units of India : 1980-81

	Areal Units (district-groups)	Values of D_A (= x_5)	Ranks of Index/Sub-index					Values of F
			D_A	x_m	x_w	x_a	F	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Srinagar + Anantanag + Baramulla + Phulwama + Badgam + Kupwara	1.0607	H	M	M	VH	H	1.4368
2	Poonch + Rajouri	0.9099	M	L	M	H	VL	0.0749
3	Jammu + Kathua	0.9910	M	M	VH	M	L	0.4443
4	Doda + Udhampur	0.8142	L	L	L	M	VL	0.1173
5	Chamba + Kangra + Hamirpur + Una	0.8592	M	L	M	M	L	0.4979
6	Kinnaur + Lahul + Spiti	0.4783	VL	VL	VL	H	M	1.1867
7	Bilaspur + Kulu + Mandi	0.8609	M	M	L	M	VL	0.3819
8	Mahasu + Simla + Sirmur + Solan	0.7185	L	VL	L	M	L	0.4637
9	Hoshiarpur + Jullundur + Rupar	1.7741	EH	EH	EH	EH	EH	2.9869
10	Patiala	2.0759	EH	EH	EH*	EH	EH	3.3781
11	Ludhiana + Sangrur	2.1148	EH	EH	EH*	EH	EH	3.3299
12	Kapurthala + Amritsar + Gurdaspur	1.8749	EH	EH	EH	EH	EH	3.6309
13	Ferozepur + Bhatinda + Faridkot	1.9045	EH	EH	EH*	EH	EH	3.0821
14	Hissar + Jind + Sirsa + Bhiwani	1.4678	EH	VH	EH	VH	M	0.8040
15	Mohindergarh	1.1492	H	H	EH	M	VL	0.3520
16	Delhi + Rohtak + Gurgaon + Sonepat + Faridabad	1.4414	EH	VH	EH	H	M	0.8267
17	Karnal + Ambala + Krurukhetra	1.9821	EH	EH	EH*	EH	EH	2.6248
18	Saharanpur + Dehradun	1.1990	VH	H	EH	H	VH	1.8243
19	Meerut + Muzaffarnagar + Gaziabad	1.3105	VH	M	EH	VH	EH	2.7787
20	Bulandshar + Aligarh	1.2777	VH	H	EH	VH	H	1.3088
21	Mathura + Agra	1.0905	H	M	H	H	M	0.9968
22	Mainpuri + Etawah	1.0071	H	L	H	H	M	1.0981
23	Jalaun + Jhansi + Hamirpur + Lalitpur	0.8378	M	M	M	L	VL	0.2701
24	Kanpur + Hardoi + Lucknow + Unnao	0.8297	M	VL	M	H	M	1.0520
25	Budaun + Etah + Farrukabad	0.9125	M	VL	H	H	H	1.2733
26	Bijnor + Moradabad	0.9687	M	VL	EH	H	H	1.5640
27	Uttar Kashi + Tehri Garwal + Garwal	0.5388	VL	VL	VL	L	VL	0.1179
28	Chamoli + Almora + Pithorgarh	0.5879	VL	VL	VL	L	VL	0.1597
29	Nainital + Rampur + Bareilly + Pillibhit + Shahjahanpur	0.9829	M	L	VH	H	VH	1.9139
30	Sitapur + Kheri	0.6143	VL	VL	H	M	M	0.9307
31	Bahraich + Gonda + BaraBanki	0.5905	VL	VL	L	L	M	0.9392
32	Basti + Gorakhpur + Deoria	0.7253	L	VL	M	M	H	1.4304
33	Azamgarh + Gazhipur + Ballia	0.6589	L	VL	M	M	VH	1.6720
34	Pratapgarh + Rae-Barelli + Sultanpur + Faizabad	0.6363	VL	VL	L	M	H	1.4333
35	Fatehpur + Banda	0.8643	M	L	M	M	VL	0.3773
36	Allahabad + Jaunpur	0.7613	L	VL	M	H	H	1.4645
37	Varanasi + Mirzapur	0.8072	L	L	M	M	M	1.1571
38	Rewa + Sidhi	0.6590	L	M	VL	VL	VL	0.1632
39	Surguja + Shahdol	0.6697	L	L	L	L	VL	0.0624
40	Bilaspur + Raigarh	0.8054	L	M	L	L	VL	0.2043
41	Raipur	0.9545	M	H	M	M	L	0.4565
42	Bastar	0.6558	L	L	L	L	VL	0.0296
43	Durg + Balaghat + Rajnandgaon	0.7388	L	M	L	L	VL	0.2221
44	Mandla + Seoni	0.6623	L	L	VL	L	VL	0.0389
45	Chindwara + Betul + Narshimhapur	0.8054	L	M	L	L	VL	0.2547
46	Damoh + Jabalpur	0.8790	M	H	M	L	VL	0.1011
47	Panna + Satna	0.7493	L	H	L	VL	VL	0.1051
48	Tikamgarh + Chattarpur	0.8344	M	M	L	M	VL	0.2795
49	Vidisa + Sagar + Raison	0.9434	M	VH	H	L	VL	0.1067
50	Hoshangabad + Sehore + Bhopal	0.8886	M	VH	M	L	VL	0.2272

Table (3.9) Continued

	Areal Units (district-groups)	Values of D_A (= x_5)	Ranks by Index/Sub-Index					Values of F
			D_A	x_m	x_w	x_a	F	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
51	East Nimar + West Nimar	0.7609	L	M	L	L	L	0.4883
52	Dhar + Jhabua + Ratlam	0.6919	L	L	L	L	L	0.4600
53	Mandsaur	0.8875	M	H	M	L	L	0.5955
54	Ujjain + Indore + Dewas	1.0333	H	VH	H	L	L	0.5123
55	Shajapur + Rajgarh	0.9393	M	H	M	L	VL	0.1232
56	Guna + Shivpuri	0.8117	L	H	M	L	VL	0.0784
57	Morena + Bhind + Gwalior + Datia	0.9552	M	M	H	M	L	0.4379
58	Bundi + Kota + Jhalawar	0.9809	M	VH	H	L	L	0.7328
59	Tonk + Ajmer	0.8776	M	H	M	L	VL	0.1213
60	Jaipur + Swai Madhopur	0.9292	M	M	M	M	VL	0.2160
61	Alwar + Bharatpur	1.0851	H	H	VH	H	VL	0.2267
62	Jhunjhunu + Sikar	0.5929	VL	VL	L	L	VL	0.0995
63	Ganganagar	1.4019	EH	VH	EH	H	M	0.9171
64	Bikaner + Churu	- .3803	VL	VL*	VL	VL	VL	0.0669
65	Nagaur + Jodhpur	0.3248	VL	VL	L	VL	VL	0.0659
66	Jaisalmer + Barmer	0.3062	VL	VL	L	VL	VL	0.0083
67	Jalore	0.8362	M	L	H	L	VL	0.1739
68	Pali + Sirohi	0.9070	M	H	H	L	VL	0.3672
69	Udaipur + Bhilwara + Chitorgarh	0.8884	M	M	M	M	L	0.4061
70	Banswara + Dungarpur	0.8795	M	L	H	M	L	0.4648
71	Panch Mahals + Kaira	1.0477	H	L	H	VH	M	1.1845
72	Ahmedabad + Sabarkantha + Gandhinagar	1.1155	H	H	VH	H	H	1.3125
73	Mehsana + Banaskantha	1.1823	VH	H	H	VH	L	0.6645
74	Surendranagar + Kutch	0.9420	M	M	VH	M	VL	0.2992
75	Jamnagar + Junagadh + Amreli	1.1276	H	L	EH	H	H	1.3629
76	Rajkot + Bhavnagar	1.2015	VH	M	EH	H	H	1.5357
77	Surat + Bharuch + Baroda	0.9246	M	L	M	H	H	1.5083
78	Dangs + Valsad + Dadra	0.8220	M	VL	L	H	H	1.3139
79	Dhulia + Nasik	0.8957	M	H	L	M	M	0.9320
80	Jalgaon + Aurangabad	0.9188	M	H	L	L	M	1.0904
81	Buldana + Akola + Amravati	0.9280	M	VH	L	L	L	0.5787
82	Wardha + Nagpur	0.8904	M	VH	L	L	L	0.6872
83	Bhandara + Chanda	0.9164	M	H	L	M	VL	0.3581
84	Yeotmal + Nanded + Parbhani	0.9148	M	VH	L	L	VL	0.3408
85	Bhir + Osmanabad + Sholapur	0.9719	M	VH	M	L	VL	0.2821
86	Pune + Ahmednagar	0.9559	M	H	M	M	L	0.7195
87	Thana + Kolaba + Greater Bombay	1.0967	H	M	L	VH	M	1.0885
88	Satara + Sangli	0.9374	M	M	H	H	M	0.9619
89	Kolhapur	1.1980	VH	L	H	EH*	EH	3.7424
90	Ratnagiri	0.6776	L	VL	VL	H	L	0.7093
91	Goa (+ Daman + Diu)	1.0956	H	H	L	VH	VH	2.0179
92	North Kanara + Shimoga	1.2587	VH	H	H	VH	VH	1.8475
93	Belgaum + Dharwar	1.0173	H	H	H	M	L	0.7947
94	Bidar + Gulbarga + Bijapur	0.8274	M	H	M	L	VL	0.2117
95	Raichur + Bellary	1.1202	H	H	H	H	VH	1.6051
96	Chitradurga + Tumkur	1.1670	H	H	M	VH	H	1.3976
97	Bangalore + Kolar	1.0335	H	M	L	VH	VH	1.8504
98	Mysore + Manda	1.2059	VH	M	M	EH	EH	2.4403
99	Chickmagalur + Hassan	1.1374	H	L	VH	VH	VH	2.2627
100	South Kanara	1.1834	VH	H	M	VH	EH	2.9541
101	Coorg	1.5075	EH	EH	EH	EH	EH	3.2157

Table (3.9) Concluded

	Areal Units (district-groups)	Values of D_A $(= x_5)$	Ranks by Index/Sub-Index					Values of F
			D_A	x_m	x_w	x_a	F	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
102	Cannanore + Kozhikode + Mallapuram + Waynad	1.1978	VH	H	M	VH	VH	1.8235
103	Palghat + Trichur	1.2692	VH	EH	M	VH	VH	1.8800
104	Ernakulam + *Kottayam* + Iddiki	1.3317	VH	M	H	EH*	EH	3.2568
105	Alleppey + Quilon + Trivandrum	1.0556	H	M	L	EH	EH	3.4493
106	Tirunelveli + Kanyakumari	1.4638	EH	VH	M	EH	VH	2.1800
107	Ramanathapuram + Madurai	1.1730	H	H	L	VH	VH	2.0008
108	Coimbatore + Periyar	1.4467	EH	VH	H	EH	EH	3.5635
109	*Nilgiris*	1.9752	EH	EH	EH*	EH	H	1.2733
110	Salem + Dharampuri	1.0117	H	L	L	VH	H	1.2883
111	Tiruchirapalli + Thanjavur + Pudukottai	1.4145	EH	VH	H	EH	EH	2.7163
112	Chingleput + South Arcot + North Arcot + Madras + Pondicherry	1.5778	EH	VH	VH	EH	EH	2.5451
113	Nellore + Chittoor	1.1546	H	H	M	VH	M	1.0811
114	Cuddapah + Anantapur	0.8486	M	L	L	M	L	0.7496
115	Kurnool + Mahbubnagar	0.8671	M	H	L	L	M	1.0331
116	Hyderabad + *Medak + Ranga Reddy*	0.8925	M	M	L	M	L	0.6925
117	Nizamabad + Karimnagar	1.1963	VH	VH	M	VH	EH	2.5408
118	Adilabad	0.8843	M	H	L	L	VL	0.2101
119	Warangal + Khammam + Nalgonda	0.8947	M	H	L	M	M	1.0376
120	Guntur + Ongole	1.1336	H	VH	M	H	VH	1.8683
121	*E. Godavari + W. Godavari + Krishna*	1.5240	EH	EH	VH	EH	EH	3.0979
122	Srikakulam + Vishakhapatnam + Vizianagaram	0.7528	L	VL	L	H	L	0.6837
123	Kalahandi + Koraput	0.9432	M	H	M	M	VL	0.0856
124	Phulbani + Bolangir	0.9191	M	M	M	M	VL	0.2832
125	Puri + Ganjam	1.1121	H	H	H	H	L	0.5208
126	*Balasore + Cuttack*	1.1129	H	H	H	H	L	0.4315
127	Mayurbhanj + Keonjhar + Dhenkanal	0.5968	VL	VL	VL	L	VL	0.1155
128	Sundargarh + Sambalpur	1.1349	H	VH	VH	M	L	0.4605
129	Ranchi + Singhbhum	0.5004	VL	VL	L	L	VL	0.1752
130	Hazaribagh + Palamau + Giridih	0.2210	VL	VL*	VL	L	VL	0.1208
131	Patna + *Gaya + Shahabad + Nalonda* + Aurangabad + Nawada	0.9022	M	M	M	M	M	0.8379
132	Saran + Siwan + Champaran + Gopalganj	0.7884	L	VL	M	M	L	0.6608
133	Muzaffarpur + Darbhanga + Vaisali + *Sitamarhi* + Madhubani + Samastipur	0.5836	VL	VL	VL	M	L	0.5835
134	Saharsa + Purnea + Katihar	0.7087	L	L	L	M	VL	0.2008
135	Monghyr + Bhagalpur + Begusarai	0.7969	L	L	L	M	L	0.5869
136	Santal Parganas + Dhanbad	0.6560	L	VL	L	M	VL	0.1520
137	Purulia + Bankura + Midnapore	1.0539	H	H	M	H	L	0.6872
138	Burdwan + Howrah + Hooghly	1.4306	EH	VH	EH	EH	VH	2.0789
139	Calcutta + 24-Parganas + Nadia	1.0042	H	M	H	H	M	1.0112
140	Murshidabad + Birbhum	1.2485	VH	H	VH	VH	M	0.9949
141	West Dinajpur + Malda	1.2700	VH	H	EH	VH	L	0.5861
142	Cooch-Behar + Jalpaiguri + Darjeeling	1.3522	VH	M	EH	VH	VL	0.3197
143	Meghalaya	0.5884	VL	VL	L	H	VL	0.3291
144	Goalpara + Kamrup	0.7012	L	VL	M	M	VL	0.0672
145	Darrang + Nowgong + Lakhimpur + Sibsagar + Dibrugarh	1.2074	VH	VL	EH*	EH	VL	0.0845
146	United Mikir & North Cachar Hills	1.0364	H	M	H	H	VL	0.0960
147	Cachar + Tripura	0.9151	M	VL	H	H	VL	0.1728
148	Mizoram	0.4880	VL	VL	VL	M	VL	0.0405
149	Manipur + Nagaland	0.8485	M	VL*	M	H	VL	0.2824
150	Arunachal Pradesh	0.6339	VL	VL	L	L	VL	0.0157
151	Andaman & Nicobar Islands	1.0637	H	H	H	H	VL	0.0677

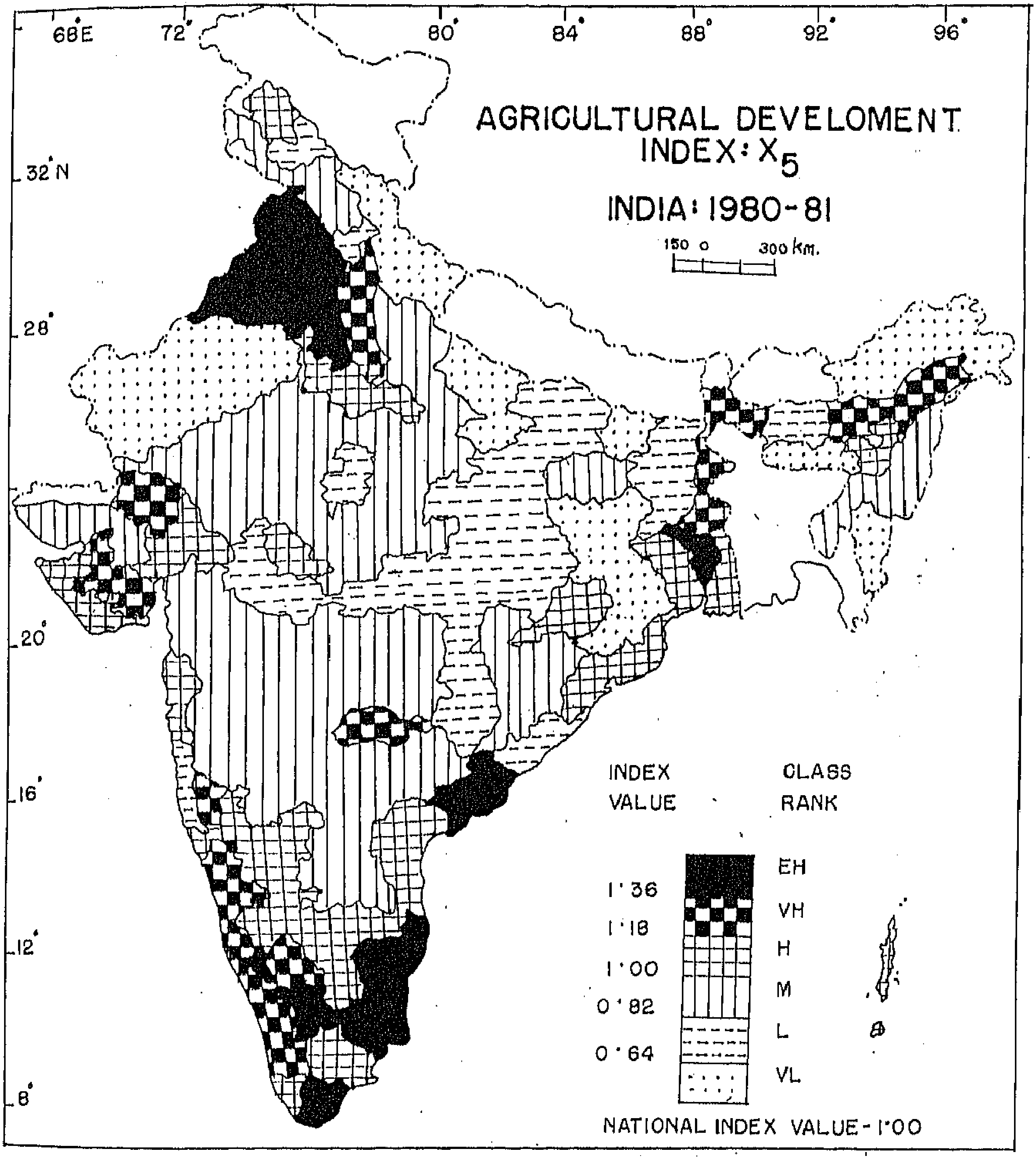
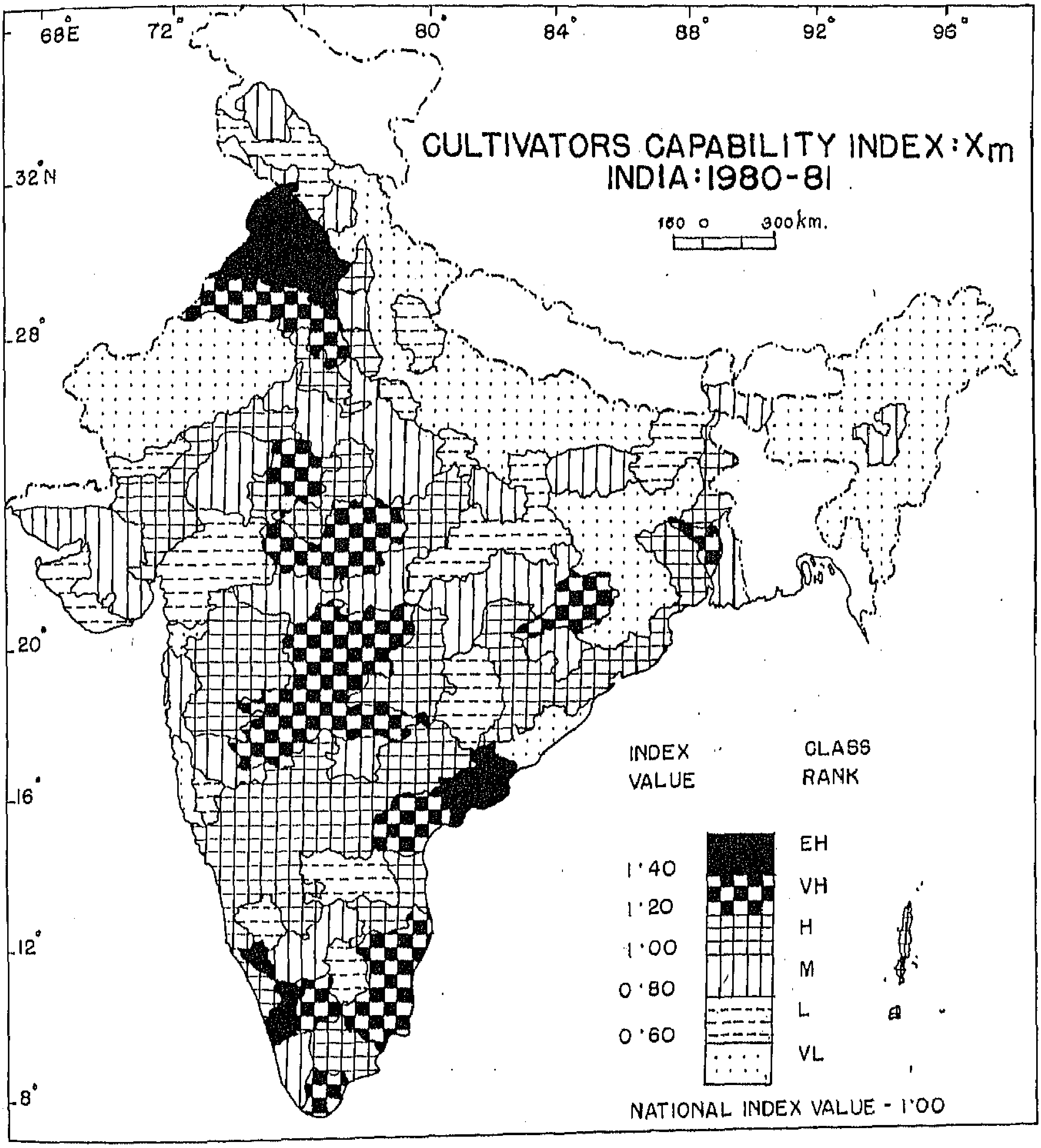

AGRICULTURAL DEVELOMENT
INDEX: X5
INDIA: 1980-81
150 0 300 km.
68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
EH
1·36
VH
1·18
H
1·00
M
0·82
L
0·64
VL
NATIONAL INDEX VALUE - 1·00

FIG-3·5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INDIA: 1980-81
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
EH
1·40
VH
1·20
H
1·00
M
0·80
L
0·60
VL
NATIONAL INDEX VALUE - 1·00

FIG-3'6

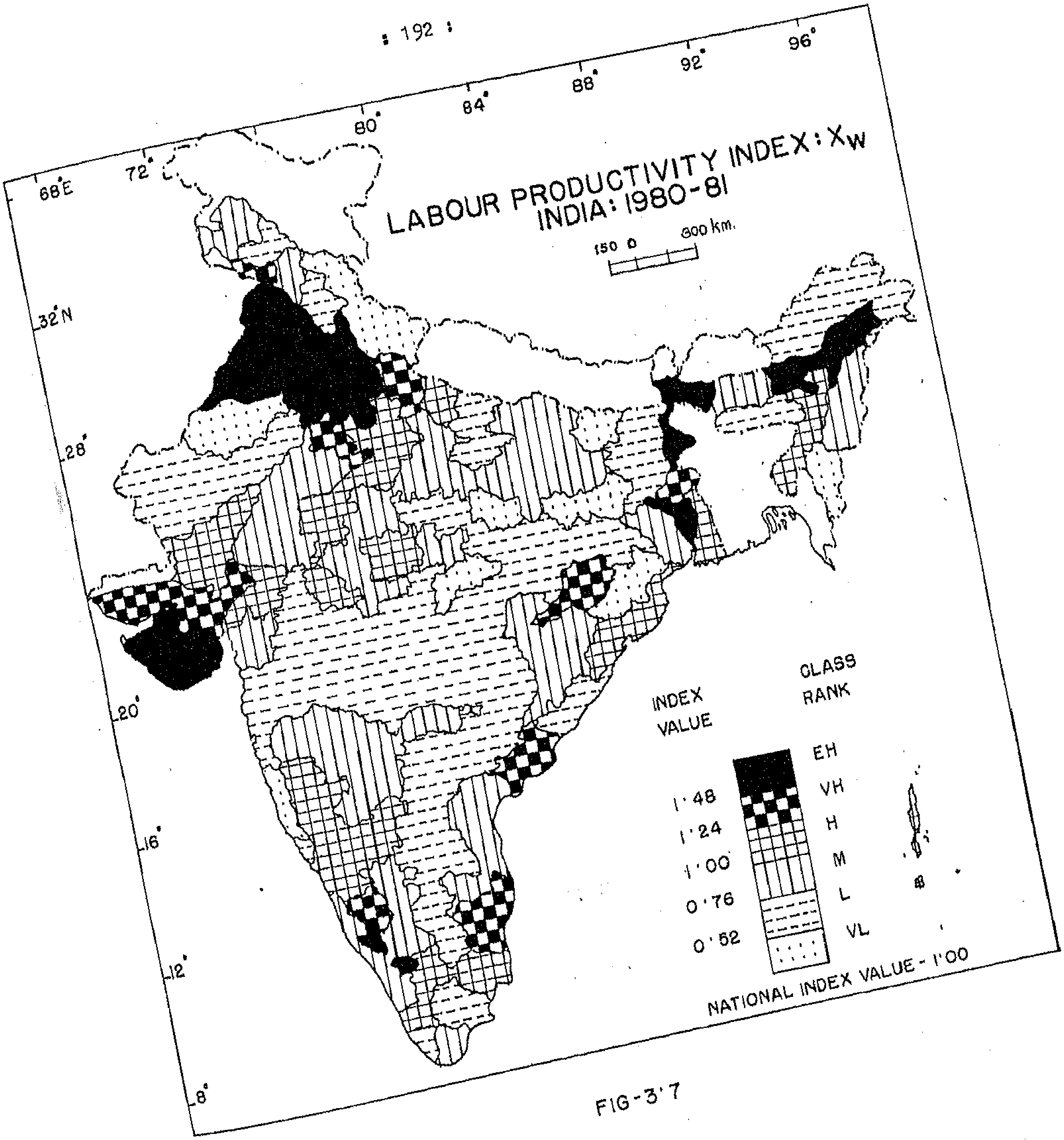

LABOUR PRODUCTIVITY INDEX : X_W
INDIA : 1980-81
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
EH
1·48
VH
1·24
H
1·00
M
0·76
L
0·52
VL
NATIONAL INDEX VALUE - 1·00

FIG-3'7

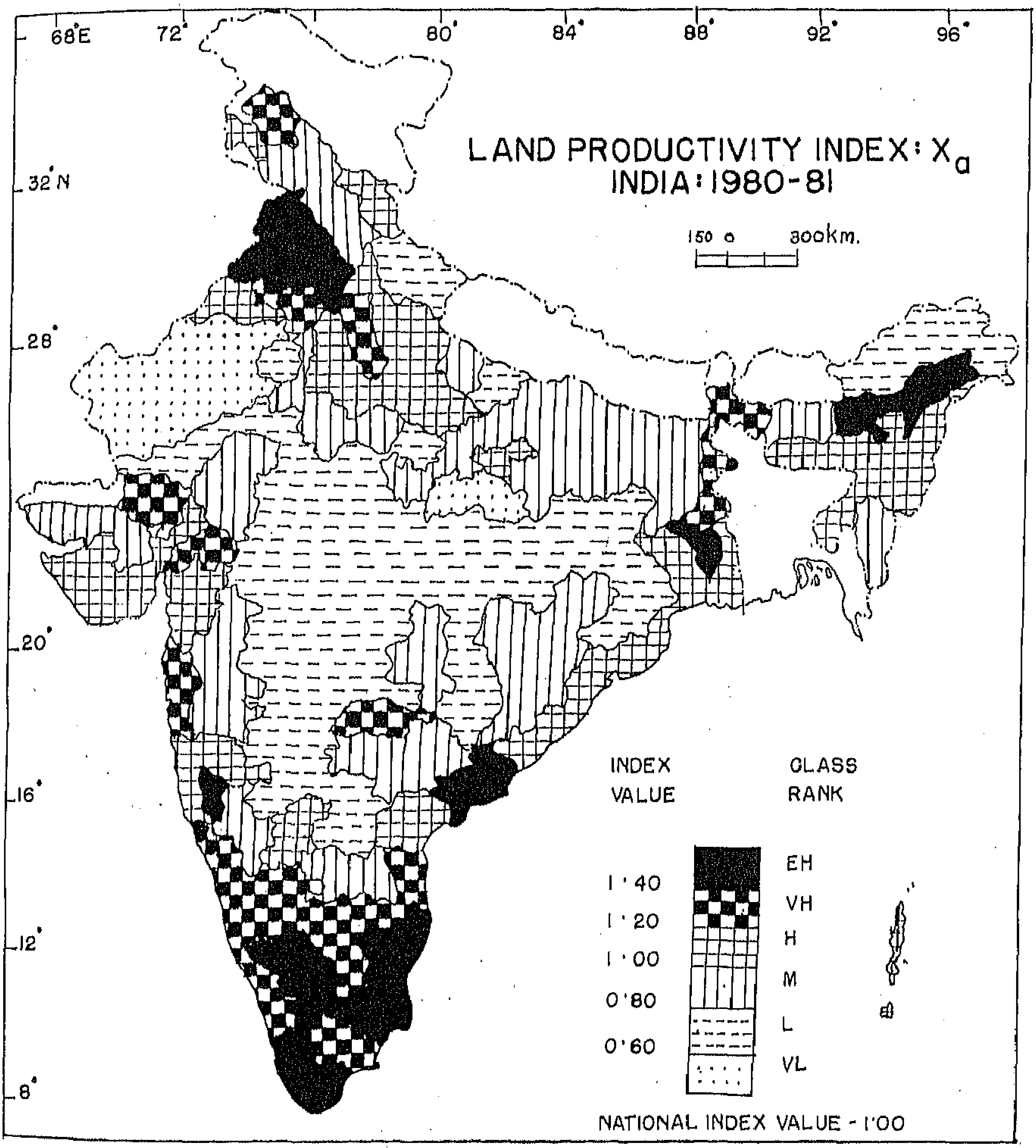
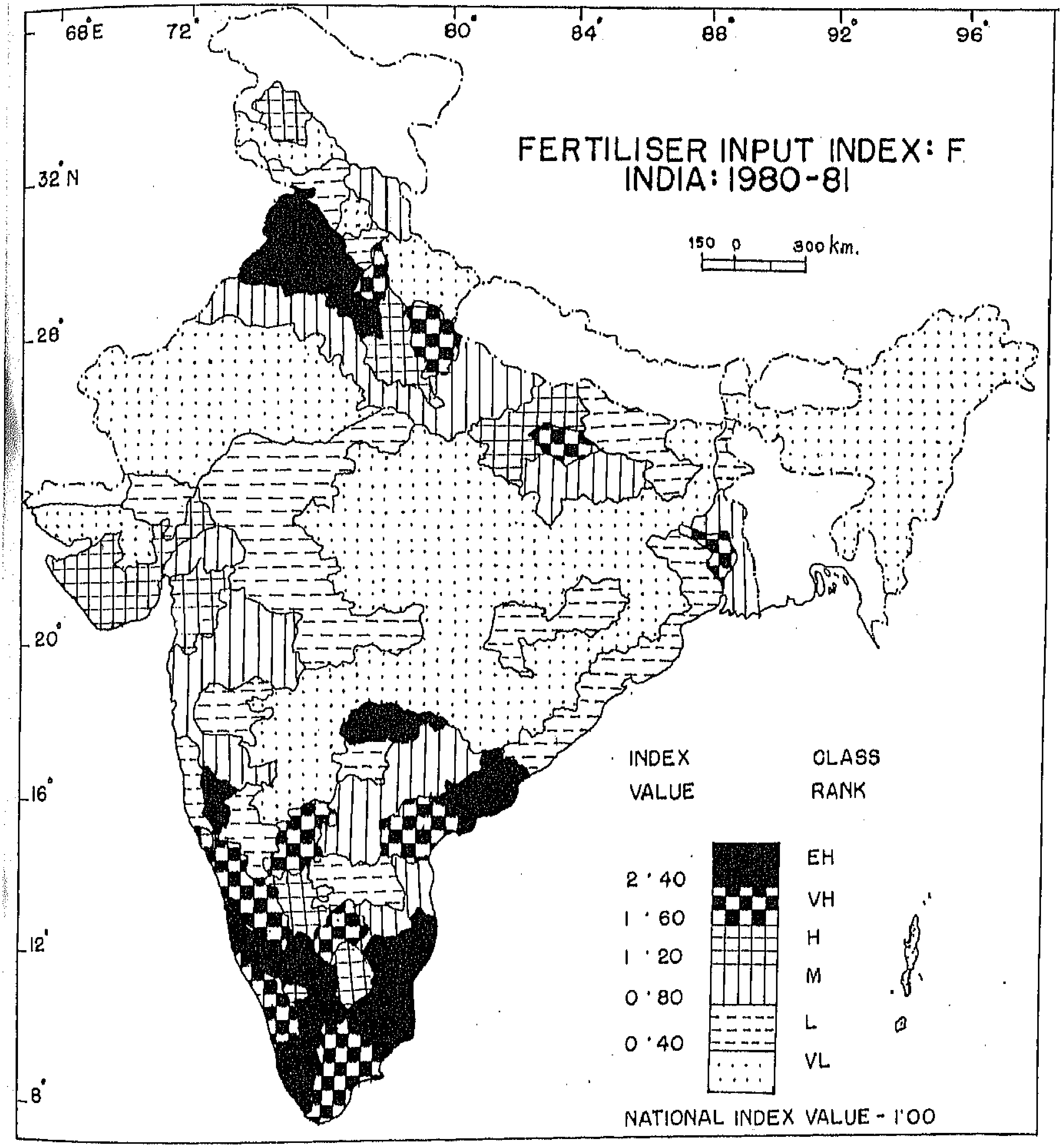

LAND PRODUCTIVITY INDEX: X_a
INDIA: 1980-81
150 0 300km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
1·40
1·20
1·00
0·80
0·60
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1·00

FIG-3·8


FERTILISER INPUT INDEX: F
INDIA: 1980-81
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68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
2·40
1·60
1·20
0·80
0·40
EH
VH
H
M
L
VL
NATIONAL INDEX VALUE - 1·00

FIG-3·9

3.8 Analyses and Findings on Spatial Patterns of Agricultural Development

Broad regional groupings of areal units do emerge in the Figure (3.5) for over-all agricultural development index D_A. Agriculturally under-developed region has occupied a very large portion of Eastern India with VL and L-ranks in D_A. It is comprised of almost entire Bihar, eastern half of Uttar Pradesh, most of Madhya Pradesh and an areal unit (comprised of districts Mayurbhanj, Keonjhar and Dhenkanal) of Orissa. Apart from this broad region, other under-developed regions (with VL-values of D_A) have occurred in hilly areas of the far-eastern India, in desert areas of Rajasthan and also in some hilly areas of Uttar Pradesh and Himachal Pradesh in the Northern India. We have noted earlier (while analysing Figure 3.1 on agricultural population's foodgrain surplus generating capability) that much of these under-developed areas have excessive labour pressure on cropped land. The land productivity figure (3.8) and also the labour productivity Figure (3.7) situations are also not very encouraging, although in the gangetic belt slightly higher M-values could be perceived in many areal units in these under-developed regions. But barring the gangetic belt in eastern U.P, all under-developed regions of India do not seem to have been associated with socalled "intensification programme under new strategy", as could be inferred from the VL or L-levels of fertiliser inputs (ref. to Figure (3.9)). We have noticed earlier in Figure (3.4) (composite surplus-deficit mapping) that there are surplus foodgrain producing regions in Central India (to the south of our most advanced wheat producing region) where also the fertiliser input has been low or very low (meaning thereby that the intensification programme operative in the north has not extended downwards to all wheat region). Naturally one could infer that the population pressure on cropped land is not yet acute in these transitional surplus areas. These transitional surplus areas generally show medium level of over-all agricultural development. As intensification programme does not show much impact in these surplus areas (ref. to Figures (3.8) and (3.9)), we could infer that much of these surplus generation has been due to an extension of cropped land in early period of planning (as corrobarated with the findings of Minhas-Vaidyanathan [1965, 1966]).

On the other extreme, the most advanced regions and areas in agricultural activities with EH values of D_A are in

I : Punjab-Haryana-Delhi-Ganganagar (Rajasthan) region;
II : Madras-Tanjavur-Coimbatore-Nilgiris (Tamil Nadu) region;
III : Tirunelveli area in the extreme south of Tamil Nadu;
IV : Krishna-Godavari deltaic area of Andhra Pradesh;
V : Coffee plantation area of Coorg in Karnataka; and
VI : Burdwan-Hooghly-Howrah area of West Bengal.

These regions and areas of EH-values have often extended to adjoining areas with VH and H-values of D_A. The most extended advanced regions are however in South India spreading mostly over the four states (Tamil Nadu, Kerala, Karnataka and Andhra Pradesh) excluding the drier Rayalaseema areas of Andhra and northern Karnataka and also in the Kolhapur district of Maharastra, neighbouring Karnataka. Here, most of west coastal and western ghats areas show VH-values. Next in areal coverage has been in the Northern India comprised of the most advanced Punjab-Haryana-Ganganagar region and their eastern neighbouring areal units of VH-values and their southern neighbouring areal units with H-values of D_A. This has been the major surplus generating region of India. Apart from these two major regions, other areas of agricultural development are in Eastern India comprised of West Bengal with extension to coastal Orissa (Mahanadi delta) and to Western India comprised of most of Gujarat. Apart from these isolated areal units of VH-values, tea and tobacco areas of Assam and Nizamabad of Andhra Pradesh have demonstrated high values of D_A. There are also three isolated areal units with only H-values, one in Orissa, one in Madhya Pradesh and the third in Jammu & Kashmir State.

We have already noticed from our statistical analyses that two most important factors of agricultural development are fertiliser input F and the foodgrain surplus generating capacity L_2; the other two minor factors are the cultivation of fibre crops (Jute, Mesta and Cotton) and plantation crops (Tea & Coffee). The most developed northern regions have taken advantage of both the major explanatory factors, although to a lesser degree in its southern and eastern parts (most benefitted part seems to be the entire Punjab state and the northern most areal unit of Haryana). The development of South Indian region could be attributed mostly to the intensification factor (i.e., fertiliser input factor F) as could be visualised from a comparison of Figures (3.9) and (3.5). The surplus generating capacity factor L_2 (as also x_m as shown in Figure (3.6)) seem to be operative in EH-value regions and areas of South India, particularly in Madras-

Tanjavur region, Krishna-Godavari deltaic area, Tirunelveli area and also the coffee plantation area. But an alarming problem of agricultural labour pressure on cropped land could be detected in almost entire Kerala state (ref. to Figure (3.2) on L_2), despite the fact that this state has been taking full advantage of intensification programme. The two minor factors (on the cultivation of coffee and cotton) are also operative (ref. to Figures (2.7) & (2.12) respectively of crop-regions of India) in some parts of advanced South Indian region.

The Western developed area in Gujarat has also taken advantage of the fertiliser input factor -- although to a lesser extent (only H-values of F), but there is also the problem of agricultural labour pressure on cropped land---although it is not that alarming at all as in advanced Kerala state. It is to be noted that the most advantage that this developed area of Gujarat has taken is from the cultivation of non-food crops, mainly cotton (ref. to relation of C_7 with D_A and x_W) and also groundnut (ref. to relation of C_5 with x_W). It is because of these non-food crops, the labour productivity is very high in this area, although agricultural population could not fully meet their foodgrain requirements from own production capacity. Judging from the angle that its agricultural population is engaged substantially in the production of non-foodgrain crops, the lack of foodgrain surplus generating capacity cannot be considered serious here.

In the developed area in Eastern India, the advantage of fertiliser input has been taken by its core developed area of EH-values in D_A (namely, in Hooghly - Howrah - Burdwan districts) and to a lessor extent in its northern and eastern neighbouring areal units. But the problem of labour pressure on cropped land is there in south-eastern part of West Bengal (namely, in Nadia - 24-Parganas - Calcutta districts). The cultivation of non-foodgrain crops like tea (in the northern part of West Bengal) and fibre crops (jute and mesta) have, however, contributed generally to the high development of this area of Eastern India. As a result of this, high agricultural labour productivity could be noticed in most parts of this area, particularly in the northern part of West Bengal when EH and VH-values have occurred in x_W (ref. to Figure (3.7)). It should be noted that all plantation areas including those of Assam and South India (Croog and Nilgiris districts) have recorded extremely high labour productivity due to remunerative prices of these crops. Unfortunately it is not so in every major fibre producing area of India (ref. to Figure (2.7) on crop regions and Figure (3.7) on x_W). A similar kind of observation is also true for all oilseeds producing areas (mainly groundnut producing areas) of India.

Much of sugarcane producing areas of Uttar Pradesh have recorded considerable consumption of fertiliser for this non-foodgrain crop, but that has not contributed much to the overall agricultural development of those areas. Sugarcane is a long-period standing crop in the field, while wheat or other cereals are not that long-period standing. So while at least two cereal crops could be grown in the same year, sugarcane can be grown only once in a year. This could be a possible explanation for less advancement in the Gangetic belt of Uttar Pradesh, despite signs of intensification particularly with sugarcane crop, that has shown some explanatory' role to x_w (it is to be noted that, of all the crops, sugarcane crop concentration has the maximum relation with the fertiliser input, showing a correlation coefficient of 0.3732).

3.9 Analysis and Findings by States of India

We would now conclude this chapter with the summary estimates and rank-symbols by States of India for the indices and sub-indices D_A, x_m, x_w, x_a and F. The state summary figures on M_2 and the corresponding all-India figure M_{2*}, as already shown in Table (3.4), could be used to derive L_2 ($= M_2/M_{2*}$). The same rank-symbols as shown in Table (3.4) for M_2 also hold good for L_2. From an analysis of these estimates by states, presented in Table (3.10), our conclusion is that, Punjab is the most advanced state in agricultural activities with EH-values in all six indices and sub-indices referred to above. Haryana (& Delhi) ranks second in agricultural development with still EH-values in D_A, x_m and x_w but its rank of land productivity falls to VH-level; the reason could be traced to the degree of application of the intensification programme, or rather fertiliser input variable F which is only at H-level. Tamil Nadu (& Pondicherry) ranks third in agricultural development with still H-values in D_A and x_a but not in x_m and x_w. In fact, here, the land productivity sub-index value is even a little higher than that of Punjab, with a little lower fertiliser input value than that of Punjab, although both the states have EH-level of fertiliser-input per unit cropped area. But the labour productivity in Tamil Nadu falls to only M-level, although its foodgrain surplus generating level has not gone down to that low. The reason for

Table (3.10) : Estimates and Rank-symbols of Agricultural Activity Indices and Sub-indices by States of India : 1980-81

State or state-group	Agricultural development index : $D_A(=x_5)$		food-surplus sub-index : $x_m(=L_1)$		labour productivity sub-index : x_w		land productivity sub-Index : x_a		fertiliser input sub-index : F	
	value	rank	value	rank	value	rank	value	rank	value	rank
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. Jammu & Kashmir	0.921	M	0.817	M	0.701	L	1.072	H	0.748	L
2. Himachal Pradesh	0.830	M	0.675	L	0.872	M	0.928	M	0.462	L
3. Punjab	1.801	EH	1.600	EH	2.705	EH	1.635	EH	3.303	EH
4. Haryana (+ Delhi)	1.486	EH	1.415	EH	2.117	EH	1.320	VH	1.204	H
5. Uttar Pradesh	0.852	M	0.585	VL	1.007	H	0.993	M	1.300	H
6. Madhya Pradesh	0.855	M	1.008	H	0.948	M	0.711	L	0.264	VL
7. Rajasthan	0.841	M	0.921	M	0.926	M	0.753	L	0.317	VL
8. Gujarat	1.000	H	0.879	M	0.957	M	1.094	H	1.181	M
9. Maharastra	0.932	M	1.129	H	0.813	M	0.830	M	0.696	L
10. Karnataka (+ Goa)	1.041	H	1.035	H	1.009	H	1.056	H	1.618	VH
11. Kerala	1.148	H	1.118	H	0.424	VL	1.418	EH	2.461	EH
12. Tamil Nadu (+ Pondicherry)	1.437	EH	1.298	VH	0.870	M	1.733	EH	2.450	EH
13. Andhra Pradesh	1.114	H	1.164	H	1.046	H	1.100	H	1.437	H
14. Orissa	1.057	H	1.064	H	1.196	H	1.004	H	0.319	VL
15. Bihar	0.714	L	0.475	VL	0.683	L	0.898	M	0.510	L
16. West Bengal	1.132	H	1.062	H	0.960	M	1.241	VH	0.947	M
17. Assam (+ Far Eastern Areas)	0.778	L	0.372	VL	1.054	H	0.977	M	0.155	VL
All-India	1.000	-	1.000	-	1.000	-	1.000	-	1.000	-

this apparent anomaly may be due to the fact that much of agricultural labour input might have been utilised for crops like coconut, which is not included in our list of crops considered (non-inclusion of coconut in the published source of data might be due to the fact that it is not an annual crop like cereals, etc.).

Of all the seventeen states (or state-groups) considered, the above mentioned three are the only states where agricultural development has been at an extremely high level. Other states do not come anywhere near these three states (note the absence of VH-rank in D_A in col. (2) of Table (3.10). Six states are showing the rank just above or at the all-India level (H-rank in D_A). In descending order of magnitudes of D_A, these states are Kerala, West Bengal, Andhra Pradesh, Orissa, Karnataka (& Goa) and Gujarat. The H-rank of Kerala is due to its H-rank in land productivity x_a, which has been made possible by its intensification programme (EH-level of fertiliser input) comparable to that of Tamil Nadu. But Kerala shows apparently anomalous VL-rank of labour productivity. The explanation to this apparent anomaly can be again (as for Tamil Nadu) sought in the non-inclusion of important crops like coconut and some other crops (such as cashew, for example) on which, it is suspected, considerable amount of agricultural labour input might have occurred without corresponding accounting in the value of agricultural production. Thus incomplete coverage of crops might be responsible for very low labour productivity rank in Kerala. Otherwise it is difficult to comprehend that this second highest fertiliser consuming state of India would have so much of labour pressure on cropped land as observed in the areal analysis made earlier.

Thus it is possible that the over-all rank of the state as measured by D_A might have been also under estimated corresponding to the under-estimation of x_m. The H-rank in over-all agricultural development has again been possible in West Bengal for VH-rank of land productivity. This state has not fully exploited the advantage of fertiliser input factor (value of F is only at M-rank in this state). Naturally, it is not surprising that this state has only M-rank in agricultural labour productivity. The states of Andhra Pradesh, Karnataka and Orissa have H-rank not only in D_A but also in all its constituent sub-indices. This has been possible in Orissa because of the inherent soil condition along Mahanadi River Courses, without exploiting much of fertiliser input possibilities (note the VL-rank for F in Orissa); while for the other two states of South India, with considerable proportion of relatively drier areas within, the maintainance of high ranks in all the four indices is due to the advantage of fertiliser input factor F (note the VH and H-ranks of F in these two states in Table (3.10)). Gujarat is really lying on the other side of the all-India value of unity in all indices quoted in Table (3.10). Its values for x_a and F are, however, higher than the national value.

On the other extreme, agriculturally most backward states are Bihar and Assam (& Far Eastern Areas) with L-rank in D_A for both. Both the states (one is a state-group) did not exploit any advantage of fertiliser input possibilities, yet both have M-rank of land productivity because of the inherent soil condition in riverine areas within these states. But Bihar has acute problem of labour pressure on cropped land, while Assam's plantation crop of tea has saved the situation to some extent (note H-rank in Assam as against L-rank in Bihar in labour productivity sub-index x_w). Both the states have, however, VL-rank in x_m, but Bihar has shown foodgrain deficit area in respect of L_2, while Assam has just managed to have marginal surplus for its agricultural population (Assam is also a deficit area, if rural population is considered instead of only agricultural population).

Remaining six states have all M-rank in D_A; these are Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan and Maharastra. Except Uttar Pradesh, none of these states has exploited much the improvement possibilities through up grading fertiliser inputs (note VL or L-values of F in these states, except in Uttar Pradesh, where it is high -- even higher than the F-value of advanced state of Haryana). The fertiliser consumption in the largest sugarcane producing state of Uttar Pradesh has really gone up due to presence of this crop (the all-India correlation coefficient of fertiliser input F is maximum with sugarcane crop concentration C_8 ($r_{C_8F} = 0.3732$) which is much above that of wheat ($r_{C_2F} = 0.1972$) or of rice ($r_{C_1F} = 0.1667$)). We have already noted that sugarcane is a long-period standing crop in the field, for which it is in a disadvantageous position against important cereal crops like wheat and rice, under intensification programme, in terms of total annual return (value term) per unit of cropped area. This is also confirmed by our statistical findings that sugarcane does not have much role in explaining the spatial variation of agricultural development D_A, when examined in conjunction with fertiliser input variable and other explanatory factors. This explains why Uttar Pradesh shows only M-rank in agricultural development despite considerable consumption of fertiliser.

Chapter 4 : COMPARATIVE SPATIAL PATTERN ANALYSIS OF AGRICULTURAL DEVELOPMENT AND GROWTH COMPONENT ANALYSIS FOR AGRICULTURAL PRODUCTION AND PRODUCTIVITY : 1960-61 TO 1980-81

4.1 Introduction

In the preceding chapters all our analyses on agricultural activities and development have been carried out for the latest time-point under consideration (1980-81). In this chapter, our attempts would be on the comparative spatial pattern analysis of agricultural development and also on the identification of the role of major growth components for explaining the spatial variations in over-all growth of agricultural production and productivity over the time-period of two decades, starting from 1960-61 . Our choice of the period, 1960-81, has been dictated by the fact that the national planning efforts with the intensification-programme based "new agricultural strategy" started getting applied orientation just after 1960-61, resulting to a state of foodgrain self-sufficiency at the national level more or less around 1980-81. So, the comparison between the two terminal time-points, 1960-61 and 1980-81, would portray agricultural progress or growth achieved in different areas during the phase of intensification leading to national foodgrain self-sufficiency. The growth studies could also be done in two sub-periods, divided by the central time-point of 1970-71. By 1970-71, possibly the intensification programmes started showing signs of progress, but the sub-period analysis would not show a comprehensive picture of total result-oriented intensification efforts. So, our inferences on the growth aspects would mainly be drawn for the entire two-decade period, although the growth path set in the 1st decade (1960-71) would also be identified as a sort of mid-period appraisal.

As reported already, three years average data, centered at each time-point, have been considered here, following the usual practice of accounting for crop-rotations. Compilations of raw data have been made, as reported already from the usual official publications. The formulation of location factors and statistical indices for the preceding time-points 1970-71 and 1960-61, have been so designed that their magnitudes permit comparisons with those of 1980-81 as formulated already. Thus all location factors for any time-point have been computed by use of the corresponding bench-mark national value of 1980-81 only in the denominator of relevant algebraic formulation. Again all algebraic formulations as empirically evaluated in 1980-81 have been used at any time-point for the same kind of index or sub-index. In the calculation of the value of agricultural production in different time-points, the same constant price-weights of 1970-71, have been used for combining the quantities of production of different crops. Thus the magnitudes of all variables are comparable for both time-points and spatial variations. The 1970-71 price structure has been used, because its variance from that of 1980-81 or 1960-61 is lower than that between 1980-81 and 1960-61. Had we used, say, 1980-81 price structure, the estimation of the 1960-61 value of algebraic production would have been much more off the track from actual situation. Regarding the question of the use of algebraic formulations of only the final time-point 1980-81 for all time-points, there can be a statistical possibility of its derivation from the correlation matrices of pooled data of all three time-points for each of the variables considered. But with the advanced agricultural activity-practices of 1980-81, the interactions between variables seem to be more rational than what would have been derived from a heterogeneous mixture of activity-practices of different time-points at different stages of maturity. Moreover, to permit our interaction studies on agricultural development (to be attempted in the next chapter) with non-agricultural activity-indices, the data of which are available only for a recent year, we have decided to use the final year algebraic formulations for agricultural development indices and sub-indices.

For identifying a variable for different time-points, we have used the following conventions in assigning symbols. The symbols Y, Y^* and Y' would refer to a same variable Y, respectively for the time-points (years) 1980-81, 1970-71 and 1960-61, with the stated adjustment for both time-point and spatial comparabilities. When it is a variable Z, involving change or rate calculations between two time-points, we would use the symbol Z, Z_1 and Z_2, referring respectively to the time-period of two decades (60-61 to 80-81), 1st decade (60-61 to 70-71) and 2nd decade (70-71 to 80-81). Taking Z, Z_1 and Z_2 as rate-measuring variables, if Z_2 is computed with reference to the base year magnitude of 1960-61 instead of its usual base of 1970-71, it would be denoted by Z_2'. That is, Z_2' is the rate of change between 1970-71 and 1980-81 relative to 1960-61 level. Clearly, we would then have $Z_2' = Z - Z_1$, since Z and Z_1 have the same 1960-61 base as in Z_2'.

4.2 Comparative Spatial Pattern Analysis : Foodgrain Surplus Measures

In this section, we would examine whether the spatial variation in agricultural activity patterns as identified for 1980-81 have been in any way different or not from those of 1970-71 and of 1960-61. This would be attempted here first for foodgrain surplus measures Σ_i's in the following three sub-sections.

4.2.1 Comparisons of all-India Estimates of Foodgrain Surplus Fertiliser-input and the Coefficients of Spatial Variation

In Table (4.1) we have recorded the direct all-India estimates, the mean estimate, (mean of all areal units of India) and the coefficient of spatial variation for the foodgrain surplus measures Σ_i's and also the fertiliser input index F. We have already noted that M_i's could be viewed as a mathematically transformed variables of Σ_i's and as such the values of direct all-India estimates M_{i*}'s, corresponding to Σ_{i*}'s, are also shown in this Table within parentheses. Again, we have also shown the actual estimates of fertiliser input in kg per hectare below the all-India index values of F. The coefficients of spatial variation for the variables Σ_i's and F, as shown in this Table, are the usual ratio of standard deviation to mean of all areal units. This coefficient shows the magnitude of divergence or disparity among spatial units in respect of values of a particular variable. The data on each variable are presented for all the three time-points in this Table. As a sort of key indicator of "intensification programme", the time-path movements of fertiliser-input have been recorded here. It would be of interest to compare and contrast the movements of different variables recorded in

Table (4.1) : Movements of All-India Foodgrain Surplus Generation Measures and Fertiliser Input over the Time-points by Direct-estimate, Mean Estimate and Coefficient of Spatial Variation

years	foodgrain surplus generation measures				Fertiliser input per unit of cropped area as a ratio of 1980-81 national value (F)
	Σ_1 (relative to cultivators (+dependents)	Σ_2 (relative to agriculture population)	Σ_3 (relative to rural population)	Σ_4 (relative to total population)	
(1)	(2)	(3)	(4)	(5)	(6)
		Direct all-India estimate :			
1980-81	2.3262 (.4989)	1.4856 (.2860)	1.2067 (.1499)	1.0015 (0.0013)	1.0000 (37.5)
1970-71	2.1651 (.4709)	1.3683 (.2355)	1.1296 (.1004)	0.9669 (-0.0300)	0.3922 (14.7)
1960-61	2.0472 (.4476)	1.2432 (.1711)	0.9244 (-0.0716)	0.8060 (-0.2106)	0.0395 (1.5)
		Mean of areal unit estimates :			
1980-81	2.4095	1.7154	1.3524	1.1037	1.0106
1970-71	2.3750	1.5283	1.2342	1.0504	0.3988
1960-61	2.3033	1.4645	0.9659	0.8327	0.0441
		Coeff. of spatial variation :			
1980-81	.5430	.7484	0.7269	0.6860	0.9589
1970-71	.6104	.5976	0.5868	0.5675	1.1259
1960-61	.5017	.5611	0.4196	0.4129	1.5283

N.B. : (i) Figures under cols. (2) to (5) for first three rows are the national estimates of Σ_{i*} (availability to requirement ratios); corresponding figures of M_{i*} (foodgrain surplus to production ratios) are shown within parentheses.

(ii) For first three rows, figures within parentheses under col. (6) are the actual estimates of fertiliser-input in kg./hectare.

this Table. Based on the data of this Table, our observations are given below :

(i) Foodgrain surplus positions have definitely improved during the period 1960-61 to 1980-81, for all categories of population, namely, (1) cultivator-population, (2) agricultural population, (3) rural population and (4) total population. Judging by the M_{1*} values, the improvement recorded is least with cultivators, more or less similarly high for rural and total population, and somewhere in between when considered for agricultural population.

(ii) As compared with the production level of foodgrains, India had a deficit of about 21 per cent in 1960-61, accounting for total population. This deficit was reduced to about 3 per cent in 1970-71 and finally it was totally wiped out in 1980-81. Thus it seems that the progress in foodgrain situation as registered in the 1st decade is more than that in the 2nd decade. However, in absolute terms, the difference in foodgrain deficit between 1960-61 and 1970-71 would not be that high as shown above, because the production level itself was much lower in 1960-61.

(iii) The change in proportion figure $(M_{3*} - M_{4*})$ has remained more or less stationary over the time-points which is somewhat in agreement with the stability of rural to urban population share during the period. But the change $(M_{2*} - M_{3*})$ has been same for 1980-81 and 1970-71, while it is much higher (nearly 1.8 times) in 1960-61 as compared with that in 1970-71. It is already reported earlier that we have adjusted for census definitional change of agricultural worker between 1961 and 1971 [with the estimates given by Pal, De and Malakar, 1978]. So our inference is that the relative absence of rural employment opportunities in non-agricultural activities as compared with agricultural activities during the initial phase of 60-61 to

70-71 might have forced the rural people to engage themselves as agricultural workers, resulting in a higher share of agricultural population to rural population in 1970-71. With the limitation of extension possibilities of agricultural land, the share of agricultural to rural population did not increase further in 1980-81. The change in proportion figure $(M_{1*} - M_{2*})$ has shown a little decline, more in the 1st decade than in the 2nd decade, which could be accounted by the fragmentation of cultivating land with the increases in the number of cultivators over the forward time-path. The falling values of $(M_{1*} - M_{2*})$ also give an indication of relatively less dependence on agricultural workers by cultivators for agricultural activities over the forward time-path.

(iv) The above mentioned fragmentation problem of agricultural land and the steep rise in the number of cultivators in the forward time-path have definitely not helped the cultivators to exhibit much improvement in their foodgrain surplus generation capability (or, rather, entrepreneurial ability) despite general improvement in foodgrain production in absolute terms. Thus the value of M_{1*} has changed from 44.76 per cent in 1960-61 to quite close values of 47.09 per cent in 1970-71 and 49.89 per cent in 1980-81 during the span of the first and the second decades respectively. However, as the absolute production level has greatly improved with the involvement of cultivators in agricultural productive activities, their entrepreneurial ability cannot be under-valued in absolute terms, despite relatively low improvements during the periods.

(v) The role of tremendous improvement in fertiliser input (merely 1.5 kg./hecture in 1960-61 against 14.7 kg./hectare in 1970-71 and 37.5 kg./hectare in 1980-81) could now be appreciated with the background observations that despite low improvement in foodgrain surplus generating capability (in terms of the proportion of surplus to total production) by cultivators, the all-India deficit of 21 per cent of total production level, accounting for total population, has totally been wiped out during the span of two decades. Cultivators (with the aid of agricultural workers, of course) could possibly improve upon the food situation of India with the advantage of progressively increased fertiliser inputs along with some other associated inputs.

(vi) The same kind of inferences can be drawn from Σ_{i*}-estimates as we have just done from corresponding M_{i*}-estimates. The variables Σ_{i*}'s are however multiplicative measures of surplus with unity signifying the balanced situation, while M_{i*}'s are additive measures of surplus with zero signifying the balanced situation. But the mathematical relation between M_i and Σ_i are such that Σ_i is more sensitive to change in the high value range (i.e., in the upper tail of its statistical distribution), while M_i is not. For this reason, we have preferred to compare the direct all-India estimate with the mean estimate for Σ_i's, but not for M_i's. It should be noted that the mean values $\bar{\Sigma}_i$ shown in 4th to 6th rows of Table (4.1) are always above the corresponding all-India estimate Σ_{i*} shown in 1st to 3rd rows . The higher the value of $\bar{\Sigma}_i$ as compared with the corresponding Σ_{i*}, the more elongated would be the spread of upper-tail in the statistical distribution of Σ_i. Such incidences of extended upper-tail have been more pronounced with the distribution of Σ_1 in 1960-61 and 1970-71 and also with that of Σ_2 in 1980-81 and 1970-71.

(vii) The situation with the distribution of F is somewhat different. Here the mean values and the direct all-India estimates have been quite close. This means that here both upper and lower tails are similarly extended. But since the coefficient of spatial variation is exorbitantly high with F, both the tails in its distribution must be quite elongated. This shows the presence of areal units with both extremely high as well as extremely low fertiliser inputs.

(viii) The coefficient of spatial variation for fertiliser-input index F has however declined in the forward time-path, yet it is extremely high even in 1980-81 — much higher than that of any Σ_i. This high spatial disparity in fertiliser-input is clearly reflective of the situation that an overwhelmingly large number of areal units are not deriving yet much advantage of fertiliser-use in proper doses.

(ix) The coefficients of spatial variation have progressively increased for all foodgrain surplus measures Σ_i's except for Σ_1 in the second decade. This general increase in spatial disparity in foodgrain surplus measures is reflective of the situation that the surplus generating capacity of an overwhelmingly large number of agriculturally backward areal units has remained stationary, while a limited number of forward areal units are on the path of progress unabatedly.

