ENVIRONMENTAL, TECHNOLOGICAL AND INSTITUTIONAL DETERMINANTS OF AGRICULTURAL PRODUCTIVITY IN TAMIL NADU - A SPATIAL AND TEMPORAL ANALYSIS - 1954-55 - 1969-70

by
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It is certified that the dissertation entitled "Environmental, Technological and Institutional Determinants of Agricultural Productivity in Tamil Nadu - A Spatial and Temporal Analysis - 1954-55 - 1969-70" submitted by Shri S. Subbiah in fulfilment of six credits out of the total requirements of twenty-four credits for the degree of Master of Philosophy (M.Phil) of the University, is his original work according to the best of my knowledge, and may be placed before the examiners for evaluation.

G. S. Bhalla
Chairman

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PREFACE

The present study unfolds the spatial variations in agricultural productivity in Tamil Nadu and then proceeds to find out the possible causes for these variations with the help of multiple regression analysis. The explanatory variables are drawn from a set of environmental, technological and institutional factors affecting agricultural productivity. The study pertains to the three time-periods, viz., 1954-55, 1964-65 and 1969-70 which have been chosen on the basis of the indices of agricultural production.

The first two chapters lay down the base for the study; the third one provides the rationale for the choice of variables; the fourth one deals with areal pattern of agricultural productivity; the fifth one identifies the significant predictors from the analysis of results of the multiple regression; and the last one sums up the findings of this study.

S. Subbiah

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CHAPTER ONE

PRELIMINARY STATEMENT

1.1 Statement of the Problem

Agriculture continues to be an important industry in the developing countries. Some 40 to 60 per cent of the national income comes from agriculture, while 50 to 80 per cent of the labour-force is engaged in it.[1] These figures clearly show the importance of agriculture in the economy of the developing countries, which has an important bearing on the pace of general economic development. In a country like India where more than 75 per cent of the population is engaged in rural pursuits - the corresponding figure for Tamil Nadú being 70 - economic development is heavily contingent on agricultural development.

The importance of agriculture in the context of overall economic growth in a developing country can be summarised as follows:[2]

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1. B.F. Johnston and J.W. Millor, "The role of agriculture in Economic development" in Karl A. Fox and D. Gale Johnson (eds.) Readings in the economics of agriculture, (1970), p.360.

2. Ibid., p.364.

(a) General economic development increases the demand for agricultural produce and failure to expand the agricultural produce commensurate to the growth of demand can seriously impede economic growth.

(b) Agricultural exports provide the bulk of the foreign exchange earnings for the import of the capital goods required for industrialization.

(c) Agriculture releases the labour to the industrial needs and even provides finance for industrial investment as it is the dominant sector of an under-developed economy.

(d) The agricultural population provides a market for industrial products not only for consumer goods but also for a wide range of equipment and materials used in agricultural production.

The supreme position of agriculture, from the point of view of its share in production, consumption, exports and employment warrants its development so that it may remain as the hard-core of economic planning in the country.[3] A depressed agriculture may retard the pace of industrialization thus jeopardising the growth of economy as a whole. An increase in production which is a necessary concommitant

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3. M.A. Bajiva, "Agriculture in Pakistan", CENTO Seminar on Agricultural Planning, (1972), p.41.

of agricultural development is possible only in two ways:

(a) the traditional method of increasing agricultural production in India and elsewhere is to bring new lands under the plough. The production may also be increased by multiple cropping method which is possible only by making new inputs in the form of irrigation and fertilizers. In India, however, an increase in area is no longer possible, except perhaps marginally, as 85 per cent of the potentially arable land has already been under cultivation (the corresponding value for Tamil Nadu being 93 per cent according to a 1969-70 survey). Over and above it, some very fertile and productive land is lost every year to the non-farm uses. During the fifteen years period - 1950-51 to 1965-66, about three million hectares of land are estimated to have thus gone out of cultivation.[4]