4.2.2 Foodgrain Surplus Patterns of 1980-81 and 1970-71 : Spatial Associations and the Relationships with Fertiliser and Over-all Growth

From the preceding analysis two main questions arise : First, is there any close agreement between the foodgrain surplus generation patterns of 1980-81 and 1970-71, when major improvements in the over-all surplus situation occurred in the 1st decade (deficit reduced from 21 to only 3 per cent in the 1st decade and only 3 per cent deficit wiped out and nothing more in the 2nd decade)? Second, when there has been so much disagreement in the changing coefficients of spatial variation between fertiliser-input and foodgrain surplus generation measures, have the increasing uses of fertiliser gone really for increasing foodgrain surplus generating areal-units? In addition we can pose third pertinent question : how far the over-all agricultural growth or progress in different decades has influenced the spatial variation in foodgrain surplus generation? Answers to all these questions are readily available from the estimates of correlation coefficients as we have shown in Table (4.2). We have already noticed that the spatial variations in surplus generation situation can be more or less similarly depicted by any of Σ_2, Σ_3 and Σ_4. Thus, in Table (4.2), we would examine the correlations related to these surplus measures only. The index Σ_1 would be dealt with later in the form of x_m alongwith other constituent variables of agricultural development D_A. The relationships between 1980-81 and 1970-71 spatial patterns have been shown in first row of this Table. In the next three rows, the relationships of surplus measures with fertiliser-input index have been shown for the three time-points. The over-all growth rates of agricultural production (at constant 1970-71 prices) as introduced now in our analysis are : Z for two decades (1960-61 to 80-81), Z_1 for 1st decade (1960-61 to 70-71), Z_2 for 2nd decade (1970-71 to 1980-81) and also $Z_2' = (Z - Z_1)$ for 2nd decade (so that Z, Z_1 and Z_2' have uniformly the same 1960-61 base production level in the calculation of rates). The relationships with these variables have been recorded in last four rows of Table (4.2).

Again as the recorded data in first row of Table (4.2) show very high correlation (with correlation coefficients 0.90 or above) between 1980-81 and 1970-71 spatial patterns, we have recorded further the estimates of 1970-71 foodgrain surplus measures Σ_i^{*} corresponding to class-

Table (4.2) : Spatial Association of Food Surplus (Availability to Requirement) Measures : Self-relations between two Recent Time-points and Interactions at Different Time-points with Agricultural Growth and Fertiliser-input

spatial correlation between	reference time-points or periods (years)	correlation coefficients with variable		
		$y = \Sigma_2$ (relative to agricultural population)	$y = \Sigma_3$ (relative to rural population)	$y = \Sigma_4$ (relative to total population)
(1)	(2)	(3)	(4)	(5)
y and y^*	1980-81 and 70-71	0.9107	0.9227	0.8995
F and y	1980-81	0.4211	0.3680	0.3255
F^* and y^*	1970-71	0.1736	0.0669	0.0198
F' and y'	1960-61	-0.1517	-0.1602	-0.2000
Z and y	1960-81 and 80-81	0.7779	0.7751	0.7695
Z_1 and y^*	1960-71 and 70-71	0.7618	0.7524	0.7218
Z_2 and y	1970-81 and 80-81	0.5213	0.5287	0.5275
Z_2' and y	1970-81 and 80-81	0.7123	0.7140	0.7080

N.B. : (i) y, y^* and y' refer to the same variable y, respectively for 1980-81, 1970-71 and 1960-61, with adjustment for both time-point and spatial comparabilities.

(ii) F, F^* and F' are the fertiliser-input per unit cropped area expressed as ratios of corresponding 1980-81 national estimate, respectively for 1980-81, 1970-71 and 1960-61.

(iii) Z, Z_1 and Z_2 are the proportionate increases in the value of agricultural production (at constant 1970-71 prices), respectively for two decades (60-61 to 80-81), 1st decade (60-61 to 70-71) and 2nd decade (70-71 to 80-81).

(iv) $Z_2' = (Z - Z_1)$ is the increase in the value of agricultural production (at constant 70-71 prices) for the 2nd decade (70-71 to 80-81) expressed as proportion of 1960-61 production level (as used in Z and Z_1, but not in Z_2).

boundaries [as used earlier in Figures (3.1), (3.2) and (3.3)] and also some special values of 1980-81 measures Σ_i in Table (4.3). The estimating VLS regressions as used to obtain these estimates are shown at the bottom of Table (4.3). As there is no multi-collinearity problem in 2-space regression, the VLS and OLS correlation coefficients are always idential in 2-space. But OLS and VLS regression coefficients do differ in magnitude even in 2-space. It is well-known that we get two OLS regressions, namely, (i) Σ_i on Σ_i^*, minimising along Σ_i - axis, and (ii) Σ_i^* on Σ_i, minimising along Σ_i^*-axis. As a result, the marginal rate $(d\Sigma_i/d\Sigma_i^*)$ as algebraically calculated from the two OLS regressions must be different, and that from regression (i) will be an under-estimate, while that from regression (ii) will be an over-estimate, because of particular minimisation bias in the two situations. This sort of minimisation bias along any particular axis is absent in a VLS regression; in that, all axes are treated equally and the minimisation is done in the space vertical to the central VLS regression line passing through the scatter of points. Thus VLS regression is always unique (i.e.,"Σ_i on Σ_i^*" and "Σ_i^* on Σ_i" are identical and one form can be obtained from the other by simple algebraic transposition). In 2-space, the VLS regression line passes through the scatter of points centrally, while the OLS regression lines are tilted towards the respective axes of minimisation and are inclined on either side of the VLS-regression line from the concurrent mean-point. Thus VLS regression estimates are preferred here for its uniqueness and centrality of representations through the scatter of points corresponding to actual value pairs (Σ_i, Σ_i^*). Again to estimate the constant "intercept

Table (4.3) : Estimates of 1970-71 Foodgrain Surplus Measures Σ_i^* Corresponding to Class-boundaries and Special Values of 1980-81 Measures Σ_i

agricultural population			rural population			total population		
80-81 class-boundary/special Σ_2	corresponding 70-71 Σ_2^*	improvement $\Sigma_2 - \Sigma_2^*$	80-81 class-boundary/special Σ_3	corresponding 70-71 Σ_3^*	improvement $\Sigma_3 - \Sigma_3^*$	80-81 class-boundary/special Σ_4	corresponding 70-71 Σ_4^*	improvement $\Sigma_4 - \Sigma_4^*$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EH-S			EH-S					
$\longrightarrow$ 3.10	2.5175	0.5825	$\longrightarrow$ 2.20	1.8613	0.3387			
VH-S			VH-S			VH-S		
$\longrightarrow$ 1.90	1.6633	0.2367	$\longrightarrow$ 1.60	1.4193	0.1807	$\longrightarrow$ 1.75	1.5562	0.1938
H-S			H-S			H-S		
$\longrightarrow$ 1.60	1.4497	0.1503	$\longrightarrow$ 1.30	1.1983	0.1017	$\longrightarrow$ 1.30	1.2019	0.0981
M-S			L-S			L-S		
$\longrightarrow$ 1.30	1.2362	0.0638	$\longrightarrow$ 1.00	0.9773	0.0227	$\longrightarrow$ 1.00	0.9657	0.0343
L-S			l-D			l-D		
$\longrightarrow$ 1.00	1.0226	−0.0226	$\longrightarrow$ 0.70	0.7563	−0.0563	$\longrightarrow$ 0.70	0.7295	−0.0295
D			h-D			h-D		
0.9682	1.0000 (S-D neutral)	−0.0318	1.0308	1.0000 (S-D neutral)	0.0308	1.0435	1.0000 (S-D neutral)	0.0435
1.0785 (improvement neutral)	1.0785	0.0000	0.9139 (improvement neutral)	0.9139	0.0000	0.8388 (improvement neutral)	0.8388	0.0000
1.4856 (all-India)	1.3683	0.1173	1.2067 (all-India)	1.1296	0.0771	1.0015 (all-India)	0.9669	0.0346

Estimating VLS regressions

$\Sigma_2^* = 0.31078 \div 0.71185 \; \Sigma_2$; VLS Correlation coefficient = 0.9107

$\Sigma_3^* = 0.24068 + 0.73665 \; \dot{\Sigma}_3$; " = 0.9227

$\Sigma_4^* = 0.17837 + 0.78735 \; \dot{\Sigma}_4$; " = 0.8995 parameter", mean value pair is assumed to lie on the line as a sort of central value pair. But from the analysis made on the direct all-India estimates and the mean estimates of Table (4.1) we thought it better to accept the direct all-India estimates, rather than mean estimates, as the more acceptable central values for estimations of the intercept parameters. Thus our estimating VLS regression would give the direct all-India estimates of 1970-71 corresponding to those of 1980-81. We have also recorded the difference $(\Sigma_i - \Sigma_i^*)$ as a sort of improvement measure for the second decade (it being understood that negative improvement means deterioration). The value for which $(\Sigma_i - \Sigma_i^*)$ is zero, i.e., the value at which $\Sigma_i = \Sigma_i^*$, can be called improvement neutral value. These values are also recorded in Table (4.3); above this improvement neutral value, the improvement measures would be gradually increasing and below the neutral value, the deterioration starts and is gradually changing to higher level of deterrioration. We have also noted that the Surplus-Deficit (S-D) neutral value of unity for 1980-81 for any Σ_i measure need not necessarily be the same S-D neutral value of Σ_i^* in 1970-71. As such, we have also recorded the value of Σ_i corresponding to S-D neutral value of Σ_i^* in this Table. Finally, all-India value pairs (Σ_i, Σ_i^*) have also been recorded in this Table to get the central value of improvement measure for comparative purposes. On the basis of the estimates tabulated in Tables (4.2) and (4.3), our observations and conclusions are given below :

(i) As already reported, there has been very strong inter-relations between 1980-81 and 1970-71 spatial patterns by any of Σ_2, Σ_3 and Σ_4. This means that agriculturally forward areal units remained forward and backward areal units, backward in the second decade. It does not however mean that the same 1970-71 status quo has been simply maintained by the areal-units over the time-period. If we look at the improvement differentials as provided in Table (4.3), it becomes clear that the more forward the areal units in 1970-71, the greater was the improvement registered by them during the period : 70-71 to 80-81. The conditions of areal units with values of Σ_1 below the corresponding improvement-neutral points (ref. to Table (4.3)), have even deteriorated during the period, the cause of which might be sought in the natural population increase and negligence of agricultural improvements in traditionally backward areas.

(ii) It could be noted that for total and rural categories of population, the improvement neutral points fall in the low-deficit (l-D) class for Σ_4 and Σ_3. Considering that near zero positive improvement is practically no improvement, we can conclude that the foodgrain surplus generation positions have not improved at all for those areal units which are in h-D (high-Deficit) and l-D (low-Deficit) classes in 1980-81 (ref. to Figures (3.2) and (3.3)). The deterioration is however more pronounced for h-D categories of areal-units.

(iii) As regards the agricultural population, the improvement neutral point falls even in the Low-Surplus (L-S) class for Σ_2. In fact, bottom-most two classes in our classification of areal units (in 1980-81) by any of Σ_2, Σ_3 and Σ_4 show no sign of improvement in food-surplus generation and the conditions of bottom-most class of areal units have definitely deteriorated during 1970-71 and 1980-81 by any surplus measure. It is clear that agricultural population do not have a viable agricultural economy even if they generate a low level of surplus of foodgrains.

(iv) Just above the two bottom-most classes with deteriorating or non-improving agricultural economy, we have M-S (Medium Surplus) class in Σ_2, and L-S (Low Surplus) class in Σ_3 and Σ_4, in which the all-India value of our improvement measure falls. These classes of Σ_i's are comparable in this sense and can be called the transitional classes between non-improving to definitely-improving categories of areal-units. Thus all high surplus generating (H-S, VH-S and EH-S) categories of areal units could be considered to be on the path of improvement during the period. The degree of improvement is however more and more as we go from H-S to EH-S category of areal units.

(v) The more developed the areal units are, the higher is their pace of progress; this feature of non-uniform improvement pattern goes certainly against the well-accepted regional planning objective on efforts for reduction of regional disparities. This kind of advanced area-biased improvement patterns was not only the feature of second decade, but of first decade also, as evidenced from the ever-increasing values of coefficients of spatial variation in the forward time-path for Σ_2, Σ_3 and Σ_4 (ref. to Table (4.1)). But the agreements between the 1960-61 and 70-71 spatial patterns were not that very high as they were between 1970-71 and 1980-81 patterns. We will investigate the relationships of 1960-61 pattern with those of 1970-71 and 1980-81 later in the following sub-section. Thus, to conclude the answers to our first query, we would say that even though there was strong agreement between 1980-81 and 1970-71 spatial patterns, the constituent areal units of the patterns themselves did not show any uniformity of improvement during the decade. The more the regression coefficients (i.e., marginal rates) are away from unity (ref. to regression equations shown at the bottom of Table (4.3)), the greater is the departure from uniform improvement state of all areal units. Thus, judging by the regression coefficients of the three population categories, the agricultural population had the maximum departure from the state of uniform improvement pattern for areal units.

(vi) Our suspicion as posed through the second query at the beginning of this subsection, apparently gains some support from the estimates given in second to fourth rows of Table (4.2). But this is not the fact; fertiliser input has not contributed much directly towards explaining the spatial variation in foodgrain surplus generation. Fertiliser-input pattern was even somewhat against the foodgrain surplus generation pattern of any population category in 1960-61 (correlation coefficients of F' was -0.15 with Σ'_2, -0.16 with Σ'_3 and -0.20 with Σ'_4). This is however understood in the background of limited supply condition of fertiliser in 1960-61, most of which might have been used then for non-foodgrain crops like sugarcane and plantation crops - the producing areas of which were not commensurate always with those of important foodgrain crops like rice and wheat. But even though the foodgrain surplus generation situation has improved mostly in the 1st decade, the 1970-71 relation between F^* and Σ^*_1 does not substantiate the belief that it has come through intensification programme through fertiliser-use in the 1st decade itself. In fact the fertiliser input pattern has been almost independent of surplus generation pattern for total population category and even for rural population category in 1970-71 (correlation coefficient of F^* has been as near to zero as 0.0198 with Σ^*_4 and 0.0669 with Σ^*_3).

(vii) An indication of some feeble relationship between fertiliser input and foodgrain surplus generation in the 1st decade comes only when the agricultural population category is considered. The correlation coefficient between F^* and Σ^*_2

has shown a value of 0.1736, which is at a respectable distance from zero. Under statistical rigour, this value is significantly different from zero at 5% level of chance by Fisher's Z-test on correlation coefficients [R.A. Fisher(1954)]. Thus, we would say that there had been only low relationship between agricultural population's surplus generation pattern and the fertiliser input pattern at the end of 1st decade.

(viii) It is only at the end of second decade (in 1980-81), we notice the existence of some moderate relationship between fertiliser input patterns and the foodgrain surplus generation patterns, more or less uniformly for all categories of population (the correlation coefficients of F have been 0.4211 for Σ_2, 0.3680 for Σ_3 and 0.3255 for Σ_4). Thus with much increased supply of fertiliser during the second decade, foodgrain crops might have been able to derive some benefit of fertiliser inputs for generating improved surplus levels. Yet the relationships in 1980-81 are not that high as one would have expected; this seems to be a little anomalous. Our conjecture to sort out this apparently anomalous fertiliser input effect on foodgrain surplus generation is as follows : It is possible that foodgrain crops might have considerable benefit from fertiliser input in respect of total production, but varying population density gradients over areal units might have blurred the effect of fertiliser-input directly on the foodgrain surplus production over and above the requirements of local people (in different categories). Our conjecture however gets a strong support from the fact that yield rate of five important cereals together per unit cropped area shows a correlation coefficient as high as 0.7446 with the fertiliser input variable in 1980-81. Of course, for the totality of all crops, this relationship with fertiliser-input has been even still higher, as observed earlier that the correlation coefficient between land productivity index x_a (related to all crops) and

F has been about 0.811. Thus, granting that our conjecture cannot be rejected, we can conclude that the full effect of fertiliser input patterns on agricultural growth (or improvement) could not be properly depicted by its revealed relationship with foodgrain surplus generation patterns, because of the distortions made by the varying population pressure on cropped land.

(ix) Our third investigation is on how far the over-all growth of agricultural production in different decades has influenced the spatial variation in foodgrain surplus generation in 1970-71 and 1980-81. In other words, our query is on whether or not the highly growing areas are also the high surplus generating areas. The results of our correlation exercises shown in Table (4.2) for the growth rates are more encouraging than what we obtained for fertiliser input factor. The spatial patterns of growth rates are highly in agreement with the foodgrain surplus generation pattern in the terminal year of the period over which the growth rates are calculated. Thus the 1st decadal growth rate Z_1 has the correlation coefficient as high as 0.7618 with Σ_2^*, 0.7524 with Σ_3^* and 0.7218 with Σ_4^*. As the production level improved more in the first decade than in the second, the second decadal growth rate Z_2 has shown a little fall in correlation coefficients with values 0.5213 with Σ_2, 0.5287 with Σ_3 and 0.5275 with Σ_4. But when assessed in terms of same 1960-61 base production level through Z_2' for the second decade, (comparable to that of Z_1), the correlation coefficients improve again considerably, although not at par with the 1st decadal growth (correlation coefficient of Z_2' is 0.7123 with Σ_2, 0.7140 with Σ_3 and 0.7080 with Σ_4). We have however a bit improved relationships when the entire period of two decades is considered for growth rates. Thus the two decadal growth rate Z has the correlation coefficient of magnitude 0.7779 with Σ_2, 0.7751 with Σ_3 and 0.7695 with Z_4. Here one interesting point is that all the surplus generation measures are practically similarly related with the relevant growth rates. So, we conclude that over-all growth rate patterns and the foodgrain surplus generation patterns are in agreement substantially, meaning thereby that agriculturally advanced areas are advanced and also backward areas are backward on both counts— over-all growth factor and foodgrain surplus generation factor.

(x) This spatial matching of both growth and surplus generation factor leads us now to pose the fourth question : If fertiliser input factor got distorted relationship with the surplus generation factor due to varying population pressure on land, should it also be a similarly distorted relationship with growth factors? Answer to this query is available in the following estimates of correlation coefficients :

$$r_{ZF} = 0.4286 \text{ (1980-81 terminal year)}$$

$$r_{Z_1F^*} = 0.2517 \text{ (1970-71 terminal year)}$$

Thus both growth factor and surplus generation factor have more or less similar kind of relationship with fertiliser input factor. As such we conclude that Fertiliser distribution pattern has not shown sufficient impact on both over-all growth rate and foodgrain surplus generation.

4.2.3 Agricultural Population's Foodgrain Surplus Patterns of 1970-71 and 1980-81 : Statistical Analysis for Relative Roles of Explanatory Factors

In the preceding analysis, we have examined the role of fertiliser-input and over-all growth factor on surplus generation pattern separately for the two time-points, 1970-71 and 1980-81. Now we would examine their joint role, along with some other factors, by VLS regression analysis. As the role of fertiliser input is best exposed on Σ_2, compared with that of Σ_3 and Σ_4, we would make our present analysis for the foodgrain surplus generation measure Σ_2 related to agricultural population proper, without further distortions of any additional non-agricultural population. Apart from the factors of fertiliser and growth, two additional factors that are now considered in the joint analysis are : 1960-61 base pattern Σ_2' and the cultivators current role in 1970-71 or 1980-81 through their capability measures x_m^* or x_m. The base year pattern Σ_2' gains importance as an explanatory factor, because of the absence of any positive role of the negligible fertiliser-input (in 1960-61) on this pattern. Moreover, any current spatial pattern is always related to corresponding past pattern (if the past is not too remote) and the inclusion of past pattern as an explanatory variable for the current pattern in the VLS variety of regression analysis helps us to assess the degree of shift in the current pattern due to other explanatory factors included. Again land-owning cultivators' role gains importance, because their foodgrain surplus generating capability is the prime factor, on which the surplus generation for the totality of agricultural community depends; other counterpart i.e., agricultural workers do not have any decision-making choice on production possibilities.

As the explanation of 1980-81 spatial pattern Σ_2 could be adequately accomplished by the corresponding 1970-71 pattern Σ_2^* (correlation coefficient 0.9107), no further VLS regression analysis with additional factors has been attempted for the period of 2nd decade. But the relationships of base 1960-61 pattern Σ_2' have not been that very high with both Σ_2^* and Σ_2. So we have attempted the VLS regressions separately for the periods of 1st decade and of two decades together in the respective 5-spaces $(\Sigma_2^*, \Sigma_2', Z_1, F^*, x_m^*)$ and $(\Sigma_2, \Sigma_2', Z, F, x_m)$. Inclusion of similar kinds of explanatory factors for both Σ_2 and Σ_2^* would enable us to compare their relative roles for the two periods through VLS regression coefficients. However, before presenting the VLS regression coefficients, we have gone through the discriminatory analysis for ascertaining Σ_2^* and Σ_2 as the best dependent variables among variables of respective spaces considered, by the comparisons of VLS correlation coefficients. The considered spaces however are extended from 3 to 5 with inclusion of additional explanatory variables for more improved explanations for the best dependent variables Σ_2^* and Σ_2. The results of these initial exercises, together with the related correlation matrix are recorded in Table (4.4). Our final results with VLS regression coefficients, both for standardised and unstandardised form of the variables, and also the final estimates on the "percentage shares of contribution to total spatial variation explained by VLS regression" have been recorded in Table (4.5). We have also shown the estimates of OLS regression and correlation coefficients in this Table itself for the purpose of showing the departures between the estimates from the two varieties of regression, one of which (the OLS) is however affected by multicollinearity distortions and axis-bias least-squaring. Despite these limitations of the OLS regression we are

Table (4.4) : Correlation Matrix and VLS Correlation Coefficients for Spatial Variables related to Agricultural Population's Foodgrain Surplus Measures Σ_2 :

1960-61 to 70-71 and 60-61 to 80-81

Variable	Correlation matrix					VLS correlation coefficients $r_{y\hat{y}}$		
						3-space	4-space	5-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Reference period : 1960-61 to 1970-71					
$y = \Sigma_2^*$	1.0000	0.5185	0.7618	0.1736	0.6385	.76729	.77199	.84962
$y = \Sigma_2'$	0.5185	1.0000	0.4339	-0.0819	0.3079	.50819	.47189	.46952
$y = Z_1$	0.7618	0.4339	1.0000	0.2517	0.3685	.70452	.73400	.68578
$y = F^*$	0.1736	-0.0819	0.2517	1.0000	0.2348	-	.15246	.16053
$y = x_m^*$	0.6385	0.3079	0.3685	0.2348	1.0000	-	-	.55447
			Reference period : 1960-61 to 1980-81					
$y = \Sigma_2$	1.0000	0.5296	0.7779	0.4211	0.5492	.80455	.81938	.83688
$y = \Sigma_2'$	0.5296	1.0000	0.3639	0.0322	0.2996	.47692	.40815	.42098
$y = Z$	0.7779	0.3639	1.0000	0.4286	0.3266	.68209	.73278	.67807
$y = F$	0.4211	0.0322	0.4286	1.0000	0.3771	-	.38088	.42432
$y = x_m$	0.5492	0.2996	0.3266	0.3771	1.0000	-	-	.51361

N.B. (i) The variables not in variable-space for VLS correlation are shown by dashes '--'.

(ii) y', y^* and y refer to the same variable y respectively for 60-61, 70-71 and 80-81.

(iii) Z_1 and Z refer to agricultural production growth variable for 1st decade (60-61 to 70-71), and two decades (60-61 to 80-81) respectively.

Table (4.5) : VLS Regression Parameters for the Spatial Variation of Agricultural Population's Foodgrain Surplus Measure (Σ_2^*, Σ_2) and their Comparisons with OLS : 60-71, 80-81

Explanatory variables	regression coefficients with standardised variables		regression coefficients with unstandardised variables		correlation coefficient		% share of contribution to total spatial variation explained by VLS regression
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regression of Σ_2^* with reference period 60-61 to 70-71							
Constant	-	-	-0.43922	-0.10386	0.84962	0.86659	-
Σ_2'	0.35243	0.14754	0.39172	0.16399			24.66
Z_1	0.45142	0.56399	2.27151	2.83796			40.45
F^*	0.13768	-0.04945	0.28005	-0.10059			3.76
x_m^*	0.39600	0.39685	0.83992	0.84172			31.13
Regression of Σ_2 with reference period 60-61 to 80-81							
Constant	-	-	-1.00120	-0.72355	0.83688	0.86564	-
Σ_2'	0.29428	0.24513	0.45948	0.38274			18.85
Z	0.41007	0.56316	1.26348	1.73519			36.61
F	0.29611	0.09896	0.39203	0.13102			19.09
x_m	0.34186	0.25451	0.95019	0.70741			25.45

presenting the OLS estimates only to stress how different these estimates are from the corresponding estimates of the more appropriate VLS regression, discovered very recently [Pal & De 1979a]. Now on the basis of estimates shown in Tables (4.4) and (4.5), we record our observations below :

(i) Both 1980-81 and 1970-71 spatial patterns of fertiliser distribution have been practically independent of 1960-61 base pattern of foodgrain surplus generation. The correlation coefficients of Σ_2' are -0.0819 with F^* (1970-71) and 0.0322 with F (1980-81), both of which are not significantly different from zero at 5% level of chance. It asserts our conjecture that traditionally promising surplus generating areas of the base year have not all been favoured alike by fertiliser distribution at any time-point. The independence of fertiliser distribution and the base year surplus generation pattern is not expected in a proper kind of intensification-programme based initiation for improvements of foodgrain production.

(ii) The 1970-71 and 1980-81 surplus patterns by Σ_2^* and Σ_2 could be seen to be the most explained dependent patterns as discriminated by VLS correlation coefficients shown in columns (7), (8) and (9) of Table (4.4). Among the three spaces considered, Σ_2^* and Σ_2 have maximum explanation of their spatial variations in respective 5-spaces which include the explanatory variables of Σ_2' (base year or initial condition), Z_1 or Z (over-all growth achievement in the past period), F^* or F (current fertiliser distribution) and x_m^* or x_m (cultivators' current capability). In the period of two decades under consideration, the 1970-71 mid-term pattern by Σ_2^* has however got explained a little better than the 1980-81 terminal pattern by Σ_2 (VLS correlation coefficients 0.850 for 1970-71 and 0.835 for 1980-81). This is understandable, because some yet unaccounted factors' role could be possibly higher in the later time-point. However, as the VLS correlation coefficients just quoted above are very high, the explained spatial variations (measured by squared VLS correlation coefficients) must be regarded as high (about 0.772 for 1970-71 and 0.700 for 1980-81).

(iii) Absurdities of OLS regression coefficients (because of multicollinearity distortions and also axis-biased least squaring) have been best manifested here in the negative values of that for F^* to explain 1970-71 pattern of Σ_2^*. We have examined earlier that the correlation coefficient between F^* and Σ_2^*, although low in magnitude, has been significantly above zero as judged by Fisher's Z-test. Under this circumstance, the negative role of F^* for Σ_2^* shown by the OLS regression coefficient is inconceivable. The relevant OLS regression coefficients as recorded in Table (4.5) are of magnitude -0.10 for unstandardised variables and -0.05 for standardised variables, whereas the corresponding VLS regression coefficients are of magnitude 0.28 and 0.14 respectively, which have not reflected any inconsistencies of impossible opposite nature of relation. If one looks at the correlation matrix as shown for the 1st decadal analysis in Table (4.4), the source of this multicollinearity distortion in the OLS regression coefficient could easily be traced from the existence of an insignificant negative correlation coefficient between F^* (for 1970-71) and Σ_2' (for 1960-61). This shows that any effort to estimate distinctly the marginal rates of the explained variable relative to all its explanatory variables by the OLS regression coefficients is futile.

(iv) Thus, all other OLS regression coefficients are either over-estimated or under-estimated, as compared with the corresponding VLS regression coefficients (except that for x_m^* for the

1st decadal analysis only). The multi-collinearity distrotions have been greater for the two-decadal analysis as compared with that for the 1st decadal one, as evidenced from the greater departure from OLS to VLS correlation coefficients for the two decadal analysis. Obviously, on the face of multi-collinearity distortions, the exaggerated notion of the total spatial variation explained through the squared OLS correlation coefficient is not acceptable.

(v) Judging by the more appropriate VLS regression coefficients and related parameters, our analysis for the relative roles of explanatory variables in explaining the total spatial variations of Σ_2^* in 1970-71 (1st decadal analysis) and Σ_2 in 1980-81 (two-decadal analysis) is given below. For both 1970-71 and 1980-81 spatial patterns of foodgrain surplus generation, the over-all growth factor has by far played the most important explanatory role, and then comes the role of cultivators' current capability as next important one. The explanatory roles of these two factors have however reduced for the later time-point (from 40.45 per cent in 1970-71 to 33.61 per cent in 1980-81 for growth factor and from 31.13 per cent in 1970-71 to 25.45 per cent in 1980-81 for cultivators' capability factor). Fertiliser distribution played the least important explanatory role in 1970-71, but its role improved substantially to third position in 1980-81 (from 3.76 per cent in 1970-71 to 19.09 per cent in 1980-81), while the influence of base year or initial pattern deteriorated with greater interval of time, as is expected (its explanatory role reduced from 24.06 per cent in 1970-71 to 18.85 percent in 1980-81).

(vi) All the estimates just quoted are shown in col. (8) of Table (4.5) which are really proportional to squared VLS regression coefficients of col. (2) for standardised variables. The differentiation in the actual marginal rates between the two periods of analysis can also be made by the VLS regression coefficients for unstandardised variables (and not in terms of standardised variables). In the unstandardised form, the intrinsic dispersals of variables in the two periods are not ironed out to the same level of unit standard deviation (as is true for standardised variables), and to that extent the picture portrayed by the comparison of two marginal rates would be a little different. Here all the marginal rates shown in col. (4) of Table (4.5) are comparable between the two periods of analysis (1st decadal and two-decadal) for all explanatory variables except the two growth rate variables in the present form. The corresponding regression coefficients could be compared if the growth rates are transformed into location factors, making necessary adjustments with the regression coefficients. All-India proportionate agricultural growth rate for the period of two decades was 0.5910. Its equivalent for one decade would be 0.2613 ($= \sqrt{1+0.5910}-1$). To convert Z_1 and Z into comparable location factors, Z_1 is to be divided by 0.2613 and Z by 0.5910. So the adjustment multipliers for the corresponding regression coefficients would be respectively 0.2613 and 0.5910. Thus the regression coefficient for Z_1 would change from present 2.27151 to comparable estimate 0.59355 and that for Z would change from present 1.26348 to comparable estimate of 0.74672. With this conversion, all regression coefficients become comparable between two periods of study. Thus in terms of marginal rates, the roles of all explanatory variables have improved at the later time-point 1980-81, as compared to that in 1970-71. This means that per unit change in the value of an explanatory variable, the spatial change in the value of foodgrain surplus generation variable is more at later time-point 1980-81. In other words, the spatial disparity in the foodgrain surplus generation has increased in 1980-81 as compared to that in 1970-71 by the interacting roles played by all explanatory variables. Without bringing in now the disparity aspect, we would however accept the relative roles of different variables as already evaluated by the shares of total spatial variation explained for Σ_2^* and Σ_2. We have already examined the spatial disparity aspect earlier in our improvement measure $(\Sigma_2 - \Sigma_2^*)$ shown in Table (4.3).

(vii) As the over-all agricultural growth rate has played very important role in explaining the spatial variation of food-grain surplus generation measure, we would like to examine its all-India values and the coefficient of spatial variation in different periods. The relevant estimates are recorded below in Table (4.6):

Table (4.6) : All-India Agricultural Growth in Different Periods : Direct-estimate, Mean-estimate and the Coefficient of Spatial Variation

items	proportionate increase in agricultural production in period			
	60-61 to 80-81 relative to 60-61 prodn. Z	60-61 to 70-71 relative to 60-61 prodn. Z_1	70-71 to 80-81 relative to 70-71 prodn. Z_2	70-71 to 80-81 relative to 60-61 prodn. $Z_2' = Z - Z_1$
①	②	③	④	⑤
1. Direct all-India estimate	0.5910	0.2353	0.2879	0.3557
2. Mean of estimates of areal-units	0.6538	0.2621	0.2975	0.3917
3. Coefficients of spatial variations	0.6369	0.6925	0.4504	0.6400

On the basis of estimates of this Table, the all-India position on over-all agricultural production has improved more in the second decade than in the first decade. The coefficient of spatial variation has remained more or less similar in any period when judged by changes Z, Z_1 and Z_2 calculated relative to the same 1960-61 production level. If however Z_1 and Z_2 are compared as actual rates over the two periods, then the coefficient of spatial variation has changed to a smaller value in the second decade. Thus the spatial disparity in over-all growth rates of agricultural production has decreased in the second decade, whereas that for foodgrain surplus generation situation has increased in 1980-81 as compared with that of 1970-71. Thus the nature of spatial disparity for total agricultural production and foodgrain surplus generation have not been similar. The distorting factor is obviously the varying population content that is implicit only in surplus generation measure, and not in the growth rates.

4.3 Comparative Spatial Pattern Analysis : Agricultural Development Index and Sub-indices

We would take up now the comparative spatial pattern analysis for the agricultural development index D_A and its three constituent sub-indices in the same way as we have just completed for foodgrain surplus measures in section 4.2. The sub-indices are : 1. comprehensive land productivity index x_a, 2. agricultural labour productivity index x_w and 3. cultivators' foodgrain surplus generation capability index x_m (= L_1). The over-all agricultural development index D_A, being a derived composite index from the sub-indices, it would be analysed later as a sort of summary picture and our prime investigation will be centred around sub-indices, particularly the land and labour productivity indices. Details of our investigation and analysis are shown in the following three sub-sections.

4.3.1 Comparisons of All-India Estimates of Agricultural Development Index and Sub-indices and the Coefficient of Spatial Variation

Comparisons for all-India estimates on D_A, x_a, x_w and x_m have been attempted over three time-points again in the same manner as we have done earlier for Σ_i's. Here all-India direct estimate, mean of areal-unit estimates and the coefficient of spatial variation are recorded in Table (4.7). Based on the data of this Table, we make the following observations :

(i) The all-India estimates of three sub-indices behaved differently in their movement patterns over the time-points : 60-61, 70-71 and 80-81. The movement of labour productivity was much higher in the 1st decade than that in the 2nd decade (by both direct all-India estimate and mean estimate). The movements of cultivators' surplus generation index have been more or less similarly low in both the decades as we could notice for agricultural labour producity index in the second decade only (by direct all-India estimate). On the other hand, only the movement of land productivity was considerably higher in the 2nd decade as compared with that of 1st decade. This movement pattern of land productivity has matched with that of fertiliser input (ref. to Table (4.1)), whereas the movement pattern of agricultural labour productivity has shown strong agreement with that of foodgrain surplus generation index Σ_4, accounting for even total population. The limited movements of the land-owning cultivators' surplus index could be very much accounted by the limited extension possibilities of agricultural land together with its fragmentation problem in the forward time-path. With the mixed kind of movement patterns between indices

Table (4.7) : Movements of All-India Agricultural Development Indices and Sub-indices over the Time-points by Direct-estimates, Mean estimates and Coefficients of Spatial Variation

Years	Agricultural development Indices and sub-indices			
	D_A (over-all agricultural development)	x_a (land productivity)	x_w (agricultural labour productivity)	$x_m = L_1$ (cultivators' foodgrain surplus)
(1)	(2)	(3)	(4)	(5)
	Direct all-India estimate			
1980-81	1.0000	1.0000	1.0000	1.0000
1970-71	0.8969	0.8471	0.9431	0.9438
1960-61	0.7704	0.7350	0.6066	0.8971
	Mean of areal units			
1980-81	0.9835	1.0372	1.0823	0.8624
1970-71	0.8762	0.8771	0.9955	0.8177
1960-61	0.7450	0.7557	0.6120	0.7933
	Coefficients of spatial variation			
1980-81	0.3561	0.2981	0.6598	0.5443
1970-71	0.3762	0.3455	0.6359	0.5266
1960-61	0.3435	0.3149	0.5100	0.6029

related to land and people, the over-all agricultural development index D_A showed more or less similar kind of movement pattern in both decades, comparable to that of land productivity in the 1st decade. Thus the movement pattern of the over-all development index has become relatively lower than that of land productivity in the 2nd decade, because of the increased pressure of population on agricultural land.

(ii) For cultivators' surplus generation index, the mean values are considerably lower than the corresponding all-India estimates in all time-points. This means that the statistical distributions of this index at all time-points have extended lower tails, signifying possibly an abundance of small and marginal cultivators with limited capacity. On the other hand, the labour and land productivities tend to show a little higher mean value than all-India estimate, with increasing difference in the forward time path -- more for labour productivity. Here the existence of a few advanced areal units in the extended upper tails of respective statistical distributions could be possible. Jointly of all sub-indices, the mean values of over-all agricultural development index are very close to the corresponding all-India estimates in all time-points.

(iii) The coefficient of spatial variation increased for labour productivity x_w and decreased for cultivators' surplus index x_m in the 1st decade, and thereafter it remained more or less stationary for both in the second decade. But the coefficient of spatial variation remained more or less stationary at all time-points for both land productivity x_a and over-all agricultural development index D_A. The magnitudes of the coefficient of spatial variation are lower for x_a and D_A as compared with those of x_w and x_m. Thus, in this predominantly agricultural country, the spatial disparity in land productivity has not been great, but with the varying population pressure on agricultural land, the spatial disparities have increased with labour productivity and cultivators' surplus generation capability. Jointly however the pattern of over-all agricultural development index D_A becomes closer to that of land productivity x_a with its dominant influence in the composition of D_A (ref. to the highest combining weight that x_a received in the statistical treatment for formulation of D_A in equation (3.17)).

4.3.2 Agricultural Development Patterns of 1980-81 and 1970-71: Spatial Associations and the Relationships with Fertiliser and Over-all Growth

In our preceding analysis, we have noted that the labour productivity, likewise the foodgrain surplus situation, experienced major improvement in the 1st decade and only marginal improvement in the 2nd decade. So, here also we could expect a strong agreement between 1980-81 and 1970-71 spatial patterns of labour productivities. Again as labour productivity and other sub-indices are all very highly related with the over-all agricultural development index, we would investigate the nature of agreements between 1980-81 and 1970-71 spatial patterns, not only for x_w, but also for D_A, x_a and x_m. Secondly, the relative movement patterns in the 1st and 2nd decades having been similar for both land productivity and fertiliser-input, we would like to investigate on the degree of relationship, not only for land productivity alone, but also for other related indices. Apart from fertiliser-input, two other important factors, namely, (i) the proportion of foodgrain production generated as surplus by the agricultural community for consumption of its counterpart of non agricultural population, and (ii) the growth rate in agricultural production over the preceding period, must have some bearing with the spatial variations in the patterns of agricultural development. So we would also like to investigate the relationship of surplus index and growth rate with the agricultural development index and its sub-indices for 1970-71 and 1980-81 spatial patterns. However, the surplus index would be taken in the form of L_2, and not in its trans-form Σ_2, for the fact that the problem of multicollinearity with growth rate variables is much less with L_2 rather than Σ_2. Moreover, L_2 gives the actual proportion of production surplus, while Σ_2 gives only the supply to requirement ratio for human consumption. Results of these investigations are shown to start with by the estimates of relevant correlation coefficients recorded in Table (4.8). In the first row of this Table we have shown the relationships between 1970-71 and 1980-81 spatial patterns for agricultural development index D_A and its sub-indices x_a, x_w and x_m. In the next three rows, we have shown the relation of these indices with fertiliser inputs by different time-points. The relationships with growth rates Z, Z_1, Z_2' and Z_2 have been shown in the next four rows of Table (4.8). Finally in the last three rows of this Table, we have recorded the relationships with the surplus index by the three time-points.

Again as the recorded estimates of correlation coefficients between 70-71 and 80-81 patterns of D_A, x_a, x_w and x_m are of very high magnitudes, we have recorded further in Table (4.9) the estimates of 1970-71 agricultural development measures D_A^*, x_a^*, x_w^* and x_m^* corresponding to class-boundary values of 1980-81 measures as shown before in

Table (4.8) : Spatial Associations on Agricultural Development Index and Sub-Indices : Self-relations between two recent Time-points and Interactions at Different Time-points with Fertiliser-input, Agricultural-growth and Foodgrain Surplus Measures

spatial correlation between	reference time-points or periods (years)	correlation coefficients with variable			
		$y = D_A$ (agricultural development	$y = x_a$ (land productivity)	$y = x_w$ (labour productivity)	$y = x_m$ (cultivators foodgrain surplus)
(1)	(2)	(3)	(4)	(5)	(6)
y and y*	80-81 and 70-71	0.9346	0.9351	0.9678	0.8737
F and y	1980-81	0.6795	0.8110	0.4558	0.3771
F^* and y*	1970-71	0.4821	0.6337	0.2991	0.2348
F' and y'	1960-61	0.3406	0.4041	0.1221	0.0605
Z and y	60-81 and 80-81	0.5886	0.4083	0.7670	0.3266
Z_1 and y*	60-71 and 70-71	0.5595	0.3676	0.7129	0.3685
Z_2' and y	70-81 and 80-81	0.5273	0.3533	0.7062	0.2902
Z_2 and y	70-81 and 80-81	0.4111	0.2763	0.5623	0.2168
L_2 and y	1980-81	0.6602	0.2598	0.5330	0.7901
L_2^* and y*	1970-71	0.6834	0.2493	0.5749	0.7775
L_2' and y'	1960-61	0.3631	0.1554	0.3106	0.4079

Table (4.9) : Estimates of 1970-71 Agricultural Development Measures orresponding to Class-boundary Values of 1980-81 Measures

over-all agricultural development index			land productivity index			agricultural labour productivity index			cultivators' foodgrain surplus index		
80-81 class-boundaries of D_A	correspon-ding 70-71 D_A^*	improve-ment $D_A - D_A^*$	80-81 class-boundaries of x_a	correspon-ding 70-71 x_a^*	improve-ment $x_a - x_a^*$	80-81 class-boundaries of x_w	correspon-ding 70-71 x_w^*	improve-ment $x_w - x_w^*$	80-81 class-boundaries of x_m	correspon-ding 70-71 x_m^*	improve-ment $x_m - x_m^*$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2.23 EH	2.0609	.1691	1.81 EH	1.6386	.1714	4.15 EH	3.7346	.4154	1.66 EH	1.5595	.1005
1.36 VH	1.2376	.1224	1.40 VH	1.2379	.1621	1.48 VH	1.3685	.1115	1.40 VH	1.3169	.0831
1.18 H	1.0672	.1128	1.20 H	1.0425	.1575	1.24 H	1.1558	.0842	1.20 H	1.1304	.0696
1.00 M	0.8969	.1031	1.00 M	0.8471	.1529	1.00 M	0.9431	.0569	1.00 M	0.9438	.0562
0.82 L	0.7266	.0934	0.80 L	0.6517	.1483	0.76 L	0.7304	.0296	0.80 L	0.7572	.0428
0.64 VL	0.5562	.0838	0.60 VL	0.4563	.1437	0.52 VL	0.5177	.0025	0.60 VL	0.5707	.0293

Estimating VLS regressions

$$\left\{\begin{array}{lll} D_A^* = -0.049411 + 0.946311\, D_A; & \text{VLS correlation coefficients} & = 0.9346 \\ x_a^* = -0.130004 + 0.977104\, x_a; & \text{"} & = 0.9351 \\ x_w^* = 0.056918 + 0.886182\, x_w; & \text{"} & = 0.9678 \\ x_m^* = 0.010958 + 0.932842\, x_m; & \text{"} & = 0.8737 \end{array}\right.$$

Table (3.7) for mapping purpose (ref. to Figures (3.5) to (3.8)). Following the reasons in favour of VLS regressions as put forward in connection with the building up of estimating equations for foodgrain surplus measures Σ_2, Σ_3 and Σ_4 in Table (4.3) earlier, we have used here also the estimating VLS regressions to build up the estimates of Table (4.9). The " intercept" parameters of these regressions have been so estimated as to give 1970-71 all-India estimate corresponding to 1980-81 all-India estimate for the related index. All these estimating equations have been shown just at the bottom of the Table (4.9). In this Table, we have also recorded the increment in 1980-81 value from corresponding 1970-71 value for each index at the selected class-boundary values. The differential improvements in the value range of each index could be depicted by these increment values. Our findings are now given below :

(i) The relationships between 1970-71 and 1980-81 spatial patterns are extremely high, not only for labour productivity index x_w alone, but also for land productivity index x_a and over-all agricultural development index D_A (correlation coefficients between 0.935 and 0.968). The similar relationship for cultivators' foodgrain production surplus index x_m has however been a little lower, but it is still very high (correlation coefficients = 0.874). This means that agriculturally developed areal units remained advanced and the backward areal units backward, in the second decade with, however, more improvements in advanced areal units as compared with that in backward areal units. But as the regression coefficients, shown in the estimating VLS regressions at the bottom of Table (4.9), are not far away from unity, the relatively more improvement of advanced areal units is not that glaring as we have noticed for foodgrain supply to requirement ratio measures earlier (ref. to Table (4.3)). Thus our improvement measures shown in columns (3), (6), (9) and (12) of Table (4.9) are slowly increasing in values as we proceed from the upper boundary value of VL class to that of EH class. Only for the labour productivity index, it looks substantially increased for the EH class. (Note that, among the four indices, labour productivity has the lowest regression coefficient below unity). Likewise the foodgrain supply requirement ratio measures, the agricultural development measures show strong agreements between 1980-81 and 1970-71 spatial patterns, with more advanced areal units showing greater improvements in the decade. As the agriculturally more developed areas have improved more in the period of consideration, the regional disparity in development must have increased in the forward time path. This undesirable feature is more pronounced with the labour productivity index.

(ii) The intensification role of fertiliser-input was best manifested in the land productivity index; with the growth of fertiliser dose per hectare in the forward time-path, the relationship became more and more close. Thus the correlation coefficient between F' and x'_a was of moderate magnitude 0.4041 in 1960-61, that between F^* and x^*_a was of high magnitude 0.6337 in 1970-71 and finally that between F and x_a became as high as of magnitude 0.8110 in 1980-81. The increasing intensification role of fertiliser-input in the forward time-path was also maintained by the other two sub-indices of agricultural development, but here the role was dampened considerably, because of the involvement of increasing number of people in these two sub-indices. Thus, the correlation coefficient of F that was very high with x_a got dampened to moderate values of 0.4558 and 0.3771 respectively with x_w

and x_m in 1980-81. In 1970-71, the high relationship of F^* with x^*_a got reduced to low values with x^*_w and x^*_m. And, in the base year 1960-61, the moderate relationship of F' with x'_a changed to insignificant values with x'_w and x'_m which were not different from zero by Fisher's Z-test at 5% level of chance. Thus the spatial distributions of cultivators and all agricultural workers have not gone in matching proportion with the spatial distribution of land productivity situation, with the result that the significant intensification role of fertiliser as manifested with land productivity does not remain that significantly pronounced with labour productivity and cultivators' surplus generation capability. As the pattern of agricultural development has to be appreciated in the proper perspective of both land-input and agricultural worker-input, we can not be satisfied with the performance of fertiliser with respect to land alone. So, with the considerations of both land-input and agricultural worker-input, our assessment of the intensification role of fertiliser has to be made in terms of its performance with the over-all agricultural development index. Here comes the importance of composite index formulation such as D_A. Thus, jointly, the intensification role of fertiliser was low-moderate (correlation coefficient between F' and D'_A was 0.3406) in 1960-61, changing to an improved moderate value (correlation coefficient between F^* and D^*_A was 0.4821) in 1970-71 and finally to a high value (correlation coefficient was 0.6795) in 1980-81. Clearly the performance of fertiliser-input as exhibited on the land productivity got deteriorated with the over-all agricultural development, because of varying population pressure on land particularly in the backward areas. It seems that the supply of fertiliser is being made on the premise of land quality variation, and not always by labour productivity consideration.

(iii) The role of growth factor on land and labour productivities is just the reverse of what happened with fertiliser-input. Here the growth rates of agricultural production for the periods commencing from the base year 1960-61 showed high relation with labour productivities in both 1980-81 and 1970-71 — much higher than what these rates exhibited with land productivity. The behaviour of cultivators' surplus generation capability with respect to growth factor had however been more or less similar to that of land productivity and not labour productivity. Thus, considering the terminal year 1980-81, the correlation coefficients of growth factor Z were 0.7670 with x_w, 0.4083 with x_a and 0.3266 with x_m. Again considering the terminal year 1970-71, the correlation coefficients of growth factor Z_1 were 0.7129 with x^*_w, 0.3676 with x^*_a and 0.3685 with x^*_m. The influence of two decades' growth factor Z was more pronounced (except for a marginal deviation with x_m) than any single decade's growth factor, not only for z_1 (1st decade) but also for Z_2 and Z'_2 (2nd decade). While Z_1 and Z'_2 (both calculated w.r. to base 1960-61) behaved similarly (except for x_m), the second decade's actual growth rate Z_2 (with base 1970-71) showed less influence as compared with the 1st decade's growth rate Z_1. The effect of growth factor on the combined index D_A was some where in between those of land and labour productivities, as expected. Relatively less influence of growth factor on land productivity could be due to the fact that all fertiliser-aided areas of high land productivity were not having equally mechanised and/or similarly labour-oriented agricultural practices. For example, on the basis of our findings with map analysis made earlier, we suspect that Tamil Nadu and Kerala had less mechanisation with more labour-use as compared with the situation prevailing in Punjab and Haryana.

(iv) As the land-owning cultivators' decision-making role has to be considered quite important for over-all agricultural development measure, the related index x_m was considered as one of its constituent sub-indices. However, our preceding findings reveal that the movement of x_m has not become that satisfactory in the forward time path, because of the fragmentation problem of limited agricultural land with the increasing number of land-owning cultivators. Moreover, land-owning cultivators have not been fully involved in actual cultivation always and everywhere. In consequence of this non-promising role of cultivators, it has become necessary for us now to examine the revealed agricultural development pattern in terms of L_2 that account for the totality of all agricultural workers. However, as $x_m (=L_1)$ and L_2 are indices of same variety on foodgrain production surplus, accounting for the coverages of the land-owning sector and the total of agricultural community respectively, strong mutual interactions between the two indices can not be ruled out, particularly with improved situation of surplus generation in recent years. Thus the spatial variation of x_m or x_m^* has been best explained by L_2 or L_2^* respectively (correlation coefficients 0.7901 in 1980-81 and 0.7775 in 1970-71). The foodgrain production surplus of agricultural community has also shown considerable relation with labour productivity in recent years, both of which have been influenced sufficiently by the common growth rate factor. However, the surplus index L_2 has very low relationship with land productivity - considerably lower than that shown by x_m

($r_{L_2 x_a}$ = 0.2598 against $r_{x_m x_a}$ = 0.4074 in 1980-81,

$r_{L_2^* x_a^*}$ = 0.2493 against $r_{x_m^* x_a^*}$ = 0.3797 in 1970-71 and

$r_{L_2' x_a'}$ = 0.1554 against $r_{x_m' x_a'}$ = 0.2508 in 1960-61). Here at least in explaining the spatial variation in land productivity, the role of cultivators has always been more pronounced and more improving in the forward time path than that of total agricultural community. This fact goes in favour of our inclusion of x_m, rather than L_2, as a constituent sub-index of over-all agricultural development measure. It is however unfortunate that the development inducing role of cultivators has not become that promising yet. This calls for planning attention to both cultivators and agricultural labourers in a sort of complementary way and not to agricultural labourers alone without due regard to cultivators.

(v) The revealed explanatory role of surplus index L_2 and L_2^* has become no less important than that of growth factors Z and Z_1 and fertiliser inputs F and F^* in explaining the spatial variation of over-all development indices D_A and D_A^* in 1980-81 and 1970-71 respectively. In fact, the role of surplus index was more pronounced in 1970-71 when the impact of fertiliser input was not that prominant as in 1980-81. It should be noted that fertiliser dose is an input factor for land in our agricultural development efforts, whereas the growth rate is a response factor from the land. Both these factors are however independent of any consideration for agricultural worker-input in their calculations. The foodgrain production surplus index is also a response factor, likewise the growth rate, but its speciality is in the fact that it is the response factor involving the agricultural worker input and not related to land alone. For this reason, its separate consideration as response factor gains importance, although the two response factors cannot be and are not unrelated.

4.3.3 Agricultural Development Patterns of 1970-71 and 1980-81 : Statistical Analysis for Relative Roles of Explanatory Factors

We have just noted the interacting roles of the important input factor of fertiliser dose, and the two response factors of agricultural production growth rate and foodgrain production surplus from the agricultural community with the over-all agricultural development index and its constituent sub-indices separately for different time-points and periods. In this sub-section, we would examine the joint roles of those factors and their relative importances in explaining the spatial variations in the patterns of agricultural development as measured by the over-all index and its sub-indices. Our investigations would be for the patterns as arrived at the mid-point 1970-71 and terminal-point 1980-81, both starting from the base-point 1960-61. We have noted that there has been strong agreements between the mid-point and the terminal-point spatial patterns. Both these patterns cannot be and really are not independent of the past base-year pattern. As such we would like to examine the relative roles of the base-pattern together with the three factors considered already for explanations of the mid-point and the terminal-point patterns.

Our assessment for identification of most relevant direct explanatory factors and the relative roles of those factors in explaining the spatial variation patterns of x_a, x_w, x_m and D_A would be by the same statistical technique of VIS regression analysis as we have applied already for the foodgrain supply-requirement ratio variable Σ_2 in sub-section 4.2.3. After estimating VIS correlation coefficients for all possible combinations of variable-spaces, we have recorded only those results which are the best, the next-best (if very close to the best) and at times some other relevant ones of interest in the possible variable-spaces (3-spaces, 4-space and 5-space) in Tables (4.10), (4.12), (4.14) and (4.16) respectively for x_a, x_w, x_m and D_A. The relevant estimates of initial correlation matrices (five by five) are also recorded in these Tables. Apart from showing pairwise inter-correlations, the results of our VIS correlation exercises help in identifying the best combination of direct explanatory factors for each of x_a, x_w, x_m and D_A at the two time-points, covering the reference periods of 1st decade (1960-61 to 1970-71) and two decades (1960-61 to 1980-81). The relative roles of the identified direct explanatory factors are evaluated by VIS regression coefficients and related parameters shown in Tables (4.11), (4.13), (4.15) and (4.17) respectively for x_a, x_w, x_m and D_A. In these Tables we have also shown the corresponding OLS estimates on regression and correlation coefficients to give an idea of distortion implicit due to the multicollinearity problem and also the axis-biased least-squaring in the usual OLS regression procedure. The regression coefficients are shown for both standardised and unstandardised variables. The relative roles are to be assessed, as usual, by percentages of squared regression coefficients of standardised variables that show the relative contributions to total explained spatial variation measured by squared VIS correlation coefficient. The regression coefficients with unstandardised variables show marginal rates of change in the spatial variables as explained per unit change in explanatory factors. These marginal rates

Table (4.10) : Correlation Matrix and VIS Correlation Coefficients for Spatial Variables related to Agricultural Land Productivity Index x_a : 1960-61 to 70-71 and 1960-61 to 80-81

Variables	correlation matrix					VIS correlation coefficients $r_{y\hat{y}}$				
						3-space	3-space	4-space	4-space	5-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Reference period 1960-61 to 1970-71										
$y = x_a^*$	1.0000	0.8849	0.6337	0.3676	0.2493	0.90571	0.91726	0.91827	0.91710	0.89143
$y = x_a'$	0.8849	1.0000	0.4407	0.1071	0.2026	0.76125	0.74779	0.70076	0.76938	0.67937
$y = F^*$	0.6337	0.4407	1.0000	0.2517	-0.0146	0.55690	-	0.57081	0.52764	0.52091
$y = Z_1$	0.3676	0.1071	0.2517	1.0000	0.4566	-	0.24900	0.27964	-	0.34674
$y = L_2^*$	0.2493	0.2026	-0.0146	0.4566	1.0000	-	-	-	0.17946	0.26298
Reference period 1960-61 to 1980-81										
$y = x_a$	1.0000	0.8611	0.8110	0.4083	0.2598	0.92360	0.91355	0.92403	0.91628	0.89403
$y = x_a'$	0.8611	1.0000	0.6402	0.1169	0.1916	0.79405	0.70387	0.71559	0.77979	0.68791
$y = F$	0.8110	0.6402	1.0000	0.4286	0.1992	0.75513	-	0.78964	0.74652	0.76424
$y = Z$	0.4083	0.1169	0.4286	1.0000	0.4000	-	0.27929	0.35112	-	0.40021
$y = L_2$	0.2598	0.1916	0.1992	0.4000	1.0000	-	-	-	0.23653	0.29808

N.B.: (i) The variables not included in variable-space for VIS correlation are shown by dashes '—'

(ii) y', y^* and y refer to the same variable y respectively for 60-61, 70-71 and 80-81.

(iii) Z_1 and Z refer to agricultural production growth rate variable for 1st decade (60-61 to 70-71) and two decades (60-61 to 80-81) respectively.

Table (4.11) : VIS Regression Parameters for the Spatial Variation of Agricultural Productivity Index (x_a^* and x_a) and their Comparison with OLS Parameters : 1960-61 to 70-71 and 1960-61 to 80-81

Explanatory variables	regression coefficients with standardised variables		regression coefficients with unstandardised variables		correlation coefficient		% share of contribution to total spatial variation explained by VIS regression
	VIS	OLS	VIS	OLS	VIS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Regression of x_a^* with reference period 60-61 to 70-71				
Constant	–	–	0.09277	-0.01101	0.91827	0.95094	–
x_a'	0.55006	0.75267	0.70029	0.95823			48.63
F^*	0.48903	0.24530	0.33001	0.16554			38.44
Z_1	0.28365	0.22525	0.47353	0.37603			12.93
			Regression of x_a with reference period 60-61 to 80-81				
Constant	–	–	0.29193	0.21426	0.92403	0.94107	–
x_a'	0.46008	0.63172	0.59946	0.82309			40.46
F	0.48530	0.32247	0.15529	0.10318			45.02
Z	0.27566	0.19624	0.20529	0.14615			14.52

Table (4.12) : Correlation Matrix and VIS Correlation Coefficients for Spatial Variables related to Agricultural Labour Productivity Index x_w : 1960-61 to 70-71 and 1960-61 to 80-81

Variables	correlation matrix					VIS correlation coefficients $r_{y\hat{y}}$				
						3-space	3-space	3-space	4-space	5-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
				Reference period : 1960-61 to 1970-71						
$y = x_w^*$	1.0000	0.9195	0.7129	0.5749	0.2991	0.85521	0.87353	0.95433	0.91815	0.92298
$y = x_w'$	0.9195	1.0000	0.4839	0.5282	0.2824	0.84385	0.83863	0.78189	0.77966	0.78810
$y = Z_1$	0.7129	0.4839	1.0000	0.4566	0.2517	-	-	0.61562	0.62874	0.63829
$y = L_2^*$	0.5749	0.5282	0.4566	1.0000	-0.0146	-	0.56319	-	0.58075	0.54634
$y = F^*$	0.2991	0.2824	0.2517	-0.0146	1.0000	0.29690	-	-	-	0.25528
				Reference period : 1960-61 to 1980-81						
$y = x_w$	1.0000	0.8607	0.7670	0.5330	0.4558	0.81394	0.83647	0.95765	0.92573	0.90854
$y = x_w'$	0.8607	1.0000	0.4488	0.4540	0.4166	0.78513	0.77794	0.71628	0.71862	0.72485
$y = Z$	0.7670	0.4488	1.0000	0.4000	0.4286	-	-	0.64048	0.63903	0.66206
$y = L_2$	0.5330	0.4540	0.4000	1.0000	0.1992	-	0.51220	-	0.52041	0.49763
$y = F$	0.4558	0.4166	0.4286	0.1992	1.0000	0.45242	-	-	-	0.46195

N.B. : (i) **The variables** not included in variable-space for VIS correlation are shown by dashes " __ " .

(ii) y′, y* and y refer to the same variable y respectively for 60-61, 70-71 and 80-81.

(iii) Z_1 and Z refer to agricultural production growth rate variable for 1st decade (60-61 to 70-71) and two decades (60-61 to 80-81) respectively.

Table (4.13) : VLS Regression Parameters for the Spatial Variation of Agricultural Labour Productivity Index (x_w^* and x_w) and their Comparisons with OLS Parameters : 1960-61 to 70-71 and 1960-61 to 80-81

Explanatory variables	regression coefficients with standardised variables		regression coefficients with unstandardised variables		correlation coefficient		% share of contribution to total spatial variation explained by VLS regression
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Regression of x_w^* with reference period 60-61 to 70-71				
Constant	-	-	-0.25498	-0.25551	0.95433	0.96914	-
x_w'	0.61061	0.75019	1.23843	1.52154			56.22
Z_1	0.53885	0.34988	1.87929	1.22025			43.78
			Regression of x_w with reference period 60-61 to 80-81				
Constant	-	-	-0.39329	-0.35956	0.95765	0.96037	-
x_w'	0.59984	0.64674	1.37285	1.48018			52.95
Z	0.56539	0.47674	0.96988	0.81782			47.05

Table (4.14) : Correlation Matrix and VIS Correlation Coefficients for Spatial Variables related to Cultivators' Foodgrain Surplus Generation Index x_m : 1960-61 to 70-71 and 1960-61 to 80-81

Variables	correlation matrix					VIS correlation coefficients $r_{y\hat{y}}$			
						3-space	3-space	4-space	5-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Reference period : 1960-61 to 1970-71									
$y = x_m^*$	1.0000	0.5408	0.7775	0.2348	0.3685	0.80916	0.81517	0.83313	0.78761
$y = x_m'$	0.5408	1.0000	0.3661	0.0562	0.1831	0.48439	-	0.48152	0.44840
$y = L_2^*$	0.7775	0.3661	1.0000	-0.0146	0.4566	0.67980	0.70513	0.65563	0.69146
$y = F^*$	0.2348	0.0562	-0.0146	1.0000	0.2517	-	0.11977	0.11690	0.16635
$y = Z_1$	0.3685	0.1831	0.4556	0.2517	1.0000	-	-	-	0.43347
Reference period 1960-61 to 1980-81									
$y = x_m$	1.0000	0.5812	0.7901	0.3771	0.3266	0.80028	0.80145	0.83666	0.78973
$y = x_m'$	0.5812	1.0000	0.4957	0.0971	0.1431	0.56997	-	0.53858	0.48833
$y = L_2$	0.7901	0.4957	1.0000	0.1992	0.4000	0.73622	0.67881	0.71429	0.71754
$y = F$	0.3771	0.0971	0.1992	1.0000	0.4286	-	0.30734	0.26987	0.34708
$y = Z$	0.3266	0.1431	0.4000	0.4286	1.0000	-	-	-	0.41241

N.B. : (i) The variables not included in variable-space for VIS correlation are shown by dashes "__".

(ii) y', y^* and y refer to the same variable y respectively for 60-61, 70-71 and 80-81.

(iii) Z_1 and Z refer to the agricultural production growth rate variable for 1st decade (60-61 to 70-71) and two decades (60-61 to 80-81) respectively.