(b) another method to raise the production is to increase the yield per hectare. This is the only alternative now available in India as no further extension of agriculture is possible due to reasons stated above. The agricultural production indicated as yield per hectare is often expressed as productivity. The term productivity is, however, more specific

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4. C.R. Ranganathan, Fertilizers, (1972), p.3.

than to denote merely the per hectare yield. Productivity growth in the agricultural sector is essential, if agricultural output is to grow at a sufficiently rapid rate to meet the demands for food and raw materials that typically accompany urbanisation and industrialisation. Failure to achieve rapid growth in productivity can result either in the drain of foreign exchange or in shifts in the internal terms of trade against industry and thus seriously impede the growth of industrial production.[5] As such is the dependency of agricultural development on productivity, examining the productivity variations in a region and exploring the possible factors responsible for those spatial and temporal variations seem to be a worthwhile exercise.

1.1.1 Objectives

The present study aims at identifying the spatial variations in agricultural productivity in Tamil Nadu at the chosen points of time viz., 1954-55, 1964-65 and 1969-70. Output per hectare in money value has been chosen as the indicator of agricultural productivity. As stated earlier, the time periods chosen here are based on the indices of agricultural production (Appendix I and Fig.1).

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5. Yufiro Hayami and V.W. Ruttan, "Agricultural productivity differences among countries", <u>The American Economic Review</u>, Vol.LX, No.5, 1970, p.895.

Further an attempt has been made to explore the possible reasons for the spatial variations in the agricultural productivity. The explanatory system developed here is based on the assumption that agricultural production is a three dimensional function: The environment (consisting of such variables as land surface, soil, moisture and heat) lays down the basis for, and defines the character of agriculture in a region; technological inputs (such as farming methods, and application of irrigation, fertilizers, pesticides and improved seeds) determine the pace of agricultural development; and thirdly the institutional factors (such as the size of land holding, land tenureship and the social background of the farming classes) either permit the application of a certain technology and thus help remove the environmental constraints on agricultural development or discourage the acceptance and application of technology and thus retard agricultural growth.

Viewed in this context the explanatory variables chosen here may be classified as follows:

Environmental:

(a) Soil Rating index of the district

(b) Total rainfall during the agricultural year

Technological:

(a) Percentage of gross irrigated area to the gross cultivated area

(b) Consumption per hundred hectares

(c) Mechanization index of the district

Institutional

(a) Agricultural labourers as percentage to the total work-force in agriculture

(b) Scheduled Caste and Scheduled Tribes as percentage of the total rural population of the district

The choice of the explanatory variables has been determined by the availability of data at the district level.

1.1.2 Study Period

The present study is designed to explore the productivity variations for three time-periods viz., 1954-55, 1964-65 and 1969-70. These periods have been chosen on the basis of a graph drawn for indices of agricultural production on a logarithimic scale. The indices of agricultural production since 1952-53 are given in Appendix I.

Fig. 1 brings out the following points: (a) agricultural production was at an uniformly high rate between 1952-53 and 1954-55; (b) there was a slow but almost uniform upward trend in agricultural production upto 1964-65; (c) after 1964-65 the agricultural production recorded a slump in the rate of growth; and (d) the production again picked up from 1968-69 and attained a peak in 1970-71. After 1970-71, however, no data are available to assess the trend of production.