Table (4.15) : VLS Regression Parameters for the Spatial Variation of Cultivators' Foodgrain Surplus Generation Index (x^*_m and x_m) and their Comparisons with OLS Parameters : 1960-61 to 70-71 and 1960-61 to 80-81

Explanatory variables	regression coefficients with				correlation coefficients		% share of contribution to total spatial variation explained by VLS regression
	standardised variables		unstandardised variables				
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Regression of x^*_m with reference period 60-61 to 70-71				
Constant	-	-	0.23140	0.36760	0.83313	0.85585	-
x'_m	0.52620	0.27953	0.47373	0.25165			39.92
L^*_2	0.62609	0.67851	0.25860	0.28025			56.51
F^*	0.15739	0.22900	0.15094	0.21961			3.57
			Regression of x_m with reference period 60-61 to 80-81				
Constant	-	-	0.17920	0.33397	0.83666	0.84991	-
x'_m	0.46325	0.25179	0.44708	0.24300			36.73
L_2	0.54353	0.61962	0.25562	0.29141			50.57
F	0.27244	0.22922	0.12977	0.10918			12.70

Table (4.16) : Correlation Matrix and VIS Correlation Coefficients for Spatial Variables related to Over-all Agricultural Development Index D_A : 1960-61 to 70-71 and 1960-61 to 80-81

Variables	correlation matrix					VIS correlation coefficients $r_{y\hat{y}}$			
						3-space	3-space	4-space	5-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Reference period : 1960-61 to 1970-71					
$y = D_A^*$	1.0000	0.7595	0.4821	0.6834	0.5595	0.86108	0.76398	0.90753	0.91064
$y = D'_A$	0.7595	1.0000	0.3782	0.4075	0.2932	0.65227	0.68770	0.69150	0.63777
$y = F^*$	0.4821	0.3782	1.0000	-0.0146	0.2517	—	0.45980	0.35515	0.36003
$y = L_2^*$	0.6834	0.4075	-0.0146	1.0000	0.4566	0.59048	—	0.49602	0.54969
$y = Z_1$	0.5595	0.2932	0.2517	0.4566	1.0000	—	—	—	0.51542
				Reference period : 1960-61 to 1980-81					
$y = D_A$	1.0000	0.7436	0.6795	0.6602	0.5886	0.81701	0.83150	0.90326	0.92299
$y = D'_A$	0.7436	1.0000	0.4669	0.4804	0.2373	0.68116	0.67054	0.69660	0.63362
$y = F$	0.6795	0.4669	1.0000	0.1992	0.4286	—	0.61934	0.54059	0.57086
$y = L_2$	0.6602	0.4804	0.1992	1.0000	0.4000	0.61462	—	0.53638	0.55717
$y = Z$	0.5886	0.2373	0.4286	0.4000	1.0000	—	—	—	0.51672

N.B. : (i) The variables not included in variable-space for VIS correlation are shown by dashes "—".

(ii) y', $y*$ and y refer to the same variable y respectively for 60-61, 70-71 and 80-81.

(iii) Z_1 and Z refer to agricultural production growth rate variable for 1st decade (60-61 to 70-71) and two decades (60-61 to 80-81) respectively.

Table (4.17) : VIS Regression Parameters for the Spatial Variation of Over-all Agricultural Development Index (D_A^* and D_A) and their Comparisons with OLS Parameters : 1960-61 to 70-71 and 1960-61 to 80-81

Explanatory variables	regression coefficient with standardised variables		regression coefficient with unstandardised variables		correlation coefficients		% share of contribution to total spatial variation explained by VIS regression
	VIS	OLS	VIS	OLS	VIS	OLS	
①	②	③	④	⑤	⑥	⑦	⑧
		Regression of D_A^* with reference period 60-61 to 70-71					
Constant	-	-	0.17481	0.22766	0.91064	0.92319	-
D'_A	0.40575	0.42351	0.52260	0.54548			33.40
F^*	0.26453	0.28775	0.19419	0.21123			14.20
L_2^*	0.36750	0.44133	0.11619	0.13953			27.40
Z_1	0.35104	0.16139	0.63747	0.29308			25.00
		Regression of D_A with reference period 60-61 to 80-81					
Constant	-	-	0.23511	0.26680	0.92299	0.92575	-
D'_A	0.36001	0.37497	0.49000	0.51037			28.97
F	0.33505	0.34466	0.12042	0.12387			25.10
L_2	0.32927	0.32220	0.11685	0.11434			24.24
Z	0.31152	0.22302	0.26057	0.18655			21.69

can be compared between the two periods of analysis by each explanatory factor except the growth rate for the two time-periods which are of different lengths. We have already pointed out in sub-section 4.2.3 that the marginal rates for growth rates Z and Z_1 become comparable when their reported values are multiplied respectively by 0.5910 and 0.2613 (= $\sqrt{1 + 0.5910} - 1$), because, then, these would be the regression coefficients for comparable location factors of growth rate, (Z/0.5910) and (Z_1/0.2613). Our analysis on the spatial patterns of agricultural development as explained by the factors considered are now summarised below on the basis of findings reported in Tables (4.10) to (4.17).

(i) Spatial variations in agricultural land productivity have been best explained in 4-space, both at mid-point 70-71 and terminal-point 80-81, by the same three explanatory factors, namely, 1. past base pattern of 60-61, 2. current fertiliser input pattern and 3. agricultural production growth rate pattern in the preceding period. This is revealed by the highest VIS correlation coefficients as shown in column (9) of Table (4.10) for the land productivity indices x_a^* and x_a at the two time-points. The remaining factor of foodgrain production surplus pattern does not show direct explanatory role as could be noticed from the fall in the value of VIS correlation coefficient for x_a^* and x_a shown in column (11) as compared with those of column (9) of Table (4.10). But as the surplus factor L_2^* and L_2 are most strongly influenced by growth factor Z_1 and Z respectively (ref. to correlation coefficients shown in column (6) for the two correlation matrices), the role of surplus factor could be considered indirectly accomplished through the growth factor. However our VIS correlation exercises reveal that direct inclusions of L_2^* and L_2 as explanatory factors of

x_a^* and x_a respectively are not necessary. This position is understandable on economic grounds also : past base, past growth and current fertiliser input could influence the current land productivity pattern, whereas the current foodgrain production surplus could reasonably be the outcome of current land productivity pattern or the past growth, and not the other way around.

(ii) As the explanatory factors are same for both x_a^* and x_a, the mode of explanation for land productivity as set in the 1st decade has simply continued subsequently, although this mode is more firmly set when the entire period of two decades is considered. This is revealed by a relatively higher magnitude of VLS correlation coefficient in the two decadal period as compared with those of 1st decadal estimates (a value of 0.9240 against 0.9183) shown in column (6) of Table (4.11). The OLS correlation coefficient for x_a^* in 1970-71 is however higher than that for x_a in 1980-81 (a value of 0.9509 against 0.9411), implying the presence of higher multicollinearity distortions initially in the 1st decade when the mode of explanation is not that firmly set.

(iii) Because of the multicollinearity and the axis-biased least squaring in the OLS regression procedure, the resulting OLS regression coefficients are sufficiently over-estimated for the past base factor and also underestimated tremendously for fertiliser-input factor and significantly for growth rate factor. The OLS under-estimation with fertiliser-input factor has been more pronounced in the 1st decade when multicollinearity disturbance has been relatively higher. Judging by the VLS estimates of marginal rates (i.e., regression coefficients with unstandardised explanatory factors shown in column (4) of Table (4.11)), the spatial change in land productivity between areal units occurred more in the 1st decade with respect to both past base and fertiliser input factors and it remained almost similar with respect to growth rate factor over the entire period (since 0.47353 x 0.2613 = 0.12373 is almost similar in magnitude to 0.12133 = 0.20529 x 0.591). Thus the tremendous improvements of the foodgrain supply requirement situation as observed in the 1st decade could be seen to be accounted matchingly by both past land productivity base and the increase in fertiliser input doses in the 1st decade itself. In fact, judging by the squared VLS regression coefficients with standardised variables, the relative contribution to the total spatial variation of land productivity as explained by past base factor was more than that by the current fertiliser input doses in 1970-71. The relative roles between the past base and fertiliser input factors got reversed in 1980-81 with the increase in time-gap from the past base year. Thus from the recorded figures of column (8) in Table (4.11), the past base factor explained 48.63 per cent of total spatial variation of x_a^*, fertiliser-input factor 38.44 per cent, and past growth rate factor 12.93 per cent in 1970-71, whereas in 1980-81, the past base factor explained 40.46 per cent of spatial variation of x_a, fertiliser input factor 45.02 per cent and the past growth rate factor 14.92 per cent. In this respect the fertiliser input dose gained more importance over the two decadal period for explaining the land productivity pattern.

(iv) Turning our attention now on labour productivity index, it could be noticed that its spatial variation had been best explained (and that too, very highly) only in 3-space, both at 1970-71 and 1980-81, by the same two explanatory factors : 1. past labour productivity base pattern and 2. the agricultural growth rate pattern in the preceding period (ref. to Table (4.12)). The other two factors, namely, the fertiliser-input pattern and the foodgrain production surplus pattern, do not play any direct explanatory roles to explain the labour productivity x_W^* in 1970-71 and x_W in 1980-81. From the correlation matrices of Table (4.12), we could easily notice that these two factors did not play much of special interacting roles towards the current labour productivity patterns of both 1970-71 and 1980-81 as constrasted with the past labour productivity base and also the preceding period's growth rate (note the narrow variations in the relevant correlation coefficients in columns (5) and (6) of Table (4.12)). Moreover, it could be also noticed that intercorrelations in the labour productivities between any two of the three time-points have been extremely high or very high. From this fact, it could be easily inferred that the past base labour productivity pattern must have remained dominant explanatory factor over the entire two decade period. The only other factor that could induce movements in the actual magnitudes in labour productivity had been the agricultural production growth rate.

(v) From the estimates of VLS regression coefficients shown in Table (4.13), the relatively dominant role of past base factor, as compared with the growth rate factor, could be numerically assessed. Thus the contribution to total spatial variation of current labour productivity in 1970-71 as explained by the past base factor was 56.22 per cent as against 43.78 per cent for growth rate factor and that in 1980-81 explained by the past base factor was 52.95 per cent as against 47.05 per cent for growth rate factor. Here, it could be noticed that the preceding period's growth rate factor has improved its explanatory role for the total spatial variation of labour productivity in 1980-81 as compared with that in 1970-71. In terms of VLS marginal rates similar conclusion could be drawn (note that 0.96988 x 0.591 = 0.5732 is of higher magnitude than 0.49106 = 1.87929 x 0.2613 with reference to estimates shown in column (4) of Table (4.13)). But the marginal rates of spatial change in labour productivity with respect to past labour productivity base increased in 1980-81 from 1970-71 position, while the relative explanatory role of the past base factor was more in 1970-71. This signifies that while the past base influence decreased with time-gap, the spatial disparity in labour productivity increased more and more among areal units in the forward time-path.

(vi) The cultivators' foodgrain surplus generating capability is the only constituent sub-index of agricultural development which has not been explained directly by the growth factor. The spatial variations in the cultivators' capability have been best explained in 4-space, by only the same three explanatory factors : 1. past base pattern of 1960-61, 2. current pattern of foodgrain production surplus from the whole agricultural community and 3. current pattern of fertiliser input. From a comparison of relative magnitudes of all VIS correlation coefficients shown for x_m^* and x_m in Table (4.14), we could also infer that none of the three explanatory factors identified can be dropped, nor the growth factor can be included for the best explanations of spatial variations of x_m^* and x_m. But the degree of statistical fit as shown for x_m^* and x_m in column (9) of this Table is only very high (VIS correlation coefficients 0.8331 and 0.8367 respectively for x_m^* and x_m), while it has been always extremely high (VIS correlation coefficients above 0.90) for other two constituent sub-indices of agricultural development. The unexplained part could have been reduced possibly by inclusion of some other explanatory factors like the amount of cultivating land owned per head of cultivators (this could be inferred from indirect evidence , but not checked here empirically). From the data of correlation matrices shown in Table (4.14) we could notice that L_2^* and L_2 are more inter-related than x_m^* and x_m with growth factors Z_1 and Z respectively. This explains why Z_1 and Z have not shown direct explanatory roles towards x^*_m and x_m. This means that growth factors have direct influence on L^*_2 and L_2 (supported earlier with the fact that the transformed indices Σ^*_2 and Σ_2 corresponding to L^*_2 and L_2, are mostly explained by the growth factors Z_1 and Z) and the influence of growth factors towards x^*_m and x_m enters only indirectly through transitive connection with L^*_2 and L_2.

(vii) From an analysis of VLS regression coefficients and related parameters shown in Table (4.15), we could infer that the cultivators' capability was best explained by the comprehensive capability of whole agricultural community for foodgrain production surplus generation. This explanatory role was slightly more pronounced in the 1st decade when the explanatory role of fertiliser-input pattern was quite lower. The explanatory role of fertiliser input, though low initially, had improved greatly in the forward time-path. However, the explanatory role of past base pattern of 1960-61 remained quite substantial over the entire two decade period, although it reduced slightly in relative magnitude with the increase in time-gap. This conclusion is derived from the appropriate VLS regression coefficients, and the role of past base pattern would have been significantly under-estimated, had we relied upon the usual OLS regression coefficients with standardised variables. Judging by the VLS marginal rates (same as the VLS regression coefficients shown in column (4) for unstandardised variables), the spatial change between areal units for x^*_m and x_m had remained more or less similar for all explanatory factors in the entire period of study under consideration. This is understandable, because we have already noticed that cultivators' capability has shown only very limited improvement along the forward time-path in the period under consideration.

(viii) Thus for all constituent sub-indices, the spatial patterns in 1970-71 and 1980-81 have been influenced by the respective past base patterns of 1960-61. Apart from the past base patterns, the most important explanatory factors have been the fertiliser input pattern for land productivity, the proceding periods' growth rate pattern for labour productivity and the comprehensive capability of agricultural community in foodgrain production surplus generation for cultivators' capability. The land productivity and the cultivators' capability have also been incluenced to some extent respectively by growth rate pattern and fertiliser input pattern, but the labour productivity has not been influenced directly by any other factor. As all the four explanatory factors have entered in some from or other in explaining the spatial patterns of different constituent sub-indices of agricultural development, it is quite natural to expect all the four factors explain the spatial variation of the over-all agricultural development D_A. Indeed, it has happened so. According to our estimates of VLS correlation coefficients shown in Table (4.16), spatial variations in the over-all agricultural development have been best explained only in 5-space and no less, both at mid-point 1970-71 and terminal point 1980-81, by the same four explanatory factors, namely, 1. past base pattern D_A' of 1960-61, 2. current fertiliser input pattern, 3. current foodgrain production surplus pattern from agricultural community and 4. agricultural production growth rate pattern of the preceding period. The VLS regression fit has been extremely high and it is higher for D_A in 1980-81 with reference to growth rate over entire two decade period (VLS correlation coefficients are of magnitude 0.911 for D_A^* in 1970-71 and 0.923 for D_A in 1980-81, as recorded in the last column of Table (4.16)).

(ix) The margin between the OLS and the VLS correlation coefficients as shown in columns (6) and (7) of Table (4.17) being quite small, particularly for D_A, the VLS and the corresponding OLS regression coefficients do not differ much, except for Z_1 and Z with under-estimated values of OLS regression coefficients — more with Z_1 and a little less with Z. Judging by the VLS marginal rates (same as the regression coefficients with unstandardised explanatory variables), the spatial change in values of D_A^* and D_A between areal units did differ much during the period of study with respect to each explanatory factor, including the growth rate (note that 0.63747 x 0.2613 = 0.1666 is not much away from 0.1540 = 0.26057 x 0.591 with reference to data shown in column (4) of Table (4.17)).

(x) On the basis of our calculations on VLS regression coefficients with standardised variables and related parameters shown in Table (4.17), the total spatial variation of D_A^* in 1970-71 was best explained by the past base pattern of 1960-61 (33.4 per cent contribution) and least explained by the current fertiliser input pattern (14.2 per cent contribution). The contributions of other two explanatory factors had been around the average value of 25 per cent each (with respect to a total of four explanatory factors). When the entire two decade period is considered, the explanatory role of fertiliser input pattern showed great improvements with over 25 per cent contribution to the total explained spatial variation of over-all agricultural development D_A in 1980-81. As a result of this, the relative roles of all other explanatory factors got a little reduced each in 1980-81 as compared with the respective 1970-71 situation. The contribution of all explanatory factors were however within a narrow range of values, between 21.7 and 29 per cent. However the highest explanatory role was played still by the past base pattern even for two decadal period of analysis. The explanatory role of fertiliser input factor became next in rank.

4.4 Growth Component Analysis of Agricultural Production and Productivity : The Mathematical Models and the Statistical Treatment

4.4.1 The Need for Growth Analysis

From the comparative spatial pattern analysis on foodgrain production surplus generation measures and agricultural development index together with its constituent sub-indices over the period of two decades between 1960-61 and 1980-81, we have identified the importance of the input factor of fertiliser dose for cropped land and also of the response factors of agricultural production growth rate and foodgrain production surplus generation from the agricultural community. By virtue of the strong explanatory roles of the fertiliser input factor as established for land productivity, there is no denying on the intensification role played by fertiliser doses in Indian agricultural scene during the period of study under consideration. The fertiliser dose is really the basic controllable factor for agricultural intensification, provided the associated inputs like assured water-supply or use of proper variety of seeds, etc., are guaranteed simultaneously. However, the two response factors named above are, as such, not the controllable factors for intensification, but they are the outcomes of intensification or some other kinds of efforts. Again, we have noted that the two response factors are not independent of each other. In fact, it has already been established that the response factor of agricultural production growth rate is more fundamental, and when the growth is assured beyond certain desirable limit, the other response factor of foodgrain surplus generation could follow automatically. It has also been established that the foodgrain supply-requirement pattern is also greatly explained by the growth rate pattern. Over and above this, the much desired progress of labour productivity has been explained substantially by the growth factor. Thus, this fundamental response factor of growth gains importance for detailed investigation. It is necessary for us now to investigate on the identification of the controllable factor or factors that induced differential spatial patterns of growth.

4.4.2 Brief Review on the Mathematical Models of Growth Component Analysis

As agricultural growth could be the outcome of intensification and other kinds of factors, our attempts would be now for decomposition of growth rates of agricultural production and productivity into component parts, separating into the intensification, the extension and some other important factors that induced agricultural progress in different degrees in space. In this connection we consider the mathematical models of Minhas and Vaidyanathan [1965, 1966], Pal [1971, 1976] and also of Pal and De [1979a, b], wherein the production and the productivity change rates between two time-points are split into several basic components and a number of all possible interaction components. The Minhas-Vaidyanathan model considered three basic component factors, namely, the component of " acreage change" (extension factor), the component of " yield rate change" (intensification factor) and the component of " crop-association change" (entrepreneurial factor). Pal's model considered four basic component factors, by replacing the '' acreage change" factor into two factors, namely " relative acreage change" and " agricultural labour employment change", and retaining the other two. The main contention in support of Pal's four factor model [1971] over Minhas' three factor model [1966] of agricultural growth is as follows :

> " As there had been a substantial increase of labour force without much opportunities for their employment in non-agricultural occupations during the reference period of decade 1951-61, as used in the Minhas-Vaidyanathan's related Indian study [1965], much of the acreage change occurred as a consequence, of the change in labour force".

Later, Pal and De [1979a] generalised the decomposition of agricultural growth into any number of basic component factors (say, m-factors) theoretically and examined different models empirically in Indian context over the period 1962-73. The results of their analysis have been that the three-factor model is better suited to explain the regional variations in agricultural growth by component factors, because of the presence of disguised unemployment of agricultural labour under the condition of Indian economic activities. All these models referred to above are for production change rates and Pal and De [1979b] proposed to tackle the labour aspect of agricultural activities in a productivity change rate model, over and above a corresponding production change rate model. Thus a four factor production change rate model would reduce to a three factor productivity change rate model. Pal and De [1979b] also gave a generalised m-factor productivity change rate model (corresponding to (m+1)-factor production change rate model). The generalisation for the decomposition into m basic component factors as shown by Pal and De [1979a, b] are as follows :

The number of basic factors is the same as the number of factors F_{kij}; k = 1, 2, ... , m, in the following product :

$$\varphi_{ij}^{(m)} = \prod_{k=1}^{m} F_{kij} , \qquad \ldots (4.1)$$

used to define total agricultural production Q_j of j-th year as follows :

$$Q_j = \sum_{i=1}^{n} W_i \ \varphi_{ij}^{(m)} , \qquad \ldots (4.2)$$

where W_i = constant price weights assigned to i-th crop; n being the total number of crops considered. Thus,

$$\varphi_{ij}^{(3)} = Y_{ij} \ A_j \ C_{ij} \qquad \ldots (4.3)$$

in the three factor model of Minhas-Vaidyanathan [1966] and

$$\varphi_{ij}^{(4)} = Y_{ij} \ R_j \ E_j \ C_{ij} \qquad \ldots (4.4)$$

in the four factor model of Pal [1971], where

Y_{ij} = yield rate per acre of i-th crop in j-th year,
A_j = gross cropped acreage in j-th year,
C_{ij} = proportion of A_j devoted to i-th crop
E_j = employment of agricultural labour in j-th year
$R_j = A_j/E_j$ = relative acreage per unit labour in j-th year.

Denoting a terminal year by suffix t and a base (or initial) year by o(i.e., j = o or t), the generalised m-factor model of production change rate is given by :

$$Z = (Q_t - Q_o)/Q_o$$

$$= \sum_{i=1}^{n} W_i \left(\prod_{k=1}^{m} F_{kit} - \prod_{k=1}^{m} F_{kio} \right) \Big/ \sum_{i=1}^{n} W_i \prod_{k=1}^{m} F_{kio} \quad .. (4.5)$$

and the mathematical identity can be written as :

$$Z = \sum_{s=1}^{m} f_s + I_m , \qquad ... (4.6)$$

where,

$$f_s = \sum_{i=1}^{n} W_i (F_{sit} - F_{sio}) \prod_{s \neq k}^{m} F_{kio} \Big/ \sum_{i=1}^{n} W_i \prod_{k=1}^{m} F_{kio}, \quad ... (4.7)$$

to be called the s-th <u>basic factor</u> of change with the change in only one s-thfactor over the period of time (0, t) in the numerator,

and I_m = sum of all interaction components of orders 2, 3, ..., m, where a r-th order interaction component $f_{s_1 ....s_r}$ is defined with changes in only r distinct factors, s_1th, ..., s_rth, over the time period between o-th and t-th years, in the numerator of defining equation (4.8) given below :

$$f_{s_1 ...s_r} = \sum_{i=1}^{n} W_i \prod_{u=1}^{r} (F_{s_u it} - F_{s_u io}) \prod_{s_u \neq k}^{m} F_{kio} \Big/ \sum_{i=1}^{n} W_i \prod_{k=1}^{m} F_{kio},$$

$$... (4.8)$$

There are $\binom{m}{r}$ number of such r-thorder interaction components, so that I_m is an aggregation of $[2^m - (m+1)]$ interaction components of all orders.

For a productivity change rate model, we have to take Q_j of equation (4.2) as a measure of productivity (i.e., production per unit labour) and the corresponding productivity change rate would be denoted by X instead of Z. The mathematical model identity for the productivity change rate would then be denoted by the following equations

$$X = \sum_{i=1}^{m} f_s + I_m^* \qquad \ldots (4.9)$$

In this I_m is replaced by I_m^* to distinguish between the aggregate interaction components of the production change rate and the productivity change rate models, but the basic factors are denoted by same notations, although some of the basic factors in the two model forms would be different.

The simpler cases of three factor production change rate model of Minhas, four factor production change rate model and three factor productivity change rate model of Pal can be written in simplified form as follows :

$$\left.\begin{array}{ll} & Z = f_1 + f_2 + f_3 + I_3 = Y + A + C + I_3, \text{ say} \\ & Z = f_1 + f_2 + f_3 + f_4 + I_4 = Y + C + R + E + I_4, \text{ say} \\ \text{and} & X = f_1 + f_2 + f_3 + I_3^* = Y + C + R + I_3^*, \text{ say} \end{array}\right\} \qquad \ldots(4.10)$$

where $Z = (Q_t - Q_o)/Q_o$, with

$$Q_j = \sum_{i=1}^{n} W_i \; Y_{ij} \; A_j \; C_{ij} = \sum_{i=1}^{n} W_i \; Y_{ij} \; C_{ij} \; R_j \; E_j,$$

$$X = (P_t - P_o)/P_o \text{ , with}$$

$$P_j = Q_j/E_j,$$

$$Y = \sum_i W_i (Y_{it} - Y_{io}) C_{io} / \sum_i W_i Y_{io} C_{io}$$

= basic factor of yield rate change in the period,

$$C = \sum_i W_i Y_{io} (C_{it} - C_{io}) / \sum_i W_i Y_{io} C_{io}$$

= basic factor of crop association change in the period,

$$A = (A_t - A_o)/A_o$$

= basic factor of acreage change in the period.

$$R = (R_t - R_o)/R_o$$

= basic factor of relative acreage change in the period,

$$E = (E_t - E_o)/E_o$$

= basic factor of labour change in the period.

and I_3 and I_4 are the aggregate interaction components of the three and the four factor models of production change rate and I_3^* is the same in the three factor model of productivity change rate.

Our empirical investigations would be on all three models as given in equations (4.10) for the total two-decade period 1960-81 and also for 1st and 2nd decades within this total period. The four factor production change rate model is interconnected with both the three factor production and productivity change rate models. It has extended the three factor production change rate model by replacement of basic factor A by the alternative pair R and E. Again the four factor production change rate model is simplified into the three factor productivity change rate model by transformation of Z and E by the related ratio X. Only the basic factors Y and C are common to all the three models. Obviously the model identity maintaining aggregate interaction components I_3, I_4 and I_3^* in the three models are not identical. The symbols used in the three models of equation (4.10) would refer to the entire two-decade period with 1960-61 as the base o-th year and 1980-81 as the terminal t-th year. These variables would be suffixed by 1 (namely, Z_1, X_1, Y_1, A_1, C_1, R_1, E_1, I_{31}, I_{41}, I_{31}^*) with reference to the period of 1st decade with 1960-61 base and 1970-71 terminal year. Again these variables would be suffixed by 2 (namely, Z_2, X_2, Y_2, A_2, C_2, R_2, E_2, I_{32}, I_{42}, I_{32}^*) with reference to the period of 2nd decade with 1970-71 base and 1980-81 terminal year.

4.4.3 Statistical Treatment on the Identification of Relative Roles of the Basic Component Factors in Explaining the Spatial Variation of Growth in Production and Productivity

Pal and De [1979a] have argued convincingly that the model identity relations as referred to in the preceding sub-section (ref. to equations (4.6), (4.9) and (4.10)) are not of much use, because of the existence of severe interpretative difficulty with the interaction components of different orders. They argue that, in the algebraic break-up of the model identity, the positive and negative signs with the basic component factors may be meaningfully interpreted. But there is an interpretative difficulty with the interaction component, since the product of two negative changes and also the product of two positive changes have to be the same positive quantity algebraically. As such there is no point in going for detailed analysis of all possible interaction components of different orders. According to their arguments, the aggregate interaction component could only be treated as the residual term in the model identity, which could be computed empirically by subtracting the sum of all basic component factors from the over-all growth rate in a model. Obviously this residual term of aggregate interaction component should preferably be of negligible magnitude as compared with that of over-all growth rate Z or X for a meaningful interpretation by its component basic factors. But this condition is hardly met in every areal unit of study in India. As such, likewise Pal and De's work for an earlier period on production change model [1979a], we have to ignore the residual interaction component I (or I^* for productivity change model) in the model identity and make additional regression analysis for the identification of important contributory component factors to explain the spatial variation in the over-all growth rate of agricultural production and productivity and also the relative importance of contributory factors.

Obviously the basic component factors of growth rate are not expected to be mutually unrelated. Pal and De realised this difficulty for identification of relative importances of component factors in explaining the stated spatial variation in distinct and unbiased forms by the usual axis-biased least-square fit of the OLS regression procedure which could not really be applied with multicollinear situations of variables when strict statistical rigour is to be adhered to. It is because of the realisation of this difficulty in a similar kind of study made for an earlier period /̅1979a _7, Pal and De developed the appropriate VLS procedure of regression analysis, eliminating the stated difficulty encountered in the OLS procedure of regression analysis. We would use the same VLS procedure of regression analysis /̅Pal and De 1979a _7 for our present study. The VLS regression estimation procedure has already been summarised earlier in subsection 3.6.3.

Our present study on the production growth rate differs from theirs, not only for the extended coverage of time-period with a view to further examine for the total result-oriented intensification phase in the Indian context, but also in the choice of size of areal unit of study. The coverage of crops is also not same for both the studies; while the present work deals with an array of 26 crops, it was only a subset of 19 crops for Pal and De /̅1979a and b _7. Their study used districts of India as areal units, while our areal units of study are sizable district groups with similar crop-association within each. Initially we also worked with districts as areal units, but that led to difficulties in proper identification of the role of basic factor C on crop association change, because of too much of areal disaggregation. Thus, ultimately we switched over to our analysis in the present form of areal units, for which the role of C has been better depicted. Again, the theoretical productivity model formulation of Pal and De /̅1979b _7 was not tested empirically by them, which would be attempted here for the first time. Results of our empirical investigations on growth rates of both agricultural production and productivity are presented in the following section.

4.5 Empirical Evaluation of the Best Fitting Combinations of Basic Components Explaining the Spatial Pattern of Agricultural Growth : 1960-71, 1970-81, 1960-81

4.5.1 Estimations related to Basic Growth Components of Production Model

We would consider all basic components related to both 3-factor and 4-factor production models together with the variable of over-all growth rate itself, for our discriminatory analysis to find the best empirical combination by the maximum value of VIS correlation coefficients. Thus our analysis begins in 5-space with variables Z_1, Y_1, A_1, C_1, E_1 for the period of 1st decade (1960-61 to 70-71), Z_2, Y_2, A_2, C_2, E_2 for the period of 2nd decade (1970-71 to 80-81), and Z, Y, A, C, E for the entire period of two decades (1960-61 to 80-81). With our data for the 151 areal units (district-groups) of India, we have the correlation matrices for the three periods as shown in Table (4.18). As the correlation matrices of this Table show that the best 2-space correlation coefficients have always been between the over-all growth of production and the corresponding yield rate change variables, the question of deletion of any of these two variables does not arise in our search for finding the best VIS correlation coefficient in differently reduced variable-spaces, from 5-space to 4-space and then to 3-space. Thus, after the computations of 5-space VIS correlation coefficients, we have gone for three possible 4-space calculations and next for two possible 3-space

Table (4.18) : Correlation Matrix for Spatial Variables on Components of Growth Rates related to Over-all Agricultural Production : 60-71, 70-81 and 60-81

Variables	correlation coefficient matrix				
(1)	(2)	(3)	(4)	(5)	(6)
		Reference period : 1960-61 to 1970-71			
Z_1	1.0000	0.8506	0.6052	0.4807	0.2171
Y_1	0.8506	1.0000	0.2065	0.3594	0.1493
A_1	0.6052	0.2065	1.0000	0.0058	0.3121
C_1	0.4807	0.3594	0.0058	1.0000	-0.1887
E_1	0.2171	0.1493	0.3121	-0.1887	1.0000
		Reference period : 1970-71 to 1980-81			
Z_2	1.0000	0.8530	0.5728	0.3300	-0.0134
Y_2	0.8530	1.0000	0.2502	0.0866	-0.0936
A_2	0.5728	0.2502	1.0000	-0.1072	0.0553
C_2	0.3300	0.0866	-0.1072	1.0000	0.1013
E_2	-0.0134	-0.0936	0.0553	0.1013	1.0000
		Reference period : 1960-61 to 1980-81			
Z	1.0000	0.8822	0.6762	0.4729	0.1539
Y	0.8822	1.0000	0.3665	0.2773	0.0451
A	0.6762	0.3665	1.0000	0.1267	0.2746
C	0.4729	0.2773	0.1267	1.0000	0.0413
E	0.1539	0.0451	0.2746	0.0413	1.0000

N.B. : (i) u_1, u_2 and u refer to the same spatial variable u respectively for 1st decade (60-61 to 70-71), 2nd decade (70-71 to 80-81) and two decades (60-61 to 80-81).

(ii) Z is agricultural production growth rate and its components are Y, A, C and E, refering respectively to yield rate change, acreage change, crop-association change and agricultural labour employment change.

calculations by deleting variables further from the best 4-space combinations. The estimates of all these VLS correlation coefficients are presented in Table (4.19). On the basis of these VLS correlation coefficients, once the discrimination for the best dependent variable together with the corresponding best combination of explanatory variables is completed, the corresponding estimates of regression coefficients and related parameters are presented in Table (4.20). Likewise any other VLS regression analyses done earlier, the present analysis also incorporates both VLS and OLS regression and correlation coefficients in Table (4.20) for the purpose of comparison. Our ultimate conclusions, particularly on the relative importances of explanatory variables, are however drawn on the basis of VLS regression coefficients (with standardised variables), for reasons already stated. Again in the discrimination made by VLS correlation coefficients, the best and the next-best combinations are observed to be very close, especially for the reference period of 1st and 2nd decade separately. Fisher's Z-test shows that the best and the next best VLS correlation coefficients are not significantly different from each other at 5 per cent level of chance for the 1st and the 2nd decades separately. However, when the reference period is taken over the entire two decades, the difference between the best and the next-best VLS correlation coefficients is very highly significant, even at less than 1 per cent level of chance. Anyway, for our interest in the relative performances of the " agricultural labour change" component of growth in the 1st and 2nd decade (E_1 and E_2 respectively), we have also shown in Table (4.21) the estimates of

Table (4.19) : VLS Correlation Coefficients for Spatial Variables on Components of Growth Rates related to Over-all Agricultural Production : 60-71, 70-81 and 60-81

variables	VLS correlation coefficient $r_{u\hat{u}}$					
	5-space	4-space	4-space	4-space	3-space	3-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reference period : 1960-61 to 1970-71						
$u = Z_1$	0.96542	0.86187	0.88438	0.96694	0.83598	0.95140
$u = Y_1$	0.67723	0.76149	0.61451	0.68832	0.74730	0.65492
$u = A_1$	0.41502	–	0.48064	0.37192	–	0.43696
$u = C_1$	0.32852	0.40786	–	0.37653	0.43806	–
$u = E_1$	0.18602	0.10351	0.26001	–	–	–
Reference period : 1970-71 to 1980-81						
$u = Z_2$	0.97196	0.88201	0.91848	0.97229	0.88407	0.91969
$u = Y_2$	0.67713	0.74000	0.68510	0.67489	0.73308	0.68136
$u = A_2$	0.40298	–	0.43469	0.40380	–	0.43729
$u = C_2$	0.15528	0.21613	–	0.15651	0.22023	–
$u = E_2$	0.01411	0.02911	0.02665	–	–	–
Reference period : 1960-61 to 1980-81						
$u = Z$	0.96122	0.89224	0.92356	0.97762	0.88638	0.95071
$u = Y$	0.68234	0.73325	0.68244	0.70487	0.74502	0.71775
$u = A$	0.53572	–	0.57584	0.51022	–	0.54654
$u = C$	0.34666	0.38846	–	0.35245	0.38992	–
$u = E$	0.16504	0.10095	0.17517	–	–	–

N.B. : The variables not included in the variable-space are shown by dashes "—".

Table (4.20) : VLS Regression Parameters for the Spatial Variation in Growth Rates of Over-all Agricultural Production (Z_1, Z_2 and Z) and their Comparisons with OLS Parameters : 60-71, 70-81 and 60-81

Explanatory variables	regression coefficients with				correlation coefficient		% share of contribution to total spatial variation explained by VLS regression
	standardised variables		unstandardised variables				
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Regression of Z_1 with reference period 60-61 to 70-71						
Constant	-	-	-0.01699	-0.03567	0.96694	0.98240	-
Y_1	0.60905	0.66907	1.06804	1.17330			52.64
A_1	0.40655	0.46566	1.25919	1.44227			23.45
C_1	0.41048	0.23754	2.11053	1.22132			23.91
	Regression of Z_2 with reference period 70-71 to 80-81						
Constant	-	-	-0.01603	-0.01088	0.97229	0.98038	-
Y_2	0.70249	0.71915	1.10226	1.12842			60.87
A_2	0.51479	0.42647	1.33946	1.10965			32.69
C_2	0.22843	0.31344	0.63243	0.86779			6.44
	Regression of Z with reference period 60-61 to 80-81						
Constant	-	-	-0.15218	-0.15971	0.97762	0.98674	-
Y	0.56190	0.66976	1.10314	1.31489			48.52
A	0.46165	0.40078	2.11474	1.83592			32.75
C	0.34917	0.23640	2.20627	1.49371			18.73

Table (4.21) : VLS Regression Parameters for the Spatial Variation in Growth Rates of Over-all Agricultural Production (Z_1, Z_2 and Z) and their Comparisons with OLS Parameters : 60-71, 70-81 and 60-81

Explanatory variables	regression coefficients with				correlation coefficient		% share of contribution to total spatial variation explained by VLS regression
	standardised variables		unstandardised variables				
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Regression of Z_1 with reference period 60-61 to 70-71						
Constant	-	-	-0.06954	-0.04075	0.96542	0.98262	-
Y_1	0.57735	0.66438	1.01245	1.16507			49.30
A_1	0.42030	0.45866	1.30177	1.42060			26.12
C_1	0.34921	0.24405	1.79553	1.25484			18.04
E_1	0.21031	0.02540	0.40307	0.04868			6.54
	Regression of Z_2 with reference period 70-71 to 80-81						
Constant	-	-	-0.00975	-0.01046	0.97196	0.98040	-
Y_2	0.70318	0.71901	1.10334	1.12819			61.03
A_2	0.51371	0.42662	1.33663	1.11003			32.57
C_2	0.22656	0.31362	0.62726	0.86829			6.34
E_2	-0.02116	-0.00147	-0.04258	-0.00295			0.06
	Regression of Z with reference period 60-61 to 80-81						
Constant	-	-	-0.27005	-0.16289	0.96122	0.98675	-
Y	0.52694	0.67006	1.03450	1.31547			44.86
A	0.45430	0.39953	2.08107	1.83018			33.34
C	0.32709	0.23630	2.06678	1.49309			17.28
E	0.16721	0.00421	0.47918	0.01207			4.52

regression coefficients of the next-best combination also, which includes this variable additionally.

4.5.2 Estimations related to Basic Growth Components of Productivity Model

In 3-factor productivity model, the basic components and the over-all productivity growth rate are four in number. Basic components like Y and C are common to both 3-factor production and 3-factor productivity models, while the basic factor of acreage change A in production model is replaced by the relative acreage change R in productivity model. We have included A as the fifth external variable in our discriminatory analysis for best fitting combination to explain the productivity growth. Further inclusion of external variable E, a basic component in 4-factor production model, is not possible since A, R and E are identically connected with the relation $(1+E)\ (1+R) = (1+A)$. As E is already involved in the calculations of both X and R of productivity model, we excluded E and preferred A as the fifth variable additionally to examine whether or not the in-built basic components alone are sufficient for explaining the productivity growth. Incidentally it should be noted that, in case of our estimations with production growth made in sub-section 4.5.1, all the factors included were inbuilt basic components of 4-factor production model. No external factor could be incorporated in the discriminatory analysis made therein, because the possible external factors available could have been X or R. But for existence of identity relations : $(1+E)(1+X) = (1+Z)$ and $(1+E)(1+R) = (1+A)$, none of them could be considered in the preceding discriminatory analysis by VLS correlation coefficients. In the present analysis we have also to begin our investigations in 5-space with variables X_1, Y_1, C_1, R_1, A_1 for the period of 1st decade (1960-61 to 70-71), X_2, Y_2, C_2, R_2, A_2 for the period of 2nd decade (1970-71 to 80-81), and X, Y, C, R, A for the entire period of two decades (1960-61 to 80-81). The correlation matrices of these variables are presented in Table (4.22). From the estimates shown in these correlation matrices, here also we notice that the best 2-space correlation coefficients have always been between the over-all growth of productivity and the corresponding yield rate change variables. So, these two variables could not be deleted in our search for finding the best VLS correlation coefficient in differently reduced variable-spaces from the starting 5-space. Thus, here also, after the computation of 5-space VLS correlation coefficients, we have gone for three possible 4-space calculations and then for two possible 3-space calculations by deleting variables further from the best 4-space combinations. The estimated values of all these VLS correlation coefficients are reported in Table (4.23). Finally the detailed estimates of parameters for the best discriminated VLS regression are presented in Table (4.24) in the same way as we did earlier in Table (4.20). Here the best discriminated relationships are significantly established (in the statistical sense), when we consider the entire period of two decades and also when the period is the 2nd decade, but it is not so in the initial period of 1st decade. As such the question of any comparative study between the estimates of two separate decades does not arise with

Table (4.22) : Correlation Matrix for Spatial Variables on Components of Growth Rates related to Over-all Agricultural Labour Productivity : 60-71, 70-81 and 60-81

Variables	Correlation coefficient matrix				
(1)	(2)	(3)	(4)	(5)	(6)
		Reference period : 1960-61 to 1970-71			
X_1	1.0000	0.7401	0.5704	0.5953	0.4041
Y_1	0.7401	1.0000	0.3594	0.0685	0.2065
C_1	0.5704	0.3594	1.0000	0.0732	0.0058
R_1	0.5953	0.0685	0.0732	1.0000	0.3987
A_1	0.4041	0.2065	0.0058	0.3987	1.0000
		Reference period : 1970-71 to 1980-81			
X_2	1.0000	0.7800	0.2331	0.7079	0.4694
Y_2	0.7800	1.0000	0.0866	0.2389	0.2502
C_2	0.2331	0.0866	1.0000	-0.1523	-0.1072
R_2	0.7079	0.2389	-0.1523	1.0000	0.6126
A_2	0.4694	0.2502	-0.1072	0.6126	1.0000
		Reference period : 1960-61 to 1980-81			
X	1.0000	0.8384	0.4373	0.6140	0.5276
Y	0.8384	1.0000	0.2773	0.1880	0.3665
C	0.4373	0.2773	1.0000	0.0260	0.1267
R	0.6140	0.1880	0.0260	1.0000	0.4163
A	0.5276	0.3665	0.1267	0.4163	1.0000

N.B. : (i) u_1, u_2 and u refer to the same spatial variable u respectively for 1st decade (60-61 to 70-71), 2nd decade (70-71 to 80-81) and two decades (60-61 to 80-81).

(ii) X is agricultural labour productivity growth rate and its components are Y, C, R, A, refering respectively to yield rate change, crop-association change, relative acreage change and acreage change.

Table (4.23) : VLS Correlation Coefficients for Spatial Variables on Components of Growth Rates related to Over-all Agricultural Labour Productivity : 60-71, 70-81 and 60-81

Variables	VLS correlation coefficient $r_{u\hat{u}}$					
	5-space	4-space	4-space	4-space	3-space	3-space
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reference period : 1960-61 to 1970-71						
$u = X_1$	0.94239	0.84432	0.85519	0.94384	0.91927	0.80082
$u = Y_1$	0.54103	0.47708	0.63900	0.56536	0.52681	0.64368
$u = C_1$	0.39651	-	0.45308	0.45937	-	0.50365
$u = R_1$	0.40818	0.46633	-	0.33206	0.38710	-
$u = A_1$	0.35180	0.41779	0.26795	-	-	-
Reference period : 1970-71 to 1980-81						
$u = X_2$	0.86720	0.85724	0.84481	0.97342	0.94641	0.78862
$u = Y_2$	0.52565	0.52218	0.65731	0.59590	0.58924	0.70800
$u = C_2$	0.03202	-	0.11455	0.08738	-	0.17078
$u = R_2$	0.64442	0.65115	-	0.50234	0.52656	-
$u = A_2$	0.52532	0.52995	0.36250	-	-	-
Reference period : 1960-61 to 1980-81						
$u = X$	0.94042	0.90052	0.87507	0.97292	0.95436	0.83663
$u = Y$	0.63147	0.61063	0.70755	0.64949	0.63682	0.72201
$u = C$	0.30233	-	0.34734	0.32674	-	0.37499
$u = R$	0.45274	0.49016	-	0.38810	0.43582	-
$u = A$	0.50198	0.52150	0.44193	-	-	-

N.B. : The variables not included in the variable-space are shown by dashes " __ ".

Table (4.24) : VLS Regression Parameters for the Spatial Variation in Growth Rates of Over-all Agricultural Labour Productivity (X_1, X_2 and X) and their Comparisons with OLS Parameters : 60-71, 70-81 and 60-81

Explanatory variables	regression coefficients with				correlation coefficient		% share of contribution to total spatial variation explained by VLS regression
	standardised variables		unstandardised variables				
	VLS	OLS	VLS	OLS	VLS	OLS	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Regression of X_1 with reference period 60-61 to 70-71						
Constant	-	-	-0.00738	0.01738	0.94384	0.96676	-
Y_1	0.56881	0.58871	0.86449	0.89473			44.90
C_1	0.49610	0.31991	2.21066	1.42553			34.15
R_1	0.38858	0.53156	0.80744	1.10454			20.95
	Regression of X_2 with reference period 70-71 to 80-81						
Constant	-	-	0.00933	0.01088	0.97342	0.98383	-
Y_2	0.66185	0.61239	1.05168	0.97309			53.81
C_2	0.13066	0.27191	0.36632	0.76235			2.10
R_2	0.59905	0.60301	1.17473	1.18249			44.09
	Regression of X with reference period 60-61 to 80-81						
Constant	-	-	0.01902	0.02819	0.97292	0.98487	-
Y	0.62459	0.68297	0.92290	1.00916			52.53
C	0.39053	0.23545	1.85725	1.11971			20.54
R	0.44722	0.47948	1.37411	1.47323			26.93

the next-best VIS regression of the 1st decade, even though it is not significantly different from the estimates of corresponding best VIS regression.

4.5.3 Findings on the Explanatory Roles of Basic Growth Factors for the Production and the Productivity Changes

The data reported in the preceding two sub-sections would now be analysed. It should be noted that our growth analysis for the entire two decadal period is our prime concern and the two sub-period estimations shown above are only to identify the relative performance between them. For the similarity of time-gap, the two sub-period estimates are comparable. But for the non-linear identity constraint in growth rates of the form

$$(1 + u_1)\ (1 + u_2) = (1 + u)$$

which hold for u = Z, X, A, R and E (and not for Y and C), linear VIS regression estimates for the entire two-decade are not strictly comparable with any of those for any of the singe decades. There are two possible alternatives : either accept the two single-decade estimations without any regard for the total two-decadal estimations, or accept only the entire two-decadal estimations. As we are interested in the entire intensification phase of the Indian agricultural economy between 1960-61 and 1980-81, we would depend our main analysis on the second alternative of entire period's analysis, although the relative performances between the two sub-periods would be judged by use of corresponding comparable estimates.

Pal and De [1979 a] have developed and used a rigorous test procedure through a screening of the VLS regression procedure by maximum likelihood model. According to this procedure, any computed VLS correlation coefficient $r_{u\hat{u}}$ is to be compared for closeness with the corresponding $r^{*}_{u\hat{u}}$ (estimation formula not shown here) which is the possible lower limit of the correlation coefficient satisfying certain maximum likelihood condition for multicollinear variables. The comparison of $r_{u\hat{u}}$ and $r^{*}_{u\hat{u}}$ is done by the usual Z-test for correlation coefficients due to R.A. Fisher [1954]. For the high magnitude of VLS correlation coefficients as obtained for our best-fitting VLS regressions, this maximum likelihood screening test could easily be satisfied, but the details of computation are not reported here. We have rather applied Fisher's Z-test to show whether any of our best VLS correlation coefficients is significantly above all other relevant values under consideration. For this we would find that critical value of correlation coefficient below which all values will be significantly different from any best VLS correlation coefficient at 5 per cent level of chance. We would also show the t-statistic related to Fisher's Z-test for comparison between the best and the corresponding next-best VLS correlation coefficients. The Fisher's Z-function corresponding to correlation coefficients $r_{u\hat{u}}$ and $r'_{u\hat{u}}$ are denoted as follows :

$$Z_u = \frac{1}{2} \ln \left(\frac{1 + r_{u\hat{u}}}{1 - r_{u\hat{u}}} \right), \qquad Z'_u = \frac{1}{2} \ln \left(\frac{1 + r'_{u\hat{u}}}{1 - r'_{u\hat{u}}} \right)$$

The test function,

$t_u = \sqrt{N-3} \left| Z_u - Z_u \right|$; N = total no. of observations, which follows student's t-distribution (with N-3 degrees of freedom), is used to examine whether $r_{u\hat{u}}$ is significantly different from $r'_{u\hat{u}}$ or not.

From the estimates of Tables (4.19) and (4.23), we can identify that the best VIS correlation coefficient is obtained in 4-space for both production and productivity growth rates with the combination of basic components as shown for 3-factor models. For production growth rate, the next-best fits have however occurred with the combination of basic components of the 4-factor model for all the three reference periods. For productivity growth rate, the next-best fit has occurred in the 1st decade with addition of the external basic component of acreage change, but in the other two reference periods, the basic component of crop-association change is dropped out for the next-best fit. With these data we applied the test procedure for statistical significance just described in the preceding paragraph. The results of the test are recorded in Table (4.25).

According to these results, the best-fitting combinations are firmly established for both production and productivity growth rates, when the entire two-decade period is considered. And the combinations of explanatory factors for both, corroborate the 3-factor model split of basic components. But when the single decade sub-periods are considered the same best-fitting 3-factor model split of basic components does not get so firmly established with statistical significance, except for the

Table (4.25) : Results of Statistical Significance Tests for Best-fit VLS Correlations on Agricultural Growth Rates

Variables	VLS correlation coefficients			t_u-value	
	$r_{u\hat{u}}$ best-value	$r'_{u\hat{u}}$		best Vs. critical	best Vs. next-best
		critical value	next-best value		
(1)	(2)	(3)	(4)	(5)	(6)
$u = Z_1$	0.96694	0.95465	0.96542	1.96	0.278
$u = Z_2$	0.97229	0.96195	0.97196	1.96	0.073
$u = Z$	0.97762	0.96924	0.96122	1.96	3.395(**)
$u = X_1$	0.94384	0.92330	0.94239	1.96	0.160
$u = X_2$	0.97342	0.96349	0.94641	1.96	4.349(**)
$u = X$	0.97292	0.96281	0.95436	1.96	3.233(**)

N.B. : (**) stands for very highly significant value at less than 1 per cent level of chance.

productivity growth rate in the 2nd decade. For the production growth rate in each subperiod, the same 4-factor model split of basic components corroborates the next-best fitting combination which is not significantly different from the corresponding best fitting combination with 3-factor model split. In this respect, the sub-period results are at least similar for only the production growth rates, but not for the productivity growth rates. All these go in favour of our earlier stand that the entire two decadal period should better be considered for agricultural growth rate analysis and the contributing factors to spatial variations in growth. Thus we can summarise our findings as follows, with further support from our detailed estimates of the best VLS regressions in Tables (4.20) and (4.24) and also the next-best VLS regressions on single decadal production growth in Table (4.21) :

(i) The spatial variation in agricultural growth in the two-decadal period has been sufficiently accounted, both for production and productivity (VLS correlation coefficients as high as 0.978 and 0.973 respectively), by the three basic components; for agricultural production growth, these are : (1) the intensification factor of land-yield rate change, (2) the extension factor of cropped acreage change, and (3) the entrepreneurial factor of crop association change. For agricultural labour productivity growth, the explanatory extension factor gets a replacement from " acreage change" to " relative acreage change", while the other two factors remain the same as before. The relative importance of these three factors in explaining the total spatial variation of agricultural growth is not however the same.

(ii) The intensification factor of yield rate change has been by far the most important contributory factor to agricultural growth, explaining about half the total spatial variation (to be exact, about 48.52 per cent variation of production growth and about 52.53 per cent variation of productivity growth). The contributory role of intensification factor has however improved to some extent in the 2nd decade as compared with that in the 1st decade. This however corroborates with the incidences of more use of fertiliser in the 2nd decade.

(iii) The next important contributory factor to agricultural growth has been the extension factor of acreage or relative acreage change. The " acreage change" factor has explained about 32.75 per cent variation of production growth and the "relative acreage change" factor, about 26.93 per cent variation of productivity growth. The incidence of labour pressure on cropped land is reflected in the fall of relative contributory role of extension factor for the change from production growth to productivity growth. The contributory role of extension factor has also improved in the second decade, likewise that of the intensification factor.

(iv) The least important contributory factor has been the entrepreneurial factor of crop association change to agricultural growth, explaining more or less a fifth of total spatial variation (to be exact, about 18.73 per cent variation of production growth and about 20.54 per cent variation of productivity growth). The crop association change follows largely due to entrepreneurial decision-making by the land-owning cultivators. Thus the cultivators' implicit contributory role to agricultural growth has not only become the least relative to other two-factors, but also deteriorated greatly in the 2nd decade. With the substantial improvement made in the foodgrain surplus-deficit situation in the 1st decade itself, a sort of statusquo has been maintained in the crop-association pattern over the 2nd decade, without going for any further innovative entrepreneurial move for the betterment of over-all agricultural growth.

(v) To reveal the relative situation of labour pressure on the agricultural sector between the two sub-periods, we would now refer to Table (4.21) for each decade's VLS regression with the additional basic component of labour change, explaining the production growth with 4-factor model split. Statistically these fits for the two single-decades are almost as significantly very high as the corresponding fits with 3-factor model split. Judging by the VLS regression coefficients, the basic component of labour change showed a positive role to agricultural production growth in the 1st decade, although its magnitude was much lower than even that of the crop association change factor. But this component showed a reverse role to agricultural growth in the second decade. The standardised VLS regression coefficient of the labour change factor changed from a positive value of 0.2103 in the 1st decade to a negative value of -0.0212 in the 2nd decade. This reversing in the role of labour change factor was even more sharply brought out when we have made the comparison by unstandardised VLS regression coefficients. It should be noted that this change of role of labour change factor between the two single decades could not be well brought out, had we depended on the OLS regression coefficients for the comparison (which is not appropriate for reasons stated earlier time and again). Our substantive conclusions on the comparative performance of the other three basic components would remain same whether we go by 4-factor production model split or by any 3-factor model split.

(vi) In view of the over-whelmingly important explanatory role of the intensification growth factor in explaining both production growth and productivity growth, we now introduce the correlation matrix in an additional Table (4.26) to examine their detailed inter-period and between variable relationships for any pair. This correlation matrix is, shown for 11 variables, Z, Z_1, Z_2, Z_2', X, X_1, X_2, X_2', Y, Y_1 and Y_2. The two additional variables $Z_2' = (Z - Z_1)$ and $X_2' = (X - X_1)$ are really the proportionate growth rates for the second decade relative to 1960-61 base level (same base level as used in Z, Z_1, X and X_1, but not in Z_2 and X_2). The estimates reported in this correlation matrix show nothing but high (.60 to .80) and very high (.80 and above) mutual inter-correlations. The correlation coefficient can at times be of a little lower magnitude (.55 to .60) when one of the variables involved is a single-decade productivity growth variable. In fact, it is

Table (4.26) : Relationships for Inter-period Growth Rates of Agricultural Production, Labour Productivity and Yield Rate Component : 1960-81, 1960-71 and 1970-81

Variables on growth rates	correlation coefficients										
	Z	Z_1	Z_2	Z_2'	X	X_1	X_2	X_2'	Y_1	Y_2	Y_3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Z	1.0000										
Z_1	0.9494	1.0000									
Z_2	0.8635	0.6742	1.0000								
$Z_2' = Z-Z_1$	0.9738	0.8530	0.9464	1.0000							
X	0.8964	0.8507	0.7823	0.8697	1.0000						
X_1	0.7897	0.8393	0.5585	0.7042	0.9022	1.0000					
X_2	0.7451	0.5856	0.8694	0.8138	0.8359	0.5467	1.0000				
$X_2' = X-X_1$	0.8462	0.7298	0.8531	0.8774	0.9299	0.6802	0.9542	1.0000			
Y	0.8822	0.8321	0.8004	0.8630	0.8384	0.7302	0.7345	0.8083	1.0000		
Y_1	0.8312	0.8506	0.6511	0.7651	0.7956	0.7401	0.6047	0.7207	0.9340	1.0000	
Y_2	0.7683	0.6363	0.8530	0.8156	0.7374	0.5696	0.7800	0.7673	0.8993	0.7035	1.0000

N.B. : Spatial variables u, u_1 and u_2 refer to the proportionate growth rates or component growth rates, respectively for the periods of two-decade, 1st decade and 2nd decade for $u = Z, X$ and Y. The spatial variable $u_2' = (u - u_1)$ refers to the same for the 2nd decade relative to 1960-61 base level for $u = Z$ and X only.

about 0.55 for the pair (X_1, X_2), about 0.56 for (X_1, Z_2) and 0.59 for (X_2, Z_1). For inter-period growth rates of same variety, the value of correlation coefficient is the least (0.55) for productivity growth pair (X_1, X_2), which improves to 0.67 and 0.70 respectively for production growth pair (Z_1, Z_2) and intensification growth pair (Y_1, Y_2). The labour pressure on agricultural sector has been responsible for the least inter-period agreement for labour productivity growth, while stability in intensification efforts showed much better agreement for both land-yield rate growth and production growth.

(vii) The relationship between production growth and labour productivity growth, which has not been examined yet in view of our treatment for separate model split, can now be investigated from the data reported in the present correlation matrix. The relationship has always remained very high in all periods. The relevant correlation coefficient was as high as 0.8964 in two-decade period, 0.8393 in the 1st decade, and, in the 2nd decade, it was 0.8694 for the pair (Z_2, X_2) which improves to 0.8774 for the pair (Z'_2, X'_2). This explains why the growth factor Z turned out to be the major explanatory factor of labour productivity index x_w in our earlier analysis. As the intensification factor of yield rate change played an overwhelmingly major role in explaining both production and productivity growths, we can infer that the spatial pattern of labour productivity gets explained ultimately, to a great extent, by the intensification growth. A similar kind of inference could be drawn for the foodgrain surplus measure Σ_2 also, which gets explained mostly by Z. In summary, the intensification growth factor can be said to be behind the scene of various spatial manifestations of agricultural progress in India during the period between 1960-61 and 1980-81.

4.6 Interaction Study on Growth Factors, Spatial Measures of Agricultural Progress and Crop-Concentrations

Having identified the relative importances of the three growth components, namely 1. the intensification-growth component, Y, 2. the extension-growth component A and 3. the entrepreneurial-growth component C, we would now investigate how they have interacted with various spatial measures of agricultural progress and crop-concentrations. In the present study the extension factor is in the form of acreage change. Its other form, namely, the relative acreage change R, has not been taken into account for our present purpose, since it is in a mixed up form with labour-change factor E. Moreover, we have the following common sort of identity relations :

$$\frac{Z - X}{1 + X} = E = \frac{A - R}{1 + R},$$

and it is better to see the labour pressure aspect as emanated from E through X, rather than R. In fact, the labour pressure aspect on the agricultural sector is best evaluated through the spatial variation in labour productivity x_w (which we have mapped and analysed already in Chapter 3). Its combined study with X only adds to further knowledge about the situation that existed in the base year. If the past situation is of no further importance for forward planning, the consideration of X could even be abandoned. However, we have considered both Z and X now to identify the interactions of over-all production growth and productivity growth factors with other spatial measures.

Important spatial measures for agricultural progress differentiation as already formulated and analysed are again considered here for this interaction study. These spatial measures are F, Σ_2, x_m, x_a, x_w and D_A. It has been noted that the fertiliser input norm F is really the intensification-inducing factor, as already exhibited by its very high relationship with land productivity index x_a. As the base year fertiliser input F' has been generally very low, we have faced the usual problem of growth rate calculations for fertiliser consumption by areal units with near-zero values often at the base year. So we could not empirically establish the intensification-inducing role of fertiliser from the growth rate of its consumption by the relationship with yield rate change factor Y. However, we have noted the progressively improved relationships between F and x_a in the forward time-path from 1960-61 to 1980-81. From this we could infer that there must be strong relationship between the growth rate of fertiliser consumption with the yield rate change component of growth Y. With these arguments we take for granted the intensification-inducing role of fertiliser on Y also, as we have by F on x_a. It should be noted that this role of fertiliser cannot be properly depicted by the relationship between F and Y. However we have included F for our present study to examine its interaction with different crop-concentrations.

Crop-concentration indices have been formulated and crop-regions are demarcated in Chapter 2. As most of the crops cannot be and have not been wide-spread in a vast country like India with its wide climatic and soil-quality variation, crop-concentration indices are not supposed to have very good inter-correlations with many wide-spread spatial variables. Yet we have included most of the crop-concentration indices here for our interaction study, only to get an idea about their comparative interaction levels. Statistically, for 148 (=N-3) degrees of freedom, a value of correlation coefficient of about 0.16 can be considered significantly different from zero at 5 per cent level of chance. We have considered all those crop concentration indices here which have at least one significant inter-correlation with other spatial measures and growth factors included for the interaction study. Thus we have considered the following crops : Wheat, rice, minor foodgrains (jowar + bajra + ragi), other foodgrains (maize + barley + gram + tur), oilseeds (mainly groundnut + mustard (including rapeseed) + sesamum + linseed + castor seed), fibre crops (mainly cotton + jute + mesta), sugarcane, spices (mainly dry chillies + black pepper + turmeric + dry ginger), plantation crops (mainly tea + coffee). With all these selected spatial measures and growth factors we make our attempts for the interaction study with the help of correlation matrix as presented in Table (4.27). It is however not a full form of correlation matrix; we have not shown here the inter-correlations between crops (for brevity only), except for wheat with others. However, we may quote the necessary correlation coefficients, if needed during the analysis. Based on this correlation matrix, the findings of our interaction study are summarised below :

(i) The most important feature revealed from an analysis of intercorrelations is that the wheat-producing areas have taken the maximum advantage of all growth factors. The

Table (4.27) : Correlation Matrix for Growth-components, Fertiliser-input, Foodgrain-surplus and Agricultural Development Measures and their Inter-correlations with crops

spatial variables	correlation coefficients											
	Z	X	Y	A	C	F	Σ_2	x_m	x_a	x_w	D_A	Wheat
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1. Z	1.0000											
2. X	0.8964	1.0000										
3. Y	0.8822	0.8384	1.0000									
4. A	0.6762	0.5276	0.3665	1.0000								
5. C	0.4729	0.4373	0.2773	0.1267	1.0000							
6. F	0.4286	0.3992	0.3572	0.3035	0.1701	1.0000						
7. Σ_2	0.7779	0.6931	0.6072	0.6131	0.3128	0.4211	1.0000					
8. x_m	0.3266	0.2718	0.2953	0.2216	0.1768	0.3771	0.5492	1.0000				
9. x_a	0.4083	0.3742	0.3554	0.3303	0.0823	0.8110	0.3941	0.4074	1.0000			
10. x_w	0.7670	0.6749	0.6058	0.6177	0.3270	0.4558	0.7837	0.4892	0.5640	1.0000		
11. D_A	0.5886	0.5170	0.4964	0.4555	0.2287	0.6795	0.6916	0.8094	0.8094	0.8094	1.0000	
12. Wheat	0.7168	0.6893	0.5743	0.5009	0.3680	0.1972	0.7365	0.2721	0.1056	0.6235	0.3841	1.0000
13. Rice	−0.0515	−0.1383	−0.1333	0.2223	−0.3622	0.1667	0.0458	0.0577	0.3353	0.0742	0.1965	−0.2445
14. Minor foodgrains	−0.0650	−0.0251	−0.0248	−0.2691	0.3127	−0.1534	−0.0393	0.0775	−0.2577	−0.0252	−0.0836	−0.1066
15. Other foodgrains	0.4016	0.4271	0.3623	0.1770	0.3201	−0.1579	0.3493	0.0894	−0.1794	0.2169	0.0382	0.6042
16. Oil seeds	0.1082	0.0679	0.1375	−0.0801	0.1776	0.0569	0.0657	0.1565	0.0168	0.1536	0.1323	−0.0122
17. Fibre crops	0.2367	0.1039	0.2980	0.0663	0.0781	0.0154	0.1429	0.2212	0.0536	0.2460	0.2096	0.0462
18. Sugarcane	0.2679	0.2003	0.1344	0.2147	0.4330	0.3732	0.0865	0.0376	0.2540	0.2908	0.2258	0.2943
19. Spices	−0.0474	−0.0643	−0.0570	0.0217	−0.0543	0.3509	0.0205	0.2463	0.3367	0.0450	0.2746	−0.2505
20. Tea & Coffee	−0.0705	−0.0310	−0.0260	0.0492	−0.2479	0.1372	−0.0051	0.1435	0.2716	0.3485	0.3023	−0.1467

line (12) against wheat in the Table (4.27) stands out uniquely for high magnitudes of correlation coefficients as compared with those of other lines below wheat, related to other crops. The correlation coefficient for wheat is 0.5743 with Y, 0.5043 with A, 0.3680 with C and consequently 0.7168 and 0.6893 with Z and X respectively. The only other lines (no. 15 and 18) where both Z and X have shown some significant (low) and moderate relations are those for other foodgrains (correlation coefficients 0.4016 and 0.4271) and sugar cane (correlation coefficients 0.2679 and 0.2003) respectively. The associated crops in Wheat producing areas are largely other foodgrains (highest correlation coefficients of 0.6042 with wheat in the last col.) and sugar cane (next to highest correlation coefficient of 0.2943 in the last col.). As such these crops have also interacted considerably with the growth components (note the significantly low and moderate correlation coefficients with these crops for Y, A, C, with the exception for sugarcane with Y where it is not significant).

(ii) The most alarming aspect that is brought out by the estimates of this correlation matrix is that rice, the most important and widespread foodgrain crop of India (ref. to Chapter 2), shows negative relation with all growth factors, except the extension growth factor A for which it has shown a low positive correlation coefficient of magnitude 0.2223 only. This small positive correlation is due to a high increase in rice-producing areas in many parts of Assam and adjoining far eastern areas. But the most negative correlation that any growth factor has with any crop is the one between the entrepreneurial-growth factor C and rice (a moderately negative value -0.3622). Rice is still grown in India with the traditional mode of cultivation by taking advantage of climatic condition and soil-quality, particularly in the major parts of rice-producing eastern India where fertiliser-input advantage has hardly been used. Because of this traditionalism, cultivators' entrepreneurial vision seems to be lacking in many rice producing areas of eastern India. Clearly the intensification efforts have not gone in favour of such an important crop like rice in the period under consideration in all rice producing areas.

(iii) On the other hand, minor foodgrains (jowar + bajra + ragi) producing areas do not have natural advantage of climatic condition as the rice-producing areas have in India. Among the crops, the inter-correlation between the minor foodgrains and rice is most negative, with a value of -0.6387, whereby we could infer that minor-foodgrain producing areas and rice producing areas are largely distinct. These minor foodgrains producing areas have taken the maximum advantage of entrepreneurial-growth factor, next to that of wheat producing areas. However, the extension-growth factor has not been much operative in the minor foodgrains producing areas; but there exists a substantial concentration of oilseeds (the minor foodgrains shows the highest correlation coefficient of 0.3234 with oilseeds) and fibre (mainly cotton) crops (ref. to Fig. 2.1) in these areas. The relationship between C and oilseeds is also positive (significant). The fibre crop shows moderate relation of about 0.30 with the intensification-growth factor Y and significant relationship with over-all production growth Z. Thus the minor foodgrain producing areas have also taken advantage of growth factors like C and Y in some form or other for the crops grown therein. In these areas, some concentration of sugarcane crop could also be noticed (ref. to Fig. 2.1) and sugarcane has the highest inter-correlation with the entrepreneurial growth factor C and also has positive relations with other growth factors. Apart from the wheat producing areas, these are the only other areas where the role of intensification-growth factor has been quite operative, particularly for the fibre crop of cotton, grown with the advantage of black-soil concentration therein. It should be noted that, without the model split of Z by growth components, the contrasting features of growth that lie between the rice-producing areas of eastern India and the minor food-grain producing areas of western and southern India could not have been brought out (it should be noted that correlation coefficients of Z with rice and also with the minor foodgrains are almost equally negative, near zero). This shows the importance of growth component analysis as we have done in the preceding section.

(iv) Among the crops, sugarcane and spices are most related to fertiliser input norm F (moderate correlation coefficients of 0.3732 and 0.3509 respectively). But sugarcane, having been an associated crop mostly in wheat producing areas, has shown positive relation with various growth factors, while spices, having been an associated crop mostly in rice producing areas (ref. to Fig. 2.1), have shown practically no relation (mostly near-zero negative values) with any growth factor. But as rice producing areas concentrating in southern India (excluding major rice producing areas of eastern India) and as the northern parts of wheat producing areas (excluding southern parts of wheat producing areas) are taking the advantage of fertiliser input dose, and also as the high fertiliser-consuming wheat areas do not have much concentration of rice, and vice versa, the inter-correlations of F with wheat and also with rice, though significant, drop to low values of 0.1972 and 0.1667 respectively. Between wheat and its associated crop sugarcane, higher interactions of sugarcane with fertiliser implies that most of sugarcane areas are taking advantage of fertiliser input dose, but not most of the wheat producing areas. Again, between rice and its associated crop spices, higher interactions of spices with fertiliser implies that most of spices areas are taking advantage of fertiliser input dose, but not most of the rice producing areas. Plantation crop (tea and coffee) has also some relation with fertiliser input dose, but the relationship is low. Tea and Coffee are extremely localised, most of tea being in Assam and West Bengal and Coffee being mainly in South India. Heavy dose of fertiliser consumption has been noticed in Southern India, but not in the tea-producing areas of eastern India. The low relationship is not only due to highly localised nature of the plantation crop, but also because the tea producing areas of eastern India are not taking much advantage of fertiliser input dose. Again the plantation crop is mainly concentrated in rice-producing areas and having been the associated crop with rice, it has interacted more or less in a similar fashion with the growth factors, particularly in respect of entrepreneurial-growth factor C (correlation coefficient of -0.2479 for plantation crop is comparable to the correlation coefficient of -0.3622 for rice as noted earlier).

(v) As only the wheat and its associated other foodgrain crops have taken the maximum advantage of all growth factors, the agricultural sector's surplus foodgrain generation (Σ_2) has mainly been accomplished by these crops in the wheat producing areas. This is reflected in the correlation coefficient of Σ_2 as high as 0.7365 with wheat and 0.3493 with other foodgrains. The relationships of Σ_2 with rice and minor foodgrains have been practically nil. In consequence, Σ_2 is seen to interact nicely with all growth factors, induced by the role of wheat and associated crops. A similar kind of arguments stands for cultivators' capability for foodgrain surplus generation x_m as we have for Σ_2. However the interactions of x_m are much less than what we have noticed for Σ_2, for reasons stated elsewhere already.

(vi) As the agricultural sector's foodgrain surplus generation capacity must be substantially related with the labour productivity (note the correlation coefficients as high as 0.7837 between Σ_2 and x_w), wheat has also interacted favourably with x_w (correlation coefficient 0.6235), likewise Σ_2. As such x_w is also seen to interact favourably with all growth factors. It should be noted that the role of intensification-inducing factor F could not be depicted by its direct interaction with wheat. However as Σ_2 is almost independent of rice concentration index (correlation coefficients 0.0458), but strongly connected with wheat concentration index (a considerable inter-correlation of magnitude 0.4558 exists between Σ_2 and F), the intensification role of F on wheat can be appreciated through Σ_2. In fact, it could have been best depicted if data of fertiliser input were available by crops; but there is no published source for such data. However, as Σ_2 is generally high in most of the wheat areas, with even low fertiliser consumption, the growth role of the wheat crop has been due to seed-quality improvements also, not due to fertiliser alone.

(vii) The land productivity index x_a, which has best depicted the intensification inducing role of fertiliser input (correlation coefficient as very high as 0.8110), is seen to be less related with the best growth factor-influenced crop of wheat than the less-influenced crop of rice, or its associated spices and plantation crops (correlation coefficients respectively are 0.1056, 0.3353, 0.3367 and 0.2716). This happens because more of rice (and associated crops) producing areal units are in traditionally high land productive areas, without much growth over the period under consideration despite high fertiliser consumption. With fertiliser input, one has to put requisite amount of other associated inputs (such as, improved seeds, etc.) for getting the intensification-inducing role of fertiliser fulfilled. Possibly these were not there in many of the highly land productive rice areas. As the best growth factor-influenced crop of wheat does not have much relation with x_a, whereas the least growth-factor influenced crop of rice has the maximum relation, the interactions of growth factors do not seem to be that high as expected particularly between the land productivity index x_a and the intensification-growth factor Y.

(viii) Although we have evaluated the decreasing importance of growth components Y, A and C to explain Z or X, as corroborated by the correlation matrix shown in the 1st five columns and rows (lines) of Table (4.27), the growth components Y and A have become closer and at times really equal, in respect of their reactions to spatial measures like Σ_2, x_a, x_w. This happens because A is seen to interact positively with both the major cereal crops (wheat and rice that have always shown positive interactions with those spatial measures of agricultural progress), but Y has interacted positively with wheat and negatively with rice. With the varying degrees of interactions between growth components and agricultural development sub-indices, we should better get the over-all relative effect of growth components through their interactions on the composite development index D_A.

(ix) Interactions of Y, A and C are again in relatively decreasing order on the over-all agricultural development index D_A (correlation coefficients 0.4964, 0.4555 and 0.2287 respectively), as we have for the best growth factor-influenced crop, wheat. Regarding the interactions of this final agricultural development index D_A on the crop concentrations, we get the following summary picture : Among foodgrain crops, wheat is most important and rice is next important crop in respect of their interacting role on agricultural development D_A. As rice is more widespread crop than wheat, this reverse interacting role is certainly not helpful in respect of our objective of reducing spatial disparity in agricultural development. Among non-foodgrain crops, the crops quoted in increasing serial number in Table (4.27) tally with their increasing interacting role on agricultural development. But as spices and plantation crops are more localised crops as compared with sugarcane, fibre crops and oilseeds, the roles of latter crops gain more importance for the spread of agricultural development.

4.7 Mappings and Map-Analysis for Spatial Patterns of Agricultural Growth and Component-Factors

The behaviour of agricultural growth factors have been just assessed by our interaction study. Naturally we would now be interested to know about their spatial distribution patterns, so that areas could be differentiated in respect of their growth factor performances. For this purpose, we now map our data on 1. production growth Z, 2. productivity growth X, 3. intensification factor of land-yield rate change Y, 4. extension factor of cropped acreage change A, and 5. entrepreneurial factor of crop-association change C, all over the entire two decade period between 1960-61 and 1980-81. On the basis of detailed frequency distribution analysis with the data of these spatial variables, we identify the following class-intervals for mapping. The details of classification and frequency distribution for these variables are presented below in Tables (4.28) and (4.29). On the basis of these classifications, we have recorded the class-ranks of all areal-units for Z, X, Y, A and C in Table (4.30) and also prepared corresponding maps shown in

Table (4.28) : Class-intervals for Production and Productivity Growth Rates and Component-factors : 1960-61 to 80-81

class-rank code	class-interval in proportionate growth rates				
	Z	X	Y	A	C
(1)	(2)	(3)	(4)	(5)	(6)
EH (extremely high growth)	1.00 and above	0.64 and above	0.64 and above	-	-
VH (very high growth)	0.84 to 1.00	0.48 to 0.64	0.52 to 0.64	-	0.12 and above
H (high growth)	0.68 to 0.84	0.32 to 0.48	0.40 to 0.52	0.24 and above	0.08 to 0.12
M (medium growth	0.52 to 0.68	0.16 to 0.32	0.28 to 0.40	0.16 to 0.24	0.04 to 0.08
L (low growth)	0.36 to 0.52	0.00 to 0.16	0.16 to 0.28	0.08 to 0.16	0.00 to 0.04
VL (very low growth)	below 0.36	-	below 0.16	below 0.08	-
N (no or negative growth)	-	0.00 and below	-	-	0.00 and below

Figures (4.1) to (4.5). In addition, the actual estimates of Z by areal units have also been recorded in Table (4.30). Estimates on other growth factors are shown in the appendix Table (A.6). We would now make brief map-analysis below in the light of our assessment already made in the preceding interaction study on growth factors. The background reference maps which would be referred to from time to time are on fertiliser input F (Fig. 3.9), foodgrain surplus-deficit for agricultural population Σ_2 (Fig. 3.1), cultivators' capacity on foodgrain surplus generation x_m (Fig. 3.6), agricultural land productivity x_a (Fig. 3.8), agricultural labour

Table (4.29) : Frequency Distribution for Production and Productivity Growth Rates and Component-factors : 1960-61 to 80-81

class-rank code	frequency of areal units for				
	Z	X	Y	A	C
(1)	(2)	(3)	(4)	(5)	(6)
EH	14	10	12	-	-
VH	7	13	12	-	14
H	19	16	22	14	19
M	43	42	47	43	28
L	46	51	39	62	49
VL	22	-	19	32	-
N	-	19	-	-	41

productivity x_w (Fig. 3.7), over-all agricultural development D_A (Fig. 3.5) and crop-regions (Fig. 2.1).

(i) In the northern part of wheat producing areas, the role of growth factors has been best manifested with top level values in all of them. If we look at our frequency Table (4.29) the top-class frequencies in every growth factor are very limited, between 10 to 14 areal units, and these areal units are mostly in this part of wheat producing areas. If we look at the estimates of Z in Table (4.30), we notice that top extreme Z-values of 1.95 to 2.88 (corresponding to annual geometric growth rate of 5.56 to 7.02 per cent) occur in the areal units of Punjab and in the adjoining Ganganagar district of Rajasthan. The next level extreme Z-values of 1.13 to 1.86 (corresponding to annual growth rate of 3.86 to 5.40 per cent) occur in the areal units of Haryana (+Delhi). Other

Table (4.30) : Values of Production Growth Rates and the Classified Ranks of Production Growth, Productivity Growth and the Related Growth-components : 1960-61 to 80-81

	Areal Units (district-groups)	values of Z (proportionate rate)	Rank symbol for over all growth measures and growth-components				
			Z	X	Y	A	C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Srinagar + Anantanag + Baramula + Phulwama + Badgam + Kupwara	.6277	M	VH	VH	VL	L
2.	Poonch + Rajouri	.7468	H	M	VH	VL	N
3.	Jammu + Kathua	.9664	VH	EH	VH	L	M
4.	Doda + Udhampur	.8150	H	VH	VH	L	L
5.	Chamba + Kangra + Hamirpur + Una	.7163	H	VH	VH	VL	M
6.	Kinnaur + Lahul + Spiti	.6729	M	L	H	VL	M
7.	Bilaspur + Kulu + Mandi	.6468	M	H	M	H	L
8.	Mahasu + Simla + Sirmur + Solan	.6677	M	M	VH	VL	L
9.	Hoshiarpur + Jullundur + Rupar	2.1287	EH	EH	EH	H	M
10.	Patiala	2.8794	EH	EH	EH	H	H
11.	Ludhiana + Sangrur	2.1049	EH	EH	EH	H	VH
12.	Kapurthala + Amritsar + Gurdaspur	2.3734	EH	EH	EH	H	M
13.	Ferozepur + Bhatinda + Faridkot	1.9527	EH	EH	EH	H	H
14.	Hissar + Jind + Sirsa + Bhiwani	1.1316	EH	H	H	M	VH
15.	Mahendragarh	1.4824	EH	EH	EH	M	VH
16.	Delhi + Rohtak + Gurgaon + Sonepat + Faridabad	1.2599	EH	EH	EH	L	VH
17.	Karnul + Ambala + Kurukshetra	1.8591	EH	EH	EH	H	VH
18.	Saharanpur + Dehradun	.8585	VH	M	M	M	VH
19.	Meerut + Muzaffarnagar + Gaziabad	1.0314	EH	H	M	H	VH
20.	Bulandshahr + Aligarh	1.0639	EH	VH	VH	L	VH
21.	Mathura + Agra	.8388	H	H	VH	L	L
22.	Mainpuri + Etawah	.8307	H	H	H	L	M
23.	Jalaun + Jhanshi + Hamirpur + Lalitpur	.3823	L	L	M	VL	L
24.	Kanpur + Hardoi + Lucknow + Unnao	.9000	VH	H	VH	L	M
25.	Budaun + Etah + Farrukabad	.7759	H	M	H	L	M
26.	Bijnor + Moradabad	.9904	VH	H	M	M	VH
27.	Uttar Kashi + Tehrigarwal + Garwal	.5465	M	H	L	M	L
28.	Chamoli + Almora + Pithorgarh	.6199	M	H	H	M	L
29.	Nainital + Rampur + Bareilly + Pilibhit + Shahjahanpur	.6768	M	L	H	M	L
30.	Sitapur + Kheri	.4423	L	N	M	L	N
31.	Bahraich + Gonda + Bara Banki	.6608	M	M	H	L	L
32.	Basti + Gorakhpur + Deoria	.7201	H	VH	H	M	N
33.	Azamgarh + Gazhipur + Balia	.7617	H	VH	M	M	L
34.	Pratapgarh + Rae-Barelli + Sultanpur + Faizabad	.6940	H	H	H	L	M
35.	Fatehpur + Banda	.6318	M	M	H	VL	M
36.	Allahabad + Jaunpur	.7687	H	VH	H	L	L
37.	Varanashi + Mirzapur	.6413	M	VH	M	L	L

N.B. : (i) Z = proportionate growth rate of agricultural production, X = growth rate of agricultural labour productivity, Y = growth component of land-yield rate change,
A = growth component of cropped acreage change, and
C = growth component of crop-association change.

(ii) Rank symbols : EH = extremely high growth, VH = very high growth, H = high growth, M = medium growth, L = low growth, VL = very low growth, N = no or negative growth.

Table (4.30) Continued

	Areal Units (district-groups)	values of Z (proportionate rate)	Rank symbol for over all growth measures and growth-components				
			Z	X	Y	A	C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
38.	Rewa + Sidhi	.7018	H	M	H	L	L
39.	Surguja + Shahdol	.5143	L	M	M	L	L
40.	Bilaspur + Raigarh	.3935	L	N	L	L	N
41.	Raipur	.4378	L	L	L	L	N
42.	Bastar	.3695	L	L	VL	M	N
43.	Durg + Balaghat + Rajnandgaon	.3508	VL	L	L	M	L
44.	Mandla + Seoni	.4147	L	L	M	L	N
45.	Chindwara + Betul + Narsimhapur	.2117	VL	N	VL	VL	L
46.	Damoh + Jabalpur	.4301	L	M	M	VL	L
47.	Panna + Satna	.5046	L	L	M	L	L
48.	Tikamgarh + Chattarpur	.4567	L	L	L	M	L
49.	Vidisa + Sagar + Raisen	.4076	L	L	L	L	N
50.	Hoshangabad + Sehore + Bhopal	.3051	VL	L	L	L	N
51.	East Nimar + West Nimar	.5520	M	L	M	L	H
52.	Dhar + Jhabua + Ratlam	.4001	L	L	M	VL	L
53.	Mandsaur	.6155	M	L	M	M	L
54.	Ujjain + Indore + Dewas	.6793	M	M	H	M	L
55.	Shajapur + Rajgarh	.5039	L	M	M	L	M
56.	Guna + Shivpuri	.3324	VL	L	L	L	N
57.	Morena + Bhind + Gwalior + Datia	.4241	L	M	L	VL	N
58.	Bundi + Kota + Jhalawar	.3951	L	L	L	L	M
59.	Tonk + Ajmer	.5624	M	H	M	M	L
60.	Jaipur + Swai Madhopur	.4656	L	M	L	M	M
61.	Alwar + Bharatpur	.3979	L	M	VL	M	H
62.	Jhunjhunu + Sikar	.4701	L	M	L	M	M
63.	Ganganagar	2.3866	EH	EH	EH	H	VH
64.	Bikaner + Churu	.3223	VL	N	VL	L	L
65.	Nagaur + Jodhpur	.3526	VL	L	VL	L	VH
66.	Jaisalmer + Barmer	.0892	VL	N	VL	VL	L
67.	Jalore	.2529	VL	N	VL	L	H
68.	Pali + Sirohi	.5681	M	M	L	L	VH
69.	Udaipur + Bhilwara + Chitorgarh	.5167	L	M	L	M	L
70.	Banswara + Dungarpur	.4991	L	H	M	L	L
71.	Panch Mahals + Kaira	.6298	M	M	H	L	L
72.	Ahmedabad + Sabarkantha + Gandhinagar	.8840	VH	VH	VH	L	H
73.	Mehsana + Banaskantha	.9244	VH	VH	EH	VL	M
74.	Surendranagar + Kutch	.8955	VH	H	EH	VL	L
75.	Jamnagar + Junagadh + Amreli	1.0026	EH	VH	VH	M	H
76.	Rajkot + Bhavnagar	1.0739	EH	VH	EH	VL	H
77.	Surat + Bharuch + Baroda	.5480	M	M	M	L	L
78.	Dangs + Valsad + Dadra	.5639	M	M	M	L	M
79.	Dhulia + Nasik	.5826	M	L	M	M	L
80.	Jalgaon + Aurangabad	.5739	M	M	M	L	H
81.	Buldana + Akola + Amravati	.4505	L	N	M	VL	L
82.	Wardha + Nagpur	.5799	M	M	M	L	M
83.	Bhanda + Chanda	.5069	L	L	M	L	N
84.	Yeotmal + Nanded + Parbhani	.5668	M	L	M	L	L
85.	Bhir + Osmanabad + Sholapur	.5175	L	M	M	VL	M
86.	Pune + Ahmednagar	.5082	L	M	M	L	M
87.	Greater Bombay + Kolaba + Thana	.3457	VL	L	M	VL	L
88.	Satara + Sangli	.6261	M	H	M	L	M
89.	Kolhapur	.5238	M	M	L	L	H
90.	Ratnagiri	.4444	L	M	M	VL	L
91.	Goa (+ Daman + Diu)	.2636	VL	L	L	VL	L

Table (4.30) Continued

Areal Units (district-groups)	values of Z (proportionate rate)	Rank symbol for over-all growth measures and growth-components				
		Z	X	Y	A	C
(1)	(2)	(3)	(4)	(5)	(6)	(7)
92. North Kanara + Shimoga	.5133	L	L	M	M	N
93. Belgaum + Dharwar	.4562	L	L	L	VL	M
94. Bidar + Gulbarga + Bijapur	.3468	VL	L	L	L	N
95. Raichur + Bellary	.6854	H	L	H	VL	M
96. Chitradurga + Tumkur	.7672	H	H	M	L	H
97. Bangalore + Kolar	.7242	H	M	H	M	N
98. Mysore + Mandya	.7279	H	M	H	VL	H
99. Chickmagalur + Hassan	.4046	L	L	M	L	N
100. South Kanara	.5564	M	M	L	M	N
101. Coorg	.3012	VL	N	L	VL	N
102. Cannanore + *Koghikode + Mallapuram + Waynad*	.5074	L	L	H	VL	N
103. Palghat + Trichur	.4378	L	L	L	L	L
104. Ernakulam + Kottayam + Iddiki	.4991	L	L	M	M	N
105. Alleppey + Quilon + Trivandram	.5795	M	M	H	L	N
106. Tirunelveli + Kanya Kumari	.3798	L	L	M	VL	L
107. Ramanathapuram + Madurai	.2063	VL	N	VL	VL	M
108. Coimbatore + Periyar	.3198	VL	N	L	L	M
109. Nilgiris	.6525	M	VH	H	M	N
110. Salem + Dharampuri	.3906	L	L	VL	L	H
111. Tiruchirapalli + Thanjavur + Pudukottai	.5825	M	M	H	L	L
112. Madras + Chingleput + North Arcot + South Arcot + Pondicherry	.7378	H	H	VH	L	M
113. Nellore + Chittoor	.4793	L	M	L	L	H
114. Cuddapah + Anantapur	.2911	VL	N	VL	L	M
115. Karnal + Mahbubnagar	.4175	L	N	L	L	M
116. Hyderabad + Medak + Ranga Reddy	.3934	L	L	VL	L	VH
117. Nizamabad + Karimnagar	.6459	M	L	L	M	VH
118. Adilabad	.6425	M	L	M	VL	H
119. Warangal + Khammam + Nalgonda	.4502	L	L	L	VL	H
120. *Guntur + Ongole*	.4731	L	L	VL	L	H
121. East Godavari + West Godavari + Krishna	.6131	M	M	M	M	H
122. *Srikakulam + Visakhapatnam* + Vizianagaram	.4425	L	M	L	L	L

Table (4.30) Concluded

	Areal Units (district-groups)	values of Z (proportionate rate)	Rank symbol for over-all growth measures and growth-components				
			Z	X	Y	A	C
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
123.	Kalahandi + Koraput	.3568	VL	N	VL	M	N
124.	Boudh-Khondmals + Bolangir	.3880	L	L	L	L	L
125.	Puri + Ganjam	.5637	M	M	M	L	N
126.	Balasore + Cuttack	.3053	VL	L	L	VL	L
127.	Mayurbhanj + Keonjhar + Dhenkanal	.3556	VL	L	VL	M	N
128.	Sundargarh + Sambalpur	.3473	VL	L	L	L	N
129.	Ranchi + Singhbhum	.1700	VL	L	VL	VL	N
130.	Hazaribagh + Palamau + Giridih	.4267	L	M	L	VL	M
131.	Patna + Gaya + Shahabad + Nalanda + Aurangabad + Nawada	.4617	L	L	L	M	N
132.	Saran + Champaran + Siwan + Gopalganj	.5307	M	M	VL	M	H
133.	Muzaffarpur + Darbhanga + Vaisali + Sitamari + Madhubani + Samastipur	.5648	M	L	L	M	N
134.	Saharsa + Purnea + Katihar	.5800	M	L	M	M	N
135.	Monghyr + Bhagalpur + Begusarai	.5848	M	M	M	L	L
136.	Santal Parganas + Dhanbad	.1938	VL	L	VL	L	N
137.	Purulia + Bankura + Midnapur	.5256	M	L	L	M	N
138.	Burdwan + Howrah + Hooghly	.6940	H	M	M	M	L
139.	Calcutta + 24-Parganas + Nadia	.6428	M	M	M	L	L
140.	Murshidabad + Birbhum	.7319	H	L	M	M	N
141.	West Dinajpur + Malda	.6693	M	N	M	M	N
142.	Cooch-Behar + Jalpaiguri + Darjeeling	.4251	L	N	L	M	N
143.	Meghalaya	.7925	H	M	H	M	N
144.	Goalpara + Kamrup	.4842	L	N	L	H	N
145.	Darrang + Lakhimpur + Sibsagar + Dibrugarh + Nowgong	.5126	L	M	L	H	N
146.	United Mikir and North Cachar Hills	.5605	M	N	L	M	L
147.	Cachar + Tripura	.6527	M	N	M	H	N
148.	Mizoram	.3289	VL	L	VL	M	N
149.	Manipur + Nagaland	.5525	M	L	M	M	N
150.	Arunachal	.5930	M	L	L	H	N
151.	The Andaman islands	.4527	L	N	VL	H	L

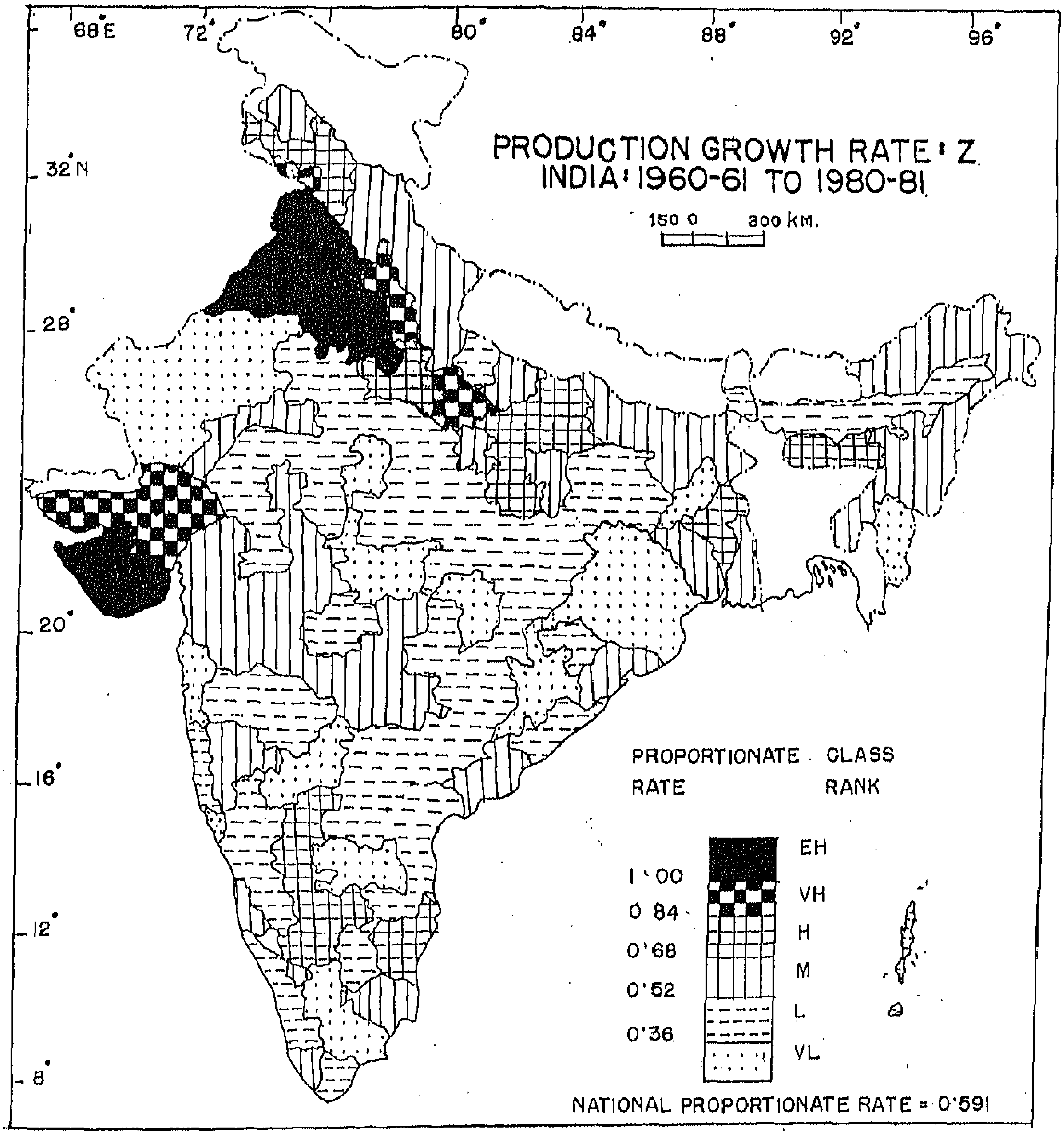

68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
PRODUCTION GROWTH RATE : Z
INDIA : 1960-61 TO 1980-81
150 0 300 KM.
PROPORTIONATE RATE
CLASS RANK
EH
1·00
VH
0·84
H
0·68
M
0·52
L
0·36
VL
NATIONAL PROPORTIONATE RATE = 0·591

FIG-4·1

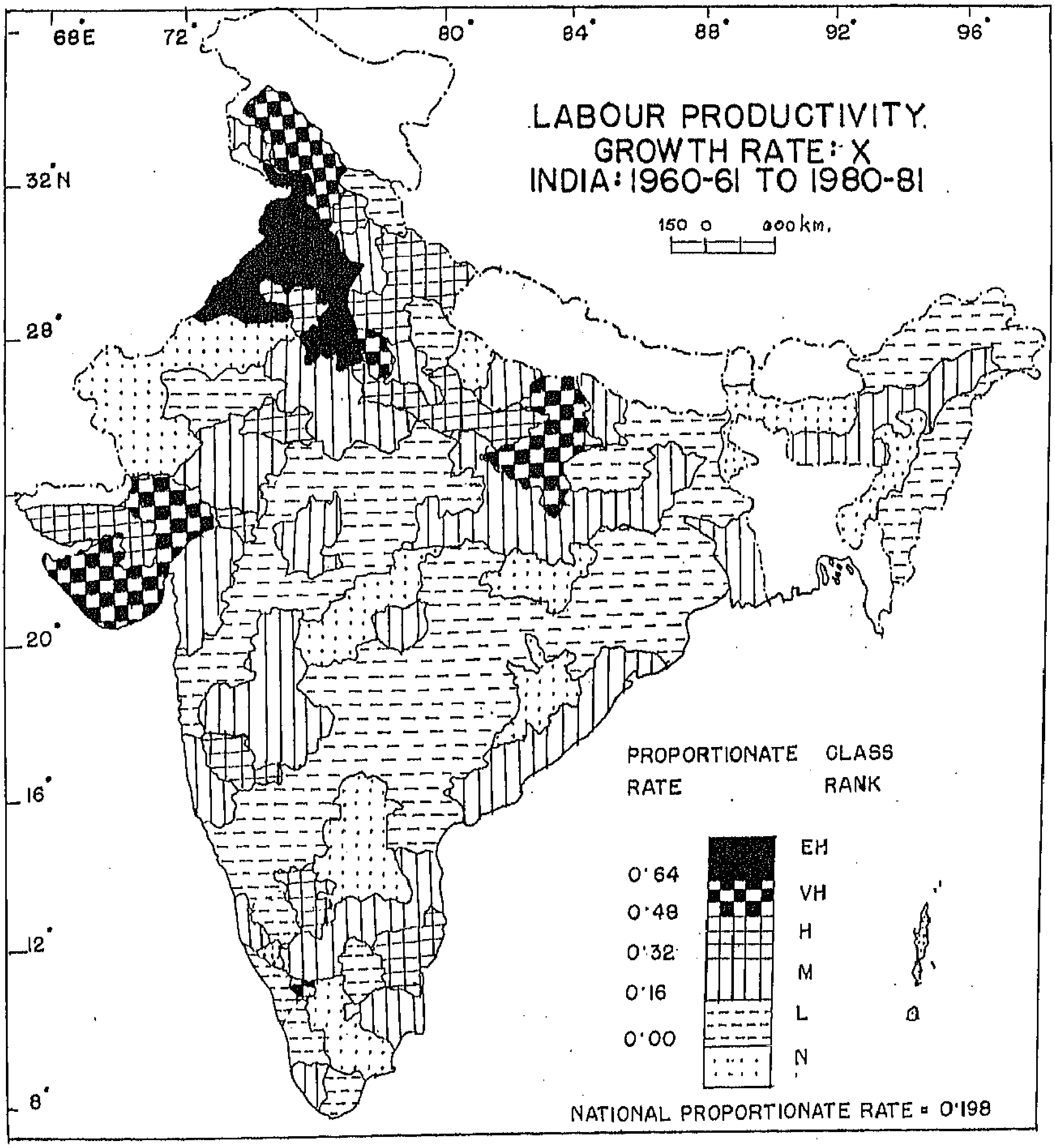
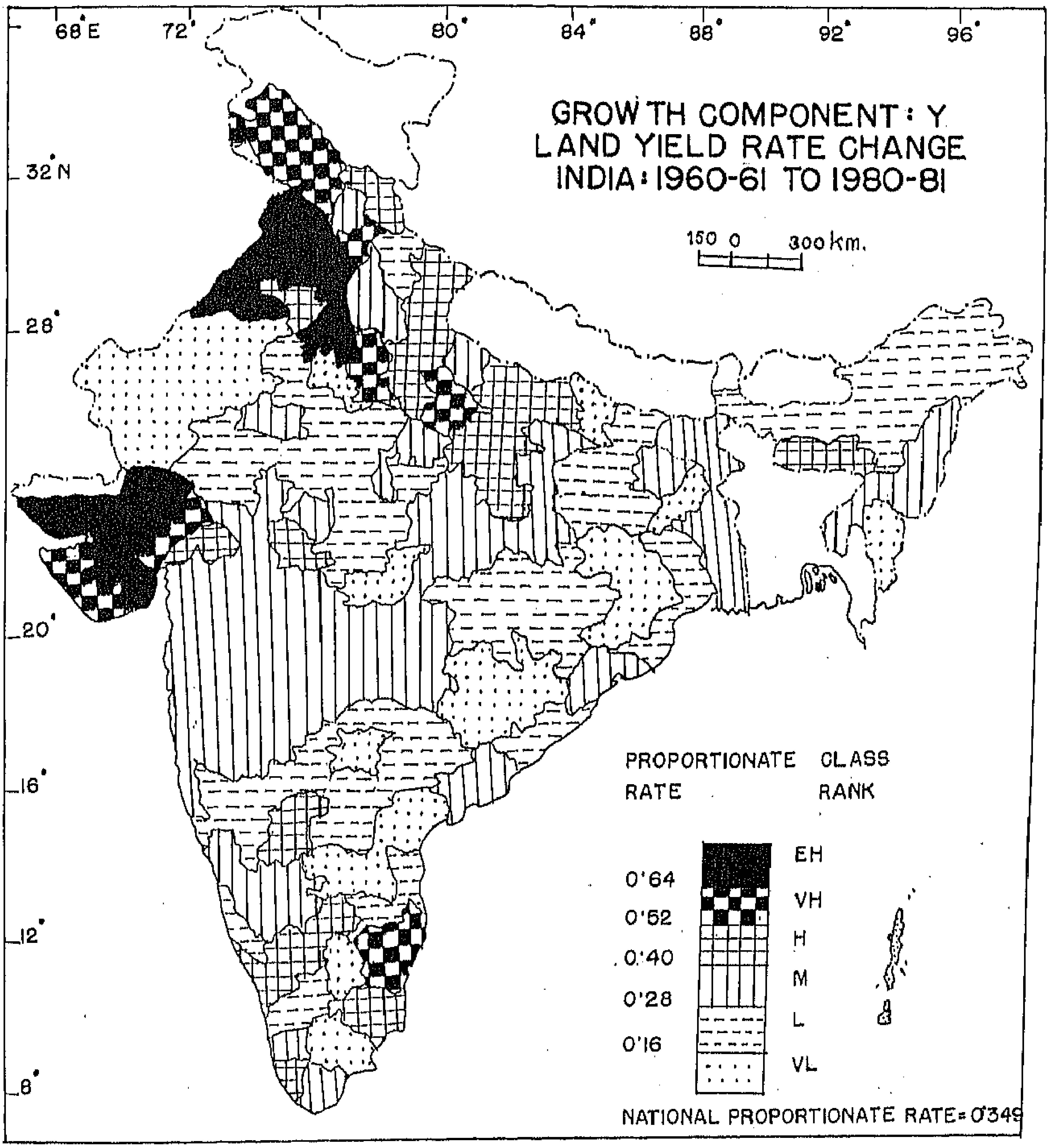

68E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
LABOUR PRODUCTIVITY
GROWTH RATE: X
INDIA: 1960-61 TO 1980-81
150 0 200 km.
PROPORTIONATE RATE
CLASS RANK
0'64
0'48
0'32
0'16
0'00
EH
VH
H
M
L
N
NATIONAL PROPORTIONATE RATE = 0'198

FIG-4'2



GROWTH COMPONENT : Y
LAND YIELD RATE CHANGE
INDIA : 1960-61 TO 1980-81
150 0 300 km.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
PROPORTIONATE RATE
CLASS RANK
EH
0'64
VH
0'52
H
0'40
M
0'28
L
0'16
VL
NATIONAL PROPORTIONATE RATE= 0'349

FIG- 4'3

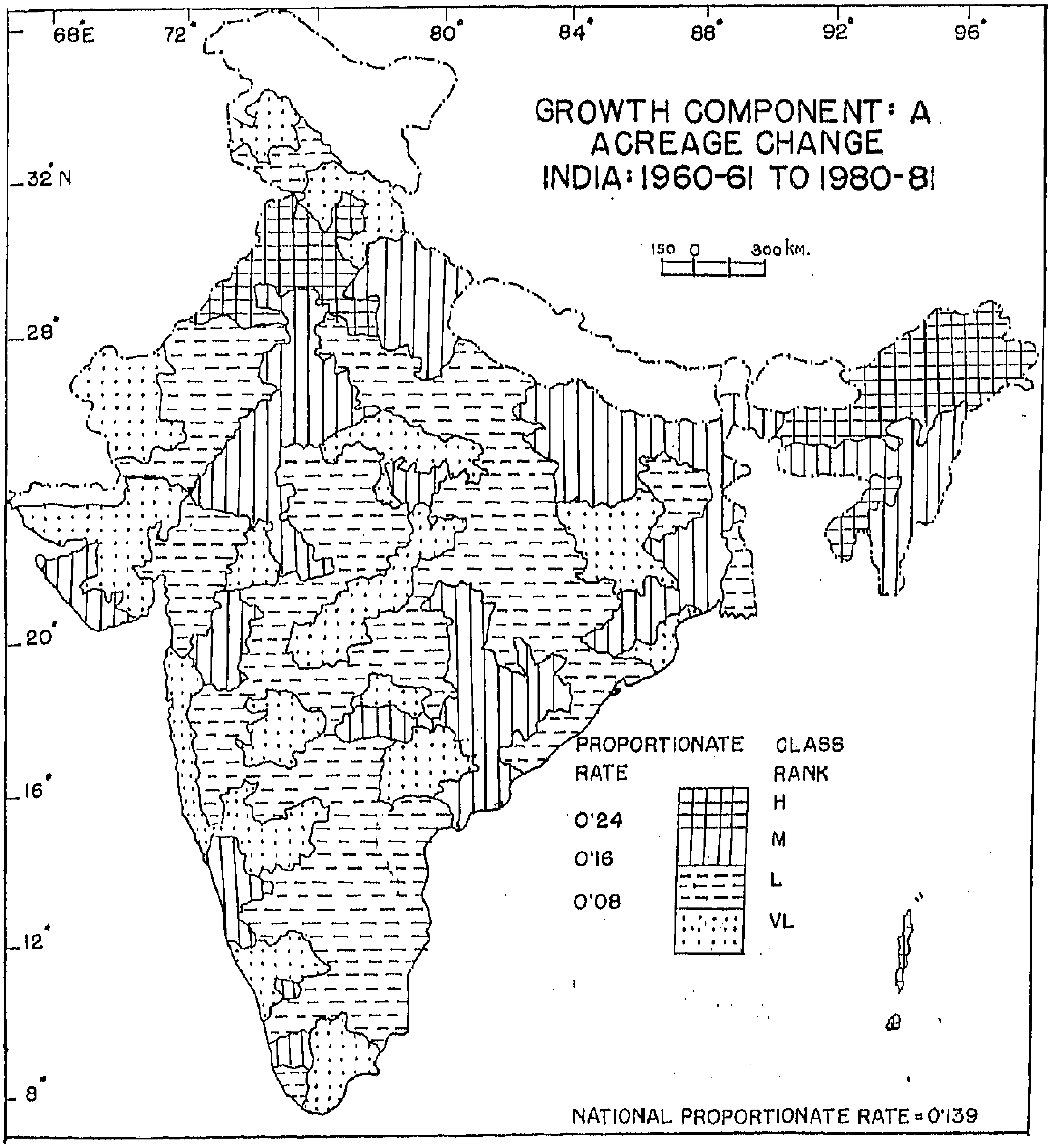

68E
72°
80°
84°
88°
92°
96°
32° N
28°
20°
16°
12°
8°
GROWTH COMPONENT: A
ACREAGE CHANGE
INDIA: 1960-61 TO 1980-81
150 0 300 km.
PROPORTIONATE RATE
CLASS RANK
0'24
0'16
0'08
H
M
L
VL
NATIONAL PROPORTIONATE RATE = 0'139

FIG-4·4

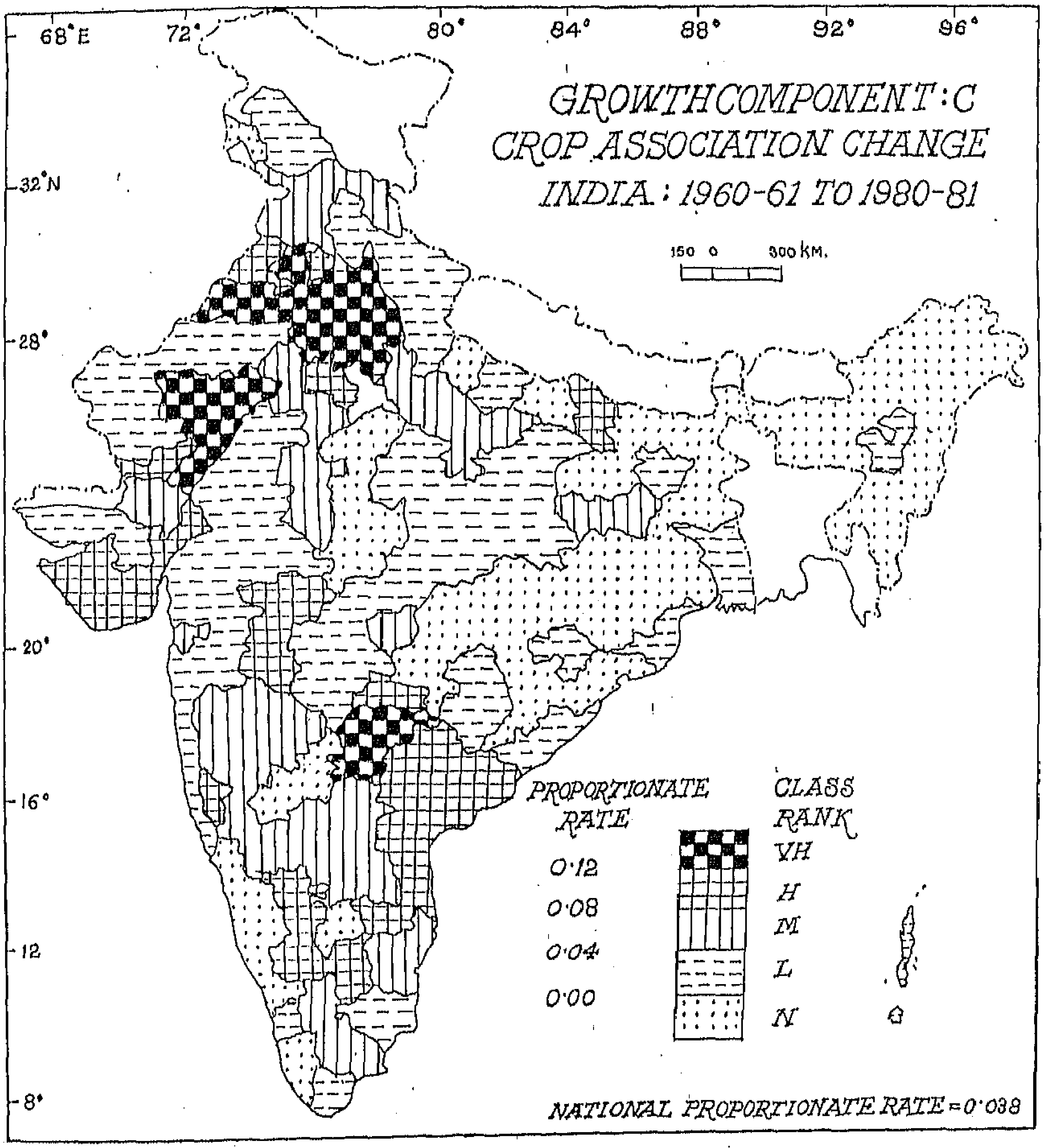

GROWTH COMPONENT : C
CROP ASSOCIATION CHANGE
INDIA : 1960-61 TO 1980-81
150 0 300 KM.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12
8°
PROPORTIONATE RATE
CLASS RANK
0·12
0·08
0·04
0·00
VH
H
M
L
N
NATIONAL PROPORTIONATE RATE = 0·038

FIG – 4·5

extreme Z-values of lower magnitude are in adjoining wheat areas of Uttar Pradesh and also in jowar-bajra-cotton-groundnut producing areas of Gujarat (only non-wheat area with EH value of Z). The class boundary values of Z in terms of their corresponding annual geometric growth rate in per cent [conversion formula is $100 \left\{ (1+Z)^{1/20} - 1 \right\}$] can be written as follows : EH 3.53 VH 3.10 H 2.63 M 2.12 L 1.55 VL. All-India value that falls in M-class is 2.35 per cent per annum corresponding to Z = 0.591. The frequency Table (4.29) and also the map on Z (Fig. 4.1) show that most areal units of India were below an annual growth rate of 2.63 per cent (i.e., in M, L and VL classes). Our population growth had been over 2 per cent per annum during the period. Considering the high deficit situation in food front in 1960-61, a growth rate of agricultural production below 3.10 (H-class boundary) does not look even impressive. Thus, if India is considered to have made considerable agricultural progress, it has been only possible for the progress made in the wheat region with EH and VH values only in the limited northern area around the capital city. India, without this limited area of EH and VH growth, would not have succeeded in eliminating huge food deficit. In summary, vast areas of India except the northern growth region have not made much progress during the period and this is what is reflected in the negative interaction of growth factor Y with the most widespread crop of rice.

(ii) Because of very high intercorrelations between Z and X and also between Z and Y, almost similar spatial patterns emerge in the maps for Z, X and Y, except for very minor departures. The map of X is however important in respect of labour-pressure aspect on agricultural sector, when it is examined in conjunction with the labour productivity map of x_w, relating to the terminal time-point of 1980-81. These two maps show that vast low or no or negative productivity-growth areas coincide largely with the low or very low labour productivity areas of 1980-81. This means that the labour productivity aspect of agricultural progress has largely remained unattended during this long two decade-period. The labour pressure should be considered as very alarming in these areas of vast dimension as could be depicted from the map of x_w. These labour pressure areas are mostly concentrated in the vast non-wheat areas to the east and south of core-wheat producing region. Our intensification efforts during the period seemed to be concerned with only the food situation through all-pervading growth of wheat-seeds and maximum intensification-attention to core wheat producing areas. At the national level, this first step towards agricultural progress has to be appreciated no doubt. But, now that the food-situation has eased, the seed-quality improvements and intensification efforts are to be directed in full swing for other crops also, grown in labour pressure areas of non-wheat regions. Unless this is done, the disparity between regions would be greatly aggravated further, to the detriment of over-all progress in India.

(iii) If we look at the map of Y in conjunction with that of F, some distinction between the eastern rice-producing region and the southern rice-producing region could be noticed in respect of traditionalism versus intensification efforts. Some incidences of high intensification-growth factor Y could be noticed in the southern rice-producing areas of India where fertiliser-use has been substantial. But it is not so in the eastern rice-producing areas of India, where traditional mode of cultivation seems to be in vogue, without much of intensification efforts. Further, if we look at the map of the entrepreneurial-growth factor C, the vast rice-producing areas of eastern India show negative values of C, while such negative C-values are witnessed only in some limited areas in the west coast of South-India. The cultivators' entrepreneurial vision for growth-oriented crop-combination seems to be lacking in these areas of negative C-values. This could be due to the predominance of rice-cultivation in the traditional rice-producing areas in the eastern India and even in the west coast. However, despite the uses of high fertiliser imput does in rice-producing areas of South India, likewise the core wheat region of north India, the rice-producing South India dose not show any trace of comparable growth as it has been achieved in the wheat-producing north India (ref. to the map of Z in Fig. 4.1). The presence of low X-values in South India is largely due to this non-growth during the two decade-period, despite the use of high fertiliser dose therein. From this, we may infer that the use of fertiliser alone would not show proper results of our intensification efforts, unless other associated inputs like seed-quality and other associated things are guaranteed for crops grown in non-wheat region. On the other hand, the southern peripheral areas of our wheat producing region, mostly in Madhya Pradesh and eastern Rajasthan, should also use proper doses of fertiliser in addition to the present possible practice of high quality wheat-seed use, so that these peripheral wheat areas become as advanced as their northern neighbouring areas.

(iv) The minor-foodgrain producing areas do not have much scope for growth from the cultivation of minor cereals alone. Moreover, if the water availability condition could be improved, there is every likelihood of switching over to more remunerative rice cultivation; it could be noticed that, in the tank-cultivation areas of Karnataka, the cultivation of rice is also in vogue along with minor cereals (ref. to Fig. 2.1). At present, the minor foodgrain producing areas have registered some signs of growth (ref. to the map of Z, C and Y in

Figs. 4.1, 4.5 and 4.3) through the judicious crop-combination between cereals - groundnut - cotton - sugarcane crops, at least in Gujarat and in some parts of Maharashtra. By a further comparison with the map of current consumption of fertiliser F, it appears that the parts in minor foodgrain-producing areas which advanced more are utilising a relatively higher dose of fertiliser, possibly more for non-foodgrain crops. We have already noticed that the fibre crops are favourably interacting with the intensification growth factor Y. We have also observed in our interaction study that the crop-association change factor of growth C shows considerable positive relation with the minor foodgrains.

(v) The map of extension-growth factor A simply highlights the fact that we have very limited extension possibilities in future. In the past however, it is again the most advanced core-wheat producing region where this factor has registered high growth. We have also pointed out already during our interaction study that the high growth in A has also been registered in Assam and adjoining far eastern areas of India. Moderate growth in A (M-values) has also been registered in many other wheat producing areas of north India and also in many other rice producing areas of eastern India. Because of this area extension, both wheat and rice, which are oppositely influenced by the intensification-growth factor Y, have shown positive interaction with the extension growth factor A, and consequently with the over-all agricultural development D_A. But, extension growth possibilities being limited in future, our intensification efforts, with proper seed-quality, fertiliser dose and associated inputs should have to be envigorated with crops that are produced in non-wheat producing regions also. The crop-combination practices have also to be altered in some traditional rice producing areas with more remunerative crops that can possibly be grown therein.

4.8 Analysis and Findings by States of India on Agricultural Growth and Component-Factors

Data on production and productivity growth rates during the two-decade period and also on all the related basic components as shown in our various model splits are recorded here by States or State-groups and for all-India in Table (4.31). In these highly aggregative estimations with diversified areal patterns within States, we cannot get a good picture of various growth factors and their basic components. For example, the state of Rajasthan is a mixture of extreme desert condition in the western areas and extreme fertility condition in the northern peripheral district, and as such, the picture depicted here for Rajasthan State is not applicable to any of these extreme areas. This problem with highly aggregative estimations is true of many other states. Yet state estimates give a kind of average of state patterns of growth that can be useful to make broad comparison between states.

We have noticed that the 3-factor model split into basic components is statistically most fitting with prevailing Indian situation for spatial analysis of both production growth and productivity growth. Yet the production growth model split should be considered more fundamental, since X and R are derived estimates through E corresponding to Z and A, while other two basic components of Z remain unaltered for X. As such, we would make our observations first on the basic components of production growth model.

Table (4.31) : Agricultural Production and Productivity Growth and the related Basic Components by States of India : 1960-61 to 1980-81

States or State-groups	Proportionate growth rate during 1960-81 relating to factors						
	Z	X	Y	A	C	R	E
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Jammu & Kashmir	0.7579	0.5645	0.5422	0.1060	0.0186	-0.0157	0.1236
Himachal Pradesh	0.6786	0.3966	0.4999	0.1100	0.0343	-0.0765	0.2019
Punjab	2.1828	1.3410	1.1962	0.4262	0.2012	0.0490	0.3596
Haryana (+ Delhi)	1.3750	0.7288	0.6892	0.2104	0.2162	-0.1189	0.3738
Uttar Pradesh	0.7301	0.3524	0.4929	0.1519	0.0439	-0.0996	0.2793
Madhya Pradesh	0.4327	0.0785	0.2621	0.1275	0.0108	-0.1512	0.3284
Rajasthan	0.4777	0.1764	0.2012	0.1321	0.0699	-0.0987	0.2561
Gujarat (+ Dadra)	0.8582	0.4437	0.6513	0.0909	0.0481	-0.1524	0.2871
Maharastra	0.5227	0.1520	0.3402	0.0965	0.0398	-0.1704	0.3218
Karnataka (+ Goa)	0.5421	0.1472	0.3239	0.1138	0.0241	-0.1714	0.3442
Kerala	0.5080	0.1534	0.3902	0.1283	-0.0360	-0.1370	0.3074
Tamil Nadu (+ Pondicherry)	0.4698	0.1189	0.3145	0.0797	0.0470	-0.1781	0.3136
Andhra Pradesh	0.4686	0.0974	0.2139	0.1159	0.0886	-0.1661	0.3382
Orissa	0.3833	0.0712	0.2153	0.1476	-0.0222	-0.1113	0.2914
Bihar	0.4144	0.0847	0.1824	0.1291	0.0160	-0.1341	0.3039
West Bengal	0.5948	0.0968	0.3131	0.1788	0.0268	-0.1893	0.4540
Assam (+ Far Eastern Areas)	0.5647	0.0636	0.2756	0.2325	-0.0160	-0.1622	0.4711
all-India	0.5910	0.1980	0.3490	0.1395	0.0383	-0.1419	0.3280

The decreasing importance of component factors Y, A and C of Z are very pronouncedly reflected in the all-India estimates and this pattern is followed in every state of India, except Haryana (& Delhi) where C exceeds A a little. The relative divergence in magnitudes of component factors are however different from state to state. Yet the strong covariation between Z and Y exists here also as we have noticed earlier in the corresponding relationship for variation over areal units.

As already noted during the preceding map analysis, most of production growth has occurred in the two states, Punjab and Haryana (& Delhi), where production growth rate during the two decade period has been about 218 and 138 per cent respectively (EH-values), as against the Indian estimate of only 59 per cent (ref. to column (2) of Table (4.31)). The state of Gujarat takes the third position with about 86 per cent growth (VH-value). The growth achievements of these three states have largely been followed by the intensification-growth factor Y. Thus, as against the above-mentioned Z-values, the corresponding Y-values are respectively 120, 69 and 65 per cent (all EH-values) for Punjab, Haryana (& Delhi) and Gujarat respectively. Other states can be arranged in decreasing ranks of Y as follows :

VH-rank : Jammu & Kashmir (54.2 per cent)

H-rank : Himachal Pradesh (50.0 per cent), Uttar Pradesh (49.3%)

M-rank : Kerala (39.0%), Maharashtra (34.0%), Karnataka (32.4%), Tamil Nadu (31.5%), West Bengal (31.3%)

L-rank : Assam (27.6%), Madhya Pradesh (26.2%), Orissa (21.6%), Andhra Pradesh (21.4%), Rajasthan (20.1%), Bihar (18.2%).

In terms of extension growth factor A, Punjab has the top most value of about 42.6 per cent, while Tamil Nadu records the bottom-most value of about 8 per cent only. Assam (& Far Eastern areas), Haryana (& Delhi) and West Bengal have recorded middle order A-values between 18 to 23 per cent, while all other states show low A-value between 8 to 16 per cent. The entrepreneurial growth factor C is highest in the states of Haryana (& Delhi) and Punjab only, both above 20 per cent, and for all other states values are far below.

Under competitive labour absorption situation of an agricultural economy, the labour-change factor E could have been possibly a growth-promoting factor, but this is not the situation in Indian agricultural economy. We can notice from the recorded data of E (ref. to col. 8 of Table (4.31), how much of growth rate in agricultural labour E have been experienced by the two bordering, states with the present nation of Bangladesh. Thus the increase rates of agricultural workers have been about 47.1 per cent and 45.4 per cent respectively in the states of Assam (& Far Eastern areas) and West Bengal as against the Indian increase rate of 32.8 per cent over the two decade period. Thus instead of becoming a growth-promoting factor, E has become a forced burden in many states with non-high production growth. This explains why the 4-factor production split did not work statistically better than the corresponding 3-factor model split in our preceding discriminatory analysis of VIS regression technique.

Indian value of E (32.8 per cent) itself is very high in comparison with the acreage growth of only 14 per cent. That is why all states, except Punjab, show negative growth for the relative acreage change form of extension factor, R. Granting that the extension possibilities in absolute acreage are limited (otherwise the ecological balance problem would ensue or get aggravated which is not desirable), we have nothing to do except accept the negative R-values in the event of the occurrence of high E-values (of course, it is also a distinct possibility to shift excess agricultural workers to non-agricultural occupations, if such opportunities could be created; but that kind of thinking would be a remote possibility with the ever-increasing unemployment situation in India). But the problem of high E-values could possibly be tackled within the agricultural economy itself, if more attention is paid to the intensification-growth factor Y and the crop-combination-growth factor C in all regions, with more emphasis in those areas where E-values are substantially high and not in conformity with the production growth rate Z. To assess such areas the productivity growth factor X plays a more important role than R.

Thus it becomes worth while to investigate the relative positions of Indian states in respect of the productivity growth rate X that have followed over the two-decade period of our intensification efforts. The ranks of different states in respect of X-values can be arranged in descending order of magnitude as follows :

EH-rank : Punjab (134.10%, Haryana & Delhi (72.88%)

VH-rank : Jammu & Kashmir (56.45%)

H-rank : Gujarat (44.32%), Himachal Pradesh (39.66%), Uttar Pradesh (35.24%)

M-rank : Rajasthan (17.64%)

L-rank : Kerala (15.34%), Maharashtra (15.20%), Karnataka (14.72%), Tamil Nadu (11.89%), Andhra Pradesh (9.74%), West Bengal (9.68%), Bihar (8.47%), Madhya Pradesh (7.85%), Orissa (7.12%), Assam & Far Eastern Areas (6.36%).

This means that the productivity growth rates are deplorably low for about eleven states (including Rajasthan in the M-class). The state of Uttar Pradesh (U.P.) has the lowest H-rank value of about 35 per cent. The Indian value of productivity growth during 20-year period had been about 20 per cent. We now make some calculations for these eleven states which have values of X below that of U.P. and that of all-India with two alternative productivity growth task.

Task Alternative I : (all-India standard) If states with values of X below national average were to achieve the national value of X = 0.20.

Task Alternative II: (U.P. standard) If states with values of X below U.P. average were to achieve the U.P. value of X = 0.35.

Using these alternative X-values and granting E-values of respective states, we can calculate the corresponding value of Z from the identity relation :

$$Z = (1 + E)(1 + X) - 1$$

The calculated values would be denoted by $\hat{Z}$, and more specifically, by $\hat{Z}$ (I) and $\hat{Z}$ (II) respectively for the all-India and U.P. standards of X-value. Again, we can write the VIS regression equation from our estimations made earlier with areal unit data, which depict the pattern of spatial change in Y corresponding to change in Z (or vice versa;

note that the VLS regressions are algebraically reversible, but not the OLS regressions, and, as such, we can use the VLS regression only for this kind of relation between two variables). The VLS regression that we have estimated is :

$$\hat{Y} = 0.047996 + 0.509366\ Z;$$

VLS correlation coefficient = 0.8822.