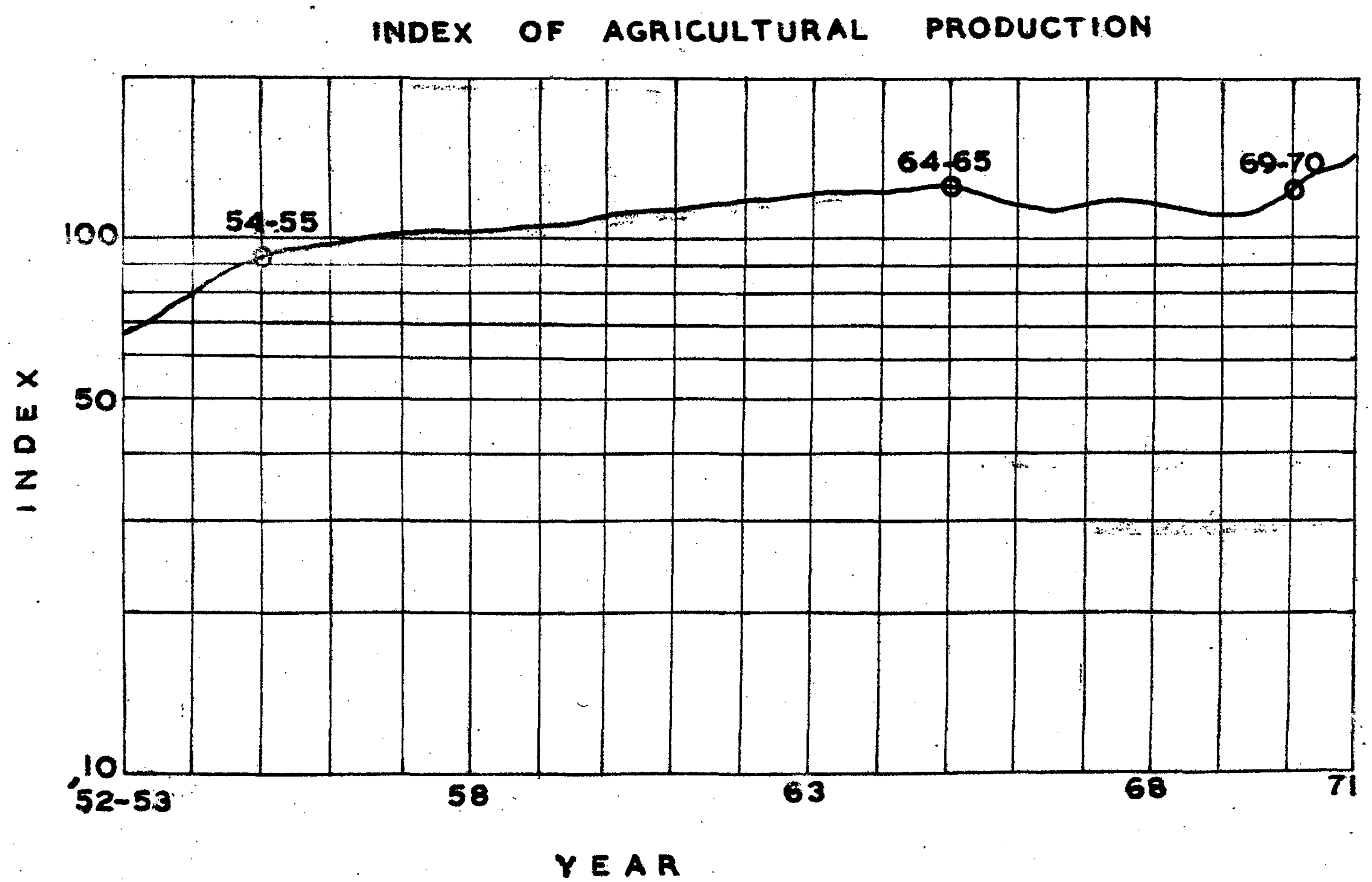
INDEX OF AGRICULTURAL PRODUCTION
INDEX
100
50
10
54-55
64-65
69-70
52-53
58
63
68
71
YEAR

Fig. 1.

Thus Fig.1 indicates three peak periods - 1954-55, 1964-65 and 1970-71, which may also be regarded as turning points in the trend of agricultural production. The detailed data are, however, not available for the year 1970-71, and therefore the year 1969-70, which is the latest period for which data are available, has been chosen for the present study.