From this equation, we take only the estimate of regression coefficient of Z as a measure of marginal rate of Y with respect to Z and make our revised estimates as follows :

$$\hat{Y} = Y + 0.509366\ (\hat{Z} - Z).$$

The estimated value of $\hat{Y}$ by use of $\hat{Z}(I)$ and $\hat{Z}(II)$ would be denoted by $\hat{Y}(I)$ and $\hat{Y}(II)$ respectively. Finally we construct the task-index T(I) and T(II) for upgrading the intensification-growth factor Y under the two alternatives by the following ratio estimates.

$$T(I) = \hat{Y}(I)/Y \quad \text{and} \quad T(II) = \hat{Y}(II)/Y$$

The values of Y, Z, $\hat{Y}$, $\hat{Z}$ and $\hat{T}$ under the two alternative tasks I and II are recorded below in Table (4.32).

The task-index exercise has been presented here, simply to point out tentatively how much of intensification growth has to be up-graded if we aim at improved standards of labour productivity under the two alternatives. Unless we are clear about the dimension of our task ahead, we cannot think about the intensification efforts needed

Table (4.32) : Estimates of Intensification Growth-upgrading Task-indices under the Alternatives of All-India (I) and U.P. (II) Standards for low Labour Productivity Growth Generating States of India : 1980-81

low labour productivity growth generating states or State-groups	proportionate rates for						Intensification growth task-index T	
	production growth $\hat{Z}$			intensification growth $\hat{Y}$				
	Z	alt. I	alt. II	Y	alt. I	alt. II	alt. I Col. (6) ÷ Col. (5)	alt. II Col. (7) ÷ Col. (5)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Rajasthan	.4777	.5073	.6957	.2012	.2163	.3122	1.0750	1.5517
2. Kerala	.5080	.5689	.7650	.3902	.4212	.5211	1.0794	1.3355
3. Maharashtra	.5227	.5862	.7844	.3402	.3725	.4735	1.0949	1.3918
4. Karnataka	.5421	.6130	.8147	.3239	.3549	.4628	1.0957	1.4288
5. Tamil Nadu	.4698	.5763	.7734	.3145	.3687	.4691	1.1723	1.4916
6. Andhra Pradesh	.4686	.6058	.8066	.2139	.2838	.3861	1.3268	1.8050
7. West Bengal	.5948	.7448	.9629	.3131	.3895	.5006	1.2440	1.5989
8. Bihar	.4144	.5647	.7603	.1824	.2590	.3586	1.4200	1.9660
9. Madhya Pradesh	.4327	.5941	.7933	.2621	.3443	.4458	1.3136	1.7009
10. Orissa	.3833	.5497	.7434	.2153	.3001	.3987	1.3939	1.8518
11. Assam (+ Far Eastern Areas)	.5647	.7653	.9860	.2756	.3778	.4902	1.3708	1.7787

N.B. : To get an idea about the relative level of other States in terms of T(II) of Col. (9), we have estimated such values as shown within parentheses below ;
U.P. (.9970), Gujarat (9057), H.P. (.9430), J. K. (.7735), Haryana + Delhi (.6154) and Punjab (0.4246).

further for reducing disparity in labour productivity growth. However, although we have given two standards on tasks ahead, the all-India standard itself is low, because of existence of so many low productivity growth generating states within. So we suggest that the high standard task under alternative II should be aimed at for intensification growth-upgrading efforts.

It should be noted that the task index can also be taken to rank the states for relative growth retardedness (or growth orientation) in productivity performance during 60-81 from labour pressure angle. Thus under alternative II target, more acute to less acute growth-retarded states can be arranged and classified as follows :

Highly Growth-retarded : Bihar (T(II) = 1.9660), Orissa (1.8518), Andhra Pradesh (1.8050), Assam (+ Far Eastern Areas) (1.7787), Madhya Pradesh (1.7009), West Bengal (1.5989), Rajasthan (1.5517).

Growth-retarded : Tamil Nadu (1.4916), Karnataka (1.4288), Maharashtra (1.3918), Kerala (1.3355).

Growth-oriented : Uttar Pradesh (0.9970), Gujarat (0.9057), Himachal Pradesh (0.9430), Jammu & Kashmir (0.7735).

Highly Growth-oriented : Haryana (+ Delhi) (0.6154) and Punjab (0.4246).

The 1980-81 position of Development level D_A is somewhat inversely related with the growth retardedness index T(II), referring to the period 1960-81. The inverse of squared D_A (i.e., $1/D_A^2$) is positively related with T(II), showing a value of correlation coefficient of about 0.44. This value is dampened for anomalous positions of four states in the east-coast, namely, West Bengal, Orissa, Andhra Pradesh and Tamil Nadu (possibly connected with climatic regime for rice cultivation) which are at higher level of development in 1980-81 and not in conformity with the relative growth performance during the two-decade period. If the correlation coefficient between T(II) and (D_A^{-2}) is estimated by ignoring the anomalous states, the magnitude shots up from 0.44 to 0.75. That is, among most of the states there is good agreement between inverse development level (D_A^{-2}) and growth retardedness level T(II).

Chapter 5 : ROLE OF AGRICULTURE IN THE OVER-ALL SPATIAL PATTERN OF ECONOMIC DEVELOPMENT AND THE REGIONAL SYNTHESIS ON AGRICULTURAL ACTIVITIES

We have just completed our investigations on various facets of agricultural activities, both for spatial variations in growth and the resulting spatial patterns. In that our prime interest had been on the details within the agricultural sector. This sector is quite important in Indian economy. However our investigations on agriculture would not be complete without an assessment of its role in the over-all spatial pattern of economic activities. In the following sections we would mainly devote our attention on the evaluation of this role and finally attempt a brief regional synthesis based on the work done already in other Chapters relating to agricultural activities.

5.1 Spatial Interactions Between Agricultural Sector and other Sectors of Economic Activities

Although we have used various spatial measures in our preceding studies, the most appropriate single measure that we can use now to represent the spatial pattern of agricultural activities is by the agricultural development index D_A, varying over our areal units (district-groups). In addition, we need now comparable spatial measures on other broad sectors of economic activities. Fresh calculations for the construction of comparable spatial measures on other sectors are not within the scope of this dissertation. Moreover, it would also be an almost impossible task for a single research worker to go for fresh additional calculations for other sectors on comparable basis as done already on agriculture. Thus there is a problem of finding synthetic measure on spatial patterns for other sectors. However this has not been an unsurmountable problem for us, simply because the data we require could be derived from the information appended in another dissertation work, done under the same guide as of the present dissertation, on industrial and relating non-agricultural activities by districts of India. So our starting point would be the use of sub-indices of non-agricultural activities available in the stated dissertation work [Vaskar Saha, 1984] as raw data for our purpose. These sub-indices have been computed with the use of either the optimal formulation [Kendall, 1939], or the equity formulation [Pal, 1963, 1971], or both, combining many relevant constituent variables involving varieties of output and labour input data. The details of these are not discussed here for the sake of brevity. We have thus compiled the raw data on the four sub-indices, denoted as x_1 to x_4, from the stated source, and, to that, added our agricultural development index D_A, redesignated as the sub-index x_5. These sub-indices are named as shown below :

x_1 = the trading activity sub-index,
x_2 = the over-all industrial activity sub-index,
x_3 = the urban central place activity sub-index, or, in short, urbanisation sub-index,
x_4 = the transportation activity sub-index, and
x_5 = the agricultural activity sub-index.

[Estimates of x_1, x_2, x_3 & x_4 by areal units are recorded in Appendix Table (A.7)].

The variable x_5 is by areal-units (or district-groups) of India, referring to the terminal time-point 1980-81. The remaining four variables were originally given by districts for 1975-76. In order to achieve commonness in unit areas and the time-point for our interaction study, all these variables are now adjusted and up-dated for the same 151 areal units and the same time-point by appropriate population weights of 1980-81 for coverages of districts within the areal-units. The correlation matrix as estimated by us from the revised data of above-mentioned variables is given below in the following Table (5.1):

Table (5.1) : Correlation Matrix for Sub-indices of Economic Activities; India : 1980-81

x_1 (1)	x_2 (2)	x_3 (3)	x_4 (4)	x_5 (5)
1.0000	0.9039	0.9079	0.9102	0.5131
0.9039	1.0000	0.9094	0.8707	0.4441
0.9079	0.9094	1.0000	0.8776	0.4234
0.9102	0.8707	0.8776	1.0000	0.3815
0.5131	0.4441	0.4234	0.3815	1.0000

Based on these estimates, our observations on the spatial interactions of agricultural sector with other sectors are as given below :

(i) Of the five variables considered here, the variables x_5 (agriculture) and x_2 (industry) relate to material production sectors, while the other three variables x_1 (trading), x_3 (urban central-place) and x_4 (transportation), are really non-producing marketing and servicing sectors. All sectors have mutually-interacted with positive spatial correlations. However the degree of spatial interactions are only moderate (values of correlation coefficient between 0.3815 and 0.5131) for the agricultural activity sector with any non-agricultural sector.

(ii) Most of Indian industries are based on the products of agricultural sector, yet the agricultural sector has not exhibited the best interaction with the other material production sector; its best interaction as revealed from the estimates of last line (or last column of Table (5.1)) has been with the trading sector. It has possibly happened because the agricultural products get their first outlet through spatially distributed small markets, while the industrial activities are largely urban-oriented both for intake of raw materials and marketing of industrial products (highest correlation coefficient of 0.9094 in the 2nd column & 3rd row for x_2 and x_3 respectively). The interaction of agricultural sector is lowest with transportation sector and is most related to trading sector.

(iii) Looking at the very high correlations among the first four variables, one cannot but infer that all non-agricultural activities are spatially polarised, while agricultural activities have not necessarily grown in all core areas of polarised non-agricultural activities, and vice versa. However, the spatially polarised non-agricultural activities are somewhat better connected with the land productivity index x_a (a sub-index of x_5, not accounting for labour aspect) rather than x_5 itself (the correlation coefficients of x_a are 0.5850 with x_1, 0.5143 with x_2, 0.4404 with x_3 and 0.4713 with x_4), indicating a better spatial-interaction pattern with the land productivity performance. But we have to make comprehensive judgement on the performance of agricultural sector through x_5 only.

5.2 Problems of Over-all Economic Development Index Formulation with Recognition of the Role of Agriculture

Before going for any further spatial association analysis between sectors, we have to get an appropriate measure of over-all economic development. As we have these five spatial measures on the levels of economic activities, comprising all broad aspects of economic development, we thought it better to construct the over-all development index of economic activities from these sub-indices themselves. But for any statistical construction of such an index, problem arises for the particular structure of correlation matrix in Table (5.1), showing very-high inter-correlations between only the non-agricultural sectors and not with the agricultural sector. In an agricultural country like India, as the foundation of over-all economic development lies on the agricultural sector (major income generation is really in this sector in India), the importance of this sector cannot be gainsaid. With a healthy between-sector interacting economy we could have expected substantial interactions of the agricultural sector with other sectors. But in the present case study we have the strong multicollinearity-bias towards only the non-agricultural sectors. The optimality criterion used in formulating Kendall's index (ref. to Chapter 2), takes the index closer to those constituent variables having greater multicollinearities and away from those showing less multicollinearities. As such it is possible to have at times such a wide range in specific representations that the index cannot be accepted as a true representative of all its constituent variables. It is to tackle this kind of problem, the equity index has been devised by Pal [1963, 1971, further reference to Pal and Chattopadhyay, 1972, for a comparative study]. But the gap-less spacing of all specific representations as in the equity formulation may at times be so strict that one or two of the best represented constituent variables may have to be pushed down so much from their positions of optimal specific representations that their "combining weights" as necessary to constitute the equity index become negative, leading to an interpretative difficulty. It should be noted that the specific representation and the "combining weights" for the same **constituent variable** must have similar algebraic sign for a proper interpretation of the constituent index. This kind of problems for the two index formulation procedures has actually arisen with the correlation matrix of Table (5.1). We have recorded in Table (5.2) the actual estimates of specific representations and the combining weights and also the derived estimates of the aggregate representation for the two index formulations.

Among the five economic activity variables, the material production variables x_5 and x_2 are the two most fundamental development measuring variables. But the optimal formulation does not account for the representation of agricultural activity variable (desirable values of r_i's should be around 0.80 or above, but, here, $r_5 = 0.57$ is only a moderate value) in it and as such this index does not project a measure of unified single index of all development activities. The weighting scheme as in-built in the optimal formulation follows from the relation :

$$w_i = r_i/(n \rho) .$$

Table (5.2) : Estimates of Specific Representations and Combining Weights for Optimal and Equity Formulations; India : 1980-81

constituent variables	optimal formulation		equity formulation	
	specific representations r_i	combining weights w_i	specific representations r_i	combining weights w_i
(1)	(2)	(3)	(4)	(5)
x_1	.97103	.21841	.81655	-0.41188
x_2	.95163	.21404	.81655	.15488
x_3	.95126	.21396	.81655	.25385
x_4	.93600	.21053	.81655	.48718
x_5	.56910	.12800	.81655	.51597
aggregate representation : ρ	.88920	-	.81655	-

As such, the criterion for the consistency of interpretation, namely, the similar algebraic sign for the estimates of r_i and w_i, is automatically satisfied. But this rigid relation followed in the optimal formulation makes w_5 equally low with r_5. In fact, any fundamental constituent variable (like x_2 and x_5), which induces the generation of marketing and servicing types of economic activities (like x_1, x_3 and x_4), should have high combining weights in a proper development index formulation, depicting its due fundamental character. If any fundamental variable did not get sufficient feed-back inducements from the induced variables (as reflected in the correlation matrix of present case study), it is all the more necessary to assure the high combining weight for it. This is not possible with the rigidity present in the optimal formulation.

On the other hand, the equity formulation takes the index to the other extreme with no variation in the specific representation of its constituent variables with increasing weights from x_1 to x_5. But in going for the gap-less spacing between specific representations, the supreme position of the most inter-acted variable x_1 is to be tampered so much that it takes an inconsistent negative weight of about -0.41. In this formulation, the least favoured variable of the optimal index, i.e., x_5, is however most favoured with due high weight as a result of its up-grading of specific representation to the same very high value of about 0.817. But the other fundamental variable, x_2, has been treated adversely in this process with an assignment of low weight to it. Any way, we are most inconvenienced in respect of the negative weight of x_1 in the equity formulation.

This kind of situation was also faced earlier by Pal [see, for example, Pal (1971), (1975)], which was remedied by a construction of a non-agricultural activity index with all variables except the agricultural activity variable, and then the two indices, non-agricultural and agricultural, are combined again at a second stage for the final development index by some external economic consideration, like the weighting by relative labour productivity weights. We have examined such a possibility also with the present data and found that such a development index has the correlation coefficients for variables x_1 to x_5 respectively as follows : 0.935, 0.901, 0.886, 0.893 and 0.616. This shows that even this kind of extra-statistical formulation does not help us to get a very high representation of the agricultural activity variable x_5.

However if one makes analysis on the basis of both agricultural and non-agricultural indices separately, there is no problem. But, then, we do not have any unified development index, representing all constituent variables very highly.

In this connection, we would also examine the suitability of application of the Hotelling's method [1933] of "component or factor analysis" [for details, ref. to Harmon, H.H. (1967)] as some times used to extract more than one "orthogonal principal component factors" out of a same set of constituent variables [ref. to Hagood, M.J., (1933); Prakasa Rao, V.L.S., (1953); Berry, B.J.L., (1960); Berry, B.J.L. and V.L.S. Prakasa Rao, (1968)]. It has been, however, pointed out by Pal, in several of his papers referred to already in this connection, that Hotelling's method cannot be applied meaningfully in usual spatial index formulation problems, in view of the difficulties of "orthogonal factorisation" clause between any two principal component factors, since often the different spatial economic activity indices are oblique (related), rather than orthogonal (totally unrelated). In the present case also, the non-agricultural index, as constructed by the optimal formulation over first four variables, is moderately related with the agricultural index with correlation coefficient of magnitude 0.459. However we have still applied Hotelling's method to examine the nature of difficulties in our case study. It should be pointed out that in view of the stated difficulties in Hotelling's method, Kendall possibly abandoned the method for his work [1939] and put forward his method of single optimal index formulation from an independendent angle, comparable to a variation of the regression approach with residual error term. Algebraically, however, Kendall's index formulation would coincide with only the 1st principal component of Hotelling. But, unlike Hotelling's approach, the Kendall's approach does not have any subsequent principal components, standing for indices that are mutually orthogonal by statistical choice. With the present data, estimates of specific representations for the first and the second principal components are as given below for the five variables x_1 to x_5 in order :

1st : .97103, .95163, .95126, .93600, .56190 and
2nd : -0.04063, -0.11633, -0.14447, -0.19242, .82155.

Clearly the agricultural activity variable x_5 which did not get adequate representation in the 1st principal component does get a very high representation in the 2nd principal component. An analyst who is not aware of the "orthogonal factorisation" trap of the factor analysis would venture to call the 2nd principal component as the index of agricultural development and the 1st one as the index of non-agricultural development. But the question is : why these two indices have to be orthogonal and also why the agricultural index should have negatively weighted and negatively inter-related non-agricultural variables in its construction? If the original non-agricultural variables are not expected to show negative correlation coefficients (ref. to Table (5.1)) with the agricultural activity variable, the negative weights as shown in the 2nd principal component must then be treated as inconsistent. All these discussions are only to show why the Kendall's formulation should be more relied upon than Hotelling's "factor analytic tools" in this kind of spatial index construction.

Both optimal and equity formulations may however pose certain problems of their own, as we have demonstrated already with the present case study. To summarise, the optimal index formulation has under-represented the agricultural activity variable x_5, because of the rigidity of unconstrained maximisation of aggregate representation. On the other hand, the equity index formulation has incorporated an inconsistently negative "combining weight" for the best inter-acting variable x_1, because of the rigidity of gap-less spacing of specific representations. Both these rigidities of the two formulations are relaxed in Pal's recent method of equi-spaced optimal formulation. The method is, however, applied for the first time in a recent paper prepared jointly with him by me in which I had full responsibility on the applied aspect, while the theoretical development of the method was fully due to him /_Pal, M.N. and Mukhopadhyay, R.(1987)_7.

The strictness of the gap-less spacing, as in the equity index, is moderated in an equi-spaced index. The equi-spaced optimal index is the one which maximises the aggregate representation subject to the equi-spacing constraint together with any other relevant constraint, if necessary. This formulation of Pal derives its mathematical support from Pal's generalised index formulation developed earlier /_Pal, (1985)_7. In fact, the equi-spaced optimal index formulation procedure is a special case of Pal's most generalised framework for a single multivariate index construction from a set of variables, satisfying certain basic premises. The equi-spaced formulation stands somewhere in between the two formulations (optimal and equity). In the mathematical development of generalised index formulation, Pal has proved theorems to show that the optimal and the equity formulations are also special cases of Pal's generalised framework. In fact, Pal has brought all existing formulations -- subjective, objective, cartographic, economic theory-based, statistical or otherwise [ref. to review made by Pal, (1973); and also the related references as quoted therein, namely, Schwartzberg, (1962); Mitra, (1961); NCAER, (1963)] --- under the common fold of generalised formulation and thereby it has been possible to get an unified procedure of assessing their relative merits statistically with the parameters estimated or to be estimated within the generalised framework. In our present study, we would however show only that the equi-spaced optimal formulation is better suited than both optimal and equity formulations in connection with the construction of multivariate spatial index of economic development for India.

5.3 Review on the Estimation Theory of Equi-spaced Optimal Index Formulation

5.3.1 Preamble

As the equi-spaced formulations and, in particular, the equi-spaced optimal formulation derive mathematical support from the method of generalised index formulations [Pal (1985)], we would restrict our present review only to that part of the theory which is needed in support of its estimation and take for granted the main results proved already for generalised formulations. In the generalised formulations, we have the following notations, parameters and relations :

The variables, satisfying the basic premises [ref. to Pal and Mukhopadhyay, (1987) for details of basic premises] as required for the construction of a composite characteristic are :

$$x_1, x_2, \ldots, x_i, \ldots, x_n,$$

each varying over N areal units of observation. The standardised variables corresponding to x_i is denoted by Z_i, where $Z_i = (x_i - \bar{x}_i)/\sigma_i$, with $\bar{x}_i$ = mean of x_i and σ_i = standard deviation of x_i. The estimated correlation matrix is given by :

$$\begin{pmatrix} r_{11} & r_{12} & \cdots\cdots & r_{1j} & \cdots\cdots & r_{1n} \\ r_{21} & r_{22} & \cdots\cdots & r_{2j} & \cdots\cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{i1} & r_{i2} & \cdots\cdots & r_{ij} & \cdots\cdots & r_{in} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots\cdots & r_{nj} & \cdots\cdots & r_{nn} \end{pmatrix},$$

where r_{ij} is the correlation coefficient between variables x_i and x_j and we have $r_{ii} = 1$ and $r_{ji} = r_{ij}$ for all i and j.

The main parameters of interest in the construction of a composite index are : the combining weight vector : $(w_1, w_2, \ldots, w_i, \ldots, w_n)$, the specific representation vector : $(r_1, r_2, \ldots, r_i, \ldots r_n)$, where r_i is the correlation coefficient between the variable x_i and the composite index to be constituted, and the derived aggregate representation ρ, where

$$\rho^2 = \frac{1}{n} \sum_{i=1}^{n} r_i^2 \qquad \ldots (5.1)$$

For the theoretical development, we also need the related

representation multiplier vector : $(m_1, m_2, \ldots, m_i, \ldots m_n)$,
where $m_i = r_i/\rho$, for each i

$$\text{i.e.,} \quad r_i = \rho\, m_i \qquad \ldots (5.2)$$

The final standardised composite index is denoted by Z_0, where

$$Z_0 = \frac{1}{\rho} \sum_{i=1}^{n} w_i Z_i \qquad \ldots (5.3)$$

This composite index can as well be written in the following unstandardised form x_0, which is quite convenient when dealing with constituent variables in the form of spatial sub-indices and location factors whose central critical values are often unity :

$$x_0 = \sum_{i=1}^{n} C_i\, x_i/C, \qquad \ldots (5.4)$$

where $C_i = w_i/\sigma_i$, for all i

$$C = \sum_{i=1}^{n} C_i,$$

with mean, $\bar{x}_0 = \sum_{i=1}^{n} c_i \bar{x}_i / C$,

and standard deviation, $\sigma_0 = \rho / C$,

so that, $Z_0 = (x_0 - \bar{x}_0)/\sigma_0$.

Clearly, if the central critical value of x_i is unity for all i, that for the composite index x_0 is the same unity. The index x_0 has the same specific and aggregate representations as those of its standardised form Z_0.

We have the following established relations for the generalised formulations

$$\sum_{i=1}^{n} m_i^2 = n, \qquad \ldots (5.5)$$

$$\sum_{i=1}^{n} w_i m_i = 1, \qquad \ldots (5.6)$$

$$\left.\begin{array}{l} \sum_{j=1}^{n} r_{ij} w_j = \rho^2 m_i , \\ \qquad \text{for } i = 1, 2, \ldots\ldots, n \end{array}\right\} \qquad \ldots (5.7)$$

If either the weight vector or the multiplier vector is known (by some external condition), the parameters of generalised index formulation can be completely solved from the algebraic solutions from above mentioned relations.

5.3.2 Special Case of Kendall's Optimal Index

Pal [1985] has proved that his generalised formulation reduces to Kendall's optimal formulation, when

$$w_i = m_i/n , \quad \text{for each } i = 1, 2, \ldots\ldots, n \qquad \ldots (5.8)$$

By use of this relation, an iterative procedure for computing its parameters can be summarised as follows :

> We begin with weights $w_i = {}^1/_n$ for all i at the first iteration. With the weight vector of, say, s-th iteration, the multiplier vector can be solved by use of relation (5.7) first and then correcting for the involved constant of proportionality, here ρ^2, by use of relation (5.5). Further, the relation (5.8) is used to get the weight vector of next (s + 1)-th iteration from the estimated multiplier vector of s-th iteration. Finally when the weight vector of two consecutive iterations are empirically identical, the iteration process is stopped and the final weight vector is obtained. With this weight vector, all other parameters can easily be computed for the optimal index.

5.3.3 Special Case of Pal's Equity Index

Clearly the generalised formulation reduces to equity formulation, when

$$m_1 = m_2 = \ldots\ldots = m_n = 1, \qquad \ldots (5.9)$$

As the multiplier vector is known here, we can solve all other parameters by use of relations (5.7) and (5.6).

5.3.4 Special Case of Pal's Equi-spaced Formulations and the Equi-spaced Optimal Formulation

For developing the estimation procedure, we further denote :

proportionate weight vector : $(w_{1*}, w_{2*}, \ldots, w_{i*}, \ldots, w_{n*})$,

$$\text{with} \quad \sum_{i=1}^{n} w_{i*} = 1. \qquad \ldots (5.10)$$

The corresponding proportional multiplier vector is :

$$(m_{1*}, \ldots, m_{i*}, \ldots, m_{n*}),$$

$$\text{where} \quad \sum_{j=1}^{n} r_{ij} w_{j*} = m_{i*}, \qquad \ldots (5.11)$$

$$\text{for } i = 1, 2, \ldots n.$$

The relations (5.11) are comparable to relations (5.7) and for relations comparable to (5.6) and (5.5), we substitute :

$$A^2 = \sum_{i=1}^{n} w_{i*} m_{i*} , \qquad \ldots (5.12)$$

$$\text{and} \quad B^2 = \sum_{i=1}^{n} m_{i*}^2/n . \qquad \ldots (5.13)$$

Then, comparing relations (5.13) and (5.5), we have

$$m_i = m_i^* / B, \quad \text{for all } i. \qquad \ldots (5.14)$$

From relations (5.12), (5.14) and (5.6), we get

$$w_i = \left(\frac{B}{A^2}\right) w_{i*} , \quad \text{for all i.} \qquad \ldots (5.15)$$

From relations (5.11), (5.15), (5.14) and (5.7), we get

$$\rho^2 = B^2/A^2, \quad \text{i.e.,} \quad \rho = B/A . \qquad \ldots (5.16)$$

Finally, from relations (5.2), (5.16) and (5.14), we get

$$r_i = m_{i*}/A, \quad \text{for all } i. \qquad \ldots (5.17)$$

By use of the relations (5.10) through (5.17), the parameters of generalised index formulations can as well be solved, starting from either the proportionate weight vector or the proportional multiplier vector given by some external conditions. The equi-spacing of specific representations provides such an external condition for equi-spaced formulations. There can be many equi-spaced formulations, depending upon the particular choices of aggregate representation ρ, lying in the range between the equity ρ-value and the optimal ρ-value. The unique equi-spaced optimal formulation is that equi-spaced index formulation which maximises ρ^2 subject to equi-spacing conditions, without or with some other desirable constraints. One such desirable constraint can be imposed by fixing an upper limit on the variance grade g_k, where

$$g_k = w_k m_k , \qquad \ldots (5.18)$$

for the most represented variable x_k (i.e., the variable with maximum specific representation) in the optimal index formulation. It is to be noted that the total unit variance of the standardized composite index Z_0 is contributed by all g_i's, when $g_i = w_i m_i$, for any variable i, so that, by relation (5.6), we have

$$\sum_{i=1}^{n} g_i = 1$$

Thus, g_i represents the variance grade of i-th constituent variable in the construction of the composite index. With the choice of upper limit for g_k at the average : $\bar{g} = {}^1/_n$, the said constraint can be written as given below :

$$g_k \leq ({}^1/_n). \qquad \ldots (5.19)$$

By virtue of relation (5.8) for the optimal index, we have :

$$(\text{optimal } g_k) = m_k^2/n,$$

with $\quad m_k = (\text{max. of all } m_i\text{'s}) > 1.$

So, by the imposition of constraint (5.19), we desire a moderation on the multi-collinearity effect of the most represented variable, favoured by the correlation matrix in the optimal index. It should be noted that both the optimal ordering (Kendall's) and the equi-spaced optimal ordering (Pal's) of variables by values of specific representations turn out to be the same. The optimal ordering of variables would be called the normal ordering, as it is supported by the revealed evidence of empirical interactions between variables as depicted in the correlation matrix. Often this normal ordering is identical with the ordering by the magnitudes of column-sums of the correlation matrix.

For convenience in presenting the equi-spacing condition in a systematic form, we assume hence forth, without any loss of generality, that the suffixes of variables x_i's are so chosen that the specific representations r_i's are in decreasing sequence of normal ordering. When r_i's are in normal ordering, the multiplier m_i's, and hence the proportional multiplier m_{i*}'s also, follow the same ordering. Thus, with our choice of suffixes, the normal ordering stands for the following sequence of values :

$$\underset{(\max.)}{m_{1*}} > m_{2*} > \quad \ldots . > m_{(n-1)*} > \underset{(\min.)}{m_{n*}}$$

From the equi-spacing conditions, we have

$$m_{1*} - m_{2*} = m_{2*} - m_{3*} = \quad \ldots . = m_{j*} - m_{(j+1)*} = \ldots = m_{(n-1)*} - m_{n*}.$$

If each difference is denoted by Δ , then we have

$$\left.\begin{array}{l} \Delta = (m_{1*} - m_{n*})/(n-1), \\ \text{and also we have, } m_{j*} = m_{1*} - (j-1)\,\Delta \;; \\ \qquad\qquad j = 1,\ 2,\ \ldots.,\ n \end{array}\right\} \quad \ldots (5.20)$$

Subtracting the last difference from each difference successively (ref. to (n-1) equalities shown in relation (5.20)), we get the following equations :

$$m_{n*} + m_{i*} - m_{(i+1)*} - m_{(n-1)*} = 0,$$

$$\text{for } i = 1,\ 2,\ \ldots.,\ (n-2).$$

Using now the relations (5.11), these equations can be converted into the following (n-2) equi-spacing constraint equations :

$$\left.\begin{array}{l} \sum_{j=1}^{n} R_{ij}\, w_{j*} = 0; \\ \qquad\qquad \text{for } i = 1, 2, \ldots, (n-2), \\ \text{where} \quad R_{ij} = r_{nj} + r_{ij} - r_{(i+1),j} - r_{(n-1),\,j} . \\ \text{From relation (5.10), we also have,} \\ \qquad \sum_{j=1}^{n} w_{j*} = 1 \end{array}\right\} \quad \ldots (5.21)$$

From these (n-1) equations, we can express w_{j*}'s as linear functions of w_{1*} as follows :

$$\left.\begin{array}{lcll} w_{1*} & = & 0 & + 1\; w_{1*} \\ w_{2*} & = & h_2 & + k_2\, w_{1*} \\ w_{3*} & = & h_3 & + k_3\, w_{1*} \\ \cdots & \cdots & \cdots & \cdots \\ w_{j*} & = & h_j & + k_j\, w_{1*} \\ \cdots & \cdots & \cdots & \cdots \\ w_{n*} & = & h_n & + k_n\, w_{1*} \end{array}\right\} \quad \ldots (5.22)$$

Denoting $h_1 = 0$ and $k_1 = 1$, we have

$$\sum_{i=1}^{n} h_i = 1 \quad \text{and} \quad \sum_{i=1}^{n} k_i = 0,$$

by virtue of relation (5.10).

Then we make the following computations as intermediate stages :

$$\left.\begin{aligned} D_1 &= \sum_{j=1}^{n} r_{1j} \ h_j \ , \\ E_1 &= \sum_{j=1}^{n} r_{1j} \ k_j \ , \\ D_n &= \sum_{j=1}^{n} r_{nj} \ h_j \ , \\ E_n &= \sum_{j=1}^{n} r_{nj} \ k_j \ , \\ S &= \sum_{j=1}^{n} (j-1) \ h_j/(n-1), \\ \text{and} \qquad T &= \sum_{j=1}^{n} (j-1) \ k_j/(n-1), \end{aligned}\right\} \qquad \ldots (5.23)$$

so that we have,

$$\left.\begin{aligned} m_{1*} &= D_1 + E_1 \ w_{1*} \ , \\ m_{n*} &= D_n + E_n \ w_{1*} \ , \\ \text{and} \qquad \alpha &= S + T \ w_{1*} \end{aligned}\right\} \qquad \ldots (5.24)$$

Using relations (5.12), (5.20), (5.10), (5.22), (5.23) and (5.24), we can deduce :

$$A^2 = w_{1*} \ m_{1*} + w_{2*} \ (m_{1*} - \Delta) + \ldots\ldots + w_{n*} \ \left\{ m_{1*} - (m-1) \ \Delta \right\}$$

$$= m_{1*} - \frac{m_{1*} - m_{n*}}{n - 1} \left\{ w_{2*} + 2 \ w_{3*} + \ldots + (n-1) \ w_{n*} \right\}$$

$$= (1 - \alpha) \ m_{1*} + \alpha \ m_{n*} \ .$$

On further simplification by use of relations (5.24), we have :

$$\left.\begin{aligned} A^2 &= Q_1 + Q_2\, w_{1*} + Q_3\, w_{1*}^2 , \\ \text{where,}\quad Q_1 &= D_1 - S\,(D_1 - D_n), \\ Q_2 &= E_1 - S\,(E_1 - E_n) - T\,(D_1 - D_n), \\ \text{and}\quad Q_3 &= -T\,(E_1 - E_n). \end{aligned}\right\} \qquad \dots (5.25)$$

Again, using relations (5.13) and (5.20), we can deduce :

$$\begin{aligned} B^2 &= \frac{1}{n}\left[m_{1*}^2 + (m_{1*} - \Delta)^2 + \;\dots\; + \left\{ m_{1*} - (n-1)\Delta \right\}^2 \right] \\ &= m_{1*}^2 + (n-1)\,\Delta\, m_{1*} + \frac{(n-1)(2n-1)}{6}\,\Delta^2 \\ &= m_{1*}^2 + (m_{1*} - m_{n*})\, m_{1*} + \frac{2n-1}{6(n-1)}\,(m_{1*} - m_{n*})^2 \\ &= \frac{1}{4}\,(m_{1*} + m_{n*})^2 + \frac{n+1}{12(n-1)}\,(m_{1*} - m_{n*})^2 \end{aligned}$$

On further simplification by use of relations (5.24), we get

$$\left.\begin{aligned} B^2 &= P_1 + P_2\, w_{1*} + P_3\, w_{1*}^2 \\ \text{where,}\quad P_1 &= \frac{1}{4}\,(D_1 + D_n)^2 + \frac{n+1}{12(n-1)}\,(D_1 - D_n)^2, \\ P_2 &= \frac{1}{2}\,(D_1 + D_n)\,(E_1 + E_n) + \frac{n+1}{6(n-1)}\,(D_1 - D_n)\,(E_1 - E_n), \\ \text{and}\quad P_3 &= \frac{1}{4}\,(E_1 + E_n)^2 + \frac{n+1}{12(n-1)}\,(E_1 - E_n)^2 \end{aligned}\right\} \qquad \dots (5.26)$$

Finally from relations (5.16), (5.25) and (5.26), we get

$$\rho^2 = \frac{P_1 + P_2\, w_{1*} + P_3\, w_{1*}^2}{Q_1 + Q_2\, w_{1*} + Q_3\, w_{1*}^2} , \qquad \dots (5.27)$$

With the estimated values shown in relations (5.23) and by use of relations (5.25) and (5.26), the values of (P_1, P_2, P_3) and also of (Q_1, Q_2, Q_3) can be estimated. Now for each particular choice of ρ in the range between equity ρ -value and optimal ρ -value, we can solve for the positive fractional estimate w_{1*} from the quadratic equation (5.27). Once w_{1*} is known, we can deduce all parameters of such an equi-spaced formulation from the relevant relations as given earlier. Thus we can solve for different equi-spaced formulations for different choices of ρ.

Next for the equi-spaced optimal formulations, we apply the mathematical first order condition for extreme ρ^2 on equation (5.27) and simplify to get :

$$\rho^2 = \frac{P_2 + 2\ P_3\ w_{1*}}{Q_2 + 2\ Q_3\ w_{1*}} = \frac{2\ P_1 + P_2\ w_{1*}}{2\ Q_1 + Q_2\ w_{1*}} \quad . \qquad \ldots (5.28)$$

On further simplification, we can deduce

$$w_{1*} = \frac{P_2\ Q_2 - 4\ P_1\ Q_3 - \rho^2\ (Q_2^2 - 4\ Q_1\ Q_3)}{2\ (P_2\ Q_3 - P_3\ Q_2)} \quad . \qquad \ldots (5.29)$$

In equations (5.28) and (5.29), ρ^2 is either $\rho^2{}_{\max}$ or $\rho^2{}_{\min}$. Putting this $\rho^2 = y$ in relation (5.28) and simplifying, we get the following quadratic equation :

$$(Q_2^2 - 4\ Q_1 Q_3)\ y^2 - 2(P_2 Q_2 - 2P_1 Q_3 - 2P_3 Q_1)\ y + (P_2^2 - P_1 P_3) = 0 \quad \ldots (5.30)$$

The two solutions of this quadratic equation, with simplified discriminant, are given by

$$y = \frac{P_2Q_2 - 2P_1Q_3 - 2P_3Q_1 \pm 2\sqrt{(P_1Q_3 - P_3Q_1)^2 - (P_2Q_3 - P_3Q_2)(P_1Q_2 - P_2Q_1)}}{Q_2^2 - 4\,Q_1Q_3} .$$

.... (5.31)

When the expression under the radical sign in the numerator of (5.31) is positive, we get two real solutions of y, one of which is ρ^2_{max} and the other ρ^2_{min}. Using ρ^2_{max} for ρ^2 in equation (5.29), we get our required equi-spaced optimal w_{1*}. With this value of w_{1*}, all parameters of the equi-spaced optimal index formulation can be solved from preceding relations. This gives the free equi-spaced optimal formulation without any further constraint.

In case we have

(free equi-space optimal g_1) $\leq$ ($^1/_r$) < (optimal g_1), ... (5.32)

then the free equi-spaced optimal index formulation can be accepted without any further constraint. If, however, the two values of g_1 of condition (5.32) show reverse inequality, we may like to impose further constraint as proposed earlier in relation (5.19). In the present suffix notation, this constraint can be written as :

$$n\,g_1 \leq 1$$

$$\text{i.e.,} \quad n\,w_{1*}\,m_{1*} \leq \Lambda^2 \qquad \text{.... (5.33)}$$

For such equi-spaced optimal index formulation, maximising ρ^2 subject to the additional constraint (5.33), we have to solve the following equation.

$$(n E_1 - Q_3) w_{1*}^2 + (n D_1 - Q_2) w_{1*} - Q_1 = 0, \qquad \ldots (5.34)$$

If this quadratic equation gives a positive fractional solution of w_{1*} which is less than the free equi-spaced optimal w_{1*} then this value of w_{1*} would correspond to the equi-spaced optimal index-formulation under the additional grade-constraint (5.33). The corresponding value of ρ^2 is then calculated by use of the value of w_{1*} in equation (5.27). This final ρ^2 with the use of constraint (5.33) would be a little lower than that obtained without the constraint (5.33). All other parameters of the final equi-spaced optimal index formulation can easily be calculated by using the estimated value of w_{1*} from equation (5.34) in the relevant relations shown already.

5.4 Empirical Estimation of the Spatial Development Index of Economic Activities

In Table (5.3), we give the estimates of parameters reated to the two equi-spaced optimal formulations, with and without the grade constraint shown in relation (5.33). The equi-spaced optimal formulations of Table (5.3), computed for normal ordering, must show the same decreasing order in the magnitudes of specific representations of variables x_1 to x_5 as that in the optimal formulation (ref. to Table (5.2)). In fact our variables were suffixed in such a way that they tally with the normal ordering as derived from the specific representations of the optimal formulation. In the present case this order has also coincided with the order as would have been obtained by column-sums of the correlation matrix (ref. to Table (5.1)). Thus the best represented variable x_1

in the optimal formulation remains the best represented variable in the two equi-spaced optimal formulations of Table (5.3).

Table (5.3) : Estimates of Specific Representations and Combining Weights for two Equi-spaced Optimal Formulations; India : 1980-81

constituent variables	Equi-spaced optimal formulation, with grade constraint $g_1 \leq \bar{g} = 0.2$		free equi-spaced optimal formulation, without grade constraint	
	specific representation r_i	combining weight w_i	specific representation r_i	combining weight w_i
(1)	(2)	(3)	(4)	(5)
x_1	0.90835	0.18772	0.91769	0.28814
x_2	0.88000	0.26039	0.88487	0.27518
x_3	0.85165	0.07034	0.85205	0.03799
x_4	0.82330	0.08926	0.81922	0.01990
x_5	0.79495	0.40196	0.78640	0.37731
aggregate representation : ρ	0.85259	-	0.85331	-

The variance grade, $g_i = r_i w_i / \rho$, for i-th variable can be estimated from the data given in Tables (5.2) and (5.3) for any index presented therein. In the optimal index formulation (ref. to Table (5.2)), the grade of its best represented variable is $g_1 = 0.23850$. This grade-value could be considered high already due to the multicollinearity advantage enjoyed by variable x_1. But the free equi-spaced optimal formulation gives a value of g_1 = 0.30889, which is still higher. The variable x_1 is also not any of the two fundamental material production variables. As such, it becomes necessary to impose a control of variance-grade here in the equi-spaced optimal formulation. Thus, we set the grade-constraint with an upper limit of g_1 and this choice of upper limit could best be at the average $\bar{g}$ = 0.2 (i.e. 1/no. of variables), which is a little lower than the optimal g_1. Thus our ultimate choice of the equi-spaced optimal index formulation is by :

> "maximising aggregate representation, subject to equi-spacing constraints on specific representations and the grade-constraint for the best represented variable".

All computations for any equi-spaced optimal formulation are done here according to steps mentioned earlier in sub-section (5.3.4). The empirical estimates on specific representations of Table (5.3) show that these have been truly ordered with equal gaps between consecutive values, verifying the correctness of Pal's estimation procedure summarised in section (5.3).

It should be noticed that if the grade-constraint is not imposed, the distribution of weights among strongly multi-collinear variables become lopsided with low weight for x_3 and x_4, as a result of further improvement of weight for the best inter-acting variable x_1 (ref. to weights for free equi-spaced optimal formulation). The imposition of grade-constraint has definitely improved the distribution of weights among those strongly multi-collinear variables. It is interesting to note that the weight of the strongly related fundamental variable

x_2 is not much affected by the introduction of grade-constraint. Both the material-production activity based variables x_5 and x_2 have now very high weights, as desirable, in the final equi-spaced optimal formulation. The specific representation of the agricultural activity variable is about 0.795 which can be regarded as marginally very high (a value of 0.80 and above is considered as very high). And this is a great improvement over what we obtained in the optimal formulation. This value is also very close to what we obtained even in the equity formulation, without bringing in the inconsistency of combining weights. The final equi-spaced optimal index formulation is now very highly representative of all its constituent variables.

It is to be noted that the equi-spaced optimal formulation with normal ordering is the global equi-spaced optimal formulation with all possible orderings. To demonstrate this, we would examine now a few selected ordering schemes as shown below :

Case I : Industrial variable one step up-graded in normal ordering :

$$r_2 > r_1 > r_3 > r_4 > r_5.$$

Case II : Transportation variable one step up-graded in normal ordering :

$$r_1 > r_2 > r_4 > r_3 > r_5.$$

Case III : Agricultural variable one step up-graded in normal ordering :

$$r_1 > r_2 > r_3 > r_5 > r_4.$$

Case IV : Agricultural variable two steps up-graded in normal ordering :

$$r_1 > r_2 > r_5 > r_3 > r_4.$$

Results of our empirical exercises are as follows :

Case I. No consistent equi-spaced optimal formulation has been possible for this ordering, since w_1 turned out to be negative here.

Case II. Again no consistent equi-spaced optimal formulation has been possible for this ordering, since w_3 turned out to be negative here.

Estimates for the equi-spaced optimal formulations with one- or two-steps up-gradings of agricultural variable in the normal ordering, are shown below in Table (5.4).

Table (5.4) : Estimates of Specific Representations and Combining Weights for two Equi-spaced Optimal Formulations with one- and two-step up-graded Orderings of Agricultural Variable; India : 1980-81

constituent variables	equi-spaced optimal formulation with one-step upgrading of agricultural variable x_5		equi-spaced optimal formulation with two-step up-grading of agricultural variable x_5	
	specific representation r_i	combining weight w_i	specific representation r_i	combining weight w_i
(1)	(2)	(3)	(4)	(5)
x_1	.88912	.14586	.87166	.05274
x_2	.86547	.25980	.85289	.28851
x_3	.84183	.12982	.81537	.03508
x_4	.79455	.03167	.79661	.15697
x_5	.81819	.43205	.83413	.46621
aggregate representation : ρ	.84250	-	.83455	-

Although consistent estimates are available for thes two orderings (cases III and IV), the aggregate representation is gradually lowered as we change our orderings from normal to one-step up-grading (case III) and then to two-step up-grading (case IV) of agricultural variable x_5. Hence we can conclude that the equi-spaced optimal formulation with normal ordering is the global equi-spaced optimal formulation. Again it is interesting to note that the high weights with the fundamental material production based variable x_2 and x_5 are more or less retained in all the three orderings, but the weights with marketing and servicing activity based variables x_1, x_3 and x_4 have high relative changes in the three orderings (ref. to Tables (5.3) and (5.4)). So any equi-spaced optimal formulation has favoured the two material production based variables in respect of combining weights. And it is quite reasonable that a proper development index of economic activities should be largely material production activity based. Here lies the success of the equi-spaced optimal formulation over the optimal and the equity formulations in this particular application to the Indian situation.

The final development index of economic activities x_0, as per the estimates of equi-spaced optimal formulation of Table (5.3) can be written as given below (ref. to equation 5.4 of section 5.3) :

$$x_0 = 0.18807\ x_1 + 0.25666\ x_2 + 0.06366\ x_3 + 0.07765\ x_4 + 0.41396\ x_5, \quad \ldots (5.35)$$

aggregate representation $\rho = 0.85259$,
mean $\bar{x}_0 = 0.93010$, and
standard deviation $\sigma_0 = 0.30749$.

Finally on the basis of this empirical formulation, the estimates of over-all economic development index x_0 have been calculated for different areal units of India and presented here in Table (5.7).

5.5 Spatial Pattern of Over-all Economic Development and the Nature of Broad Activity-mix with Special Reference to Agricultural Activity

As all the sectors of economic activities are now very highly represented in our over-all economic development index x_0, there would be very good spatial association between x_0 and any of the economic activity sectors, including the sector of our interest x_5. The variable x_5 is same as the agricultural development index D_A which has already been mapped (ref. to Fig. (3.5)) and analysed. However, despite very high representations of all sectors in x_0, there must be local peculiarities to bring forth variations in economic activity-mix in important areas of economic development. Afterall, we have noticed in our study on the between-sector interaction analysis that the spatial polarisation of economic activities is higher for sectors of non-agricultural activities. Naturally it becomes important now to find the degree of association of agricultural activities in important areas of economic development. Thus to identify the important areas of economic development and their development characteristics in terms of activity-mix, we would make comparable classification of all variables x_0, x_1, x_2, x_3, x_4 and x_5. As the classification of x_5 is already done in Figure (3.5) of Chapter 3, we have simply to match the classification of other variables with that of x_5. The classification procedure as followed here is given below.

For the variable x_5, values have already been classified into six classes, ranked as EH, VH, H, M, L and VL in decreasing sequence of values, with the critical national value of unity demarcating the boundary between H and M classes, and with the class-interval length of 0.18. The critical value being unity for all indices under consideration, the class-boundary value between H and M classes would remain invariant at the same value for all indices. To get the comparable class interval length, we set

$$\Delta x_0 = \Delta x_i \; (r_i \; \sigma_i/\sigma_0) \; ; \qquad \ldots (5.36)$$

$$i = 1, 2, \ldots, 5,$$

where any Δx_j denotes the class-interval length of variable x_j for $j = 0, 1, 2, \ldots, 5$. We have $\Delta x_5 = 0.18$. Using this value in relation (5.36), we first estimate the value of $\Delta x_0 = 0.20$. Once Δx_0 is known, it is easy to determine remaining Δx_i from the above relations (5.36). The values for other variables turn out to be as shown below

$\Delta x_1 = 0.21$, $\Delta x_2 = 0.21$, $\Delta x_3 = 0.22$ and $\Delta x_4 = 0.22$.

Thus we have the following class boundaries between consecutive classes for all the indices shown in Table (5.5).

The frequency distribution of areal units by six classes, EH to VL, are shown in Table (5.6).

Table (5.5) : Comparable Class-boundaries of Indices

Index and sub-indices	boundary value between consecutive classes				
	(EH, VH)	(VH, H)	(H, M)	(M, L)	(L, VL)
(1)	(2)	(3)	(4)	(5)	(6)
x_0	1.40	1.20	1.00	0.80	0.60
x_1	1.42	1.21	1.00	0.79	0.58
x_2	1.42	1.21	1.00	0.79	0.58
x_3	1.44	1.22	1.00	0.78	0.56
x_4	1.44	1.22	1.00	0.78	0.56
x_5	1.36	1.18	1.00	0.82	0.64

Table (5.6) : Frequency Distribution of Areal Units by six Rank-classes of Indices; India : 1980-81

Development Index and activity sub-indices	frequency of areal-units by rank-classes					
	EH	VH	H	M	L	VL
(1)	(2)	(3)	(4)	(5)	(6)	(7)
x_0 (Over-all Dev.)	13	14	23	49	37	15
x_1 (Trading)	14	11	22	50	38	16
x_2 (Industrialisation)	8	9	21	35	47	31
x_3 (Urbanisation)	10	14	27	36	40	24
x_4 (Transportation)	11	13	29	41	36	21
x_5 (Agriculture)	17	17	28	48	24	17

An interesting feature that has been revealed from comparisons of the frequency distributions of a sub-index x_i and the over-all index x_0 is as follows : For the over-all economic development index, about a third of total number of areal units is in the high classes above the national value and another one-third is in the middle class. But substantially more than a third of all areal units are above national level in agricultural activity, while substantially less than a third of areal units are above national level in industrial activity. The frequency-rise in agriculture is however compensated by the frequency-fall in industrialisation, so that jointly they make it again one-third above the critical national value. A more distributive nature of high levels in agricultural activity and a more localised nature of high levels in industrial activity are well-brought out in our procedure for comparative frequency classifications.

On the basis of above-mentioned comparable classification schemes, the rank symbols, EH to VL, have been recorded by areal units for the over-all economic development index x_0 and its constituent activity sub-indices x_1 to x_5 in Table (5.7). Further, we have used the statistical regression equations of x_i on x_0, $i = 1, 2, \ldots, 5$, to determine the estimate $\hat{x}_i$ and identify the statistically significant departures of actual x_i from the estimated $\hat{x}_i$ (at 5% level of chance). The rank of x_i in a particular areal unit is specially marked by asterisk (*) in Table (5.7), if its EH or VH or H value is significantly above the value level of x_0 and also if its VL or L value is significantly below the national level of x_0. This shows further local peculiarities of the constituent activity sub-indices if any, as compared with the general level of development. As the specific representations of constituent variables are very high, we do not get many such local peculiarities. There are 4 such areal units for x_1, 8 for x_2, 4 for x_3, 4 for x_4 and 5 for x_5. There are overlaps of areal units when all of x_1 to x_5 are considered together. We have only 12 areal units with significant departures in values of some combination of x_1 to x_5 from their x_0 - value level.

The economic development rank x_0 of an areal unit comes from the contributions of economic activity levels of x_1 to x_5. The contributions of agricultural and industrial activities are however more fundamental. The spatial polarisation of other economic activities with industrial activity has really helped all non-agricultural activities to get good representation in the over-all economic development. In this sense the over-all economic development is the result of really the material production activity-mix. However, as x_0 is very highly representative of all activity sub-indices x_1 to x_5, there are good agreements in their ranks in many areal units. Yet there are departures, since the achieved level of spatial development might be due to regional specialisations in only one or two economic activities, and not all. The ranks shown in Table (5.7) for all indices depict the details of activity-mix or disagreement in different areal units.

We have also mapped the over-all level of economic development x_0 and shown in Figure (5.1). The map of x_5 is already there in

Table (5.7) : Values of Development Index and the *Classified Ranks* of the Index and its Constituent Sub-indices of Economic Activities by Areal Units : India:1980-81

Areal units (district-groups)	values of x_0	Rank symbol for Index and sub-indices					
		x_0	x_1	x_2	x_3	x_4	x_5
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Srinagar + Anantanag + Baramulla + Phulwama + *Badgam* + Kupwara	.9469	M	M	M	M	H	H
2. Poonch + Rajouri	.6001	L	VL	VL	VL	VL	M
3. Jammu + Kathua	.9682	M	M	M	M	VH	M
4. Doda + Udhampur	.6419	L	VL	VL	VL	VL	L
5. *Chamba* + *Kangra* + Hamirpur + Una	.6805	L	L	VL	VL	L	M
6. Kinnaur + Lahul + Spiti	.3688	VL	VL	VL	VL	VL	VL
7. Bilaspur + Kulu + Mandi	.7246	L	L	L	VL	L	M
8. *Mahasu* + *Simla* + Sirmur + Solan	.7165	L	L	L	L	M	L
9. *Hoshiarpur* + Jullundur + Rupar	1.4322	EH	VH	H	VH	H	EH
10. Patiala	1.6030	EH	VH	VH	H	M	EH*
11. Ludhiana + Sangrur	1.5870	EH	VH	H	VH	H	EH*
12. Kapurthala + *Amritsar* + Gurdaspur	1.4528	EH	VH	M	VH	VH	EH
13. Ferozepur + Bhatinda + Faridkot	1.3241	VH	H	L*	M	M	EH*
14. Hissar + Jind + Sirsa + Bhiwani	1.1094	H	M	L	H	H	EH
15. Mahendragarh	.9665	M	M	M	M	M	H
16. Delhi + Rohtak + Gurgaon + Sonepat + *Faridabad*	1.7934	EH	EH*	EH	EH*	EH	EH
17. Karnal + *Ambala* + Kurukshetra	1.4584	EH	H	H	H	H	EH*
18. Saharanpur + Dehradun	1.2009	VH	H	H	H	VH	VH
19. Meerut + Muzaffarnagar + Gaziabad	1.2953	VH	H	VH	VH	H	VH
20. Bulandshar + Aligarh	1.0998	H	M	M	H	M	VH
21. Mathura + *Agra*	1.1612	H	VH	H	VH	VH	H
22. Mainpuri + Etawah	.8638	M	M	L	M	L	H
23. Jalaun + Jhanshi + Hamirpur + Lalitpur	.7615	L	L	L	M	M	M
24. Kanpur + Hardoi + Lucknow + Unnao	1.0494	H	H	H	VH	H	M
25. *Budaun* + Etah + Farrukhabad	.8024	M	M	L	M	L	M
26. Bijnor + Moradabad	.9950	M	M	M	H	H	M
27. Uttarkashi + Tehri Garwal + Garwal	.4636	VL	VL	VL	VL	VL	VL
28. Chamoli + Almora + *Pithorgarh*	.4863	VL	VL	VL	VL	VL	VL
29. Nainital + Rampur + Bareilly + Pilibhit + Shahjahanpur	.9610	M	M	M	H	H	M
30. Sitapur + Kheri	.6689	L	L	L	L	L	VL
31. Bahraich + Gonda + Bara Banki	.6210	L	L	L	L	L	VL
32. Basti + Gorakhpur + Deoria	.7494	L	L	M	L	L	L
33. Azamgarh + Gazhipur + Balia	.7073	L	L	L	L	L	L
34. *Pratapgarh* + *Rae-Barelli* + Sultanpur + Faizabad	.6535	L	L	L	L	L	VL
35. Fatehpur + Banda	.7145	L	L	VL	L	VL	M
36. *Allahabad* + Jaunpur	.8490	M	M	M	M	M	L
37. Varanashi + Mirzapur	.9748	M	H	H	H	H	L
38. Rewa + Sidhi	.5612	VL	VL	VL	VL	VL	L
39. Surguja + Shahdol	.5586	VL	VL	VL	VL	VL	L
40. Bilaspur + *Raigarh*	.7044	L	L	L	L	L	L
41. Raipur	.8189	M	L	L	M	L	M
42. Bastar	.4960	VL	VL	VL	VL	VL	L
43. Durg + Balaghat + Rajnandgaon	.7802	L	L	M	M	L	L
44. Mandla + *Seoni*	.5239	VL	VL	VL	VL	VL	L
45. Chindwara + Betul + Narsimhapur	.6673	L	L	VL	L	L	L
46. Damoh + Jabalpur	.9955	M	M	H	VH	H	M
47. Panna + Satna	.7002	L	L	L	L	L	L
48. *Tikamgarh* + Chattarpur	.6278	L	VL	VL	VL	VL	M

Table (5.7) Continued

Areal units (district-groups)	values of x_0	Rank symbol for index and sub-indices					
		x_0	x_1	x_2	x_3	x_4	x_5
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
49. Vidisa + Sagar + Raisen	.7985	L	L	L	L	L	M
50. Hoshangabad + Sehore + Bhopal	.7797	L	L	L	L	L	M
51. East Nimar + West Nimar	.7422	L	L	L	M	L	L
52. Dhar + Jhabua + Ratlam	.6594	L	L	L	L	L	L
53. Mandsaur	.8209	M	M	L	M	L	M
54. Ujjain + Indore + Dewas	1.1368	H	H	VH	VH	H	H
55. Shajapur + Rajgarh	.7122	L	L	VL	VL	VL	M
56. Guna + Shivpuri	.6489	L	L	VL	L	VL	L
57. Morena + Bhind + Gwalior + Datia	.8582	M	M	L	H	L	M
58. Bundi + Kota + Jhalawar	.8974	M	M	M	L	M	M
59. Tonk + Ajmer	.9183	M	M	L	H	VH	M
60. Jaipur + Swai Madhopur	.9541	M	M	M	H	H	M
61. Alwar + Bharatpur	.8557	M	L	L	L	L	H
62. Jhunjhunu + Sikar	.6475	L	L	L	L	L	VL
63. Ganganagar	.9983	M	M	L	L	L	EH
64. Bikaner + Churu	.2332	VL	L	VL	M	M	VL*
65. Nagaur + Jodhpur	.5190	VL	L	VL	L	M	VL
66. Jaisalmer + Barmer	.3632	VL	VL	VL	VL	VL	VL
67. Jalore	.6400	L	L	VL	VL	VL	M
68. Pali + Sirohi	.8240	M	M	L	L	M	M
69. Udaipur + Bhilwara + Chitorgarh	.7811	L	L	L	L	L	M
70. Banswara + Dungarpur	.6534	L	L	VL	VL	VL	M
71. Panch Mahals + Kaira	.9638	M	M	M	M	M	H
72. Ahmedabad + Sabarkantha + Gandhinagar	1.4015	EH	EH	EH*	EH	VH	H
73. Mehsana + Banaskantha	1.0110	H	H	M	M	M	VH
74. Surendranagar + Kutch	.9135	M	M	M	M	H	M
75. Jamnagar + Junagadh + Amreli	1.0581	H	H	M	H	M	H
76. Rajkot + Bhavnagar	1.1504	H	H	H	VH	H	VH
77. Surat + Bharuch + Baroda	1.0841	H	H	VH	VH	H	M
78. Dangs + Valsad + Dadra	.9693	M	M	H	M	H	M
79. Dhulia + Nasik	.9077	M	M	M	H	M	M
80. Jalgaon + Aurangabad	.8808	M	M	L	M	M	M
81. Buldana + Akola + Amravati	.8576	M	M	L	M	M	M
82. Wardha + Nagpur	1.1393	H	H	H	EH	EH*	M
83. Bhanda + Chanda	.8043	M	L	L	L	L	M
84. Yeotmal + Nanded + Parbhani	.7886	L	M	L	M	L	M
85. Bhir + Osmanabad + Sholapur	.8553	M	M	L	M	L	M
86. Pune + Ahmednagar	1.0596	H	H	H	H	H	M
87. Greater Bombay + Kolaba + Thana	2.2257	EH	EH*	EH*	EH*	EH*	H
88. Satara + Sangli	.9128	M	M	M	M	M	M
89. Kolhapur	1.1086	H	H	H	H	M	VH
90. Ratnagiri	.6553	L	L	VL	VL	M	L
91. Goa, (+ Daman + Diu)	1.2755	VH	EH	H	H	EH*	H
92. North Kanara + Shimoga	1.0731	H	M	M	M	H	VH
93. Belgaum + Dharwar	1.0278	H	H	M	H	H	H
94. Bidar + Gulbarga + Bijapur	.8418	M	M	L	M	M	M
95. Raichur + Bellary	.9603	M	M	L	M	M	H
96. Chitradurga + Tumkur	.9684	M	M	L	M	M	H
97. Bangalore + Kolar	1.2862	VH	VH	VH	EH*	EH	H
98. Mysore + Mandya	1.0431	H	M	M	H	M	VH
99. Chickmagalur + Hassan	.8982	M	M	L	L	M	H
100. South Kanara	1.2322	VH	VH	VH	H	VH	VH
101. Coorg	1.0729	H	H	VL*	VL*	M	EH

Table (5.7) Concluded

Areal units (district-groups)	values of x_0	Rank symbol for index and sub-indices					
		x_0	x_1	x_2	x_3	x_4	x_5
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
102. Cannanore + Kozhikode + Mallapuram + Waynad	1.2416	VH	EH	H	H	VH	VH
103. Palghat + Trichur	1.2745	VH	EH	H	H	VH	VH
104. Ernakulam + Kottayam + Iddiki	1.3704	VH	EH	VH	H	EH	VH
105. Alleppey + Quilon + Trivandrum	1.2736	VH	EH	EH	VH	EH	H
106. Tirunelveli + Kanyakumari	1.3901	VH	EH	VH	VH	H	EH
107. Ramanathapuram + Madurai	1.1932	H	VH	H	VH	H	H
108. Coimbatore + Periyar	1.4504	EH	EH	EH	VH	VH	EH
109. Nilgiris	1.5107	EH	VH	H	EH	VH	EH
110. Salem + Dharampuri	1.0555	H	H	H	H	H	H
111. Tiruchirapalli + Thanjavur + Pudukottai	1.2317	VH	VH	M	H	H	EH
112. Madras + Chingleput + North Arcot + South Arcot + Pondicherry	1.5607	EH	EH	EH	EH	EH	EH
113. Nellore + Chittoor	.9643	M	H	L	M	M	H
114. Cuddapah + Anantapur	.8385	M	M	L	M	M	M
115. Karnal + Mahbubnagar	.8348	M	M	L	L	L	M
116. Hyderabad + Medak + Ranga Reddy	1.2173	VH	EH*	VH	EH	EH	M
117. Nizamabad + Karimnagar	1.0525	H	M	M	M	M	VH
118. Adilabad	.8395	M	M	M	L	L	M
119. Warangal + Khammam + Nalgonda	.8327	M	M	L	L	M	M
120. Guntur + Ongole	1.0863	H	H	M	M	H	H
121. East Godavari + West Godavari + Krishna	1.2933	VH	VH	M	H	VH	EH
122. Srikakulam + Visakhapatnam + Vizianagaram	.8970	M	H	M	M	H	L
123. Kalahandi + Koraput	.6496	L	VL	VL	VL	VL	M
124. Boudh-Khondmals + Bolangir	.6942	L	L	VL	VL	VL	M
125. Puri + Ganjam	.9495	M	M	L	M	M	H
126. Balasore + Cuttack	.9225	M	M	L	L	M	H
127. Mayurbhanj + Keonjhar + Dhenkanal	.5567	VL	VL	VL	VL	L	VL
128. Sundargarh + Sambalpur	1.0165	H	L	H	M	M	H
129. Ranchi + Singhbhum	.7831	L	L	H*	H	M	VL
130. Hazaribagh + Palamau + Giridih	.4962	VL	L	L	L	L	VL
131. Patna + Gaya + Shahabad + Nalanda + Aurangabad + Nawada	.9024	M	M	M	M	M	M
132. Saran + Champaran + Siwan + Gopalganj	.7384	L	L	L	L	L	L
133. Muzaffarpur + Darbhanga + Vaisali + Sitamari + Madhubani + Samastipur	.6578	L	M	L	L	L	VL
134. Saharsa + Purnea + Katihar	.6895	L	M	VL	L	L	L
135. Monghyr + Bhagalpur + Begusarai	.8419	M	M	M	M	M	L
136. Santal Parganas + Dhanbad	.8142	M	M	M	H	H	L
137. Purulia + Bankura + Midnapur	.9026	M	L	M	L	H	H
138. Burdwan + Howrah + Hooghly	1.5877	EH	EH	EH*	EH	EH	EH
139. Calcutta + 24-Parganas + Nadia	1.6659	EH	EH*	EH*	EH	EH*	H
140. Murshidabad + Birbhum	.9954	M	M	M	L	M	VH
141. West Dinajpur + Malda	.9552	M	M	L	L	M	VH
142. Cooch-Behar + Jalpaiguri + Darjeeling	1.1298	H	H	M	M	VH	VH
143. Meghalaya	.5731	VL	L	VL	L	L	VL
144. Goalpara + Kamrup	.8109	M	H	L	L	H	L
145. Darrang + Lakhimpur + Sibsagar + Dibrugarh + Nowgong	1.0269	H	M	M	L	M	VH
146. United Mikir & North Cachar Hills	.6978	L	VL	VL*	VL	VL	H
147. Cachar + Tripura	.8162	M	M	L	L	M	M
148. Mizoram	.4875	VL	VL	VL	L	VL	VL
149. Manipur + Nagaland	.6845	L	L	VL	L	L	M
150. Arunachal	.3546	VL	VL	VL	VL	VL	VL
151. The Andamans island	.9827	M	M	M	VL	M	H

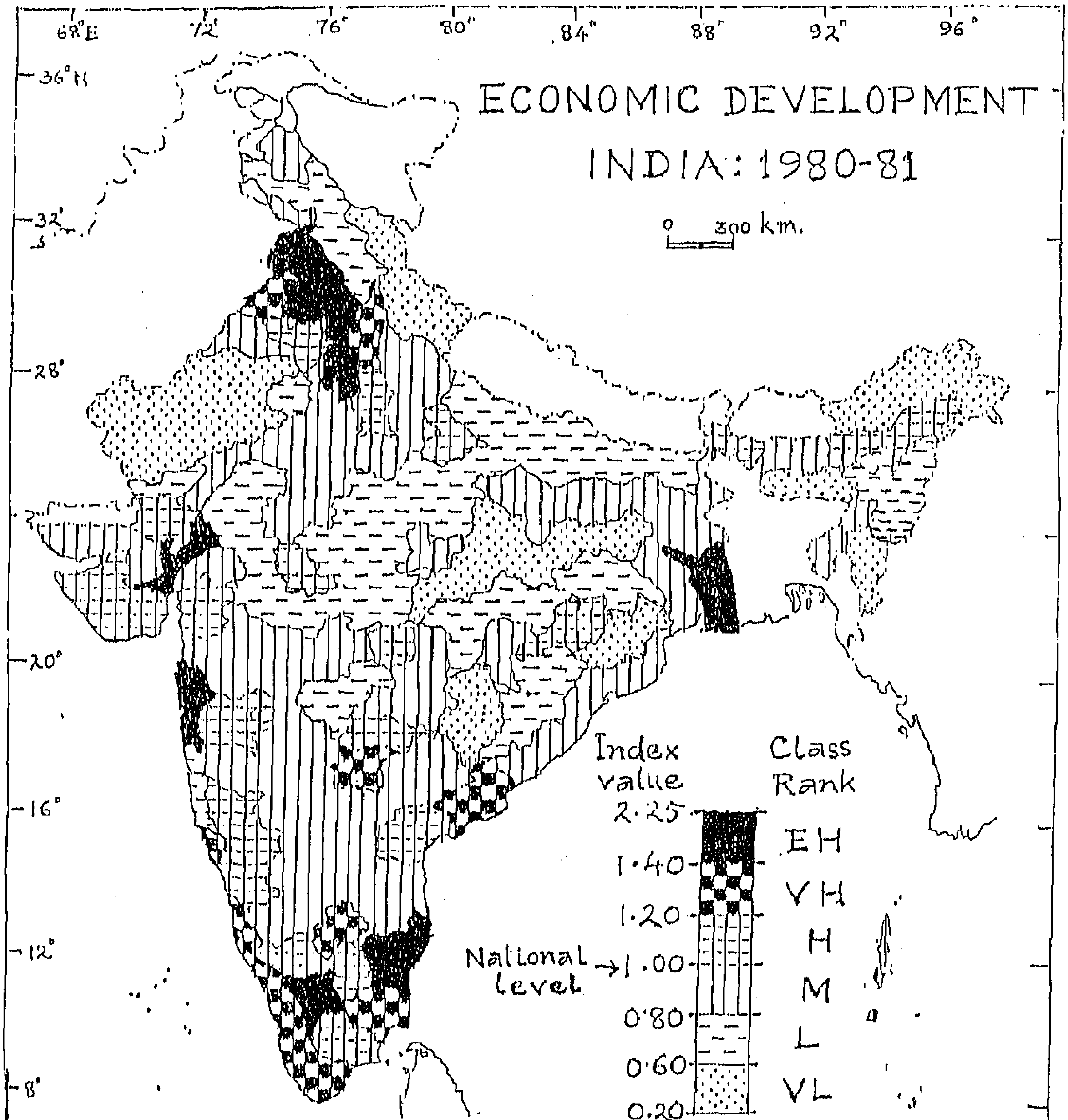

ECONOMIC DEVELOPMENT
INDIA: 1980-81
0 300 km.
68°E
72°
76°
80°
84°
88°
92°
96°
36°N
32°
28°
20°
16°
12°
8°
Index value
Class Rank
2.25
EH
1.40
VH
1.20
H
National level → 1.00
M
0.80
L
0.60
VL
0.20

Fig. 5.1

Figure (5.5). As spatial polarisations are there for non-agricultural activity sectors, there is no need for mapping of them separately, since these sectors are adequately represented in x_0. As the spatial interactions between x_5 and other sectors have not been adequate, the map-comparisons between x_0 and x_5 could be of use in depicting the degree of interaction of the agricultural sector with economic development in different areas. However, we would also consult the tabulated ranks of all activities, together with the maps of x_5 and x_0 in our subsequent analysis on the nature of activity-mix in important areas of economic development.