The peak periods are specifically chosen to avoid the seasonal fluctuations in the production due to weather conditions. Here the assumption is that favourable weather is a pre-requisite for high agricultural production. As a matter of fact, seasonal conditions were not adverse to the production in any one of the time periods chosen here. During 1954-55, the rainfall in the state as a whole was 10.4 per cent in excess of the normal and 'the seasonal conditions during the Fasli continued to be satisfactory'.[6] During 1964-65, the rainfall deviated from the normal only by 4 per cent. During 1969-70, rainfall was 9.6 per cent more than the normal and 'the seasonal conditions during the Fasli viewed as a whole were more favourable than those during the previous year'.[7]

Further, the time-periods selected may very well show the gradual development of agriculture in Tamil Nadu:

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6. Department of Statistics, Madras, Season and Crop Report of Madras State, 1954-55, p.2

7. Department of Statistics, Madras, Season and Crop Report of Madras State, 1969-70, p.2

(a) 'A modest beginning towards an increase in food production was made as early as 1942 through the Grow More Food Campaign. However, the increase in food production till in late fifties was mainly due to an expansion of area under food crops'.[8] Thus the period, 1954-55, represents a phase when the traditional practices dominated the agricultural scene.

(b) The new era in the agricultural sector actually started only after the introduction of Intensive Agricultural District Programme (IADP), popularly known as package programme. The programme was sponsored during 1961-62 but only after 1966-67, the impact of improved technological inputs could be noticed over vast areas.[9] Thus 1964-65, falling in between 1961-62 and 1966-67, may be designated as a transitional period. 1969-70 represents a period which is almost in the grip of the so-called 'Green Revolution'. This statement is further strengthened by a study of the Tamil Nadu Planning Commission (1972) which notes that 'with the spread of high yielding varieties during the year 1969-70 over large areas, there was a break through in the entire gamut of agricultural production.[10]

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8. C.R. Ranganathan, op. cit., p.2.
9. A.P. Shinde, Agriculture, (1973), pp.9-14 and Borns D. Brown, Agricultural Development in India's districts, (1971), pp.28-49.
10. State Planning Commission, Madras, Towards a Greener Revolution, (1972), Vol.I, p.6.

1.1.3 Data Base

The data for this study have been collected from a number of sources. The basic data on productivity was derived from the Season and Crop Reports of Tamil Nadu for the years 1954-55, 1964-65 and 1969-70. The Season and Crop Reports give details regarding acreage and production for each district and harvest and whole-sale prices of the commodities. Data for rainfall and irrigation have also been collected from these reports. The area and production figures for tea, coffee and rubber have been taken from the Annual Statistical Abstracts for Tamil Nadu.

The Soil Rating Index developed by R.E.Storie (1933 and 1959) and adopted by S.P. Ray Chaudhary and K.B. Shome (1960)[11] has been taken as the index of soil fertility. The data on fertilizer consumption are available not for 1954-55 but only from 1959-60 onwards. The data on fertilizer consumption for the year 1964-65 has been derived from the USAID survey report[12] and the Fertilizer Statistics, 1971-72 for the year 1969-70.[13] The data on tractors, electrical pumpsets and oil engines have been obtained from the

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11. S.P. Ray Chaudhary and K.B. Shome, "Ratings of Soils of India", Proceedings of the National Institute of Sciences of India, (1960), Vol.XXVI, (a) Supplement I.
12. W.B. Donde and D.D. Brown, Effective demand for fertilizers in India, (1970), Appendix Table XIII.
13. Fertilizer Association of India, Fertilizer Statistics, 1972-73, (1972), pp.214-215.

Season and Crop Reports. On aspects such as agricultural labour and the proportion of Scheduled Castes and Scheduled Tribes, Census data have been used.[14]

1.1.4 Methodology

The following statistical methods have been used in the present study:

(a) The time periods chosen for this study are based on indices of agricultural production for Tamil Nadu. The researcher has based himself on two studies: One by Union Ministry of Agriculture[15] and the other by Robert E. Everson and D. Jha.[16] The indices have been calculated in the following manner, taking 1956-57 as the base year.

$$\text{Index of Agricultural Production} = \frac{\sum P_{ij} \; pio}{\sum P_{io} \; pio} \times 100$$

P_{ij} = Production of the i-the crop during the j-th year

P_{io} = Production of the i-th crop during the base year

pio = Price per unit of the i-th crop in the base year

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14. Census of India, 1951, Madras and Coorg - Part II B (Tables); Census of India, 1961, Madras-General Population Tables - Part II A; and Census of India, 1971, Tamil Nadu-General Population Tables - Part II A.