The broad regional groupings of areal units as emerged in respect of levels of over-all economic development (ref. to Fig. 5.1) are as follows : A higher level of economic development relative to national level could be seen to occur in two broad regions, six areas (each with two or more areal units) and six isolated areal units. On the basis of the rank-data presented in Table (5.7), these regional grouping of areal units can be described and characterised briefly as follows :

I <u>North-Indian More-Developed Region</u>

Coverage : Areal unit numbers 9 to 13 (all Punjab), 14, 16, 17 (Delhi and Haryana except Mahendragarh district), 18 to 21 (Western fringe of U.P.)

Characteristics : Leading agriculturally developed region with associated industrial development. Generally EH*, EH and VH agricultural development in this region with its core area of all-round EH development around the capital city of Delhi. Industrial development in this region is generally VH except for areal units

13 (L*), 14 (L), 12(M) and 20 (M). Marketing and servicing activities generally very high in the northern part which decreases to lower values in the southern part of this region.

II South-Indian More-Developed Region

Coverage : Areal unit numbers 106 to 112 (all Tamil Nadu), 102 to 105 (all Kerala), 97, 98, 100, 101 (Southern fringe of Karnataka).

Characteristics : Generally all-round development in all economic activities in this region (except the agriculturally developed coffee plantation area of Coorg (101) where industrial and urbanisation activities are significantly very low).

1. More-Developed Area in the West-Coast with Ahmedabad Core

Coverage : Areal unit numbers 72, 73, 75, 76 and 77 (major part of Gujarat).

Characteristic : Developed area of cotton and related textile production based agro-industrial activities, with industrial cores mainly in Ahmedabad (72, EH*), and next in Surat (77, VH). Agricultural development is generally high (except in areal unit 77). In the two cores, the associated marketing and servicing activities are also correspondingly high.

2. More-Developed Area in the West-Coast with Bombay core

Coverage : Areal unit number 86 and 87 (in Maharashtra).

Characteristic : Most advanced leading industrially developed area with associated marketing and servicing activity development. Extremely high (EH*) development in all non-agricultural activities in the core.

3. <u>More-Developed Area in the West Coast with Goa Core</u>

Coverage : Areal unit numbers 91 (Goa), 92, 93 (north-Western fringe of Karnataka), and 89 (Kolhapur district at the Southern-most tip of Maharashtra).

Characteristics : High or very high agricultural development with extremely high trading and transportation activities in the core.

4. <u>More-Developed area in the East-Coast</u>

Coverage : Areal unit numbers 120, 121 (in Andhra Pradesh).

Characteristics : Agriculturally developed area of Krishna-Godavari delta; its southern part (120) is the well-known tobacco producing area.

5. <u>More-Developed Area with Hyderabad Core in South India</u>

Coverage : Areal unit numbers 116, 117 (in Andhra Pradesh).

Characteristics : This area has the northern agriculturally developed area (117) and the remaining core area (116) showing extremely high or very high non-agricultural activity development. The core is a significant trading centre (with EH* value).

6. More-Developed Area of Calcutta Conurbation in Eastern India

Coverage : Areal unit numbers 138, 139 (in West Bengal).

Characteristics : Extremely high all-round development with significant industrial activities.

More-Developed Isolated Areal Units /

(i) Areal unit number 24 (Kanpur-Lucknow core) : Very high urban development with non-agricultural activities.

(ii) Areal unit number 82 (Nagpur core): Extremely high development as transport and urban centre with industrial and trading activities.

(iii) Areal unit number 54 (Ujjain-Indore core) : All-round high development with very high industrial and urban development.

(iv) Areal unit number 128 (Sundargarh + Sambalpur) : Just high industrial and agricultural development without much of marketing and servicing activities.

(v) Areal unit number 142 (Tea producing area of West Bengal) : Very high development in agricultural and transportation activities and high trading.

(vi) Areal unit number 145 (Tea producing area of Assam) : Very high agricultural development without much of non-agricultural development.

Apart from these developed areas, the transitional medium level of over-all economic development occurs quite extensively around the highly developed regions and areas. All low and very low levels of economic development mostly occur in the eastern and central parts of India, in the mountainous areas of north and far-east and also in the extremely dry areas (desert condition) of Rajasthan. If we look at the tabulated rank-classes of the areal units of these areas, it seems that these areas are depressed in most of the activity indices together with that of agricultural performance.

From our regionalisation and characteristics-evaluation on activity-mix, one gets an impression that there seems to be good spatial interaction, not only among non-agricultural sectors, but also between agricultural sector and at least some of the non-agricultural sectors in most of the areas. However this agreement on the spatial interaction is not well-brought out by the magnitudes of correlation coefficients shown in Table (5.1). Our impression gets strengthened when we make two-way frequency classifications of areal units for their class-ranks with different sectors and over-all economic activities. We extract the main results of this frequency analysis in the following summarised Tables (5.8), (5.9) and (5.10). In these Tables the symbol A is used to indicate advanced areal units with EH, VH and H levels and symbol B stands for backward areal units with VL and L levels in any activity. The symbol M indicates, as before, the same moderate level below the critical national value.

Table (5 8) : Frequency Distribution of Agriculturally Advanced Areal Units by Activity Sectors; India : 1980-81

Activity level	Frequency by activity index and sub-indices				
	x_1 trading	x_2 industry	x_3 urbanisation	x_4 transport	x_0 over-all economic
(1)	(2)	(3)	(4)	(5)	(6)
A	39	29	36	36	45
M	19	19	15	22	16
B	4	14	11	4	1
total number of agriculturally advanced areal unit	62	62	62	62	62

In Table (5.8), we have tried to examine how many of 62 agricultural advanced areal units remain advanced in different non-agricultural sec also. The frequency entries in the line against B, show that these are quite insignificant for x_1, x_4 and x_0, but these are not that insignificant for x_2 and x_3 which are highly connected because of urban orientation of industrial activities. It hints that India is not that industrialised and urbanised as it is agriculturally advanced. But the most important feature brought out from this Table (5.8) is that most of agriculturally advanced areal units are also advanced in non-agricultural activities also, except for marginal lowering of frequency in industrial sector x_2 for reasons stated already. In this Table the best agreement that we have for agriculturally advanced areal units is, naturally, with the over-all economic activity index. Of the total 50 over-all economically advanced areal units, only 5 are marginally not in agreement with agricultural advancement (these 5 are in medium category of agricultural activity level). From the comparisons of frequencies shown in the line against A in Table (5.8), we notice a slight fall in sectoral frequencies (not so slight however for industry), from that of the over-all index x_0. To trace the nature of fall we refer to Table (5.9) for the details about 45 advanced areal units in both agricultural activity and over-all economic activity levels.

Table (5.9) : Frequency Distribution of Agriculturally and Over-all Economically Advanced Areal Units by Activity Sectors; India : 1980-81

Activity level	Frequency by activity sub-indices			
	x_1	x_2	x_3	x_4
(1)	(2)	(3)	(4)	(5)
A	38	29	36	34
M	6	13	7	11
B	1	3	2	0
total number of agriculturally and over-all economically advanced areal units	45	45	45	45

In this Table also, the frequency entries in the line against B are all insignificant. The frequency entries against line A in both the Tables (5.8) and (5.9) are practically identical sector by sector. So the stated fall of frequency from the bottom line total 45 to the frequencies for advanced level A is really marginal in nature, because the shift is mostly to M-level, not much to B-level. This is all about agriculturally advanced areal units. We now turn our attention to agriculturally backward areal units and their activity levels in other sectors.

Table (5.10) : Frequency Distribution of Agriculturally Backward Areal Units by Activity Sectors, India : 1980-81

Activity level	Frequency by activity index and sub-indices				
	x_1	x_2	x_3	x_4	x_0
(1)	(2)	(3)	(4)	(5)	(6)
A	3	2	3	4	0
M	5	6	6	7	7
B	34	34	33	31	35
total number of agriculturally backward areal unit	42	42	42	42	42

The Table (5.10) is self-explanatory. Here we notice that most of the agriculturally backward areal units are backward in all sectors including the over-all sector; the frequencies against line B are not only predominant but also almost same. The frequencies against line A are also practically negligible. Thus we conclude that agriculturally backward areal units have mostly remained backward in all activity sectors. All these frequency analyses establish our earlier impression that the role of agricultural sector is strongly positive with sufficient interactions with the activities of other sectors. The little snag that is noticed for industrial and urban activities is due to the fact that India is not yet sufficiently industrialised and urbanised.

The estimation of linear correlation coefficients may at times produce unsatisfactory result for existance of even a few discordantly associating observations as shown, say, in the line against B of Table (5.8) and the line A of Table (5.10), or for even non-matching statistical distributions between variables (for example, we have seen earlier that two different forms of the same surplus measure, Σ_2 and L_2, have shown different inter-correlations with some other agricultural activity measure like x_w, Z). So, on the evidence of actual class-rank associations between different sectors, the conclusions that have been drawn on the spatial interactions between x_5 and other sectors x_1 to x_4, go in support of our formulation of equi-spaced optimal index x_o for over-all economic development measure that depicts strong inter-correlations with each sectoral index including even x_5. We would now conclude this section by showing inter-correlations of all these activity indices x_0 to x_5 with different other key measures of agricultural activities in Table (5.11).

In this Table, we notice that, among the equally represented sub-indices x_m, x_w and x_a of agricultural development x_5, the agricultural land productivity x_a is best related, and cultivators' foodgrain production surplus generating capacity index x_m is next to best related with all activity sectors and the over-all economic development index x_0. The intensification-inducing variable of fertiliser input F, which is strongly connected with x_a, has also shown high inter-relations — higher than even that shown by x_m. Again x_m (i.e., L_1) and L_2 are the same kind of foodgrain surplus indices, accounting respectively for cultivators' surplus and agricultural population's surplus. But the interactions of

Table (5.11) : Spatial Intercorrelations Between the Sectors of Over-all Economic Development and the Key Measures of Agricultural Activities; India : 1980-81

measures of agricultural activities	Correlation coefficients for economic development indices					
	x_0 over-all economic	x_1 trading	x_2 industry	x_3 urbanisation	x_4 transport	x_5 agriculture
(1)	(2)	(3)	(4)	(5)	(6)	(7)
x_5	.7950	.5131	.4441	.4234	.3815	1.0000
$x_m = L_1$	.6129	.3747	.3251	.3181	.2751	.8094
x_w	.5698	.3075	.2520	.3026	.2031	.8094
x_a	.7490	.5850	.5143	.4404	.4713	.80[illegible]
F	.6644	.5424	.4894	.4349	.4137	.6795
L_2	.3872	.1355	.0971	.1412	.0762	.6602
Σ_2	.4349	.1956	.1447	.1845	.0924	.6916
Z	.3990	.1975	.1756	.2051	.0983	.5886
X	.4150	.2533	.2465	.2830	.1874	.5170
Y	.3577	.1986	.1705	.2029	.1309	.4964

x_m is much higher than those of L_2 with the non-agricultural and over-all economic activity sectors. Thus the non-agricultural sectors' agreement in spatial interaction is best revealed with agricultural land-quality and cultivators' capacity and not so much with any measures covering entire agricultural workers or population or the related measures. Thus measures like Σ_2 and growth factors Z, X, Y, which revealed best connections with x_w, as compared with other two sub-indices x_m and x_a (ref. to Table (4.27)), have now shown much lower interactions with non-agricultural and over-all economic activity sectors, likewise x_w. The interactions of those related variables of x_w are even much worse.

5.6 Regional Synthesis and the Dimension of Task-Ahead

5.6.1 The Need for Synthetic Assessment of Growth-Retardedness and Backwardness

From our preceding analyses, we notice that all 1960-81 growth factors of importance X, Z and Y have not shown satisfactory spatial interaction with the level of economic development. These growth factors have also shown inferior spatial relation with the level of 1980-81 agricultural development x_5, and much inferior spatial relation with the level of 1980-81 land productivity x_a, as compared with the level of 1980-81 labour productivity x_w (ref. to Table (4.27)). This means that labour productivity growth, agricultural production growth and land yield rate change have gone together (as strong intercorrelations exist among the growth factors X, Z and Y) in favour of high labour-productive areas of 1980-81, but not so much of all the agriculturally developed areas or the land-productive areas of 1980-81. From the angle of labour pressure on agriculture, this is certainly not a happy situation for the vast areas of low labour-productivity, where all growth factors must have been generally low, as indicated by the strong intercorrelation among x_w, X, Z and Y. We have also noticed from our comparative growth factor analysis for the two sub-periods that the agricultural worker increase factor E has also reached a point of saturation, showing the negative marginal rate of increase for production growth in the 2nd decade (ref. Table (4.21)).

gain as the agricultural population's foodgrain surplus measure Σ_2 is also strongly related with x_w, the low labour productive areas are also generally at low levels in surplus generating situation. In fact, from the results of our comparative study on Σ_2 for the two time-points 1970-71 and 1980-81 (ref. to Table (4.3)), we can infer that the foodgrain surplus situations have deteriorated in the period with increased deficit for the low labour productivity areas, as one could expect from the influence of population change factor E. The ever-increasing number of agricultural workers would further aggravate this gloomy aspect of no-improvement in the low labour-productivity or the low productivity growth areas. As such, it becomes necessary for us to examine the growth factors X, Z, Y and also the labour change factor E in conjunction with x_5 for a synthetic assessment of growth-retardedness and backwardness for different areas. On the basis of such synthetic assessments, we would then be able to visualise the dimension of task ahead on growth efforts towards reducing regional disparities.

5.6.2 The Index of Growth-Retardedness cum Backwardness (1960-81) and the Dimension of Task Ahead on Growth Efforts

In the concluding section (4.8) of preceding Chapter, we have done some analysis in this regard by States of India. There, under two alternative labour-productivity growth standards, namely :

I. growth target setting at all-India average labour productivity growth (i.e., a proportionate rate of 0.20 over two-decade period) and

II. growth target setting at U P. State average labour productivity growth (i.e., a proportionate rate of 0.35 over two-decade period);

we have devised a sort of tentative task index, T(I) and T(II). It has also been mentioned there that this kind of index is nothing but a measure of relative growth-retardedness (or growth-orientation, when the index value turns out to be below unity for those areal units which are at higher productivity growth levels relative to prescribed standard) in productivity performance during 1960-81 from the labour pressure angle. Here, we would use the same formulations of T(I) and T(II) by areal units and call them only the indices of growth-retardedness under the prescribed growth standards I and II. In the concluding paragraph of section (4.8), we have noted that the index T(II) has some positive relationship with the measure $(1/D_A^2) = (1/x_5^2)$. Taking the clue from this, we would define the index of depressed agro-economic condition or backwardness and designate it by D, thus, we have :

$$D = (1/x_5^2).$$

Our findings with state level data are that there is good agreement generally between D-values and T-values, except for a few states which showed high level of development in 1980-81 and low level of productivity growth in the preceding two-decadal period. Clearly these states with non-conformal (T, D) values are in a better situation as compared with another state having similar T-value and a D-value which is conformal with the T-value. Thus, in an areal unit, if its low productivity is associated with high development level x_5, it is in a better-off situation than what is warranted by its low productivity. Naturally it is better to get a synthetic index involving both T and D for a proper assessment of relative situation of areal units. In other words, the tentative T-values are to be moderated by corresponding D-values for a proper formulation of task index on growth efforts towards reducing regional disparities.

It should be noted that, in many areal units, opportunities of labour-absorption in non-agricultural activities are relatively better. For example, areas with adequate metropolitan development have better non-agricultural opportunities. Again in many desert or hill areas, agricultural opportunities (in pure cropping activities only) could be relatively more limited than non-agricultural ones. So, at this stage, we would bring in the supporting roles of non-agricultural sectors through our over-all economic development index x_0. This index has been formulated with a due recognition of the role of agricultural sector in over-all economic development. Thus our x_0 is as highly inter-related with x_5 as it is with any other sector. Taking advantage of this very high inter-connection between x_5 and x_0 in our formulation, we could determine the level of x_5, say $\hat{x}_5$, as would correspond to the level of x_0, through the regression equation of x_5 on x_0. Here our interest lies in those $\hat{x}_5$-values which are higher than actual x_5 (without any interest for regression coefficients), and as such, we have gone for the OLS regression fit, by minimising $\Sigma\ (\hat{x}_5 - x_5)^2$, for making optimal judgement on the identification of $\hat{x}_5 > x_5$. This regression is given by

$$\hat{x}_5 = 0.14135 + 0.90533\, x_0; \qquad \dots (5.36)$$

$$r_{x_5x_0} = 0.795.$$

If x_5 is lower than the estimated $\hat{x}_5$, we can take that non-agricultural supportive activities are in better situations than agricultural activities. Thus, for the purpose of integration between T and D, we revise our estimates of D to D* as follows :

we put, $$D^* = (1/x_5^*)^2 , \qquad \dots (5.37)$$

where $$x_5^* = \text{max. of } (x_5, \hat{x}_5).$$

The areal-units in VL-class (ref. to Figure (3.5) on $x_5 = D_A$ in Chapter 3) have certain limitations for future growth possibilities, such as the disadvantageous desert condition, condition of uneven terrain type, bad climatic condition, etc. The boundary value of x_5 between (VL, L) classes is 0.64. Just a little lower value of about 0.6325 corresponds to a value of D at 2.5. Because of the limitation of future agricultural possibilities in these areas, we would treat all these areal units with x_5 (or x_5^*) value below 0.6325 at the same near-boundary value of 0.6325, so that D (or D^*) never exceeds a value of 2.5. Here the national value of x_5 (and also of x_0) corresponds to the critical value of unity. The national value of T(I) is the same unity, while the national value of T(II) is 1.29. As such, for comparability, we also set the upper limit for values of T(I) at 2.5 and that for T(II) at 3.2 (which is approximately equal to the product 1.29 x 2.5). Thus our D, D^* and T(I) values for areal units have an upper limit of 2.5, while T(II) values do not exceed 3.2. Our intensification growth task efforts can hardly be multiplied, in the forward 2-decade period beyond 1980-81, by more than the above mentioned upper limits under the two standards in unfavourable areas of agricultural activities.

Our synthetic index of growth-retardedness cum backwardness is an average of T and D^* values. The national value of D is unity and that for T(I) and T(II) are respectively 1.00 and 1.29. Thus, we can consider T(I) and D^* as additive for averaging, while for the other standard at higher level, we can consider T(II) and $(1.29D^*)$ as additive for averaging. Thus, our final indices of growth-retardedness cum backwardness, designated by T_1 and T_2 under the two growth standards I and II, can be written as :

$$\left.\begin{aligned} T_1 &= \frac{1}{2} \left[T(I) + D^* \right], \\ \text{and} \quad T_2 &= \frac{1}{2} \left[T(II) + 1.29\, D^* \right]. \end{aligned}\right\} \quad \ldots (5.38)$$

These T_1 and T_2 values are bounded as shown below :

$$0 < T_1 \leqq 2.5 \text{ and } 0 < T_2 \leqq 3.2 \quad \ldots (5.39)$$

It should be understood that T_1 and T_2 "index values below unity" correspond to the situation of "growth-orientedness cum advancedness" as compared with the two growth standards I and II respectively.

As these indices are ultimately to be used in ascertaining the "intensification growth task ratio" (say, for the forward two-decade period beyond 1980-81), we have retained the letter T (signifying

Task ahead) for designating the above synthetic index of growth retardedness and backwardness. It should be noted that when T_1 and T_2 are treated as the "intensification growth task ratio" index for the forward two-decade period, the areal units with index values "below unity" should be read as "unity", in order to retain their own higher growth standard, above the prescribed ones. That is, we suggest that as task indices, T_1 and T_2 have the following lower and upper bounds

$$1 \leq T_1 \leq 2.5 \text{ and } 1 \leq T_2 \leq 3.2 \qquad \ldots (5.40)$$

In our state data on T(II) as shown in section (4.8), the below-unity index values have more or less a class interval length of 0.35 and the above-unity cases have a class interval length of 0.55. For our classification of T_2 we have retained the two below-unity and above-unity interval lengths, while for classification of T_1, we have used uniformly the same below-unity interval length for all values above and below unity. Thus our index-values between consecutive class-ranks are as follows :

T_1 : EGRB (1.70) HGRB (1.35) GRB (1.00) GOA (0.65) HGOA,

T_2 : EGRB (2.10) HGRB (1.55) GRB (1.00) GOA (0.65) HGOA.

The interpretation of rank-symbols are as follows :

EGRB = Extreme Growth-Retardedness cum Backwardness

HGRB = High Growth-Retardedness cum Backwardness

GRB = Growth-Retardedness cum Backwardness

GOA = Growth-Orientedness cum Advancedness

HGOA = High Growth-Orientedness cum Advancedness.

The frequency distribution of areal units by these ranked-classes are as follows :

Index	frequency of areal units by classes				
	EGRB	HGRB	GRB	GOA	HGOA
T_1	16	27	47	46	15
T_2	20	40	57	25	9

Clearly, for switching to higher standard II from I, corresponding frequency in above-unity classes has relatively increased. Although we have given estimates under the two standards, our aim for growth efforts should be better geared to the higher standard with prescribed task T_2, since the targeted tasks often fell short of achievements in Indian planning era. Finally, on the basis of our classifications, we have recorded the class-ranks of all areal-units for T_1 and T_2 in Table (5.12) and prepared the corresponding maps shown in Figures (5.2) and (5.3). The estimates of T_1 and T_2 are also recorded in the same Table.

The synthetic indices T_1 and T_2 are almost highly correlated with T(I) and T(II) respectively. The correlation coefficients between T_1 and T(I) is about 0.785, while that between T_2 and T(II), about 0.794. Thus our synthesis has not taken away the T_1 and T_2 values far away from the corresponding T(I) and T(II) values. In addition, we have now almost similar kind of spatial association of quite high magnitude with the agricultural development index x_5. The correlation coefficient for $D = (1/x_5)^2$ with T_1 is 0.7811 and that with T_2 is 0.7891. This shows that the welfare objective of reducing the regional

Table (5.12) : Estimates of the Index of Growth-Retardedness cum Backwardness (1960-81) by two Alternative Standards (I and II) of Labour Productivity Growth/or the Intensification Growth Task Ratio Index (1980-2001) to aim at the Prescribed Standards for the Areal Units of India

	Areal units (district-groups)	all-India average growth : Standard I		U.P. State average growth : Standard II	
		T_1 index values	T_1 rank symbols	T_2 index values	T_2 rank symbols
	(1)	(2)	(3)	(4)	(5)
1.	Srinagar + Anantanag + Baramulla + Phulwama + Badgam + Kupwara	.7737	GOA	.9807	GOA
2.	Poonch + Rajouri	1.0528	GRB	1.3087	GRB
3.	Jammu + Kathua	.6868	GOA	.8955	GOA
4.	Doda + Udhampur	1.0694	GRB	1.3758	GRB
5.	Chamba + Kangra + Hamirpur + Una	.9856	GOA	1.2553	GRB
6.	Kinnaur + Lahul + Spiti	1.8049	EGRB	2.2658	EGRB
7.	Bilaspur + Kulu + Mandi	1.3493	GRB	1.3817	GRB
8.	Mahasu + Simla + Sirmur + Solan	1.2416	GRB	1.5607	HGRB
9.	Hoshiarpur + Jullundur + Rupar	.2475	HGOA	.3455	HGOA
10.	Patiala	.1616	HGOA	.2459	HGOA
11.	Ludhiana + Sangrur	.1752	HGOA	.2643	HGOA
12.	Kapurthala + Amritsar + Gurdaspur	.2845	HGOA	.3796	HGOA
13.	Ferozepur + Bhatinda + Faridkot	.2483	HGOA	.3438	HGOA
14.	Hissar + Jind + Sirsa + Bhiwani	.5888	HGOA	.7935	GOA
15.	Mahendragarh	.5071	HGOA	.6885	GOA
16.	Delhi + Rohtak + Gurgaon + Sonepat + Faridabad	.2797	HGOA	.3850	HGOA
17.	Karnal + Ambala + Kurukshetra	.2355	HGOA	.3537	HGOA
18.	Saharanpur + Dehradun	.8499	GOA	1.1049	GRB
19.	Meerut + Muzaffarnagar + Gaziabad	.5823	HGOA	.8034	GOA
20.	Bulandshahr + Aligarh	.5426	HGOA	.7239	GOA
21.	Mathura + Agra	.7072	GOA	.8950	GOA
22.	Mainpuri + Etawah	.9859	GOA	1.1513	GRB
23.	Jalaun + Jhanshi + Hamirpur + Lalitpur	1.3298	GRB	1.6911	HGRB
24.	Kanpur + Hardoi + Lucknow + Unnao	.7884	GOA	.9886	GOA
25.	Badaun + Etah + Farrukabad	1.0873	GRB	1.3951	GRB
26.	Bijnor + Moradabad	.8165	GOA	1.1082	GRB
27.	Uttarkashi + Tehrigarwal + Garwal	1.5475	HGRB	2.0534	HGRB
28.	Chamoli + Almora + Pithorgarh	1.6135	HGRB	2.0646	HGRB
29.	Nainital + Rampur + Bareilly + Pilibhit + Shahjahanpur	1.0414	GRB	1.3116	GRB
30.	Sitapur + Kheri	1.7167	EGRB	2.1764	EGRB

N.B. : (i) T_1 and T_2 "Index values below unity" correspond to the situation of "Growth-Orientedness cum Advanceness" compared to Standards I and II respectively.

(ii) The Intensification Growth Task Ratio T_1 and T_2 for areal units with "Index values below unity" should be read as "unity" to retain their own higher standards above the prescribed ones.

(iii) Index value between consecutive ranks are as follows :

T_1 : EGRB (1.70) HGRB (1.35) GRB (1.00) GOA (0.65) HGOA

T_2 : EGRB (2.10) HGRB (1.55) GRB (1.00) GOA (0.65) HGOA.

(iv) Rank Symbols :

EGRB = Extreme Growth-Retardedness cum Backwardness,
HGRB = High Growth-Retardedness cum Backwardness,
GHR = Growth-Retardedness cum Backwardness,
GOA = Growth-Orientedness cum Advanceness,
HGOA = High Growth-Orientedness cum Advanceness.

Table (5.12) Continued

	Areal units (district-groups) (1)	all-India average growth : Standard I T_1 index values (2)	T_1 rank symbols (3)	U.P. State average growth : Standard II T_2 index values (4)	T_2 rank symbols (5)
31.	Bahraich + Gonda + Bara Banki	1.4220	HGRB	1.8289	HGRB
32.	Basti + Gorakhpur + Deoria	.9873	GOA	1.3078	GRB
33.	Azamgarh + Gazhipur + Balia	1.0233	GRB	1.3953	GRB
34.	Pratapgarh + Rae-Barelli + Sultanpur + Faizabad	1.2701	GRB	1.6452	HGRB
35.	Fatehpur + Banda	1.1438	GRB	1.4486	GRB
36.	Allahabad + Jaunpur	.8337	GOA	1.1150	GRB
37.	Varanashi + Mirzapur	.7443	GOA	.9846	GOA
38.	Rewa + Sidhi	1.5989	HGRB	2.0485	HGRB
39.	Surguja + Shahdol	1.5732	HGRB	2.0257	HGRB
40.	Bilaspur + Raigarh	1.5799	HGRB	2.0126	HGRB
41.	Raipur	1.2242	GRB	1.5955	HGRB
42.	Bastar	2.0730	EGRB	2.8370	EGRB
43.	Durg + Balaghat + Rajnandgaon	1.5525	HGRB	2.0515	HGRB
44.	Mandla + Seoni	1.8792	EGRB	2.3967	EGRB
45.	Chindwara + Betul + Narsimhapur	1.8538	EGRB	2.5943	EGRB
46.	Damoh + Jabalpur	.9540	GOA	1.2298	GRB
47.	Panna + Satna	1.3991	HGRB	1.8039	HGRB
48.	Tikamgarh + Chattarpur	1.3566	HGRB	1.8402	HGRB
49.	Vidisa + Sagar + Raisen	1.2534	GRB	1.6086	HGRB
50.	Hoshangabad + Sehore + Bhopal	1.3284	GRB	1.7385	HGRB
51.	East Nimar + West Nimar	1.3516	HGRB	1.7374	HGRB
52.	Dhar + Jhabua + Ratlam	1.5991	HGRB	2.0171	HGRB
53.	Mandsaur	1.2393	GRB	1.5923	HGRB
54.	Ujjain + Indore + Dewas	.7858	GOA	1.0109	GRB
55.	Shajapur + Rajgarh	1.0996	GRB	1.4341	GRB
56.	Guna + Shivpuri	1.5383	HGRB	1.9898	HGRB
57.	Morena + Bhind + Gwalior + Datia	1.0919	GRB	1.4213	GRB
58.	Bundi + Kota + Jhalawar	1.1877	GRB	1.5653	HGRB
59.	Tonk + Ajmer	.8562	GOA	1.1585	GRB
60.	Jaipur + Swai Madhopur	.9084	GOA	1.3268	GRB
61.	Alwar + Bharatpur	.9189	GOA	1.4054	GRB
62.	Jhunjhunu + Sikar	1.4982	HGRB	2.0484	HGRB
63.	Ganganagar	.4349	HGOA	.5493	HGOA
64.	Bikaner + Churu	2.3407	EGRB	3.0933	EGRB
65.	Nagaur + Jodhpur	2.5000	EGRB	3.2000	EGRB
66.	Jaisalmer + Barmer	2.5000	EGRB	3.2000	EGRB
67.	Jalore	1.9651	EGRB	2.5224	EGRB
68.	Pali + Sirohi	1.0570	GRB	1.4136	GRB
69.	Udaipur + Bhilwara + Chitorgarh	1.1134	GRB	1.4731	GRB
70.	Banswara + Dungarpur	1.0339	GRB	1.3612	GRB

Table (5.12) Continued

	Areal units (district-groups)	all-India average growth : Standard I		U.P. State average growth : Standard II	
		T_1 index values	T_1 rank symbols	T_2 index values	T_2 rank symbols
	(1)	(2)	(3)	(4)	(5)
71.	Panch Mahals + Kaira	.9074	GOA	1.1573	GRB
72.	Ahmedabad + Sabar Kantha + Gandhinagar	.5737	HGOA	.7282	GOA
73.	Mehsana + Banaskantha	.6919	GOA	.8578	GOA
74.	Surendranagar + Kutch	.9795	GOA	1.1946	GRB
75.	Jamnagar + Junagadh + Amreli	.6675	GOA	.8717	GOA
76.	Rajkot + Bhavnagar	.6785	GOA	.8474	GOA
77.	Surat + Bharuch + Baroda	.9240	GOA	1.1777	GRB
78.	Dangs + Valsad + Dadra	.9473	GOA	1.2299	GRB
79.	Dhulia + Nasik	1.0967	GRB	1.4148	GRB
80.	Jalgaon + Aurangabad	1.0616	GRB	1.3814	GRB
81.	Buldana + Akola + Amravati	1.3640	HGRB	1.7237	HGRB
82.	Wardha + Nagpur	.7964	GOA	1.0308	GRB
83.	Bhanda + Chanda	1.1445	GRB	1.4518	GRB
84.	Yeotmal + Nanded + Parbhani	1.2461	GRB	1.5929	HGRB
85.	Bhir + Osmanabad + Sholapur	1.0421	GRB	1.3191	GRB
86.	Pune + Ahmednagar	.9287	GOA	1.1945	GRB
87.	Greater Bombay + Kolaba + Thana	.6681	GOA	.8453	GOA
88.	Satara + Sangli	.9144	GOA	1.1905	GRB
89.	Kolhapur	.7816	GOA	1.0867	GRB
90.	Ratnagiri	1.4009	HGRB	1.7982	HGRB
91.	Goa (+ Daman + Diu)	1.1421	GRB	1.5048	GRB
92.	North Kanara + Shimoga	1.0127	GRB	1.2807	GRB
93.	Belgaum + Dharwar	1.0550	GRB	1.3632	GRB
94.	Bidar + Gulbarga + Bijapur	1.4510	HGRB	1.8986	HGRB
95.	Raichur + Bellary	1.0152	GRB	1.2580	GRB
96.	Chitradurga + Tumkur	.7040	GOA	.9570	GOA
97.	Bangalore + Kolar	.6973	GOA	.9058	GOA
98.	Mysore + Mandya	.7861	GOA	.9874	GOA
99.	Chickmagalur + Hassan	1.0391	GRB	1.3215	GRB
100.	South Kanara	.8294	GOA	1.1098	GRB
101.	Coorg	1.0333	GRB	1.2857	GRB
102.	Cannanore + Kozhikode + Mallapuram + Waynad	.8896	GOA	1.1024	GRB
103.	Palghat + Trichur	.9394	GOA	1.2138	GRB
104.	Ernakulam + Kottayam + Iddiki	.7977	GOA	.9999	GOA
105.	Alleppey + Quilon + Trivandrum	.7526	GOA	.9473	GOA
106.	Tirunelveli + Kanya Kumari	.7836	GOA	.9843	GOA
107.	Ramanathapuram + Madurai	1.5851	HGRB	1.8968	HGRB
108.	Coimbatore + Periyar	1.2542	GRB	1.6177	HGRB
109.	Nilgiris	.4062	HGOA	.5445	HGOA
110.	Salem + Dharampuri	1.3013	GRB	1.7924	HGRB
111.	Tiruchirapalli + Thanjavur + Pudukottai	.7125	GOA	.8946	GOA
112.	Madras + Chingleput + North Arcot + South Arcot + Pondicherry	.5936	HGOA	.7421	GOA

Table (5.12) Concluded

	Areal units (district-groups)	all-India average growth : Standard I		U.P. State average growth : Standard II	
		T_1 index values	T_1 rank symbols	T_2 index values	T_2 rank symbols
	(1)	(2)	(3)	(4)	(5)
113.	Nellore + Chittoor	.9018	GOA	1.2754	GRB
114.	Cuddapah + Anantapur	1.5582	HGRB	2.0661	HGRB
115.	Karnal + Mahbubnagar	1.5263	HGRB	1.9478	HGRB
116.	Hyderabad + Modak + Ranga Reddy	1.1305	GRB	1.6123	HGRB
117.	Nizamabad + Karimnagar	1.0082	GRB	1.4171	GRB
118.	Adilabad	1.2388	GRB	1.5663	HGRB
119.	Warangal + Khammam + Nalgonda	1.3359	GRB	1.7373	HGRB
120.	Guntur + Ongole	1.3403	GRB	1.8437	HGRB
121.	East Godavari + West Godavari + Krishna	.6736	GOA	.9095	GOA
122.	Srikakulam + Visakhapatnam + Vizianagaram	.9291	GOA	1.2531	GRB
123.	Kalahandi + Koraput	1.6136	HGRB	2.1251	EGRB
124.	Boudh-Khondmals + Bolangir	1.2607	GRB	1.6396	HGRB
125.	Puri + Ganjam	.8992	GOA	1.1416	GRB
126.	Balasore + Cuttack	1.1431	GRB	1.5059	GRB
127.	Mayurbhanj + Keonjhar + Dhenkanal	1.9064	EGRB	2.5806	EGRB
128.	Sundargarh + Sambalpur	1.1185	GRB	1.4584	GRB
129.	Ranchi + Singhbhum	1.7315	EGRB	2.4921	EGRB
130.	Hazaribagh + Palamau + Giridih	1.8078	EGRB	2.4201	EGRB
131.	Patna + Gaya + Shahabad + Nalanda + Aurangabad + Nawada	1.1329	GRB	1.5145	GRB
132.	Saran + Champaran + Siwan + Gopalganj	1.2627	GRB	1.8059	HGRB
133.	Muzaffarpur + Darbhanga + Vaisali + Sitamari + Madhubani + Samastipur	1.5335	HGRB	2.0089	HGRB
134.	Saharsa + Purnea + Katihar	1.5492	HGRB	1.9964	HGRB
135.	Monghyr + Bhagalpur + Begusarai	1.1362	GRB	1.4787	GRB
136.	Santal Parganas + Dhanbad	1.4430	HGRB	2.2507	EGRB
137.	Purulia + Bankura + Midnapur	1.0992	GRB	1.4333	GRB
138.	Burdwan + Howrah + Hooghly	.6959	GOA	.9103	GOA
139.	Calcutta + 24-Parganas + Nadia	.6605	GOA	.8621	GOA
140.	Murshidabad + Birbhum	.8821	GOA	1.1441	GRB
141.	West Dinajpur + Malda	1.0723	GRB	1.3333	GRB
142.	Cooch-Behar + Jalpaiguri + Darjeeling	1.1574	GRB	1.4503	GRB
143.	Meghalaya	1.6439	HGRB	2.1021	HGRB
144.	Goalpara + Kamrup	1.5752	HGRB	2.0090	HGRB
145.	Darrang + Lakhimpur + Sibsagar + Dibrugarh + Nowgong	.7237	GOA	1.0084	GRB
146.	United Mikir and North Cachar Hills	1.7155	EGRB	2.1794	EGRB
147.	Cachar + Tripura	1.3948	HGRB	1.7506	HGRB
148.	Mizoram	2.2109	EGRB	2.9693	EGRB
149.	Manipur + Nagaland	1.8187	EGRB	2.3341	EGRB
150.	Arunachal	2.0032	EGRB	2.5825	EGRB
151.	The Andamans islands	1.6919	HGRB	2.1700	EGRB

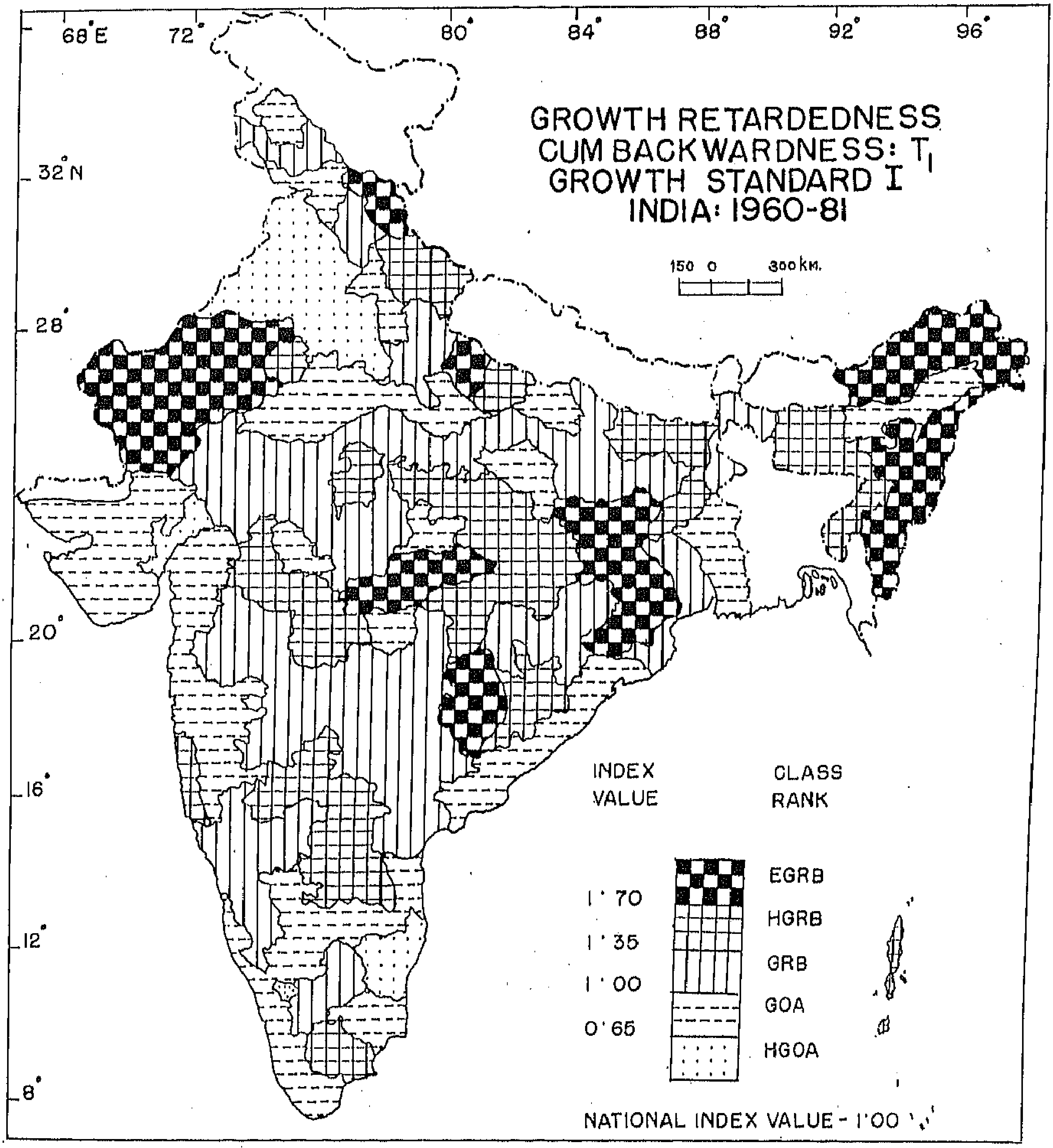

68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
GROWTH RETARDEDNESS CUM BACKWARDNESS: T_1
GROWTH STANDARD I
INDIA: 1960-81
150 0 300 KM.
INDEX VALUE
CLASS RANK
1·70
1·35
1·00
0·65
EGRB
HGRB
GRB
GOA
HGOA
NATIONAL INDEX VALUE - 1·00

FIG-5·2

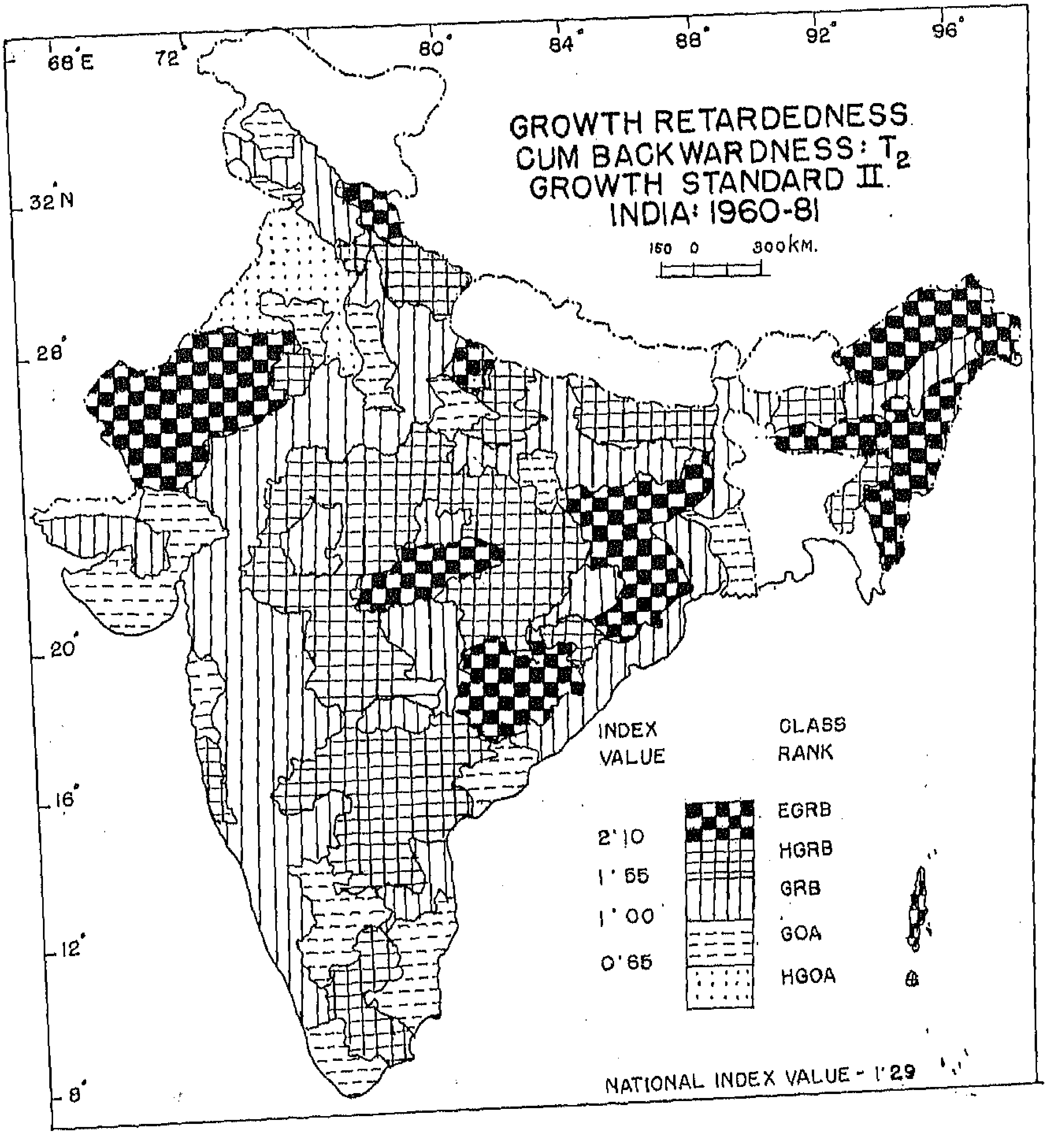

GROWTH RETARDEDNESS
CUM BACKWARDNESS: T_2
GROWTH STANDARD II.
INDIA: 1960-81
150 0 300 KM.
68°E
72°
80°
84°
88°
92°
96°
32°N
28°
20°
16°
12°
8°
INDEX VALUE
CLASS RANK
2·10
1·55
1·00
0·65
EGRB
HGRB
GRB
GOA
HGOA
NATIONAL INDEX VALUE - 1·29

FIG-5·3

disparities in development is taken care of, if our growth efforts are geared up according to above-unity index values of T_1 and T_2; this is done more effectively if geared up by T_2. The growth efforts by above-unity T_1 or T_2 values take care of not only the relative backwardness, but also the relative growth-retardedness during 1960-81, taking into account the prevailing spatial pattern of labour change rate.

As T_1 and T_2 are derived from the same set of variables with only two different labour productivity growth standards, the correlation coefficient between them is extremely high with a value equal to 0.9929. The regression of T_2 on T_1 is given by

$$T_2 = 0.0078 + 1.3002\ T_2, \qquad \ldots (5.41)$$

correlation coefficients = 0.9929.

As the intercept parameter is almost zero, we can take that T_2 value is generally 1.3 times higher than corresponding T_1 value. This means that two maps as shown for T_1 and T_2 in Figures (5.2) and (5.3) would have been almost identical, had we ascertained the comparable class boundaries for T_2 by the regression equation (5.41) corresponding to boundary values of T_1. But for our interests in the critical value of unity, referring to the neutral position between growth-retardedness and growth orientedness or between backwardness and advancedness under the two separate standards, we have not gone for any comparable classification between T_1 and T_2, particularly for above-unity values where T_1 and T_2 are effective as growth task-effort variables.

As a result of our sticking to the neutrality demarcating critical value of unity for prescribed standards, considerable areas which are ranked as GOA by T_1 are identified as GRB by T_2 — needing above-unity growth task effort. Thus in the Figure of T_2, both GOA and HGOA areas are narrowed down to core growth-oriented and advanced areas under the relatively stiff standard II. Obviously, under this stiff standard, all GRB areas of different ranks have expanded and the shape of core areas with HGRB and EGRB ranks take quite formidable shape in the map of India in Figure (5.3). Whether we go by map of T_1 or T_2, the picture of more acute growth-retarded cum backward areas are same, extending mostly in eastern and central India, in desert areas of Rajasthan, in some hilly rugged terrain, and also in some drier Rayalaseema areas of South India. Naturally, the dimension of our growth task efforts must have to be more vigorous for the welfare of people engaged in this important material-production sector of agriculture.

5.6.3 Concluding Remarks

From our assessment and demarcation of areas by synthetic measure T_2, the most irrefutable conclusion that emerged is that the high growth-oriented cum advanced (HGOA) area in India is almost entirely spread in a limited part of north India, extending generally over Punjab, Haryana, Delhi and Ganganagar district (in the northern periphery of Rajasthan). This most progressive area (Punjab + Haryana + Delhi + Ganganagar district) stands out in almost all our previous findings depicting different important aspects of Indian agriculture, including the foodgrain surplus-deficit situation, accounting for total population (ref. to Figure 3.3 on Σ_4). According to our assessment made in Chapter 3, India became more or less self-sufficient in food-situation by 1980-81. That is, the foodgrain availability-requirement ratio Σ_4 as calculated for total population from India's own production capacity was about 1.0015 in 1980-81. If the most progressive areas of India are excluded from the calculation, the corresponding value of Σ_4 would then come down to about 0.9063. This means India without the most progressive area would have remained deficit for quite substantial an amount, about 9.37 per cent of total requirement. Similarly the 1960-81 production growth rate Z would have fallen from a value of 59.1 per cent to a value of 44.82 per cent, the labour productivity growth rate x from 19.8 per cent to merely 9.67 per cent, the most contributing growth component of land yield rate change Y from 34.90 per cent to 29.09 per cent, and so on, when we take the accounts for India with and without the most progressive areas. The fall in the values of growth factor estimates as given above are respectively 24.2 per cent for Z, 51.16 per cent for x and 16.59 per cent for Y. The most sorry situation is the one with the labour productivity growth factor, despite the fact that the labour change rate E was even considerably higher in the most progressive area than the rest of India (ref. to Table 4.31). If the labour productivity growth had been merely 9.67 per cent in 20 years, i.e., less than half per cent per annum (to be exact, 0.4626 per cent per annum), it is very difficult for any regional analyst to admit the common place exalted assessment made usually by national analyst about

India's tremendous agricultural progress to be valid for the rest of India.

As the most progressive area of India produces wheat as the major foodgrain crop, the growth orientation and advancement has been accomplished in this area mostly for wheat and associated crops grown in this area through a proper combination of input measures like fertiliser, seed-quality, assured water (through irrigation) and the like. This means that our growth efforts have been applied not only in a particular area around the capital city, but also on a particular foodgrain crop mainly. True that some rice producing areas in South India and also in the Gangetic West Bengal are getting the benefit of fertiliser-input. Yet, it seems, all associated input-factors, like seed-quality and the like are not possibly assured properly. Traditional rice producing areas derive most of the advantage from the climatic regime and often the deltaic soil-quality. Yet our growth factor estimates do not show much encouraging results, despite fertiliser-input, particularly in South India. Something more has to be done regarding the supply of quality seeds and other timely inputs.

But the major traditional rice producing areas of eastern Indiaare not even seen to get or take the advantage of fertiliser input even, together with a proper kind of associated inputs like quality-seeds. In our findings shown in sub-section (2.6.3), we have noted that rice is such a crop for which the land productivity rating is considerably less in the core or predominantly rice producing areas as compared with that in the less important rice producing areas (such as in many parts of South India, ref. to Figure (2.2) on rice concentration). It could be noted in our maps of T_2 and T_1 (Figures (5.3) and (5.2) respectively) that the vast GRB areas of eastern India coincide with most of the predominantly rice producing areas therein. There, the cultivators' attitude for mono-culture has not helped them in getting the advantage, if it could be derived, from the entrepreneurial vision on crop-combination change for growth. As rice is the most important and widespread crop in much of GRB areas, it goes without saying that our growth efforts should be diverted to this major cereal crop and also to the crop-combination possibilities with rice cultivation, on grounds of the regional-spread aspect of development and improvement for the economic condition of labour associated with rice-cultivation.

Among non-foodgrain crops, Sugarcane seems to have influenced growth and development, not only in wheat producing areas but also in other areas. If a comparison is made between the map of T_1 (ref. to Figure (5.2)) and the map of sugarcane concentration (ref. to Figure (2.8)), we notice that much of GOA areas coincide often with sugar-cane producing areas. Cotton and oilseeds (ref. to Figure (2.1)) seem to have played some role in growth and development in some selected areas such as in Gujarat and even in the most progressive areas of India in its western part. Non-foodgrain crops being associated crops mostly with some major cereals, proper crop-combination and more remunerative non-foodgrain prices are mainly responsible for their growth.
We have noted in Chapter 2 that the price factor has been particularly

favourable for sugarcane and also for some spices and plantation crops produced in South India. The plantation crops however are extremely localised which cannot be extended to any new areas. All spices have not been, however, similarly remunerative; for example, much of spices (mainly dry chillies) producing areas in the drier parts of Andhra Pradesh coincide with GRB areas as shown in the maps of T_2 and T_1. Again for a widespread non-foodgrain crop like cotton, there does not seem to have remunerative price advantage at the production stage of raw cotton. As such, many GRB areas coincide with cotton producing areas in south India. Of course, the minor cereal producing areas, coinciding with cotton and oilseed producing areas do not have much advantage of climatic regime as we have in rice-producing areas. The growth of production of non-foodgrain crops in these areas is mainly due to entrepreneurial vision on crop-combinations. Relative price aspect on the non-foodgrain crops at the raw production stage is another important factor to be investigated, but it is not within the scope of present dessertation.

Granting that our growth efforts had been for limited areas with most of our attention bestowed only on wheat and some associated crops, we stress the importance of present diagnostic study on spatial pattern of agricultural activities and detailed analysis on growth factors. Whatever be our achievement in food-situation, it has come only from a very limited area; in vast areas, many important crops and also proper crop-combination aspect have remained largely unattended. The most important growth promoting component of land-yield rate change has also not been uniformly taken care of with associated input factors in proper form. The labour pressure problem has also remained largely unattended in most of low labour productivity areas or low labour productivity growth areas. Considering all these findings in our investigative spatial analysis, the assessment of areas for growth-retardedness cum backwardness by T_2 or T_1 gains importance. The above-unity values, preferably of T_2, give mainly the intensification growth ratio which indicates how much the existing land yield rate should preferably be multiplied in, say, another two-decade period for removal or reduction of the present glaring form of regional disparity in growth-efforts. As Z and Y are strongly inter-related, one could as well use those T_2-values, say, for assessing our total production task even through Z; it is possible that Z might be improved through entrepreneurial growth factor of crop-association change C. We stress the importance of crop-association, since we are now facing deficit in many non-foodgrain crops these days, for example, in oil-seed production. Again intensification possibilities have largely remained unexplored for many crops except wheat. This aspect is really the most important factor for all-pervading growth of agricultural activities in all areas and for all important crops of our requirements.

5.7 Summary and Conclusion

The main objective of this dissertation has been an empirical identification and evaluation of the regional variations in the pattern and growth of agricultural activities in India during the period 1960-61 to 1980-81, with appropriate use of some of the advanced quantitative methods and statistical tools developed recently in the field of Regional Science and Planning. During the period under consideration, the over-all national agricultural productions have been greatly improved, eliminating India's dependence on foodgrain imports, through certain intensification measures initiated at the beginning of the period. But the pursuance of over-all growth efforts has not been inter-woven with sound regional strategies and as such regional imbalances have become more pronounced in recent years. Thus the need for the study of this kind is felt for a detailed investigation towards diagnosis and evaluation of the spatial patterns on the nature and growth of agricultural activities, so that our vision for a proper perspective of regional plan formulations can be clarified. Our regional analysis has been attempted for the said period by about 151 areal units (district-groups) of India; it has been carried out mainly in the following four important aspects of agricultural production activities :

(i) The identification of broad characteristics and spatial concentration patterns for about 26 field crops of India and the formulation of crop-combinations regions for the terminal year 1980-81;

(ii) Identification of spatial variations in the development of agricultural activities, with spatial reference to the measurement and evaluation of marketable surplus of foodgrains, agricultural land productivity, labour productivity and over-all agricultural development in 1980-81;

(iii) Comparative spatial pattern analysis of agricultural development measures between time-points, 1960-61, 1970-71 and 1980-81 and also the agricultural production and productivity growth analysis by component factors for the period 1960-81 and its two sub-periods; and

(iv) Identification of the role of agriculture in the spatial pattern of economic development and the synthetic measurement of agricultural growth-retardedness cum backwardness by areal-units towards evaluating the dimension of growth task ahead.

Detailed investigations on all these aspects would be useful in providing not only an insight in the regional problems, short-falls, and the growth-efforts needed for agricultural activity development, but also the detailed background regional information for an incorporation of the much needed distributional objective more scientifically into our planned efforts for proper agricultural development, based on the objective of national optimisation with sectoral balance. Our study has been however limited to the diagnosis and evaluation of spatial patterns for broad parameters of agricultural activities; a full-fledged plan formulation for agricultural development with incorporation of necessary regional dimensions, that would require additionally much of spatial linkage, interaction and flow studies with detailed micro agro-economic parameters, is not however within the scope of the present study made by an individual research worker with his limited available resources. What has been aimed at here is to show a regional approach for understanding the present pattern and growth-trend so that a desirable spatial pattern of agricultural activities based on sound regional principles with special attention to less-progressive areas could easily be visualised for future. The present regional approach is essentially of interdisciplinary nature in which an integration of the economic principles of production and productivity analysis and the geographic principles of spatial variation analysis in the context of agricultural activities has been attempted through the use of statistical techniques and quantitative methods.

The statistical and quantitative tools that have been applied in our empirical investigations with success can be broadly summarised as follows :

(a) Although the geographic principle of superposing technique of mapping for identification of a "formal" regional configuration of several connected spatial variables could not be totally abandoned, particularly in the formulation of crop-combination regions, the limitation of the principle as experienced with too many variables has been considerably eliminated through the statistical formulation of a single index variable in lieu of many inter-related variables. When we are to deal with a multi-dimensional (in mathematical sense) composite economic characteristic of several inter-related spatial variables, the said geographic principle is not of much help in an unidimensional ranking of spatial unit observations, here district-groups, for the composite economic characteristic. This limitation has been greatly overcome by the formulation of composite regional indices with the application of some multivariate statistical methods, developed already or recently in the field of Regional Science and Planning. Many such composite regional indices have been used for the depictions of diversified spatial patterns. Some of the main regional indices thus formulated are : (i) crop concentration indices, (ii) land productivity index and sub-indices (iii) over-all agricultural development coefficients, and also when it is important that relationship between two variables has to be reversible for prediction purpose of one from other without any consideration for their dependent or independent role. To tackle these kinds of situation of practical importance the recently developed advanced regression technique, called the VLS (Vertical Least Squares) regression method (Pal and De 1979a) has been used very satisfactorily. We have used this advanced VLS regression technique in identifying the explanatory factors and their distinct contribution for explaining the spatial variation of many economic measures of importance in our context. Although we based our inferences on the VLS regression estimates, we have often given side by side the OLS regression estimates to show the extent of multicollinearity cum axis-biased least-squaring distortions present in the OLS estimates of parameters.

(d) It should be noted that the superiority of the VLS regression over the OLS regression is demonstrated not only in the evaluation of the role of highly multicollinear explanatory variables distinctly and truely (in the regression coefficients), but also in the elimination of a variable that does not explain directly the dependent variable; this has been possible by virtue of the discriminatory power of the VLS correlation coefficient : it does not always increase with each inclusion of an additional variable considered for explanation of the dependent variable, unlike the OLS correlation coefficient. It is this discriminatory power that helps us in identifying, for example, the proper role of relevant component-growth factors and also the redundancy of some others in explaining the spatial variation of agricultural production and productivity growth in the period and sub-periods under consideration.

(e) Agricultural growth analysis involves various forms of mathematical model split (due to Minhas-Vaidyanathan, Pal, Pal-De) into basic components, both for production and productivity growth. The above mentioned discriminatory power of VLS correlation coefficient has actually helped us in identifying the best fitting model-split with relevant explanatory basic components as applicable in the Indian situation during the period. The productivity model split has however been empirically verified for the first time in this dissertation.

(f) Statistical and quantitative tools have been most integrated in our formulation of an index of growth-retardedness cum backwardness that has been devised here, not only by use of the statistical methods of index formulation referred to here in (a), but also by application of economic constraints and relations involving growth factors, labour-change, etc., and also the regression techniques. This index gains importance in our analysis, since it has helped us in evaluating the dimension of our growth task ahead with the objective of reducing regional disparities in agricultural progress.

By application of these statistical and quantative methods, selected or devised with the fitness of situations, the regional analyses -- mainly along the direction of formal regionalisation and interaction analysis -- have been attempted on various agricultural characteristics and also on the factors that influence them or get influenced by them. Apart from the diagnosis and evaluation of spatial patterns and problem areas, here our principle has been to take lessons from the favourable formal regional structures, and try to examine whether the conditions that led to favourable structure could be created in or transferred to an area where relatively less favourable formal structure is existing. Some of our main findings and observations as reported in different Chapters are highlighted below :

1. Our arable cropping is mostly devoted to production of foodgrains (80 per cent of gross-cropped area, generating 70 per cent of total output-value over 26 crops considered). Of these, rice is the most important crop (28.7 per cent of gross-cropped area with 35.8 per cent of output-value) and wheat is the next important crop (15.6 per cent of gross cropped area with 16.5 per cent of output-value). Non-foodgrain crops have obviously the relative price advantage and in this category, according to output-value share, sugarcane is the most important crop (8.9 per cent of output-value). In terms of gross-cropped acreage share, cotton is however the most important non-foodgrain crop (5.4 per cent of gross cropped area). Naturally sugarcane seems to be more remunerative than cotton at the raw production stage. From the comparative productivity-ratings between core producing area to other producing area of any particular crop, we infer that the core wheat producing areas are in much more advantageous position in respect of physical yield rates than the core rice producing areas in the country. It is rather alarming that the most important crop of rice has not exhibited the deserving attention that it would require for a betterment of physical yield rates in its wide-spread core areas in line with the nation's second important crop of wheat.

2. Our judgement on the important producing areas of a crop has been based on the joint consideration of (i) crop-concentration indices,

depicting the relative national level importance of the crop and (ii) local acreage share, depicting the local importance among crops. Based on these assessments of producing areas by crops, crop-combination regions have been delineated and shown in Figure (2.1); crop-concentration indices for selected individual crops and crop-groups have also been shown in Figures (2.2) to (2.9). Finally a tabular analysis (ref. to Table (2.14)) has been attempted for each of the crop-combination regions, about 30 in number, summarising the characteristic, nature and other details, both for general cropping pattern and local peculiarities, if any.

3. Various economic principles and statistical and quantitative methods have been used in Chapter 3 for construction of ratio and index measures on foodgrain production surplus generation by four categories of population : (1) cultivators (including dependants), (2) agricultural population, (3) rural population, (4) total population. For these categories of population, following transformable measures are formed :

(i) availability-requirement ratio : $(\Sigma_1, \Sigma_2, \Sigma_3, \Sigma_4)$,

(ii) food surplus-total production ratio : (M_1, M_2, M_3, M_4);

where $M_i = 0.875\ (\Sigma_i - 1)/\Sigma_i$,

(iii) location factor of food surplus to total production :

$$(L_1 = x_m,\ L_2, L_3),$$

obtained on division of M_i by corresponding national value, provided it is considerably above zero.

The measure x_m is considered alongwith the statistical formulations of agricultural land productivity index x_a as also the labour productivity index x_w, for a final comprehensive formulation of the over-all agricultural development index D_A. Finally the fertiliser input norm (kg./hectare), expressed as location factor, F, has been formulated. Individual surplus measures, Σ_2 to Σ_4 (or equivalently M_2 to M_4 on the same map) have been mapped in Figures (3.1) to (3.3) and a composite food surplus-deficit situation, based on all four (including Σ_1), shown in Figure (3.4). The over-all index D_A and its three sub-indices x_m, x_w and x_a and also F have been mapped in Figures (3.5) to (3.9). Estimates of these indices have been recorded along with classified ranks in Tables shown in appropriate places. On the basis of spatial analysis through statistical and cartographic tools, we have made various observations recorded in Chapter 3.

4. Correlation matrix depicts strong spatial association for Σ_2, Σ_3 and Σ_4 , obviously with falling magnitudes with wider coverages of population for any areal unit. In the composite food-surplus-deficit mapping (Fig. 3.4) and also in all three preceding Figures, we could identify two extreme cases : (a) one of technology advancement together with least agricultural-labour pressure on cropped land, and (b) the other of highest agricultural labour pressure on cropped land. The occurrence of case (a) is in the most advanced region in the north, comprised of Punjab State, Haryana State (excluding Mahendragarh districts), Delhi, and Ganganagar district of Rajasthan. The occurrences of case (b) with food deficit even for agricultural population are in

(i) an extensive region comprised of Bihar and eastern Uttar Pradesh, (ii) almost entire Kerala State, (iii) Rajasthan desert area, (iv) in the far-eastern India in tribal areas bordering Bangladesh (v) in south-eastern fringe of West Bengal (vi) in southern part of Gujarat and also in isolated single areal units in Orissa, Andhra Pradesh, Maharashtra and Himachal Pradesh. In fact, generally speaking entire far-eastern and eastern regions, west coastal belt, and the Rajasthan desert area could be considered as extreme food deficit regions. On the other hand, the food-surplus generation is most strongly associated with the spatial concentration of wheat crop (correlation coefficient 0.757 with Σ_4). Food-surplus-deficit situation by states have been recorded in Table (3.4). Highly deficit States are : (i) Kerala, (ii) Bihar, (iii) Assam (+ Far Eastern Areas). Low-deficit States are (i) Uttar Pradesh, (ii) Gujarat, (iii) Karnataka, (iv) Andhra Pradesh (v) West Bengal. Very high surplus states are : (i) Punjab, (ii) Haryana (& Delhi); rests are low surplus states.

5. Results of our statistical regression analysis for important explanatory factors for the spatial variations in the magnitude of different development sub-indices and the index are as follows

(i) The land productivity index is very highly explained by fertiliser input ;

(ii) The labour productivity x_w got explained mostly by Σ_2 (41.8%) and x_a (36.7%) and not very strongly by the following non-foodgrain crops individually : plantation crops (7.7%), sugar-cane (7.6%), fibre crops (4.6%) and oilseeds (1.6%) ; and

(iii) The over-all agricultural development index D_A has been explained by F (44.6%), L_2 (41.0%), Plantation crops -- Tea + Coffee (12.2%) and fibre crops -- Cotton + Jute + Mesta (4.2%).

6. Map analysis on agricultural development patterns (Fig. (3.5)) reveals that agriculturally under-developed region has occurred in a very large portion of eastern India with VL and L ranks in D_A. Apart from this broad region, other under-developed regions have occurred in hilly areas of the far-eastern India, in desert area of Rajasthan, and also in some bordering mountaneous areas of Uttar Pradesh and Himachal Pradesh in the North. From the preceding statistical finding, intensification-inducing variable of fertiliser input F and foodgrain production surplus generating variable L_2 do not seem have been favourably associated with these under-developed areas. On the other extreme, the most advanced regions and areas in agricultural activities, favoured by both F and L_2, are in

I. Punjab - Haryana - Delhi - Ganganagar (Rajasthan) region
II. Madras - Tanjavur - Coimbatore - Nilgiri (Tamil Nadu) region
III. Tirunelveli area in the extreme south of Tamil Nadu
IV. Krishna - Godavari deltaic area of Andhra Pradesh
V. Coffee plantation area of Coorg in Karnataka
VI. Burdwan - Hooghly - Howrah area of West Bengal

These regions of EH values have often extended to adjoining areas with VH and H values of D_A. The most extended advanced region is however in South India, and the next in areal coverage is the advanced region I, with extension in its eastern neighbourhood. The ranks of states by agricultural development sub-indices, the index D_A and fertiliser input F can be noted from the data supplied in Table (3.10).

7. All foodgrain production surplus measures and agricultural development index and its sub-indices formulated in Chapter 3 have been considered for comparative analysis by three time-points : 1960-61, 1970-71 and 1980-81, in the first part of Chapter 4. In the second part of this Chapter, agricultural production growth rate Z and labour productivity growth rate X during 60-81 (also for two sub-periods) have been analysed for explanation by component factors of growth, such as the intensification factor of land yield rate change Y, the extension factor of crop-acreage change A, the entrepreneurial factor of crop-association change C. These growth factor variables are mapped in this Chapter for map-analysis and shown in Figures (4.1) to (4.5). Apart from this map-analysis, all other analyses in this Chapter have largely been statistical in nature. For comparative analyses over the three time points, we have investigated on the (i) movements of all-India estimates of the relevant statistical index-variable, (ii) changes in the spatial disparity by coefficients of spatial variation, (iii) the nature of agreements between the spatial patterns of each index-variable for 1970-71 and 1980-81 by correlation coefficients, (iv) changes in the degree of interactions for the index-variables with fertiliser input F or growth factor Z calculated for appropriate preceding period, etc. We have also designed our statistical analysis to identify those areal units which have shown the undesirable negative or insignificant

improvements in the sub-period of 2nd decade. We have made further VIS regression analysis on selected index-variable for identifying how far the past-base pattern and which other factors are responsible for ~~expla~~ explaining the current spatial pattern of 1970-71 and 1980-81. For our growth component analysis of agricultural production and productivity growth variables, we have considered the basic components by both production and productivity model-split for detailed VIS regression analysis for best-fitting combination of component factors and their contribution towards explaining the total spatial variation of production and productivity growths. We have also made further interaction study of growth factors with key foodgrain surplus measure, agricultural development index and sub-indices and also important crop-concentrations. Details of all these investigations and corresponding findings are recorded at appropriate places in Chapter 4. We can quote only some of the findings below :

8. As compared with the production level of foodgrains, India had a deficit of about 21 per cent in 1960-61, accounting for total population. This deficit was reduced to about 3 per cent in 1970-71 and finally it was totally wiped out in 1980-81. Thus it seems that the progress in foodgrain situation as registered in the 1st decade is more than that in the 2nd decade. However, in absolute term the difference in foodgrain deficit between 1960-61 and 1970-71 would not be that high as shown above, because the production level itself was much lower in 1960-61.

9. The coefficients of spatial variation have progressively increased for foodgrain surplus measures Σ_2, Σ_3, Σ_4. This general increase in spatial disparity in foodgrain surplus measures is reflective of the situation that the surplus generating capacity of an overwhelmingly large number of agriculturally backward areal units has remained stationary or deteriorated, while a limited number of forward areal units are on the path of progress unabatedly. This finding is also substantiated by the incidences of strong inter-relations between 1980-81 and 1970-71 spatial patterns by any of Σ_2, Σ_3, Σ_4. This agreement really signifies that agriculturally forward areal units remained forward and backward areal units, backward in the 2nd decade.

10. If we look at the improvement differentials as provided in Table (4.3), it becomes clear that more forward the areal units in 1970-71, the greater was the improvement registered by them during the period : 1970-71 to 80-81. Further, for total and rural categories of population the foodgrain surplus generation positions have not improved at all for those areal units which are in h-D (high-deficit) and l-D (low-deficit) classes in 1980-81 (ref. to Figures (3.2) and (3.3)). The deterioration is however more pronounced for h-D categories of areal units. As regards the agricultural population, the improvement neutral point falls even in the L-S (low-surplus) class for Σ_2. In fact, bottom-most two classes in our classification of areal units (in 1980-81) by any of Σ_2, Σ_3, Σ_4 show no sign of improvement in food-surplus generation, and the condition of bottom-most class of areal units have definitely deteriorated in 2nd decade. It is clear that agricultural population do not have a viable agricultural economy even if they generate a

low level of surplus of foodgrains. On the other hand, our analysis indicates that all high surplus generating (H-S, VH-S and EH-S) categories of areal units could be considered to be on the path of improvement during the period. The degree of improvement is however more and more as we go from H-S to EH-S category of areal units; this non-uniform improvement pattern, is certainly against the well accepted regional planning objective on efforts for reduction of regional disparities. Our further interaction analysis with production growth factor reveals that the spatial pattern of growth rates are highly in agreement with the foodgrain surplus generation pattern at the terminating year of the period over which the agricultural production growth rates are calculated.

11. As regards the agricultural development index and sub-indices, our analysis reveals that relationships between 1970-71 and 1980-81 spatial patterns are extremely high. Again this means that agriculturally developed areal units remained advanced and the backward areal units, backward in the second decade with, however, more improvements in advanced areal units as compared with that in backward areal units. However, the relatively more improvement of advanced areal units is not that glaring as we have notived for foodgrain surplus measures.

12. The intensification role of fertiliser-input was best manifested in the land productivity index; with the growth of fertiliser dose per hectare in the forward time-path, the relationship became more and more close. The corresponding correlation coefficient was of moderate

magnitude 0.4041 in 1960-61, of high magnitude 0.6377 in 1970-71 and finally of very high magnitude 0.8110 in 1980-81. The increasing intensification role of fertiliser input in the forward time-path was also maintained by the other two sub-indices of agricultural development, but here the role has been dampened considerably, because of the disturbing involvement of increasing population size in these two sub-indices.

13. The role of production growth factor on land and labour productivities just got reversed of what happened with fertiliser input. Here the growth rates of agricultural production for the period commencing from the base-year 1960-61 showed high relation with labour productivities in both 1980-81 and 1970-71 — much higher than what these rates exhibited with land productivity. The behaviour of cultivators' surplus generation capability with respect to growth factor had however been more or less similar to that of land productivity. The effect of growth factor on the combined index D_A was somewhere in between those of land and labour productivities, as expected.

14. Our VIS discriminatory analysis reveals that the spatial patterns in 1970-71 and 1980-81 have been influenced by the respective past base pattern of 1960-61 for all constituent sub-indices of agricultural development. Apart from the past base patterns, the most important explanatory factors have been the fertiliser input pattern for land productivity, the preceding period's growth rate pattern for

labour productivity and comprehensive capability of agricultural community in foodgrain production surplus generation for cultivators' capability. The land productivity and cultivators' capability have also been influenced to some extent by growth rate pattern and fertiliser input respectively, but the labour productivity has not been influenced directly by any other factor. Thus, it is quite natural that all four factors explain the spatial variation of the over-all agricultural development D_A. On the basis of our calculations on VLS regression coefficients with standard sed variables and related parameters shown in Table (4.17), the total spatial variation of 1970-71 development index D_A^* was best explained by past base pattern of 1960-61 (33.4 per cent contribution) and least explained by the current fertiliser input pattern (14.2 per cent contribution). The contribution of other two explanatory factors had been around the average value of 25 per cent each (with respect to a total of four explanatory factors). When the entire two-decade period is considered the explanatory role of fertiliser input pattern showed a great improvements with over 25 per cent contribution to the total explained spatial variation of over-all agricultural development D_A in 1980-81. As a result of this, the relative roles of all other explanatory factors got a little reduced each in 1980-81 as compared with the respective situation in 1970-71. The contribution of all explanatory factors were however within a narrow range of values, between 21.7 and 29 per cent. Thus, although the explanatory role of fertiliser input factor has greatly improved by 1980-81, the base-pattern of 1960-61 still played the highest explanatory role.

15. The spatial variation in agricultural growth in the two-decadal period has been sufficiently accounted, both for production and productivity (VIS correlation coefficients as extremely high as of magnitude 0.978 and 0.973 respectively), by the three basic components (with factor A of production model replaced by relative acreage change R for productivity model). The intensification factor of land yield rate change Y has been by far the most important contributory factor to agricultural growth explaining about half the total spatial variation (to be exact about 48.52 variation of production growth and about 52.53 per cent variation of productivity growth). The contributory role of intensification factor has however improved to some extent in the 2nd decade. This, however, corroborates with the incidences of more use of fertiliser in the 2nd decade.

16. The next important contributory factor to agricultural growth has been the extension factor of "acreage" or "relative acreage" change. The "acreage change" factor has explained about 32.75 per cent variation of production growth and "relative acreage change" factor, about 26.93 per cent variation of productivity growth. The incidences of labour presure on cropped land are reflected in the fall of relative contributory role of extension factor for the change from production growth to productivity growth. The contributory role of extension factor has also improved in the second-decade, likewise that of the intensification factor.

17. The least important contributory factor has been entrepreneurial factor of crop association change to agricultural growth, explaining more or less a fifth of total spatial variation. The crop association change follows largely due to entrepreneurial decision-making by the land-owning cultivators. Thus the cultivators' implicit contributory role to agricultural growth has not only become the least relative to other two-factors, but also deteriorated greatly in the 2nd decade. With the substantial improvement made in the foodgrain surplus-deficit situation in the 1st decade itself, a sort of statusquo has been maintained in the crop-association pattern over the 2nd decade, without going for any further innovative entrepreneurial move for the betterment of over-all agricultural growth.

18. From Table (4.26) of correlation matrix for Z, X and Y, for each of the three time points, we notice that strong inter-correlations exist between any pair of variables for all the three time points. The very high relationship between Z and X explains why the growth factor Z turned out to be the major explanatory factor of labour productivity index x_W in our earlier analysis. As the intensification factor of land yield rate change played an overwhelmingly major role in explaining both production and productivity growths, we can infer that the spatial patterns of labour productivity get explained ultimately, to a great extent, by the intensification growth. A similar kind of inference could be drawn for the foodgrain surplus measure Σ_2 also, which gets explained mostly by Z. In summary, the intensification growth factor can be said to be behind

the scene of various spatial manifestations of agricultural progress in India during the period 1960-61 to 1980-81.

19. The most important feature revealed from an analysis of intercorrelations shown in Table (4.27) is that the wheat-producing areas have taken the maximum advantage of all growth factors. "Other foodgrains" (Maize + barley + gram + tur) and sugarcane, being largely the associated crops in wheat producing areas, have also interacted considerably with growth factors.

20. The most alarming aspect brought out by the same correlation matrix is that rice, the most important and widespread foodgrain crop of India, shows negative relation with all growth factors, except the extension-growth factor A for which it has shown a low positive correlation coefficients of magnitude 0.2223 only. This small positive correlation is due to a high increase in rice producing areas in many parts of Assam and adjoining far eastern areas. But the most negative correlation that any growth factor has with any crop is the one between the entrepreneurial-growth factor C and rice (a moderately negative value -0.3622). Rice is still grown in India with the traditional mode of cultivation by taking advantage of climatic condition and inherent soil-quality, particularly in the major parts of rice producing eastern India where fertiliser-input advantage has hardly been used. Because of this traditionalism, cultivators' entrepreneutrial vision seems to be lacking in many rice-producing areas of eastern India. Clearly the intensification efforts have not gone in favour of such an important crop like rice in the period under consideration in all rice-producing areas.

21. Interaction of Y, A and [illegible] are in relatively decreasing order on the over-all agricultural development index, similar to what we have seen for Z and what exists for the best growth factor-influenced crop, wheat. Regarding the interaction of this final agricultural development index D_A on the crop concentrations, we get the following summary picture. Among foodgrain crops, wheat is most important and rice is next important crop in respect of their interacting role on agricultural development D_A. As rice is more widespread crop than wheat, this reverse interacting role is certainly not helpful in respect of our objective of reducing spatial disparity in agricultural development.

22. From our map-analysis on growth factors, we notice that, in the northern part of wheat producing areas, the role of growth factors has been best manifested with top level values in all of them. If we look at the Table (4.29) of frequency distribution, the top-class frequencies in every growth factor are very limited, between 10 to 14 areal units (out of total 151), and these areal units are mostly in this part of wheat producing areas. Thus, if India is considered to have made considerable agricultural progress, it has been only possible for the progress made in the wheat region with EH and VH values only in the limited northern area around the capital city. India, without this limited area of EH and VH growth, would not have succeeded in eliminating huge food deficit. In summary, vast areas of India except the northern growth region have not made much progress during the period and this is what is reflected in the negative interaction of growth factor Y with the most wide-spread crop of rice.

23. Because of very high intercorrelation between Z and X and also between Z and Y, almost similar spatial patterns emerge in the maps for Z, X and Y, except for very minor departures. The map of X is however important in respect of labour pressure aspect on agricultural sector, when it is examined in conjunction with the labour productivity map of x_w, relating to the terminal time-point of 1980-81. These two maps show that vast low or no or negative productivity-growth areas coincide largely with the low or very low labour productivity areas of 1980-81. This means that the labour productivity aspect of agricultural progress has largely remained unattended during this long two-decade-period. The labour pressure should be considered as very alarming in these areas of vast dimension as could be depicted from the maps of x_w. These labour pressure areas are mostly concentrated in the vast non-wheat areas to the east and south of core-wheat producing region. Our intensification efforts during the period seemed to be concerned with only the food situation through all-pervading growth of wheat-seeds and maximum intensification-attention to core wheat-producing areas.

24. Finally in the Chapter 5, we have examined the role of agriculture in the over-all sphere of all economic activities through interaction studies, and also other supporting frequency analysis, with different non-agricultural sectors like, trading, industry, urban-activities, and transportation. These variables are designated in the above order by x_1, x_2, x_3 and x_4, and our agricultural development index D_A is redesignated by x_5. From these sub-indices of these economic sectors, we have constructed the over-all economic development index x_0, with due

recognition of the important material-production role of agriculture for economic development. The construction of x_0 has been possible because of our access to the most recently developed method of Pal's equi-spaced optimal formulation. According to this formulation, now all sub-indices x_1 to x_5 are very highly represented in the over-all index x_0. The relation between x_0 and x_5 is now about 0.795.. This achievement would not have been possible by either Kendall's optimal formulation or by Pal's equity formulation. Ultimately by an appropriate integration of growth factors X, Z, Y and also labour change rate E with x_5 and x_0 through various economic, mathematical and statistical considerations we have formulated an index of growth-retardedness cum backwardness under two separate labour productivity growth standards. This index with lower standard is designated by T_1 while the other one is designated by T_2. The values of T_1 or T_2 below unity would correspond to the situation of growth-orientedness cum advanceness. Indices x_0, T_1 and T_2 are mapped as shown in Figures (5.1) (5.2) and (5.3). The above-unity values of T_1 and T_2 have been used in giving the dimension of growth-task ahead, since growth-task index T_1 and T_2 assume a value of unity, for all lower values.

25. Granting that our growth efforts had been for limited areas with most of our attention bestowed only to wheat and some associated crops, we stress the importance of present diagnostic and evaluation study on spatial pattern of agricultural activities and detailed analysis on growth factors. Whatever be our achievement in food-situation, it has come only from the very limited area, and vast areas

with many important crops and also proper crop-combination aspect have remained largely unattended. The most important growth promoting component of land - yield rate change has not been also uniformly taken care of with associated input factors like, seed-quality, in proper form. The labour pressure problem has also remained largely unattended in most of low labour productivity areas or low productivity growth areas. Considering all these findings in our investigative spatial analysis, the assessment of areas for growth-retardedness cum backwardness by T_2 or T_1 gains importance. The above-unity values, preferably of T_2, gives mainly the intensification growth ratio task which indicates how much of existing land yield rate should preferably be multiplied in, say, another two-decade period for removal or reduction of the present glaring form of regional disparity in growth efforts. As Z and Y are strongly inter-related, one could as well use those T_2-values, say, for assessing our total production task, even through Z, it is possible that Z might be improved through entrepreneurial growth factor of crop-association change C. We stress the importance of crop-association, since we are now facing deficit in many non foodgrain crops these days, for example, in oil-seed production. Again intensification possibilities have largely remained unexplored for many crops except wheat. This aspect is really the most important factor for all-prevaling growth of agricultural activities in all areas and for all important crops of our requirements.

26. By all the above discussions and findings, we wanted to drive home the fundamental point that India's growth and development

prospects have rested on the creation of more remunerative form of agricultural production activities, through proper crop-combination and proper intensification efforts, with the full utilisation of increasing human labour resources at the regions of their origin, as far as could be feasible. If it is possible to achieve tremendous success in one region, there is no reason why the lessons cannot be transferred or transmitted to other regions as well. If it has not been done yet, it is because the aspect of proper regional planning attention is not ingrained in the present form of planning efforts. If this aspect of proper regional planning attention for growth to proper areas is not incorporated now, India's ever-increasing human labour force located in different regions is going to face still more serious unemployment hazards or a fall in purchasing power. It is really not fruitful in the longrun, if agricultural production is optimised at one area and then go for a follow-up redistribution of essential products to people in other regions without any opportunities for improvement of their purchasing power.

APPENDIX TABLES

Table (A.1) : Brief Description of the Areal Units by States; India : 1970-71*

Areal unit code number	Member districts of the areal units	Locally important major crops separately maintaining similarity in cropping pattern within the areal unit
(1)	(2)	(3)
	JAMMU & KASHMIR	
1	Srinagar + Anantanag + Baramulla	Rice (50) & Maize (31)
2	Poonch + Rajauri	Maize (56), Wheat (29) & Rice (10)
3	Jammu + Kathua	Wheat (43), Rice (30) & Maize (12)
4	Doda + Udhampur	Maize (57), Wheat (25) & Rice (10)
	HIMACHAL PRADESH	
5	Chamba + Kangra	Maize (41), Wheat (34) & Rice (12)
6	Kinnaur + Lahul & Spiti	Barley (51) & Wheat (29)
7	Bilaspur + Kulu + Mandi	Wheat (47), Maize (28) & Rice (13)
8	Mahasu + Simla + Sirmur	Wheat (36), Maize (33) & Rice (7)
	PUNJAB	
9	Hoshiarpur + Jullundur + Rupar	Wheat (48), Maize (22) & Rice (12)
10	Patiala	Wheat (47), Rice (25) & Maize (8)
11	Ludhiana + Sangrur	Wheat (48), Maize (13), Rice (8) & Cotton (8)
12	Kapurthala + Amritsar + Gurdaspur	Wheat (48) & Rice (28)
13	Ferozepur + Bhatinda	Wheat (43), Cotton (22) & Gram (11)
	HARYANA & DELHI	
14	Hissar + Jind	Gram (33), Bajra (23), Wheat (19) & Cotton (11)
15	Mohindergarh	Bajra (44), Gram (34) & Wheat (10)
16	Rohtak + Gurgaon + DELHI	Wheat (37), Bajra (20), Gram (15) & Jowar (10)
17	Karnal + Ambala	Wheat (43), Rice (25) & Maize (7)
	UTTAR PRADESH	
18	Saharanpur + Dehradun	Wheat (36), Sugar (23) & Rice (20)
19	Meerut + Muzaffarnagar	Wheat (40) & Sugar (35)
20	Bulandshar + Aligarh	Wheat (41), Maize (15), Bajra (14) & Sugar (11)
21	Mathura + Agra	Wheat (38), Bajra (25) & Barley (8)
22	Mainpuri + Etawah	Wheat (33), Rice (16), Bazra (14) & Maize (10)
23	Jalaun + Jhansi + Hamirpur	Wheat (32), Gram (30) & Jowar (17)
24	Kanpur + Lucknow + Hardoi + Unnao	Wheat (32), Rice (18), Gram (8), Maize (7) & Jowar (6)
25	Budaun + Etah + Farrukhabad	Wheat (36), Bajra (15), Maize (12) & Rice (7)
26	Bijnor + Moradabad	Wheat (34), Sugar (24) & Rice (18)
27	Uttar Kashi + Tehri Garhwal + Garhwal	Wheat (45) & Ragi (41)
28	Chamoli + Almora + Pithorgarh	Wheat (44) & Ragi (42)
29	Nainital + Rampur + Bareilly + Pillibhit + Shahjahanpur	Wheat (37), Rice (27) & Sugar (11)
30	Sitapur + Kheri	Wheat (29), Rice (28), Sugar (12) & Gram (7)
31	Bahraich + Gonda + BaraBanki	Rice (37), Wheat (27) & Maize (15)
32	Basti + Gorakhpur + Deoria	Rice (44) & Wheat (35)
33	Azamgarh + Ghazipur + Ballia	Rice (39), Wheat (25), Barley (7) & Gram (6)
34	Pratapgarh + Rae-Barelli + Sultanpur + Faizabad	Rice (39), Wheat (26), Barley (7) & Gram (7)
35	Fatehpur + Banda	Gram (25); Wheat (23), Rice (19) & Jowar (12)
36	Allahabad + Jaunpur	Rice (29), Wheat (26), Gram (8) & Barley (8)
37	Varanasi + Mirzapur	Rice (40), Wheat (21), Barley (8) & Gram (8)

NB : Percentage of gross cropped area devoted to the crop is shown within parenthesis, to the right of the crop shown in column (3).

* While the district compositions of the areal units refer to the situation prevailing in 1970-71, the similarity of cropping pattern for the member districts of any areal unit refers to the position of 1980-81.

Table (A.1) Continued

Areal unit code number	Member districts of the areal units	Locally important major crops separately maintaining similarity in cropping pattern within the areal unit
(1)	(2)	(3)
	MADHYA PRADESH	
38	Rewa + Sidhi	Rice (29), Wheat (21), Gram (12) & Barley (8)
39	Surguja + Shahdol	Rice (65), Maize (8) & Wheat (7)
40	Bilaspur + Raigarh	Rice (84)
41	Raipur	Rice (88)
42	Bastar	Rice (85)
43	Durg + Balaghat	Rice (71) & Linseed (11)
44	Mandla + Seoni	Rice (38), Wheat (28) & Gram (9)
45	Chindwara + Betul + Narsimhapur	Wheat (23), Jowar (21), Gram (20) & Tur (10)
46	Damoh + Jabalpur	Wheat (38), Rice (25) & Gram (18)
47	Panna + Satna	Wheat (36), Rice (25), Gram (11) & Linseed (11)
48	Tikamgarh + Chattarpur	Wheat (31), Jowar (16), Gram (15), Rice (10) & Barley (10)
49	Vidisa + Sagar + Raisen	Wheat (57) & Gram (22)
50	Hashangabad + Sehore	Wheat (39), Gram (16), Jowar (15) & Linseed (6)
51	East Nimar + West Nimar	Jowar (33), Cotton (28), Groundnut (10) & Wheat (6)
52	Dhar + Jhabua + Ratlam	Jowar (19), Maize (17), Gram (14), Wheat (13) & Cotton (12)
53	Mandsaur	Jowar (35), Gram (16), Maize (15) & Wheat (11)
54	Ujjain + Indore + Dewas	Jowar (27), Wheat (26), Gram (18) & Cotton (8)
55	Shajapur + Rajgarh	Jowar (37), Wheat (16), Cotton (11) & Gram (11)
56	Guna + Shivpuri	Wheat (35), Jowar (26) & Gram (17)
57	Morena + Bhind + Gwalior + Datia	Wheat (30), Gram (23), Mustard (9), Jowar (9) & Bajra (9)
	RAJASTHAN	
58	Bundi + Kota + Jhalawar	Jowar (31), Wheat (28), Gram (14) & Maize (8)
59	Tonk + Ajmer	Jowar (30), Wheat (20), Gram (13) & Maize (9)
60	Jaipur + Swai Madhopur	Bajra (30), Wheat (20), Gram (17) & Barley (9)
61	Alwar + Bharatpur	Gram (27), Bajra (23), Wheat (20) & Mustard (11)
62	Jhunjhunu + Sikar	Bajra (75)
63	Ganganagar	Gram (43), Wheat (22), Cotton (15)
64	Bikaner + Churu	Bajra (83)
65	Nagaur + Jodhpur	Bajra (74)
66	Jaisalmer + Barmer	Bajra (95)
67	Jalore	Bajra (72) & Wheat (9)
68	Pali + Sirohi	Bajra (33), Wheat (18), Sesamum (16) & Maize (7)
69	Udaipur + Bhilwara + Chitorgarh	Maize (33), Wheat (20), Jowar (11) & Gram (8)
70	Banswara + Dungarpur	Maize (33), Rice (21), Gram (14) & Wheat (12)
	GUJARAT & DADRA	
71	Panch Mahals + Kaira	Rice (18), Bajra (18), Maize (16), Cotton (11), Wheat (10) & Groundnut (6)
72	Ahmedabad + Sabarkantha + Gandhinagar	Cotton (31), Wheat (16), Bajra (14), Groundnut (9) & Jowar (8)
73	Mehsana + Banaskantha	Bajra (43), Jowar (20) & Wheat (12)
74	Surendranagar + Kutch	Cotton (37), Bajra (25) & Jowar (20)
75	Jamnagar + Junagadh + Amreli	Groundnut (56), Bajra (16) & Jowar (10)
76	Rajkot + Bhavnagar	Groundnut (43), Bajra (19) & Cotton (18)
77	Surat + Bharuch + Baroda	Cotton (38), Jowar (21), Rice (12) & Groundnut (6)
78	Dangs + Valsad + DADRA & NAGAR HAVELI	Rice (51), Ragi (17) & Jowar (9)

Table (A.1) Continued

Areal unit code number	Member districts of the areal units	Locally important major crops seperately maintaining similarity in cropping pattern within the areal unit
(1)	(2)	(3)
	MAHARASTRA	
79	Dhulia + Nasik	Bajra (37), Jowar (17), Groundnut (12) & Wheat (11)
80	Jalgaon + Aurangabad	Jowar (41), Bajra (15), Cotton (13) & Wheat (8)
81	Buldana + Akola + Amravati	Jowar (36), Cotton (38) & Wheat (7)
82	Wardha + Nagpur	Jowar (35), Cotton (24), Wheat (12) & Tur (7)
83	Bhandara + Chanda	Rice (49), Jowar (22) & Wheat (7)
84	Yeotmal + Nanded + Parbhani	Jowar (42), Cotton (30) & Wheat (6)
85	Bhir + Osmanabad + Sholapur	Jowar (57), Bajra (7), Tur (6) & Wheat (6)
86	Poona + Ahmednagar	Jowar (49) & Bajra (26)
87	Thana + Kolaba + Greater Bombay	Rice (84)
88	Satara + Sangli	Jowar (44), Bajra (19) & Groundnut (11)
89	Kolhapur	Rice (28), Groundnut (16), Jowar (15) & Sugar (14)
90	Ratnagiri	Rice (72) & Ragi (23)
	GOA	
91	Goa, Daman & Diu	Rice (88)
	KARNATAKA	
92	North Kanara + Shimoga	Rice (62), Ragi (9) & Jowar (7)
93	Belgaum + Dharwar	Jowar (24), Cotton (22), Groundnut (12), Wheat (10) & Rice (10)
94	Bidar + Gulbarga + Bijapur	Jowar (37), Bajra (15), Groundnut (10), Cotton (9) & Tur (7)
95	Raichur + Bellary	Cotton (32), Jowar (27), Groundnut (12) & Bajra (7)
96	Chitradurga + Tumkur	Ragi (32), Jowar (18), Rice (13) & Groundnut (11)
97	Kolar + Bangalore	Ragi (59), Groundnut (13) & Rice (12)
98	Mandya + Mysore	Ragi (34), Rice (22) & Jowar (20)
99	Chickmagalur + Hassan	Ragi (35), Rice (24), Coffee (12) & Jowar (10)
100	South Kanara	Rice (95)
101	Coorg	Rice (54) & Coffee (38)
	KERALA	
102	Cannanore + Kozhikode + Mallapuram	Rice (65), Black Pepper (17) & Coffee (10)
103	Palghat + Trichur	Rice (84)
104	Ernakulam + Kottayam	Rice (67) & Black Pepper (14)
105	Alleppey + Quilon + Trivandrum	Rice (79)
	TAMIL NADU & PONDICHERRY	
106	Tirunelveli + Kanyakumari	Rice (48), Bajra (17) & Cotton (15)
107	Ramanathapuram + Madurai	Rice (43), Jowar (11), Cotton (10) & Groundnut (10)
108	Coimbatore	Jowar (30), Groundnut (16), Rice (14), Bajra (9) & Cotton (9)
109	Nilgiris	Ragi (39), Tea (30) & Potato (13)
110	Salem + Dharampuri	Groundnut (22), Jowar (21), Ragi (18) & Rice (15)
111	Tiruchirapalli + Thanjavur	Rice (60), Jowar (11) & Groundnut (10)
112	Chingleput + South Arcot + North Arcot + Madras + PONDICHERRY	Rice (54) & Groundnut (23)

Table (A.1) Concluded

Areal unit code number (1)	Member districts of the areal units (2)	Locally important major crops separately maintaining similarity in cropping pattern within the areal unit (3)
	ANDHRA PRADESH	
113	Nellore + Chittoor	Rice (44), Groundnut (27) & Jowar (8)
114	Cuddapah + Anantapur	Groundnut (38), Jowar (22) & Rice (15)
115	Kurnool + Mahbubnagar	Jowar (39), Rice (15), Groundnut (14) & Cotton (8)
116	Hyderabad + Medak	Jowar (40), Rice (22) & Maize (11)
117	Nizamabad + Karimnagar	Rice (40), Jowar (22) & Maize (20)
118	Adilabad	Jowar (49), Cotton (17) & Rice (13)
119	Warangal + Khammam + Nalgonda	Jowar (33), Rice (31) & Bajra (11)
120	Guntur + Ongole	Rice (42), Jowar (15), Tobacco (11) & D. Chillies (8)
121	East Godavari + West Godavari + Krishna	Rice (78)
122	Srikakulam + Visakhapatnam	Rice (46), Mesta (12), Groundnut (10) & Bajra (9)
	ORISSA	
123	Kalahandi + Koraput	Rice (62) & Ragi (12)
124	Phulbani + Bolangir	Rice (73)
125	Puri + Ganjam	Rice (78)
126	Balasore + Cuttack	Rice (86)
127	Mayurbhanj + Keonjhar + Dhenkanal	Rice (84)
128	Sundargarh + Sambalpur	Rice (86)
	BIHAR	
129	Ranchi + Singhbhum	Rice (84)
130	Hazaribagh + Palamau	Rice (56), Maize (13) & Wheat (6)
131	Patna + Gaya + Sahabad	Rice (56) & Wheat (28)
132	Saran + Champaran	Rice (44), Wheat (28) & Maize (11)
133	Muzaffarpur + Darbhanga	Rice (54), Wheat (20) & Maize (11)
134	Saharsa + Purnea	Rice (52), Wheat (16) & Jute (10)
135	Monghyr + Bhagalpur	Rice (35), Wheat (27) & Maize (22)
136	Santal Parganas + Dhanbad	Rice (78)
	WEST BENGAL	
137	Purulia + Bankura + Midnapore	Rice (90)
138	Burdwan + Howrah + Hooghly	Rice (79)
139	Nadia + 24-Parganas + Calcutta	Rice (72) & Jute (12)
140	Murshidabad + Birbhum	Rice (63) & Wheat (16)
141	West Dinajpur + Malda	Rice (66) & Jute (10)
142	Cooch-Behar + Jalpaiguri + Darjeeling	Rice (58), Jute (10) & Tea (8)
	MEGHYALAYA	
143	Garo Hills + United K & J Hills	Rice (57), Potato (11) & Maize (10)
	ASSAM & TRIPURA	
144	Goalpara + Kamrup	Rice (81)
145	Darrang + Nowgong + Lakhimpur + Sibsagar	Rice (72) & Tea (10)
146	United M.N.C Hills	Rice (77)
147	Cachar + TRIPURA	Rice (85)
	MIZORAM	
148	Mizoram	Rice (87)
	MANIPUR & NAGALAND	
149	Manipur + Nagaland	Rice (84)
	ARUNACHAL PRADESH	
150	Arunachal Pradesh	Rice (77) & Maize (22)
	ANDAMAN & NICOBAR ISLANDS	
151	Andaman & Nicobar Islands	Rice (100)

Table (A.2) : Estimated Values of the Crop-concentration Index I for Selected Crops and Crop-aggregates by Areal Units; India: 1980-81

Areal units (1)	Rice (2)	Wheat (3)	Minor food-grains (4)	Other food-grains (5)	Oil-seeds (6)	Ground-nut (7)	Fibre crops (8)	Sugar-cane (9)	Potato (10)	Spices (11)	Tobacco (12)	Plantation crops (13)
1	1.428	0.321	0.0	1.569	0.733	0.0	0.001	0.0	0.400	0.254	0.043	0.0
2	0.322	1.375	0.002	4.925	0.143	0.0	0.008	0.025	0.058	0.102	0.051	0.0
3	1.149	2.502	0.289	1.467	0.281	0.0	0.041	0.192	0.453	0.029	0.240	0.0
4	0.238	1.126	0.003	4.098	0.151	0.0	0.002	0.042	0.071	0.053	0.103	0.0
5	0.386	1.695	0.017	3.584	0.338	0.002	0.014	0.152	0.691	0.025	0.109	1.210
6	0.012	1.085	0.072	2.218	0.007	0.0	0.0	0.0	5.718	0.0	0.0	0.0
7	0.429	2.521	0.118	2.833	0.057	0.003	0.003	0.091	1.464	0.102	0.336	0.252
8	0.186	1.580	0.098	3.168	0.122	0.127	0.008	0.153	5.536	1.399	0.193	0.0
9	0.918	4.726	0.027	3.669	0.682	0.827	0.248	2.669	5.510	0.598	0.051	0.0
10	2.213	6.662	0.092	2.163	1.513	2.028	0.858	1.743	0.992	3.556	0.004	0.0
11	0.869	7.361	0.530	3.526	2.276	3.129	2.493	1.509	0.657	1.229	0.010	0.0
12	2.050	5.287	0.081	1.712	0.765	0.380	0.561	1.730	0.936	0.931	0.012	0.0
13	1.001	6.135	0.518	2.388	0.727	0.121	7.695	0.394	0.228	0.440	0.004	0.0
14	0.306	2.934	2.326	5.012	0.885	0.007	4.213	1.720	0.195	0.422	0.089	0.0
15	0.0	1.931	4.082	6.115	0.984	0.0	0.293	0.418	0.0	0.0	0.298	0.0
16	0.108	4.343	2.211	2.600	0.510	0.013	0.156	3.409	0.272	0.676	0.128	0.0
17	2.156	4.979	0.380	1.956	0.360	0.237	0.196	4.121	3.015	1.394	0.100	0.0
18	0.716	2.186	0.177	0.882	0.345	0.456	0.075	8.627	0.752	0.214	0.211	0.0
19	0.206	2.947	0.134	1.246	0.023	0.017	0.155	14.568	2.206	0.159	0.139	0.0
20	0.066	3.697	1.062	3.310	0.120	0.037	0.195	5.170	2.897	0.142	0.113	0.0
21	0.035	3.160	1.517	2.299	1.212	0.062	0.093	1.419	1.530	0.129	0.142	0.0
22	0.666	2.676	1.002	2.344	1.049	0.274	0.006	0.500	5.330	0.193	0.110	0.0
23	0.127	2.708	1.105	3.579	0.697	0.019	0.001	0.229	0.348	0.092	0.029	0.0
24	0.600	2.193	0.613	2.370	1.409	1.484	0.008	1.003	3.159	0.040	0.041	0.0
25	0.300	2.740	1.063	2.190	1.397	1.749	0.010	1.573	9.343	0.084	1.348	0.0
26	0.651	2.358	0.349	0.740	0.769	1.035	0.016	10.314	1.760	0.250	0.293	0.0
27	0.0	1.765	1.375	0.610	0.0	0.0	0.0	0.0	0.0	0.031	0.0	0.0
28	0.0	1.770	1.442	0.655	0.0	0.0	0.0	0.0	0.0	0.122	0.0	0.0
29	1.031	2.626	0.311	1.148	0.686	0.513	0.006	4.612	1.806	0.374	0.132	0.0
30	0.975	1.927	0.151	1.518	1.099	1.212	0.430	5.109	1.019	0.206	0.250	0.0
31	1.366	1.883	0.075	2.340	0.370	0.205	0.118	1.333	2.057	0.061	0.072	0.0
32	1.578	2.327	0.018	0.852	0.170	0.095	0.009	2.724	2.135	0.170	0.008	0.0
33	1.251	1.694	0.198	2.224	0.018	0.009	0.018	2.424	2.880	0.018	0.010	0.0
34	1.257	1.606	0.462	1.770	0.103	0.105	0.001	1.014	3.444	0.035	0.025	0.0
35	0.850	1.747	1.105	3.602	0.273	0.016	0.001	0.500	1.060	0.060	0.048	0.0
36	0.915	1.735	0.685	2.635	0.128	0.003	0.0	0.833	4.800	0.054	0.047	0.0
37	1.173	1.149	0.291	1.745	0.288	0.007	0.001	1.006	2.019	0.043	0.001	0.0
38	0.816	1.351	0.299	2.453	1.112	0.0	0.047	0.009	0.390	0.019	0.115	0.0
39	1.776	0.346	0.082	1.106	0.733	0.100	0.011	0.026	0.577	0.084	0.118	0.0
40	2.518	0.134	0.013	0.407	0.535	0.240	0.035	0.098	0.156	0.111	0.024	0.0
41	2.896	0.133	0.011	0.068	0.667	0.160	0.004	0.032	0.024	0.150	0.011	0.0
42	2.267	0.031	0.118	0.499	0.298	0.0	0.023	0.057	0.025	0.140	0.166	0.0
43	2.163	0.298	0.012	0.655	1.061	0.001	0.004	0.112	0.028	0.232	0.011	0.0
44	1.115	1.426	0.122	1.263	1.071	0.191	0.001	0.078	0.218	0.061	0.069	0.0
45	0.306	1.316	1.021	2.505	0.814	0.915	0.157	0.498	0.990	0.452	0.012	0.008
46	0.874	2.140	0.331	1.789	0.721	0.081	0.001	0.020	0.389	0.098	0.005	0.0
47	0.739	2.451	0.317	1.505	1.332	0.0	0.017	0.031	0.413	0.040	0.036	0.0
48	0.272	2.050	0.963	2.113	1.026	0.018	0.005	0.119	0.544	0.444	0.082	0.0
49	0.084	4.431	0.566	2.310	1.103	0.397	0.032	0.044	0.298	0.108	0.001	0.0
50	0.102	2.625	1.018	2.021	1.393	0.160	0.700	0.344	0.139	0.395	0.001	0.0

Table (A.2) Continued

Areal units	Rice	Wheat	Minor food-grains	Other food-grains	Oil-seeds	Ground-nut	Fibre crops	Sugar-cane	Potato	Spices	Tobacco	Planta-tion crops
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
51	0.202	0.531	2.150	0.913	1.702	2.478	3.870	0.206	0.014	0.875	0.242	0.0
52	0.159	1.004	1.258	3.074	1.710	2.181	1.841	0.290	0.136	0.937	0.144	0.0
53	0.008	1.031	2.059	3.291	2.007	2.656	0.509	0.322	0.012	1.097	0.011	0.0
54	0.019	2.167	2.034	2.328	1.226	1.145	1.272	0.537	1.136	0.833	0.006	0.0
55	0.096	1.501	2.806	2.195	1.935	2.800	1.694	0.315	0.076	1.108	0.015	0.0
56	0.089	2.407	1.592	2.494	0.968	0.305	0.136	0.212	0.179	0.281	0.032	0.0
57	0.208	2.269	1.125	2.732	1.491	0.037	0.021	0.440	0.617	0.140	0.027	0.0
58	0.185	2.359	1.680	2.410	1.046	0.442	0.231	0.308	0.127	0.910	0.039	0.0
59	0.002	2.034	1.833	3.536	1.213	1.120	0.376	0.168	0.026	0.958	0.012	0.0
60	0.026	1.625	2.012	2.974	1.277	1.342	0.001	0.111	0.013	0.463	0.274	0.0
61	0.032	2.007	1.704	4.114	2.237	0.400	0.002	0.330	0.109	0.301	0.203	0.0
62	0.001	0.525	3.879	2.097	0.187	0.088	0.001	0.008	0.003	0.174	0.328	0.0
63	0.192	3.004	0.699	6.148	1.192	0.026	4.991	0.467	0.057	0.058	0.002	0.0
64	0.001	0.148	3.181	1.042	0.351	0.0	0.051	0.013	0.008	0.003	0.009	0.0
65	0.0	0.685	3.570	0.475	1.216	0.272	0.050	0.006	0.015	1.305	0.068	0.0
66	0.0	0.252	5.975	0.028	0.359	0.001	0.001	0.0	0.003	0.035	0.010	0.0
67	0.003	1.113	4.590	0.327	2.541	0.003	0.072	0.002	0.006	0.564	0.147	0.0
68	0.002	1.747	1.782	2.219	2.438	0.174	0.474	0.002	0.023	0.953	0.128	0.0
69	0.057	1.413	0.431	4.287	0.911	0.878	0.508	0.607	0.023	0.707	0.461	0.0
70	0.871	0.948	0.087	4.586	0.434	0.197	0.933	0.280	0.013	0.385	0.088	0.0
71	0.614	0.655	1.326	2.015	0.946	1.173	1.770	0.033	0.870	0.413	23.176	0.0
72	0.222	1.320	1.185	1.217	1.971	2.149	5.718	0.135	0.326	0.453	1.555	0.0
73	0.031	1.250	3.965	0.279	1.973	0.287	1.723	0.066	0.300	0.500	1.477	0.0
74	0.004	0.562	2.471	0.064	1.949	2.336	8.271	0.052	0.081	0.148	0.0	0.0
75	0.033	0.593	1.968	0.062	11.586	17.372	1.392	0.644	0.268	0.683	0.0	0.0
76	0.010	0.685	2.173	0.022	8.398	12.560	4.032	0.537	0.006	0.685	0.014	0.0
77	0.378	0.388	1.217	0.549	0.832	1.110	5.417	0.482	0.142	0.420	6.864	0.0
78	1.243	0.169	0.862	0.332	0.226	0.245	0.389	0.780	0.006	0.824	0.0	0.0
79	0.185	0.699	2.874	0.308	1.863	2.705	0.546	1.393	0.158	1.077	0.0	0.0
80	0.065	0.666	3.621	0.506	1.405	1.696	2.061	0.985	0.022	1.268	0.065	0.0
81	0.060	0.596	3.174	0.763	1.059	1.294	6.073	0.085	0.007	1.088	0.015	0.006
82	0.266	0.877	2.283	0.826	1.217	0.630	3.342	0.023	0.013	3.184	0.032	0.0
83	1.725	0.340	0.877	0.281	0.865	0.027	0.348	0.044	0.036	1.508	0.135	0.0
84	0.181	0.477	3.381	0.802	0.950	0.885	4.961	0.454	0.007	2.100	0.015	0.0
85	0.106	0.484	4.654	1.117	1.390	1.507	0.748	1.297	0.009	1.425	0.133	0.0
86	0.180	0.450	3.592	0.320	0.556	0.766	0.091	2.901	0.796	0.709	0.062	0.0
87	1.746	0.004	0.319	0.084	0.041	0.0	0.011	0.009	0.0	0.231	0.0	0.0
88	0.234	0.333	3.175	0.451	1.892	2.841	0.116	2.808	0.716	2.075	1.219	0.0
89	0.897	0.110	1.231	0.284	1.615	2.392	0.036	5.355	0.035	1.483	2.769	0.0
90	1.448	0.0	0.600	0.012	0.159	0.026	0.0	0.078	0.0	0.382	0.0	0.0
91	1.863	0.0	0.307	0.0	0.0	0.0	0.0	0.088	0.0	0.0	0.0	0.0
92	1.738	0.003	0.872	0.073	0.392	0.549	0.150	0.883	0.005	2.131	0.211	0.041
93	0.540	0.580	2.113	0.728	1.964	2.872	3.171	1.638	0.337	3.488	4.998	0.0
94	0.086	0.481	3.433	1.290	2.327	2.672	2.094	0.667	0.016	0.969	0.105	0.0
95	0.508	0.220	2.383	0.561	2.113	2.954	5.588	1.148	0.014	0.382	0.471	0.0
96	0.553	0.026	2.918	0.486	1.711	2.301	0.660	0.706	0.012	0.765	1.040	0.0
97	0.352	0.011	2.625	0.639	1.530	2.161	0.005	0.619	0.948	0.345	1.103	0.0
98	0.802	0.001	2.383	0.293	0.861	0.986	0.119	1.949	0.022	0.969	2.313	0.256
99	0.761	0.010	1.969	0.200	0.603	0.550	0.179	0.467	1.317	1.059	0.529	19.039
100	2.118	0.0	0.009	0.001	0.037	0.044	0.0	0.259	0.0	1.477	0.050	0.013

Table (A.2) Concluded

Areal units	Rice	Wheat	Minor food-grains	Other food-grains	Oil-seeds	Ground-nut	Fibre crops	Sugar-cane	Potato	Spices	Tobacco	Plantation crops
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
101	1.906	0.0	0.200	0.044	0.043	0.046	0.074	0.008	0.066	1.023	0.034	53.943
102	1.294	0.0	0.026	0.0	0.067	0.068	0.002	0.009	0.0	8.993	0.429	12.517
103	2.167	0.0	0.065	0.045	0.766	1.087	0.225	0.113	0.0	1.309	0.0	1.615
104	1.219	0.0	0.001	0.0	0.021	0.0	0.0	0.239	0.0	8.623	0.0	13.654
105	1.324	0.0	0.035	0.0	0.158	0.0	0.0	0.332	0.0	4.265	0.0	1.697
106	1.434	0.0	1.098	0.016	0.361	0.432	1.144	0.099	0.0	4.446	0.155	0.660
107	1.160	0.001	1.020	0.061	1.325	1.746	0.994	0.561	0.254	3.212	0.395	1.774
108	0.476	0.001	1.656	0.212	1.888	2.662	1.373	2.385	0.0	3.230	4.611	4.432
109	0.319	0.073	3.518	0.014	0.008	0.0	0.0	0.063	20.459	4.218	0.0	87.855
110	0.504	0.001	1.914	0.108	2.761	3.837	0.403	1.330	0.032	0.951	0.227	0.811
111	2.172	0.0	0.850	0.133	1.532	2.032	0.107	0.775	0.0	2.139	0.211	0.0
112	2.125	0.001	0.821	0.099	3.145	4.546	0.057	1.983	0.0	0.786	0.052	0.0
113	1.207	0.001	0.787	0.024	3.017	4.500	0.024	0.930	0.008	2.752	1.588	0.0
114	0.532	0.010	1.437	0.136	3.984	5.869	0.315	0.455	0.001	2.068	0.420	0.0
115	0.689	0.016	2.189	0.219	2.445	2.867	1.126	0.038	0.001	1.836	4.996	0.0
116	0.700	0.049	1.609	0.959	0.515	0.130	0.025	0.928	0.077	1.715	0.336	0.0
117	1.326	0.020	0.703	1.534	0.507	0.509	0.039	1.250	0.001	3.277	1.405	0.0
118	0.536	0.045	2.353	0.808	0.494	0.308	2.479	0.197	0.0	3.230	0.108	0.0
119	1.061	0.001	1.558	0.394	1.454	1.135	0.037	0.033	0.0	2.731	2.921	0.0
120	1.199	0.001	0.935	0.118	0.458	0.351	0.438	0.230	0.001	8.371	22.811	0.0
121	2.669	0.0	0.241	0.060	0.484	0.404	0.053	1.634	0.002	2.854	8.014	0.006
122	1.018	0.0	0.834	0.069	1.420	1.746	3.568	1.681	0.008	2.102	1.135	0.054
123	1.924	0.064	0.694	0.608	0.857	0.129	0.288	0.431	0.129	2.001	3.299	0.004
124	2.123	0.095	0.184	0.329	0.749	0.269	0.279	0.464	0.268	4.897	0.820	0.0
125	2.408	0.019	0.428	0.117	0.757	0.450	0.261	0.447	0.578	1.122	0.109	0.0
126	2.912	0.082	0.056	0.047	0.615	0.534	1.847	0.309	1.356	1.465	0.148	0.0
127	2.812	0.061	0.064	0.318	0.609	0.298	0.414	0.202	0.291	1.070	0.298	0.0
128	2.824	0.133	0.054	0.125	0.758	0.705	0.171	0.327	0.475	1.169	0.152	0.0
129	2.037	0.114	0.210	0.294	0.105	0.046	0.008	0.005	1.223	0.025	0.053	0.0
130	1.080	0.274	0.140	1.081	0.316	0.038	0.002	0.264	2.297	0.099	0.039	0.0
131	1.873	1.730	0.060	0.777	0.286	0.030	0.018	0.321	2.776	0.203	0.023	0.0
132	1.349	2.097	0.045	1.334	0.276	0.001	0.178	2.552	3.181	0.525	0.133	0.0
133	1.483	1.248	0.163	1.194	0.235	0.0	0.110	0.514	2.888	1.045	2.162	0.0
134	1.577	1.076	0.099	0.840	0.363	0.001	4.409	0.102	1.617	0.289	0.754	0.0
135	0.995	1.493	0.020	2.004	0.241	0.010	0.021	0.251	1.378	1.023	0.085	0.0
136	1.952	0.220	0.056	0.812	0.178	0.003	0.025	0.074	0.671	0.027	0.119	0.0
137	2.877	0.297	0.003	0.058	0.098	0.0	0.498	0.166	2.960	0.397	0.049	0.0
138	2.753	0.424	0.001	0.040	0.200	0.0	2.776	0.177	12.678	0.107	0.013	0.0
139	2.091	0.476	0.0	0.254	0.193	0.0	5.115	0.226	1.437	0.922	0.031	0.0
140	2.672	1.426	0.002	0.498	0.401	0.0	3.824	0.698	3.327	0.321	0.077	0.0
141	3.122	0.828	0.004	0.444	0.612	0.0	4.857	0.270	2.300	0.568	0.445	4.138
142	1.963	0.453	0.069	0.325	0.771	0.0	3.846	0.030	2.149	0.552	4.155	23.806
143	1.070	0.042	0.0	0.368	0.260	0.0	1.635	0.032	8.416	3.499	0.190	0.0
144	2.077	0.188	0.0	0.039	0.497	0.0	2.197	0.159	1.375	0.603	1.555	1.409
145	1.881	0.109	0.0	0.040	0.520	0.0	1.199	0.573	1.218	0.381	0.421	23.181
146	2.285	0.081	0.0	0.255	0.577	0.0	1.052	1.125	0.382	0.495	0.641	0.0
147	3.199	0.056	0.0	0.010	0.255	0.0	1.062	0.628	1.456	0.802	0.737	12.943
148	1.476	0.0	0.0	0.096	0.029	0.0	0.124	0.440	0.608	2.119	0.973	0.0
149	1.709	0.003	0.0	0.353	0.123	0.0	0.011	0.245	1.396	1.114	0.0	0.0
150	1.409	0.027	0.0	1.033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
151	1.810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.045

Table (A.3) : Estimated Values of the Crop-concentration Index I and the Associated Sub-indices I_α (area) and I_β (population) for the Crops Rice & Wheat by Areal Units; India:1960-81