15. Ministry of Agriculture, Directorate of Economics and Statistics, Estimates of Area and Production of principal crops in India, 1971-72.

16. Robert E. Everson and D. Jha, "The contribution of agricultural research system to agricultural production in India", Indian Journal of Agricultural Economics, Vol.XXVIII, No.4, (19), pp.212-230.

(b) Agricultural productivity of a district has been computed by converting the production of each crop into money value at the constant prices at the state level and aggregating the value of production for each crop in a district and thus deriving the value per hectare.

(c) Taking the productivity as a dependent variable and the other variables as independent, a step-wise regression programme was run in the IBM 1620 computer for each time-period separately. The aim was to identify the respective share of the independent variables in explaining the dependent variable.

1.1.5 Cartographic methods

The main aspects of this study such as the spatial distribution pattern of the dependent and the independent variables have been depicted on the maps using the choropleth technique.

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independent variables have been depicted on the maps

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CHAPTER TWO

TAMIL NADU - ASPECTS OF ENVIRONMENT AND AGRICULTURAL ECONOMY

The present study is made for three time-periods, 1954-55, 1964-65 and 1969-70, selected on the basis of indices of agricultural production for Tamil Nadu. The administrative divisions, however, did not remain the same at those three time-periods. There were 14 districts in 1954-55, 13 in 1964-65 and 14 in 1969-70 (Fig. 4, 12 and 20). This involved considerable changes in the administrative boundaries during the period 1951-71.[1] These changes in the administrative boundaries and divisions create formidable difficulties in any attempt of comparative analysis between the three points of time chosen.

Tamil Nadu, formerly known as Madras State, is situated at the southeastern extremity of the Indian peninsula and lies between lat.8°5'N and 13°85'N and long.76°15'E and 80°20'E. The state has a coast line of 990 km. and extends over an area of 130,009 km.^{2} According to the 1971 census, there were 41,199,168 people in Tamil Nadu, the average density being 317 persons per km.^{2}

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1. Census of India, 1961, Madras, <u>Atlas of the Madras State</u>, Vol.IX, Part IX, Map 3 and Census of India, 1971, Tamil Nadu, <u>Administrative Atlas</u>, Series 19, Part IXa, Map 7.

The geographers usually identify the following physiographic regions in Tamil Nadu:[2] (a) the coromandal coastal plain; (b) the Tamil Nadu Hills; (c) the Ponnaiyar/Palar Trough; (d) Kongunad; (e) the Cauvery delta and (f) the dry south-east. However, speaking in general terms one can identify the following regions (Fig.1A):

(a) Coastal plain

(b) Eastern Ghats

(c) Plateaus

(d) Western Ghats

The coastal plain stretches for 992 km. from Pulicate Lake to Kanyakumari. The northern part of it is comprised by Chingleput district, a major part of South Arcot district, the eastern part of North Arcot district and northern part of Tiruchirappalli district. It is about 80 to 90 km. wide with an average elevation of 80 m. The middle part of the plain is the Cauvery delta, occupying Tanjavur district and parts of Tiruchirappalli district. The southern coastal plain is shared by Ramanathapuram, Tirunelveli and Kanyakumari districts.

Between the rivers of Palar and Cauvery, the coastal plain is backed by a discontinuous line of hills, termed as 'Tamil Nadu Hills'[3] which are the southern tail of Eastern Ghats.

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2. O.H.K. Spate and A.T.A. Learmouth, <u>India and Pakistan</u> (1967), p.739.