Areal units	Rice			Wheat		
	I	I_α	I_β	I	I_α	I_β
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	1.428	1.497	1.367	0.321	0.346	0.288
2	0.322	0.305	0.338	1.375	1.333	1.430
3	1.149	1.072	1.217	2.502	2.375	2.666
4	0.238	0.227	0.248	1.126	1.140	1.107
5	0.386	0.365	0.406	1.695	1.659	1.741
6	0.012	0.016	0.009	1.085	1.414	0.660
7	0.429	0.395	0.459	2.521	2.378	2.706
8	0.186	0.199	0.174	1.580	1.685	1.443
9	0.918	0.847	0.981	4.726	4.276	5.309
10	2.213	1.906	2.489	6.662	5.479	8.190
11	0.869	0.763	0.965	7.361	6.164	8.908
12	2.050	1.951	2.139	5.287	4.835	5.871
13	1.001	0.787	1.194	6.135	4.708	7.980
14	0.306	0.244	0.362	2.934	2.291	3.765
15	0.0	0.0	0.0	1.931	1.591	2.369
16	0.108	0.096	0.119	4.343	3.798	5.048
17	2.156	1.876	2.408	4.979	4.208	5.976
18	0.716	0.771	0.666	2.186	2.293	2.047
19	0.206	0.249	0.168	2.947	3.299	2.490
20	0.066	0.076	0.056	3.697	4.002	3.304
21	0.035	0.040	0.030	3.160	3.489	2.735
22	0.666	0.754	0.588	2.676	2.873	2.421
23	0.127	0.111	0.141	2.708	2.439	3.056
24	0.600	0.741	0.473	2.193	2.552	1.729
25	0.300	0.349	0.257	2.740	2.987	2.420
26	0.651	0.742	0.569	2.358	2.535	2.129
27	0.0	0.0	0.0	1.765	2.141	1.278
28	0.0	0.0	0.0	1.770	2.090	1.358
29	1.031	1.095	0.973	2.626	2.681	2.555
30	0.974	1.077	0.884	1.927	2.023	1.804
31	1.366	1.637	1.123	1.883	2.104	1.598
32	1.378	2.090	1.118	2.327	2.822	1.687
33	1.251	1.653	0.890	1.694	2.067	1.212
34	1.257	1.613	0.937	1.606	1.919	1.202
35	0.850	0.890	0.814	1.747	1.755	1.736
36	0.915	1.189	0.669	1.735	2.097	1.267
37	1.173	1.368	0.998	1.149	1.299	0.956
38	0.816	0.777	0.851	1.351	1.326	1.382
39	1.776	1.590	1.944	0.346	0.316	0.386
40	2.518	2.392	2.632	0.134	0.127	0.143
41	2.896	2.705	3.068	0.133	0.123	0.145
42	2.267	1.844	2.646	0.031	0.027	0.036
43	2.163	2.137	2.185	0.298	0.288	0.311
44	1.115	1.038	1.184	1.426	1.321	1.563
45	0.306	0.285	0.324	1.316	1.228	1.429
46	0.874	0.821	0.922	2.140	2.009	2.310
47	0.739	0.637	0.831	2.451	2.244	2.719
48	0.272	0.244	0.297	2.050	1.954	2.173
49	0.084	0.062	0.104	4.431	3.426	5.731
50	0.102	0.087	0.115	2.625	2.264	3.092
51	0.202	0.187	0.216	0.531	0.507	0.561
52	0.159	0.144	0.172	1.004	0.938	1.090
53	0.008	0.007	0.009	1.031	0.928	1.165
54	0.019	0.016	0.021	2.167	1.957	2.440
55	0.096	0.077	0.114	1.501	1.245	1.835
56	0.089	0.071	0.105	2.407	1.930	3.024
57	0.208	0.181	0.232	2.269	2.012	2.601
58	0.185	0.150	0.217	2.359	1.958	2.878
59	0.002	0.001	0.002	2.034	1.726	2.432
60	0.026	0.023	0.028	1.625	1.540	1.736
61	0.032	0.028	0.036	2.007	1.810	2.261
62	0.001	0.001	0.001	0.525	0.512	0.542
63	0.192	0.118	0.258	3.004	1.896	4.437
64	0.001	0.001	0.001	0.148	0.171	0.118
65	0.0	0.0	0.0	0.685	0.625	0.762
66	0.0	0.0	0.0	0.252	0.194	0.325
67	0.003	0.002	0.003	1.113	0.823	1.488
68	0.002	0.001	0.002	1.747	1.441	2.141
69	0.057	0.052	0.061	1.413	1.353	1.490
70	0.871	0.817	0.919	0.948	0.902	1.008
71	0.614	0.689	0.548	0.655	0.705	0.590
72	0.222	0.227	0.218	1.320	1.362	1.264
73	0.031	0.027	0.033	1.250	1.157	1.371
74	0.004	0.003	0.005	0.562	0.445	0.714
75	0.033	0.023	0.042	0.593	0.437	0.795

Table (A.3) Concluded

Areal units	Rice			Wheat		
	I	I_α	I_β	I	I_α	I_β
(1)	(2)	(3)	(4)	(5)	(6)	(7)
76	0.010	0.008	0.012	0.685	0.566	0.838
77	0.378	0.434	0.328	0.388	0.442	0.320
78	1.243	1.544	0.972	0.169	0.205	0.125
79	0.185	0.186	0.184	0.699	0.676	0.728
80	0.065	0.065	0.064	0.666	0.641	0.699
81	0.060	0.059	0.062	0.596	0.554	0.650
82	0.266	0.278	0.254	0.877	0.860	0.899
83	1.725	1.581	1.854	0.340	0.306	0.383
84	0.181	0.171	0.190	0.477	0.428	0.542
85	0.106	0.093	0.119	0.484	0.406	0.586
86	0.180	0.180	0.180	0.450	0.434	0.470
87	1.746	2.217	1.324	0.004	0.005	0.003
88	0.234	0.224	0.242	0.333	0.312	0.360
89	0.897	1.017	0.789	0.110	0.125	0.091
90	1.448	1.778	1.153	0.0	0.0	0.0
91	1.863	2.122	1.631	0.0	0.0	0.0
92	1.738	1.647	1.819	0.003	0.003	0.003
93	0.540	0.525	0.554	0.580	0.536	0.636
94	0.086	0.077	0.093	0.481	0.406	0.578
95	0.508	0.455	0.557	0.220	0.186	0.264
96	0.553	0.564	0.543	0.026	0.027	0.026
97	0.352	0.450	0.265	0.011	0.014	0.008
98	0.802	0.880	0.732	0.001	0.001	0.001
99	0.761	0.718	0.800	0.010	0.009	0.010
100	2.118	2.506	1.769	0.0	0.0	0.0
101	1.906	1.248	2.497	0.0	0.0	0.0
102	1.294	1.694	0.955	0.0	0.0	0.0
103	2.167	2.852	1.553	0.0	0.0	0.0
104	1.219	1.566	0.907	0.0	0.0	0.0
105	1.324	2.069	0.655	0.0	0.0	0.0
106	1.434	1.756	1.145	0.0	0.0	0.0
107	1.160	1.429	0.919	0.001	0.002	0.001
108	0.476	0.554	0.407	0.001	0.001	0.001
109	0.319	0.088	0.526	0.073	0.030	0.128
110	0.504	0.629	0.392	0.001	0.002	0.001
111	2.172	2.576	1.809	0.0	0.0	0.0
112	2.125	2.469	1.817	0.001	0.001	0.001
113	1.207	1.243	1.174	0.001	0.001	0.001
114	0.532	0.536	0.528	0.010	0.010	0.010
115	0.689	0.672	0.704	0.016	0.015	0.018
116	0.700	0.880	0.538	0.049	0.058	0.036
117	1.326	1.442	1.222	0.020	0.021	0.018
118	0.536	0.513	0.558	0.045	0.041	0.051
119	1.061	1.087	1.037	0.001	0.001	0.001
120	1.199	1.250	1.152	0.001	0.001	0.001
121	2.669	3.037	2.338	0.0	0.0	0.0
122	1.018	1.237	0.821	0.0	0.0	0.0
123	1.924	1.621	2.196	0.064	0.057	0.074
124	2.123	1.869	2.352	0.095	0.088	0.106
125	2.408	2.519	2.309	0.019	0.020	0.018
126	2.912	3.340	2.527	0.082	0.090	0.071
127	2.812	2.472	3.118	0.061	0.055	0.068
128	2.924	2.357	3.235	0.133	0.117	0.154
129	2.057	2.218	1.875	0.114	0.125	0.100
130	1.080	1.345	0.842	0.274	0.357	0.193
131	1.873	2.395	1.403	1.730	2.064	1.299
132	1.349	1.810	0.935	2.097	2.576	1.477
133	1.483	2.191	0.848	1.248	1.671	0.701
134	1.377	2.131	1.079	1.076	1.344	0.730
135	0.995	1.345	0.682	1.493	1.885	0.987
136	1.952	2.390	1.560	0.220	0.261	0.166
137	2.877	3.394	2.142	0.297	0.334	0.250
138	2.753	3.785	1.826	0.424	0.535	0.280
139	2.091	2.806	1.449	0.476	0.602	0.313
140	2.672	3.352	2.062	1.426	1.650	1.136
141	3.122	3.707	2.597	0.828	0.910	0.722
142	1.963	2.077	1.860	0.453	0.460	0.444
143	1.070	1.162	0.988	0.042	0.047	0.035
144	2.077	2.496	1.700	0.188	0.219	0.149
145	1.881	1.837	1.192	0.109	0.107	0.113
146	2.285	1.656	2.851	0.081	0.066	0.100
147	3.199	2.258	4.044	0.056	0.041	0.074
148	1.476	1.563	1.398	0.0	0.0	0.0
149	1.709	1.728	1.693	0.003	0.003	0.002
150	1.409	1.439	1.382	0.027	0.030	0.025
151	1.810	1.793	1.825	0.0	0.0	0.0

Table (A.4) : Estimated Values of the Crop-concentration Index I by Crops and by Crop Regions; India:1980-81

Crop Regions	Rice	Wheat	Jowar	Bajra	Ragi	Maize	Barley	Gram	Tur	Groundnut	Mustard & Rapeseed	Sesamum	Linseed	Castorseed	Cotton	Jute	Mesta	Sugarcane	Potato	Dry Chillies	Black Pepper	Turmeric	Dry Ginger	Tobacco	Tea	Coffee
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
A1	0.648	1.376	0.0	0.079	0.294	6.141	1.247	0.264	0.005	0.017	1.374	0.465	0.721	0.0	0.014	0.0	0.0	0.090	1.119	0.138	0.0	0.018	3.511	0.139	0.404	0.0
A2	0.0	1.674	0.0	0.002	11.250	0.366	3.754	0.0	0.073	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.544	0.0	0.0	0.0	0.0
A3	0.708	4.971	0.015	1.619	0.0	1.162	1.629	7.860	0.041	0.083	6.777	0.030	0.002	0.0	9.789	0.0	0.0	0.407	0.182	0.378	0.0	0.0	0.0	0.003	0.0	0.0
A4	0.775	4.304	0.181	2.363	0.044	3.181	2.552	2.916	0.415	0.528	2.710	0.369	0.047	0.0	1.387	0.004	0.0	4.639	1.934	0.875	0.0	0.001	0.348	0.094	0.0	0.0
A5	0.706	2.432	0.323	0.993	0.015	1.911	2.141	1.283	1.747	1.221	2.196	0.145	0.106	0.007	0.007	0.262	0.0	4.124	3.496	0.250	0.0	0.028	0.025	0.381	0.0	0.0
A6	0.532	2.037	0.958	0.870	0.035	0.775	3.757	3.805	3.357	0.042	2.372	1.665	3.439	0.053	0.002	0.0	0.148	0.381	1.798	0.118	0.0	0.025	0.508	0.055	0.0	0.0
A7	0.448	2.365	1.183	0.004	0.007	0.712	0.062	3.497	2.998	0.369	0.746	1.620	5.601	0.024	0.236	0.0	0.065	0.197	0.406	0.295	0.0	0.003	0.297	0.016	0.0	0.008
A8	0.058	1.964	2.361	2.099	0.0	1.375	4.677	4.711	1.045	0.958	3.035	1.443	2.041	0.010	0.612	0.0	0.235	0.279	0.287	0.853	0.0	0.001	0.043	0.120	0.0	0.0
B1	1.314	1.889	0.121	0.258	0.153	1.562	3.676	1.058	1.780	0.080	0.687	0.139	0.660	0.045	0.001	0.187	0.097	1.968	2.550	0.051	0.0	0.930	0.193	0.045	0.0	0.0
B2	1.520	1.453	0.014	0.012	0.666	1.929	1.153	0.544	0.407	0.014	0.822	0.135	1.985	0.410	0.016	3.161	2.135	0.320	2.216	0.521	0.0	1.271	0.241	0.714	0.0	0.0
C1	1.991	0.179	0.0	0.0	0.110	0.196	0.050	0.010	0.087	0.0	3.570	0.349	0.043	0.110	0.020	6.757	2.472	0.379	1.378	0.354	0.0	1.733	1.445	1.387	21.173	0.018
C2	1.039	0.040	0.0	0.0	0.0	0.908	0.0	0.009	0.051	0.0	1.974	0.175	0.0	0.025	0.351	3.435	7.578	0.032	7.115	0.538	0.0	4.729	44.175	0.189	0.0	0.0
C3	1.357	0.026	0.0	0.0	0.0	2.535	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C4	1.614	0.002	0.0	0.0	0.0	0.760	0.0	0.003	0.0	0.0	0.516	0.376	0.0	0.0	0.034	0.035	0.0	0.278	1.073	1.185	0.0	0.089	7.420	0.167	0.0	0.0
D1	2.525	0.748	0.001	0.001	0.005	0.058	0.525	0.416	0.281	0.0	1.287	0.800	1.095	0.0	0.0	14.364	2.755	0.324	5.311	0.549	0.0	0.407	0.734	0.113	1.017	0.0
D2	2.032	0.226	0.008	0.025	0.715	0.832	0.213	0.149	0.319	0.018	0.426	0.509	0.466	0.021	0.002	0.577	0.530	0.127	1.864	0.191	0.0	0.135	0.243	0.058	0.0	0.0
D3	2.253	0.190	0.048	0.0	0.128	0.600	0.193	0.422	0.895	0.106	0.807	0.683	4.351	0.076	0.004	0.0	0.202	0.069	0.140	0.179	0.0	0.074	0.084	0.052	0.0	0.0
D4	2.435	0.070	0.042	0.011	2.108	0.408	0.0	0.092	0.483	0.386	1.135	2.437	0.484	1.636	0.020	1.480	2.481	0.344	0.531	1.345	0.0	4.893	1.085	0.786	0.0	0.003
D5	1.304	0.106	1.822	0.431	0.052	1.287	0.001	0.173	0.708	0.622	0.002	1.329	1.753	8.039	0.176	0.0	0.143	0.362	0.010	2.820	0.0	2.503	0.150	1.668	0.0	0.0
E1	1.818	0.0	0.493	0.736	1.730	0.049	0.0	0.018	0.452	2.330	0.005	1.587	0.002	0.716	0.155	0.0	5.360	1.283	0.002	3.280	0.002	2.011	0.823	5.162	0.0	0.033
F1	1.004	0.001	1.167	1.163	1.583	0.087	0.0	0.044	0.348	1.738	0.002	1.319	0.0	0.253	1.765	0.0	0.0	1.019	0.107	3.643	0.051	4.306	0.029	1.635	1.887	3.131
G1	1.409	0.0	0.009	0.0	0.285	0.004	0.0	0.001	0.071	0.249	0.0	0.526	0.0	0.019	0.080	0.0	0.0	0.149	0.003	0.355	46.533	3.559	23.650	0.126	5.135	25.518
G2	1.626	0.022	0.242	0.076	3.029	0.044	0.0	0.033	0.402	0.174	0.002	0.373	0.001	0.258	0.130	0.0	0.052	0.364	0.002	1.092	0.604	0.297	1.784	0.056	0.0	0.051
H1	0.541	0.010	1.215	0.313	13.198	0.580	0.001	0.045	0.685	2.047	0.039	1.035	0.0	2.259	0.422	0.0	0.005	0.993	0.748	0.914	0.062	0.688	0.846	0.977	2.536	12.362
H2	0.478	0.245	3.171	1.130	1.284	0.629	0.012	0.358	2.033	2.920	0.007	0.956	0.984	4.133	2.850	0.0	1.250	0.769	0.077	2.105	0.0	1.487	0.139	2.044	0.0	0.0
H3	0.247	0.519	5.003	0.519	0.378	0.134	0.011	0.392	3.546	1.009	0.030	1.329	2.237	0.209	5.501	0.0	1.058	0.369	0.009	2.064	0.0	1.410	0.076	0.034	0.0	0.007
H4	0.228	0.457	4.772	2.293	1.105	0.200	0.073	0.572	1.980	1.830	0.017	0.608	1.058	0.078	0.399	0.0	1.848	2.251	0.348	1.418	0.0	1.247	0.198	0.459	0.0	0.0
I1	0.299	0.909	1.198	1.007	0.249	4.347	1.466	1.204	1.116	1.392	0.049	1.373	0.664	1.393	4.022	0.0	0.007	0.307	0.255	0.728	0.0	0.045	0.540	5.848	0.0	0.0
J1	0.021	0.747	1.459	4.790	0.006	0.116	0.060	0.096	0.128	8.616	1.249	1.581	0.0	9.535	4.579	0.0	0.0	0.355	0.186	0.711	0.0	0.0	0.0	0.378	0.0	0.0
J2	0.001	0.679	0.168	8.684	0.0	0.385	2.347	1.444	0.033	0.107	2.654	5.738	0.043	0.176	0.138	0.0	0.018	0.005	0.010	0.764	0.0	0.0	0.0	0.104	0.0	0.0

Table (A.5) : Estimates of Foodgrain Availability to Requirement Ratios (Σ_1, Σ_2, Σ_3 & Σ_4) and Estimates of Cultivators' Capability (x_m), Labour Productivity (x_v) and Land Productivity (x_a) by Areal Units of India : 1980-81

Areal unit code (1)	Σ_1 (2)	Σ_2 (3)	Σ_3 (4)	Σ_4 (5)	x_m (6)	x_v (7)	x_a (8)
1.	1.9235	1.8238	1.2958	0.9616	0.8421	0.8816	1.2807
2.	1.7893	1.7345	1.3786	1.5191	0.7737	0.8660	1.0257
3.	2.1372	1.9529	1.3017	1.0478	0.9333	1.4469	0.8761
4.	1.5699	1.5557	1.2157	1.1436	0.6366	0.6741	0.9910
5.	1.7912	1.6665	1.1616	1.1128	0.7747	0.8369	0.9280
6.	0.9481	0.8733	0.5876	0.5876	−0.0960	0.1533	1.0061
7.	1.9463	1.9177	1.5937	1.5148	0.8527	0.7376	0.9092
8.	1.3365	1.2992	1.3461	1.2202	0.4416	0.6153	0.9546
9.	8.6808	5.3394	3.5719	2.8275	1.5518	2.9529	1.5301
10.	14.9156	9.2917	7.1502	5.4119	1.6362	4.1517	1.6813
11.	14.2065	9.0899	7.0918	5.1126	1.6304	4.0475	1.8017
12.	11.3907	6.8568	5.0213	3.8460	1.5999	3.1656	1.6307
13.	10.6471	6.8496	5.8027	4.7166	1.5891	3.4876	1.5890
14.	4.1064	3.1283	2.5777	2.1993	1.3267	2.5322	1.2043
15.	2.8680	2.4601	1.7834	1.5768	1.1423	1.8330	0.9191
16.	3.9779	3.1192	2.2009	1.7521	1.3129	2.4804	1.1775
17.	9.1353	5.8370	4.3283	3.3808	1.5618	3.7698	1.6723
18.	2.3289	1.3774	1.0819	0.8005	1.0008	1.6498	1.1878
19.	2.1038	1.3940	1.0362	0.7945	0.9202	2.0603	1.3357
20.	2.7558	2.0248	1.6593	1.3801	1.1175	1.6519	1.2651
21.	2.2238	1.7671	1.3663	1.0090	0.9651	1.2110	1.1399
22.	1.7204	1.4761	1.3112	1.1797	0.7344	1.1641	1.1508
23.	1.9754	1.4882	1.4743	1.2012	0.8661	0.9436	0.7809
24.	1.3836	1.1885	1.0673	0.7785	0.4863	0.9204	1.0474
25.	1.4777	1.3193	1.2062	1.0561	0.5668	1.1013	1.0981
26.	1.4188	1.1234	0.9474	0.7488	0.5177	1.5326	1.0845
27.	1.3861	1.1683	0.9907	0.8383	0.4895	0.2398	0.6781
28.	1.3861	1.3277	0.9916	0.9281	0.4885	0.3079	0.7564
29.	1.8240	1.5320	1.3759	1.1075	0.7923	1.3057	1.0100
30.	1.0472	0.9555	0.8954	0.8267	0.0792	1.0070	0.8672
31.	1.1604	1.0236	0.9549	0.8987	0.2423	0.7436	0.7901
32.	1.2945	0.9745	0.8654	0.8164	0.3989	0.8132	0.9517
33.	1.1505	0.8328	0.7065	0.6586	0.2295	0.7996	0.9217
34.	1.1069	0.8551	0.7630	0.7229	0.1694	0.7101	0.9493
35.	1.7628	1.2700	1.1442	1.0579	0.7589	0.9053	0.9267
36.	1.2831	0.9467	0.7848	0.6937	0.3871	0.7918	1.0221
37.	1.5606	0.9882	0.7298	0.6024	0.6300	0.8160	0.9325
38.	1.9211	1.1641	1.0207	0.9542	0.8408	0.5002	0.5817
39.	1.6724	1.2202	1.0742	0.9619	0.7052	0.6288	0.6381
40.	2.1114	1.4111	1.2566	1.1332	0.9232	0.7033	0.7550
41.	2.9300	1.8343	1.6266	1.3963	1.1553	0.8233	0.8541
42.	1.5971	1.2945	1.1898	1.1318	0.6556	0.6406	0.6611
43.	1.9579	1.3524	1.1802	0.9836	0.8581	0.6011	0.6996
44.	1.7548	1.2240	1.1123	1.0463	0.7545	0.4940	0.6534
45.	2.2197	1.3465	1.1686	0.9992	0.9637	0.6216	0.7539
46.	3.1356	1.8149	1.3894	0.9410	1.1946	0.7976	0.6783

Note : Σ_1 = Foodgrain availability to requirement ratio for cultivators; Σ_2 = Foodgrain availability to requirement ratio for agricultural population ;
Σ_3 = Foodgrain availability to requirement ratio for rural population ; Σ_4 = Foodgrain availability to requirement ratio for total population ;
x_m = Foodgrain surplus generating capacity sub-index ; x_v = Agricultural labour productivity sub-index ;
x_a = Agricultural land productivity sub-index.

Table (A.5) Continued

Areal unit code (1)	Σ_1 (2)	Σ_2 (3)	Σ_3 (4)	Σ_4 (5)	x_m (6)	x_w (7)	x_a (8)
47.	2.4538	1.4649	1.2134	1.0794	1.0391	0.6292	0.5805
48.	2.1532	1.7070	1.4926	1.3214	0.9593	0.6700	0.8148
49.	4.1500	2.5240	1.9641	1.6332	1.3313	1.0276	0.6334
50.	3.2272	1.8362	1.5516	1.0148	1.2105	0.8730	0.6606
51.	1.9204	1.1664	1.0516	0.8794	0.8406	0.7068	0.7217
52.	1.7417	1.3955	1.2847	1.1083	0.7468	0.6792	0.6563
53.	2.5952	2.0548	1.8198	1.5141	1.0780	0.8075	0.7769
54.	4.1596	2.5247	2.1443	1.2980	1.3321	1.1248	0.7853
55.	3.1044	2.1403	1.8624	1.6423	1.1888	0.9457	0.7562
56.	2.3382	1.8770	1.7008	1.5127	1.0038	0.8046	0.6749
57.	2.2440	1.9770	1.7558	1.3498	0.9723	1.0673	0.9044
58.	3.2363	2.5711	2.0484	1.6571	1.2119	1.1109	0.7689
59.	3.0959	2.7257	2.1178	1.5139	1.1874	0.9529	0.6272
60.	2.1316	1.9834	1.5606	1.1826	0.9310	0.9859	0.9091
61.	2.3520	2.1749	1.7910	1.5895	1.0082	1.2875	1.0712
62.	1.2357	1.1564	0.8940	0.7464	0.3345	0.7543	0.7247
63.	4.6893	3.7589	3.2423	2.7034	1.3798	2.5062	1.0385
64.	0.5139	0.4981	0.4351	0.3136	−1.6590	0.3061	0.3106
65.	0.9922	0.9223	0.7927	0.6326	−0.0138	0.5716	0.4853
66.	1.0409	0.9943	0.8398	0.0451	0.0690	0.6584	0.3571
67.	1.7784	1.5311	1.3010	1.2189	0.7677	1.1401	0.7815
68.	2.6663	2.0233	1.4931	1.2744	1.0960	1.0259	0.7292
69.	2.1903	2.0138	1.6379	1.4503	0.9531	0.7871	0.8764
70.	1.8107	1.6516	1.4127	1.3430	0.7853	1.0103	0.9029
71.	1.5626	1.1594	0.9773	0.8504	0.6314	1.0952	1.3331
72.	2.4735	1.4642	1.1161	0.5988	1.0449	1.3859	1.0737

Areal unit code (1)	Σ_1 (2)	Σ_2 (3)	Σ_3 (4)	Σ_4 (5)	x_m (6)	x_w (7)	x_a (8)
73.	2.8256	1.9004	1.4866	1.3016	1.1331	1.2193	1.2052
74.	2.0157	1.1947	0.8986	0.6957	0.8837	1.3892	0.8305
75.	1.7052	1.2136	0.9900	0.7419	0.7254	2.0644	1.0971
76.	2.1779	1.4508	1.1604	0.7929	0.9485	1.9174	1.1389
77.	1.7443	0.8012	0.6536	0.4582	0.7484	0.8212	1.0878
78.	1.4326	0.8823	0.6559	0.5464	0.5296	0.5277	1.1350
79.	2.5221	1.4150	1.2281	0.9681	1.0585	0.6862	0.8497
80.	3.1611	1.6672	1.4553	1.1805	1.1990	0.7129	0.7864
81.	4.0286	1.5865	1.4202	1.1408	1.3185	0.6485	0.7411
82.	4.0336	1.6907	1.3709	0.8047	1.3191	0.6931	0.6476
83.	2.9552	1.8291	1.4697	1.3226	1.1604	0.7136	0.8093
84.	3.5624	1.6906	1.4759	1.2726	1.2750	0.7190	0.7209
85.	3.8513	2.1469	1.8078	1.5042	1.2985	0.8922	0.7626
86.	2.4006	1.6098	1.2970	0.9377	1.0233	0.9238	0.9180
87.	2.0998	1.5358	1.0603	0.7545	0.9186	0.6320	1.3854
88.	1.8626	1.3409	1.0611	0.9192	0.8122	1.0128	1.0023
89.	1.6591	1.3091	1.0655	0.8539	0.6967	1.1218	1.5873
90.	1.1160	0.9939	0.7761	0.7279	0.1824	0.4573	1.1121
91.	2.4381	1.3786	1.1038	0.8903	1.0345	0.6120	1.3061
92.	2.9748	1.7884	1.3820	1.0817	1.1644	1.0826	1.3877
93.	2.5881	1.4231	1.1915	0.8976	1.0762	1.0545	0.9618
94.	2.6104	1.2088	0.9974	0.8081	1.0820	0.8064	0.6502
95.	3.1585	1.5021	1.2988	1.0171	1.1986	1.1293	1.0602
96.	2.3677	1.5713	1.3468	1.1396	1.0130	0.8619	1.3835
97.	1.9039	1.3494	1.1045	0.5799	0.8326	0.7067	1.2913
98.	1.9984	1.4064	1.2118	0.9740	0.8761	0.9099	1.5466

Table (A.5) Concluded

Areal unit code	Σ_1	Σ_2	Σ_3	Σ_4	x_m	x_w	x_a
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
99.	1.8359	1.4119	1.0535	0.9147	0.7986	1.2483	1.3448
100.	2.9066	1.6440	0.8902	0.7056	1.1505	0.7951	1.3405
101.	5.0803	3.0227	1.3166	1.1465	1.4087	1.8716	1.4540
102.	2.6211	0.7934	0.3660	0.3106	1.0248	0.9032	1.3809
103.	5.6159	1.4140	0.7517	0.6505	1.4416	0.8264	1.2964
104.	2.2445	0.9302	0.4211	0.3382	0.9725	1.1170	1.6657
105.	1.8504	0.6016	0.4000	0.2426	0.3060	0.4489	1.4450
106.	4.5713	1.9040	1.2559	0.9550	1.3676	0.8810	1.7337
107.	2.8959	1.4371	1.1538	0.8293	1.1481	0.6964	1.3548
108.	3.4707	1.3531	1.0163	0.6689	1.2485	1.0869	1.7139
109.	19.4914	1.5487	0.6717	0.3761	1.6639	3.7331	1.5967
110.	1.8207	1.0510	0.8542	0.6967	0.7905	0.6082	1.3106
111.	4.5409	2.2384	1.8573	1.4939	1.3676	1.0253	1.5822
112.	4.8396	2.3755	1.9236	1.5100	1.3915	1.2844	1.8136
113.	2.4591	1.2387	1.0219	0.8606	1.0407	0.8591	1.3388
114.	1.7807	0.9050	0.7532	0.6251	0.7689	0.6519	0.9739
115.	2.5901	1.2353	1.0328	0.8777	1.0768	0.6490	0.7901
116.	2.2986	1.3119	1.0255	0.5570	0.9908	0.5468	0.9401
117.	3.7101	1.9855	1.4897	1.2721	1.2812	0.7773	1.2788
118.	2.7801	1.4321	1.1674	0.9748	1.1231	0.6582	0.7890
119.	2.6879	1.3029	1.0528	0.9186	1.1014	0.6118	0.8421
120.	3.2023	1.2615	1.0376	0.8376	1.2063	0.9228	1.1534
121.	7.2901	2.3628	1.8549	1.4543	1.5133	1.2805	1.6154
122.	1.2153	0.7364	0.5858	0.4825	0.3107	0.6339	1.1141
123.	2.4355	1.5456	1.3751	1.2580	1.0337	0.9304	0.8821
124.	2.2215	1.4060	1.2126	1.1270	0.9643	0.9056	0.8910
125.	2.3719	1.3702	1.2300	1.0356	1.0720	1.0687	1.1560
126.	3.0637	2.0011	1.0509	0.9399	1.1814	1.1251	1.0198
127.	1.3312	1.2731	1.1738	1.0256	0.4364	1.1878	1.0375
128.	3.4744	2.1330	1.7095	1.3809	1.2491	1.2883	0.9994
129.	1.1496	0.8622	0.7326	0.5556	0.2281	0.5671	0.6748
130.	0.7300	0.5003	0.4129	0.3689	-0.6489	0.4186	0.7834
131.	1.8716	0.9887	0.8559	0.7345	0.8168	0.8112	0.9953
132.	1.4172	0.8056	0.7215	0.6828	0.5165	0.7960	0.9829
133.	1.1416	0.5570	0.4898	0.4642	0.2175	0.5042	0.8762
134.	1.5405	0.6658	0.6048	0.5646	0.6154	0.5597	0.8274
135.	1.5844	0.7629	0.6610	0.5859	0.6470	0.5397	0.9939
136.	1.2269	0.9056	0.6995	0.5539	0.3243	0.6354	0.9034
137.	2.3506	1.3955	1.1109	1.0329	1.0078	0.9879	1.1100
138.	3.2976	1.4660	0.9843	0.6952	1.2221	1.4896	1.5614
139.	1.9408	0.9901	0.7082	0.4899	0.8503	1.0035	1.1160
140.	2.9837	1.5185	1.1741	1.0860	1.1660	1.4010	1.2559
141.	3.1162	1.7492	1.4623	1.3614	1.1914	1.5789	1.2207
142.	2.1168	1.4337	0.9067	0.7973	0.9252	2.2853	1.3410
143.	0.9858	0.8536	0.7078	0.6026	-0.0253	0.5666	1.0406
144.	1.1416	1.0002	0.9106	0.8241	0.2175	0.9437	0.9683
145.	1.2212	1.0760	0.7775	0.7140	0.3177	2.4436	1.4274
146.	2.0122	1.8491	1.3999	1.3547	0.8821	1.1480	1.1099
147.	1.3650	0.9973	0.7862	0.7268	0.4690	1.2071	1.1381
148.	0.9021	0.8880	0.5659	0.4314	-0.1902	0.4688	0.9862
149.	1.3751	1.2026	0.8624	0.8067	0.4784	0.7645	1.1455
150.	1.9823	1.3293	0.9101	0.8178	0.8691	0.4176	0.7747
151.	2.7130	1.1543	0.8952	0.7513	1.1074	1.0738	1.0286

Table (A.6) : Estimates of Production Growth Rates (Z), Productivity Growth Rates (X) and the Related Growth Components (Y, A & C) of Indian Agriculture by Areal Units : 1960-61 to 1980-81

Areal unit code	Estimates of Different Growth Components				
	Z	X	Y	A	C
(1)	(2)	(3)	(4)	(5)	(6)
1.	0.6277	0.5279	0.5211	0.0606	0.0035
2.	0.7468	0.2952	0.6339	0.0627	-0.0001
3.	0.9664	0.8445	0.5916	0.1345	0.0538
4.	0.8150	0.5160	0.3212	0.1519	0.0260
5.	0.7163	0.5921	0.5514	0.0690	0.0415
6.	0.6729	0.1257	0.5121	0.0771	0.0443
7.	0.6468	0.3379	0.3310	0.2789	0.0238
8.	0.6677	0.3033	0.5634	0.0578	0.0147
9.	2.1287	1.3880	0.9636	0.4665	0.0760
10.	2.8794	1.5475	1.1500	0.6461	0.0917
11.	2.1049	1.3554	0.8884	0.3841	0.1358
12.	2.3734	1.3580	1.2086	0.4357	0.0713
13.	1.9527	1.2526	0.9020	0.3606	0.1172
14.	1.1316	0.3565	0.4370	0.2397	0.1899
15.	1.4824	0.9741	0.6674	0.1779	0.2742
16.	1.2599	1.1705	0.6757	0.1066	0.2411
17.	1.8591	0.9225	0.6985	0.2991	0.2099
18.	0.8585	0.1824	0.3778	0.1682	0.1828
19.	1.0314	0.4189	0.3585	0.3149	0.1347
20.	1.0639	0.6274	0.5234	0.1594	0.1390
21.	0.8388	0.4521	0.5631	0.1017	0.0345
22.	0.8307	0.3308	0.4353	0.1485	0.0497
23.	0.3823	0.0862	0.3141	0.0195	0.0172
24.	0.9000	0.4309	0.6571	0.0935	0.0442
25.	0.7759	0.2149	0.4176	0.1079	0.0559
26.	0.9904	0.3364	0.3595	0.1909	0.2720
27.	0.5465	0.3949	0.2717	0.1893	0.0191
28.	0.6199	0.4025	0.4365	0.2067	0.0181
29.	0.6768	0.1386	0.4381	0.1969	0.0076
30.	0.4423	-0.0405	0.2874	0.1181	-0.0182
31.	0.6608	0.3158	0.4231	0.1264	0.0145
32.	0.7201	0.5674	0.4001	0.1973	-0.0072
33.	0.7617	0.5283	0.3268	0.2221	0.0110
34.	0.6940	0.4289	0.4304	0.1003	0.0432
35.	0.6318	0.2346	0.4560	0.0746	0.0405
36.	0.7687	0.5815	0.4023	0.1411	0.0277
37.	0.6413	0.5421	0.3986	0.1280	0.0043
38.	0.7018	0.2685	0.4399	0.1455	0.0346
39.	0.5143	0.2484	0.3587	0.1080	0.0117
40.	0.3935	-0.0217	0.2601	0.1147	-0.0066
41.	0.4378	0.0748	0.2419	0.1593	-0.0035
42.	0.3695	0.0448	0.1138	0.2253	0.0046
43.	0.3508	0.0200	0.1702	0.1689	-0.0110
44.	0.4147	0.0080	0.2868	0.0849	0.0131
45.	0.2117	-0.1173	0.1336	0.0193	0.0266
46.	0.4301	0.2063	0.3180	0.0784	0.0072
47.	0.5046	0.1384	0.3085	0.1407	0.0067
48.	0.4567	0.1245	0.1797	0.2151	0.0148
49.	0.4076	0.0505	0.2662	0.1361	-0.0124
50.	0.3051	0.0708	0.2055	0.0936	-0.0132
51.	0.5520	0.1139	0.3194	0.1135	0.0935
52.	0.4001	0.0207	0.3448	0.0763	0.0052
53.	0.6155	0.1072	0.3299	0.2195	0.0100
54.	0.6793	0.2996	0.4139	0.1712	0.0377
55.	0.5039	0.1710	0.2883	0.1501	0.0407
56.	0.3324	0.0190	0.2158	0.1042	-0.0058
57.	0.4241	0.1613	0.2748	0.0769	-0.0031
58.	0.3951	0.0690	0.2156	0.0978	0.0611
59.	0.5624	0.3734	0.2917	0.1940	0.0195
60.	0.4656	0.2472	0.1633	0.1715	0.0513
61.	0.3979	0.2024	0.1222	0.1784	0.0841
62.	0.4701	0.1708	0.1736	0.1715	0.0530
63.	2.3866	1.1752	1.1735	0.4029	0.2070
64.	0.3223	-0.0200	0.1280	0.0809	0.0396
65.	0.3526	0.0085	0.0548	0.0935	0.1694
66.	0.0892	-0.1374	0.0074	0.0366	0.0293

Note : Z = Rate of production change;
X = Rate of productivity change;
Y = Basic factor of yield rate change;
A = Basic factor of acreage change; and
C = Basic factor of crop association change.

Table (A.6) Concluded

Areal unit code	Estimates of Different Growth Components				
	Z	X	Y	A	C
(1)	(2)	(3)	(4)	(5)	(6)
67.	0.2529	−0.0278	0.0215	0.1445	0.0894
68.	0.5681	0.2423	0.2675	0.1446	0.1656
69.	0.5167	0.2179	0.2705	0.1865	0.0001
70.	0.4991	0.3207	0.3101	0.1052	0.0112
71.	0.6298	0.2623	0.4188	0.1084	0.0576
72.	0.8840	0.5270	0.5780	0.1484	0.0916
73.	0.9244	0.6001	0.7391	0.0521	0.0442
74.	0.8955	0.3331	0.8987	0.0100	0.0031
75.	1.0026	0.5755	0.5383	0.1906	0.1014
76.	1.0739	0.5677	0.7380	0.0768	0.0935
77.	0.5408	0.1704	0.3643	0.1266	0.0208
78.	0.5659	0.2360	0.3381	0.1539	0.0518
79.	0.5826	0.1466	0.3257	0.1774	0.0022
80.	0.5739	0.2055	0.3212	0.0830	0.0920
81.	0.4505	−0.0222	0.2962	0.0762	0.0064
82.	0.5799	0.2780	0.3662	0.0846	0.0644
83.	0.5069	0.1453	0.3733	0.1085	−0.0095
84.	0.5668	0.0715	0.3219	0.1235	0.0354
85.	0.5175	0.1845	0.3964	0.0551	0.0746
86.	0.5082	0.1836	0.3331	0.1115	0.0547
87.	0.3457	0.1378	0.3094	0.0247	0.0022
88.	0.6261	0.3479	0.3900	0.1234	0.0623
89.	0.5238	0.2491	0.2283	0.1315	0.1134
90.	0.4444	0.2298	0.3487	0.0297	0.0346
91.	0.2636	0.0131	0.1724	0.0765	0.0013
92.	0.5133	0.0325	0.3173	0.1877	−0.0188
93.	0.4562	0.1013	0.2775	0.0557	0.0711
94.	0.3468	0.0119	0.1883	0.0804	−0.0032
95.	0.6854	0.0625	0.4761	0.0696	0.0553
96.	0.7672	0.3670	0.3568	0.1548	0.1057
97.	0.7242	0.3166	0.4050	0.2067	−0.0291
98.	0.7279	0.2853	0.3057	0.0759	0.0817
99.	0.4046	0.0655	0.2956	0.1117	−0.0531
100.	0.5564	0.1897	0.2650	0.2293	−0.0278
101.	0.3012	−0.0492	0.2773	0.0754	−0.0564
102.	0.5074	0.0505	0.4265	0.0511	−0.0047
103.	0.4378	0.0873	0.2687	0.1323	0.0117
104.	0.4991	0.1575	0.3902	0.2534	−0.1517
105.	0.5795	0.2635	0.4412	0.1231	−0.0173
106.	0.3798	0.1454	0.3463	0.0055	0.0122
107.	0.2063	−0.1598	0.1049	0.0418	0.0517
108.	0.3198	−0.0633	0.1825	0.1160	0.0575
109.	0.6525	0.5291	0.4081	0.2035	−0.0211
110.	0.3906	0.0439	0.1373	0.1171	0.0996
111.	0.5825	0.2512	0.4405	0.0887	0.0159
112.	0.7378	0.3782	0.5337	0.0841	0.0511
113.	0.4793	0.1849	0.1801	0.1183	0.0970
114.	0.2911	−0.0014	0.1501	0.0870	0.0540
115.	0.4175	−0.0517	0.2366	0.1183	0.0412
116.	0.3934	0.0812	0.1269	0.1181	0.1331
117.	0.6459	0.1226	0.1821	0.1954	0.1615
118.	0.6425	0.0757	0.3913	0.0760	0.0887
119.	0.4502	0.0559	0.2379	0.0369	0.1194
120.	0.4731	0.0268	0.1403	0.1575	0.1078
121.	0.6131	0.2361	0.2773	0.1984	0.0801
122.	0.4425	0.3103	0.2557	0.1086	0.0372
123.	0.3568	−0.0374	0.1545	0.2342	−0.0789
124.	0.3680	0.0778	0.2374	0.0985	0.0198
125.	0.5637	0.2061	0.3956	0.1120	−0.0095
126.	0.3053	0.0539	0.1925	0.0746	0.0060
127.	0.3556	0.0992	0.1540	0.1817	−0.0222
128.	0.3473	0.0480	0.2161	0.1002	−0.0012
129.	0.1700	0.0557	0.0754	0.0760	−0.0020
130.	0.4267	0.1669	0.1781	0.0740	0.0748
131.	0.4617	0.1407	0.2183	0.1673	−0.0125
132.	0.5307	0.1999	0.1513	0.1925	0.0937
133.	0.5648	0.1188	0.2564	0.1738	−0.0289
134.	0.5800	0.0528	0.2868	0.1926	−0.0206
135.	0.5848	0.1785	0.3116	0.1039	0.0213
136.	0.1938	0.1286	0.0652	0.1190	−0.0055
137.	0.5256	0.0903	0.2625	0.1648	−0.0010
138.	0.6940	0.2045	0.3440	0.1937	0.0116
139.	0.6428	0.2235	0.3458	0.1383	0.0119
140.	0.7519	0.1456	0.3417	0.2143	−0.0322
141.	0.6693	−0.0299	0.3841	0.1844	−0.0221
142.	0.4251	−0.0694	0.2738	0.2208	−0.1016
143.	0.7925	0.2039	0.4532	0.1993	−0.0174
144.	0.4842	−0.0592	0.2463	0.2435	−0.0402
145.	0.5126	0.2966	0.2406	0.2828	−0.0493
146.	0.5605	−0.1609	0.2243	0.1993	0.0272
147.	0.6527	−0.0444	0.3617	0.2841	−0.0549
148.	0.3289	0.0307	0.1206	0.1792	−0.0034
149.	0.5525	0.0347	0.2932	0.1726	−0.0122
150.	0.5930	0.0223	0.2724	0.2538	−0.0002
151.	0.4527	−0.1155	0.0821	0.3161	0.0001

Table (A.7) : Estimates of four Major Non-agricultural Activity Indices by Areal Units of India : 1980-81

Areal unit code	Estimates of non-agricultural indices			
	x_1	x_2	x_3	x_4
(1)	(2)	(3)	(4)	(5)
1.	0.8610	0.8040	0.3110	1.1320
2.	0.4640	0.3250	0.3250	0.4130
3.	0.9730	0.7930	0.9790	1.4050
4.	0.5100	0.5600	0.3260	0.5720
5.	0.6020	0.5480	0.3260	0.6470
6.	0.3610	0.2520	0.0	0.4930
7.	0.5950	0.6920	0.4750	0.6250
8.	0.7350	0.7080	0.5750	0.8050
9.	1.2720	1.1200	1.2680	1.1640
10.	1.2120	1.4120	1.1990	0.9910
11.	1.3050	1.1720	1.2830	1.0770
12.	1.3910	0.9300	1.2470	1.2490
13.	1.0980	0.7670	0.9760	0.9050
14.	0.9770	0.7840	0.8690	0.7920
15.	0.8760	0.8200	0.8370	0.8020
16.	2.1950	1.7710	2.4650	2.2210
17.	1.1670	1.0200	1.1360	1.0860
18.	1.1730	1.1640	1.3170	1.3050
19.	1.1970	1.3660	1.2970	1.2170
20.	0.9950	0.9330	1.0790	0.9740
21.	1.2570	1.0830	1.3950	1.3730
22.	0.8290	0.7210	0.8210	0.6910
23.	0.7500	0.6010	0.8580	0.8510
24.	1.1900	1.1740	1.3590	1.2150
25.	0.8000	0.6370	0.8810	0.7050
26.	0.9540	0.9630	1.1960	1.1760
27.	0.4860	0.3660	0.5200	0.4490
28.	0.4930	0.3720	0.2980	0.4610
29.	0.9370	0.8650	1.1000	1.1130
30.	0.6910	0.7400	0.7100	0.6370
31.	0.6920	0.6150	0.6840	0.5800
32.	0.7360	0.8100	0.7170	0.7360
33.	0.7890	0.7520	0.7610	0.5760
34.	0.7520	0.6300	0.6320	0.6020
35.	0.7080	0.5410	0.7050	0.5130
36.	0.9770	0.8540	0.9990	0.8670
37.	1.0170	1.1350	1.1560	1.0880
38.	0.5170	0.5090	0.4770	0.3890
39.	0.4730	0.4690	0.5470	0.4790
40.	0.6180	0.6210	0.6480	0.6970
41.	0.7810	0.6520	0.7930	0.7610
42.	0.4010	0.3620	0.3970	0.3980
43.	0.7010	0.9070	0.8270	0.7360
44.	0.5100	0.3540	0.4200	0.4660
45.	0.6440	0.4620	0.6070	0.7150
46.	0.9270	1.1100	1.2510	1.1940
47.	0.6240	0.7260	0.6140	0.6030
48.	0.5570	0.4530	0.5440	0.3930
49.	0.7220	0.6600	0.7580	0.7020
50.	0.7390	0.6550	0.7430	0.7400
51.	0.7670	0.7200	0.8050	0.5980
52.	0.6980	0.5860	0.6270	0.6620
53.	0.8700	0.6900	0.8690	0.7400
54.	1.1450	1.2630	1.4320	1.0100
55.	0.7150	0.4720	0.4760	0.4820
56.	0.6400	0.4240	0.6530	0.5430
57.	0.7930	0.7320	1.1070	0.7120
58.	0.7990	0.8830	0.7650	0.8460
59.	0.9700	0.7850	1.1370	1.2710
60.	0.9480	0.9370	1.0760	1.0580
61.	0.7430	0.6390	0.7770	0.6860
62.	0.7500	0.6370	0.7650	0.6290
63.	0.8060	0.6420	0.7750	0.6730
64.	0.7630	0.4700	0.9800	0.8250
65.	0.6970	0.5490	0.7580	0.8280
66.	0.5150	0.2950	0.4350	0.4660

Note : x_1 = The trading activity sub-index;
x_2 = The over-all industrial activity sub-index;
x_3 = The urbanisation sub-index; and
x_4 = The transportation activity sub-index.

Table (A.7) Concluded

Areal unit code	Estimates of non-agricultural indices			
	x_1	x_2	x_3	x_4
(1)	(2)	(3)	(4)	(5)
67.	0.6870	0.4420	0.3140	0.4020
68.	0.5590	0.7190	0.6560	0.8300
69.	0.7630	0.7060	0.6630	0.5950
70.	0.5880	0.4460	0.3610	0.5310
71.	0.9200	0.8660	0.9400	0.9650
72.	1.5060	1.7530	1.5940	1.3540
73.	1.0050	0.8200	0.8310	0.8920
74.	0.9590	0.8040	0.8610	1.0560
75.	1.0830	0.9640	1.0670	0.9310
76.	1.1890	1.0130	1.2610	1.1480
77.	1.0920	1.3050	1.2670	1.0550
78.	0.9130	1.1990	0.9710	1.1300
79.	0.9210	0.8780	1.0390	0.9300
80.	0.8950	0.7800	0.9800	0.8960
81.	0.9010	0.6920	0.9710	0.8310
82.	1.1980	1.1240	1.5030	2.0760
83.	0.6990	0.7650	0.6960	0.6800
84.	0.8180	0.6130	0.7890	0.6250
85.	0.8550	0.6990	0.8950	0.7180
86.	1.0350	1.2050	1.1980	1.0780
87.	2.9960	2.9530	3.1840	3.1900
88.	0.8690	0.9200	0.8670	0.9010
89.	1.0010	1.1090	1.1170	0.8840
90.	0.7490	0.5650	0.4180	0.8020
91.	1.4250	1.1760	1.1610	2.2950
92.	0.9720	0.9160	0.8500	1.0310
93.	1.1070	0.9520	1.1000	1.0830
94.	0.9340	0.7790	0.8810	0.8700
95.	0.9170	0.7300	0.9530	0.9970
96.	0.8980	0.7790	0.8450	0.8070
97.	1.3980	1.4110	1.7090	1.6040
98.	0.9530	0.8730	1.0150	0.9790
99.	0.8280	0.6120	0.7750	0.8400
100.	1.3800	1.2510	1.0470	1.2240
101.	1.0610	0.5760	0.5270	0.8750
102.	1.5250	1.1030	1.0600	1.3960
103.	1.4590	1.1820	1.0040	1.3830
104.	1.4400	1.3480	1.2190	1.6070
105.	1.4810	1.4250	1.2340	1.4650
106.	1.4480	1.3240	1.2950	1.1530
107.	1.4020	1.1040	1.2920	1.0090
108.	1.5590	1.4550	1.4110	1.2240
109.	1.2470	1.0220	1.5200	1.2810
110.	1.1270	1.0530	1.0540	1.1250
111.	1.3230	0.9450	1.1220	1.0740
112.	1.6140	1.4550	1.5940	1.8930
113.	1.0040	0.6620	0.8400	0.9540
114.	0.9930	0.6990	0.8420	0.8690
115.	0.9780	0.7360	0.7710	0.6940
116.	1.5570	1.2860	1.5520	1.6250
117.	0.9950	0.9840	0.8320	0.8320
118.	0.8220	0.8710	0.7180	0.6580
119.	0.9200	0.7060	0.7290	0.7950
120.	1.1660	0.9960	0.9840	1.0240
121.	1.3290	0.9390	1.1270	1.2850
122.	1.0880	0.8880	0.9410	1.1970
123.	0.5570	0.3190	0.4640	0.5540
124.	0.5510	0.5160	0.4910	0.5250
125.	0.9320	0.7820	0.8050	0.7970
126.	0.2250	0.1520	0.1180	0.0400
127.	0.8290	0.7360	0.7720	0.8740
128.	0.7290	1.0930	0.9230	0.9050
129.	0.7180	1.1810	1.0000	0.9500
130.	0.6220	0.7260	0.7200	0.7160
131.	0.9790	0.8260	0.9430	0.9370
132.	0.7390	0.7140	0.6800	0.5990
133.	0.8130	0.6310	0.6340	0.7850
134.	0.7940	0.5760	0.7110	0.6920
135.	0.8660	0.8530	0.9100	0.9310
136.	0.8560	0.8690	1.0250	1.1370
137.	0.6960	0.8090	0.7570	1.0250
138.	1.4210	1.9290	1.6120	1.6810
139.	2.3360	1.9680	1.8480	2.4230
140.	0.8750	0.7950	0.7080	0.8360
141.	0.8380	0.6210	0.7790	0.8100
142.	1.0280	0.8740	0.8830	1.2380
143.	0.6740	0.4470	0.6030	0.6390
144.	1.0080	0.7840	0.7700	1.0410
145.	0.9480	0.9050	0.6970	0.9290
146.	0.5590	0.4220	0.2200	0.5320
147.	0.9010	0.6240	0.6840	0.8270
148.	0.3500	0.4000	0.6000	0.5300
149.	0.6690	0.4600	0.5760	0.6790
150.	0.5570	0.5110	0.4170	0.5670
151.	0.9390	0.9870	0.5490	0.9980

References

Aitken, A.C. (1942) : Determinants and Matrices, Oliver and Boyd, London.

Bhalla, G.S. and Alagh, Y.K. (1979) : Performance of Indian Agriculture : A Districtwise Study, Sterling Publication, New Delhi.

Berry, B.J.L. (1960) : "An Inductive Approach to the Regionalisation of Economic Development", in Essays on Geography and Economic Development, Ginsburg, N. (ed.), Chicago University Press, Chicago, Illinois, pp. 78-107.

Berry, B.J.L. and Rao, V.L.S.P. (1968) : "Urban-Rural Duality in the Regional Structure of Andhra Pradesh : A challenge to Regional Planning and Development", paper contributed to the Symposium on Regional Planning, 21st International Geographical Congress, New Delhi, India, November-December, 1968.

Coffee Board, Bangalore, India : Coffee Statistics; Different issues.

Das Gupta, B. (1971) : "Socio-Economic Classification of Districts : A Statistical Approach", Economic and Political Weekly, Vol. 6, No. 33, August 14, 1971, pp. 1763-74.

Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India : Agricultural Situation in India; Various issues.

__________ : Estimates of Area and Production of Principal Crops in India; Various issues.

Directorate General of Commercial Intelligence and Statistics, Government of India : Monthly Statistics of the Foreign Trade of India; Difference issues.

Fisher, R.A. (1954) : Statistical Methods for Research Workers, Oliver and Boyd, Edinburg, 12th revised edition.

Fertiliser Association of India : Fertiliser Statistics; Different issues.

Hagood, M.J. (1943) : "Statistical Methods of Delineation of the Regions to Data on Agriculture and Population", Social Forces, Vol. 21, pp. 287-297.

Harmon, H.H. (1967) : Modern Factor Analysis, The Chicago University Press, Chicago, 2nd revised edition.

Hartshorne. R. (1958) : "What do we mean by regions ", Contribution to 54th Annual Meeting of the Association of American Geographers, Los Angeles (California), 18-22 August, 1958.

Harvey, D. (1969) : Explanation in Geography, Arrold Publishers, London.

Hermansen, T. (1969) : "Information Systems for Regional Development Control : Framework for Research Project", in Regional Planning, Misra, R.P. (ed.), University of Mysore, India.

Hotelling, H. (1933) : "Analysis of Complex Statistical Variables into Principal Components", Journal of Educational Psychology, Vol. 24, pp. 417-420 and 498-520.

Isard, W. (1956) : Location and Space-Economy, M.I.T. Press, Cambridge and John Wiley & Sons, Inc., New York.

Isard, W., Bramhall, D.F., Alonso, W. and Stevens, B.H. (1958) : "The core and Boundaries of Regional Science", Papers and Proceedings to the Regional Science Association, Vol. 4, pp. 3-13.

Keeble, D.E. (1967) : "Models in Economic Development", in Models in Geography, Chorby, R.J. and Haggett, P. (ed.), Mathen and Co. Ltd., pp. 243-302.

Kendall, M.G. (1939) : "The Geographical Distribution of the Crop Productivity in England", Journal of the Royal Statistical Society, Vol. 102, pp. 21-46.

Learmonth, A.T.A. and Pal, M.N. (1959) : "A Method of Plotting Two Variables on the Same Map Using Isopleths", Erdkunde, Vol. 13, pp. 145-150.

Learmonth, A.T.A., et. al (1960) : Mysore State, Vol. 1 : An Atlas of Resource, Asia Publishing House, Bombay, India.

____________________ (1962) : Mysore State, Vol. 2 : Regional Synthesis, Indian Statistical Institute, Calcutta, India.

Lorenz, M.O. (1905) : "Methods of Measuring the Concentration of Wealth", Journal of the American Statistical Association, Vol. 9.

Mitra, A. (1961) : "Levels of Regional Development in India", Census of India, 1961, Vol. I, Part I-A(i) : Text, 1965, Government of India Press, New Delhi; Part I-A(II) : Tables, 1966, Government of India Press, New Delhi.

Minhas, B.S. and Vaidyanathan, A. (1965) : "Growth of Crop Onput in India, 1951-54 to 1958-61 : An Analysis by Component Elements", Journal of the Indian Society of Agricultural Statistics, Vol. 17, pp. 230-252.

Minhas, B.S. (1966) : "Rapporteur's Report on Measurement of Agricultural Growth", Indian Journal of Agricultural Economics, Vol. 21, pp. 165-182.

Monkhouse, F.J. and Wilkinson, H.R. (1956) : Maps and Diagrams, Mathuen and Co. Ltd., London.

Ministry of Information and Culture, Government of India : India; Year Book for different years.

National Sample Survey Organisation, Department of Statistics, Ministry of Planning, Government of India : Tables with Notes on Consumer Expenditure, 16th round (July 1960-August, 1961), Report No. 138.

________________ : Tables with Notes on Consumer Expenditure, 25th round (July 1970-June 1971), Report No. 231.

________________ : Tables with Notes on Consumer Expenditure, 32nd round (July 1977-June 1978), Sarvekshana, Vol. 9, No. 3, January, 1986.

NCAER (1963) : Inter-District and Inter-State Income Differentials - 1955-56.

Padmanabha, P. (1981) : "The Decisive Decade : A Note on the Provisional Results of the 1981 Census of India", Yojana, Vol. XXV, No. 9, pp. 16-31.

Pal, M.N. (1963a) : "Zur berechnung eines Kombiniarten konzentration - sindexes", Raumforschung and Raumordinung, Vol. 21, pp. 87-93.

________ (1963b) : "A Method of Regional Analysis of Economic Development with Special Reference to South India", Journal of Regional Science, Vol. 5, pp. 41-58.

________ (1968) : "Use of Principal Components in Regional Analysis", Paper contributed to the Symposium on Regional Planning, 21st International Geographical Congress, New Delhi, November-December, 1968.

________ (1971) : "Quantitative Techniques for Regional Planning", Indian Journal of Regional Science, Vol. 3, No. 1, pp. 1-33.

Pal, M.N. (1973) : "Regional Studies and Research for consistent and Optimal Plan Formulations : The Need for a Right kind of Orientation", Indian Journal of Regional Science, Vol. 5, No. 1, pp. 1-33.

________ (1974) : "Regional Informations, Regional Statistics and Regional Planning in India", in Regional Information and Regional Planning, Kuklinski, A. (ed.), United Nations Research Institute for Social Development, Geneva, Regional Planning Series, Vol. 6, Mouton.

________ (1975) : "Regional Disparities in the Level of Development in India", Indian Journal of Regional Science, Vol. 2, No. 1, pp. 35-52.

________ (1985) : "A Generalised Formulation of Multivariate Spatial Indices for Formal Regional Analysis", Paper presented to the International Conference : ASI on Regional Science and Planning, December, 1985, IIT, Kharagpur.

________ (1986) : "Discriminatory Powers of the VLS over the OLS Regression Techniques and Some Uses in Regional Analysis", Indian Journal of Regional Science, Vol. 18, No. 1, pp. 49-62.

Pal, M.N. & Chattopadhyay, R.N. (1972): "Some Comparative Studies on the Construction of Composite Regional Index", Indian Journal of Regional Science, Vol. 4, No. 2, pp. 132-142 (1972) and pp. 101-102 (1973).

Pal, M.N. and De, R.N. (1979a) : "On an Identification of Contributory Factors to Spatial Dynamism in Agricultural Growth in India", Sankhyā, Series D, Vol. 41, Parts 1 & 2, pp. 19-47.

________ (1979b) : "An Index of Agricultural Labour Pressure on Cropped Land and Production for a Classification of Indian Districts", Indian Journal of Regional Science, Vol. 11, No. 2, pp. 52-60.

Pal, M.N., De, R.N. and Malakar, B. (1978) : "A Statistical Revision of 1961 Agricultural Workers for the Comparability with the 1971 Census Estimates by Indian Districts", Indian Journal of Regional Science, Vol. 10, pp. 11-18 and 18A-18L.

Pal, M.N. and Maity, S.K. (1976) : "Components of Agricultural Growth by Districts of West Bengal : 1961-71", Special publication on 'Regional Development and Planning', Indian Journal of Regional Science, Vol. 8, pp. 58-65.

Pal, M.N. and Mukhopadhyay, R. (1987) : "The Equi-Spaced Optimal Index Formulation and the Multivariate Spatial Index of Economic Development for India", submitted for publication in the *Annals of the National Association of Geographers, India*.

Pant, B.D. (1982) : Statistical Analysis of Economic Activities for Regional Planning in Nepal, Ph.D. Thesis, Indian Statistical Institute, Calcutta.

Prakasa Rao, V.L.S. (1953) : "Rational Groupings of the Districts of the Madras State", *Indian Geographical Journal*, Vol. 28, pp. 33-43.

Preston, J.E. (1958) : "Discussion : The Core and Boundaries of Regional Science", *Papers and Proceedings of the Regional Science Association*, Vol. 4, pp. 23-26.

Rao, K.S. (1960) : "Operational Dimensions of Our Food Problem", *Agricultural Situation in India*, October, 1960, pp. 819-843.

Registrar General and Census Commissioner, Government of India : Primary Census Abstract; *General Population Tables*, Census of India; 1961, 1971 and 1981.

Saha, V. (1984) : " Regional Analysis of Industrial Productions : A Statistical Study on the Spatial Variations by Districts of India", Ph.D. Thesis, Jadavpur University, Calcutta.

Schwartzberg, J.E. (1962) : "Three Approaches to the Mapping of Economic Development in India", *Annals of Association of American Geographers*, Vol. 52, pp. 455-468.

Sergant, Florence (1954) : *Economic Survey of Europe*, United Nations, Department of Economic and Social Affairs, pp. 136-160.

Spate, O.H.K. and Learmonth, A.T.A. (1967) : *India and Pakisthan*, 3rd edition, Metheun, London.

Stevens, B.H. (1959) : "Inter Regional Linear Programming", *Journal of Regional Science*, Vol. 1, No. 1, pp. 60-98.

Tea Board, Calcutta, India : *Tea Statistics*; Different issues.

Wright, J.K. (1936) : "Some Measures of Distribution", *Annals of Association of American Geographers*, Vol. 27, pp. 177-213.

Wold, H. and Jureen, L. (1953) : *Demand Analysis : A Study in Econometrics*, John Wiley, New York.

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