3. <u>Ibid</u>., p.740.

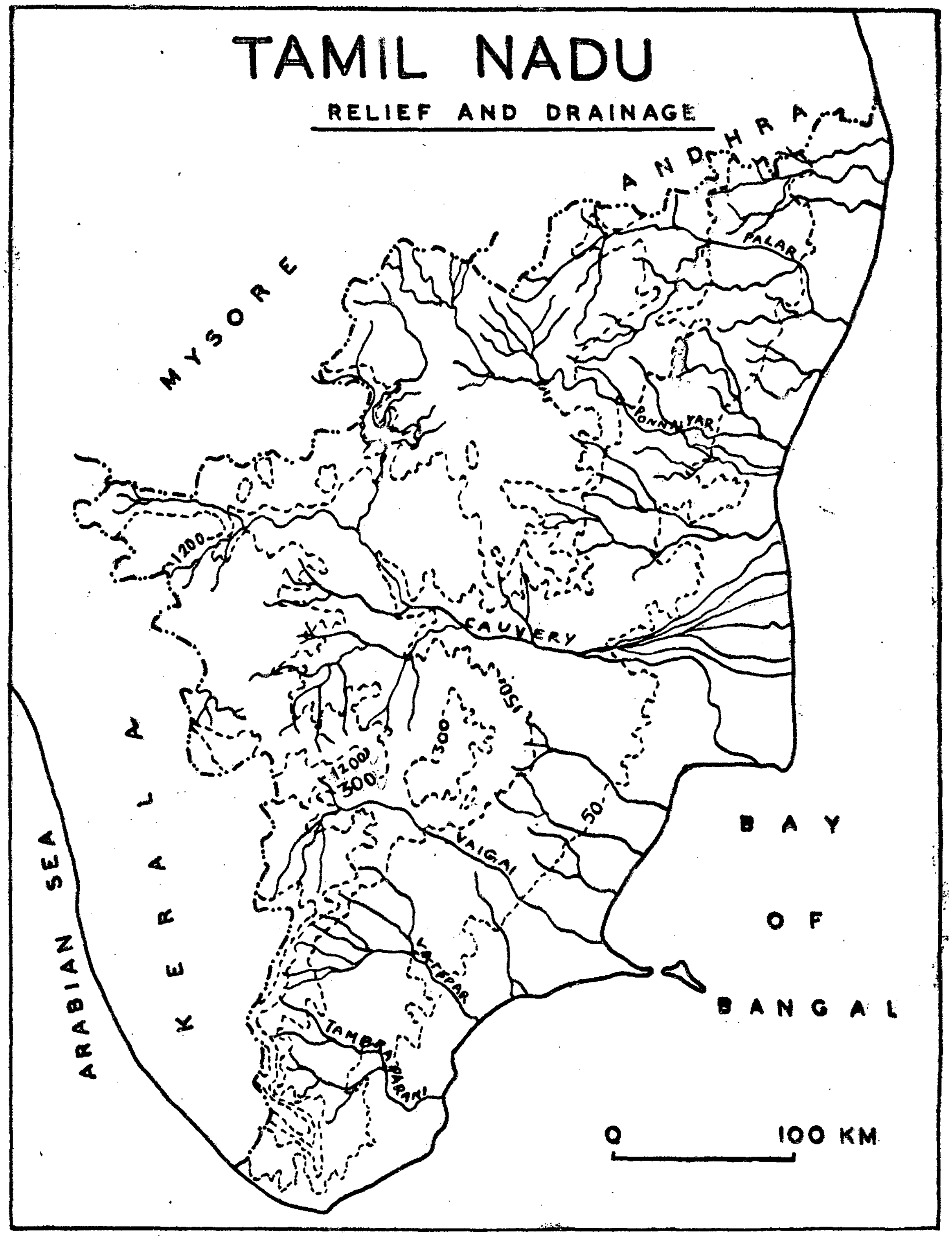
TAMIL NADU
RELIEF AND DRAINAGE
ANDHRA
MYSORE
PALAR
PONNAIYAR
1200
CAUVERY
150
300
1200
300
50
VAIGAI
VAIPPAR
TAMBRAPARNI
KERALA
ARABIAN SEA
BAY OF BANGAL
0
100 KM

FIG. 1A

The plateau area lies between the Eastern and Western Ghats, with an elevation ranging between 170 and 650 m. and having an undulating topography. It embraces the Coimbatore district and part of Salem district with the Cauvery valley nestled in between the plateau.

Along the whole length of the western part, at a distance varying from 450 km. to 25 km. away from Bay of Bengal runs a continuous ridge known as the Western Ghats. On either side of the Palghat gap, the higher mountains of the Peninsula dominate. They are the Nilgiris on the north, where the Eastern and Western Ghats intersect, and the Anamalai, Palani and Cardamom Hills in the south.

The major rivers in the state are the Cauvery, Palar, Pennar, Vaigai and Tambraparni. The Cauvery, known as the '*Dakshina* Ganga' is the most important one for the state, as its delta is the 'granery of Tamil Nadu'.

2.1 Rainfall

The rainfall, as a natural source of water supply in a large part of the state, is low. The general distribution of rainfall can be seen in Fig.2. Rainfall is high along the northern coastal belt and along the western hills and low in between these two

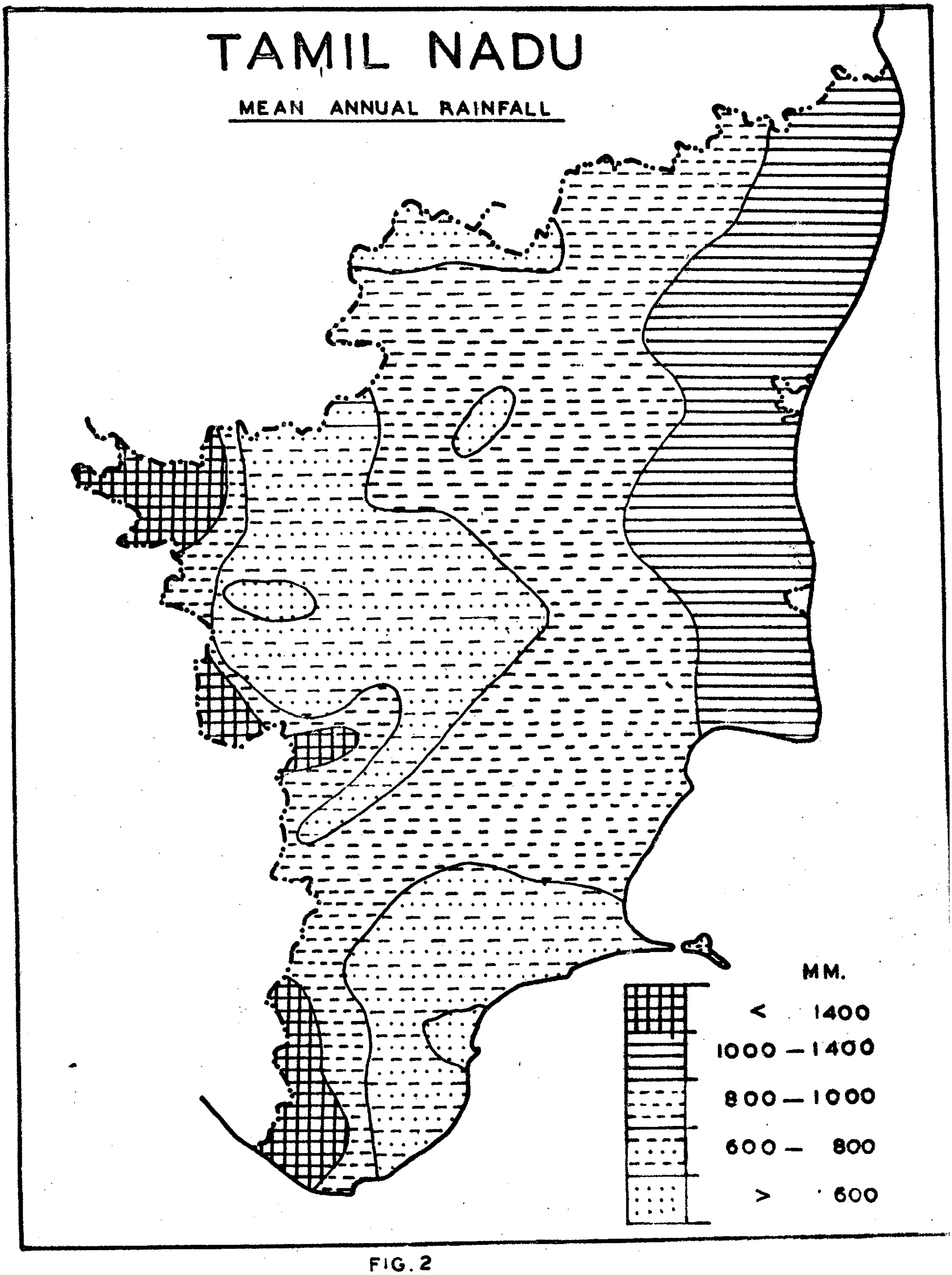
TAMIL NADU
MEAN ANNUAL RAINFALL
MM.
< 1400
1000 — 1400
800 — 1000
600 — 800
> 600

FIG. 2

belts and South Tamil Nadu. Nearly three-fourths of its area falls in the rain-shadow where annual precipitation ranges normally between 50 cm. to 110 cm. per year, resulting in semi-arid conditions.[4] Some districts get rainfall from both the south-west and the north-east monsoons, but several others get it mostly from the north-east monsoon. Broadly, Madurai and the north-eastern districts of Chingleput, North Arcot, South Arcot and Tanjavur get a fairly well distributed rainfall from both the monsoons. The total rainfall in these districts is also higher than in all other districts except the Nilgiris and Kanyakumari. Tirunelveli, Coimbatore, Tiruchirappalli and Ramanathapuram get less rainfall, a major portion of which comes from the north-west monsoon. The average rainfall received in the districts is tabulated in Table No.I.[5]

The rainfall is highly inconsistent in about one-third of Coimbatore and in a small coastal area in South Arcot, where the coefficient of variation of rainfall is more than 35 per cent. Less inconsistent is the rainfall in another one-third of Coimbatore, about half of Ramanathapuram, Tiruchirappalli and Chingleput and one-third of Tanjavur and South Arcot, where the coefficient of variation ranges between

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4. USAID, "Regional Differences in Crop Output Growth in Madras State, 1952-53/64-65", USAID Study Report, (1968).

5. Fertilizer Association of India, Soils of India, (1972), p.252.

Table No.I

AVERAGE ANNUAL RAINFALL

Districts	Rainfall in mm.
The Nilgiris	1710
Chingleput	1180
South Arcot	1130
Tanjavur	1115
Kanyakumari	980
North Arcot	930
Salem (and Dharmapuri)	860
Tiruchirappalli	840
Madurai	830
Ramanathapuram	805
Tirunelveli	740
Coimbatore	690
State average	985

25.1 and 35 per cent. The other areas which have a coefficient of variation of 25 per cent and below may be described as areas of consistent rainfall.[6]

2.2 Soils

Eight types of soils[7] are generally identified in Tamil Nadu (Fig.3). However, as seen from the map, major types are only four: red, black, alluvial and laterite. Of these, red soils are quite predominant in the state. It is found almost in all districts, the largest concentration being in Madurai and North Arcot districts followed by Chingleput, Salem, Coimbatore, Tirunelveli and Tiruchirappalli districts. It is generally less fertile than the black soil. It is poor in

6. USAID, Op.cit., p.45.
7. Census of India, 1961, Op.cit., Map.10.

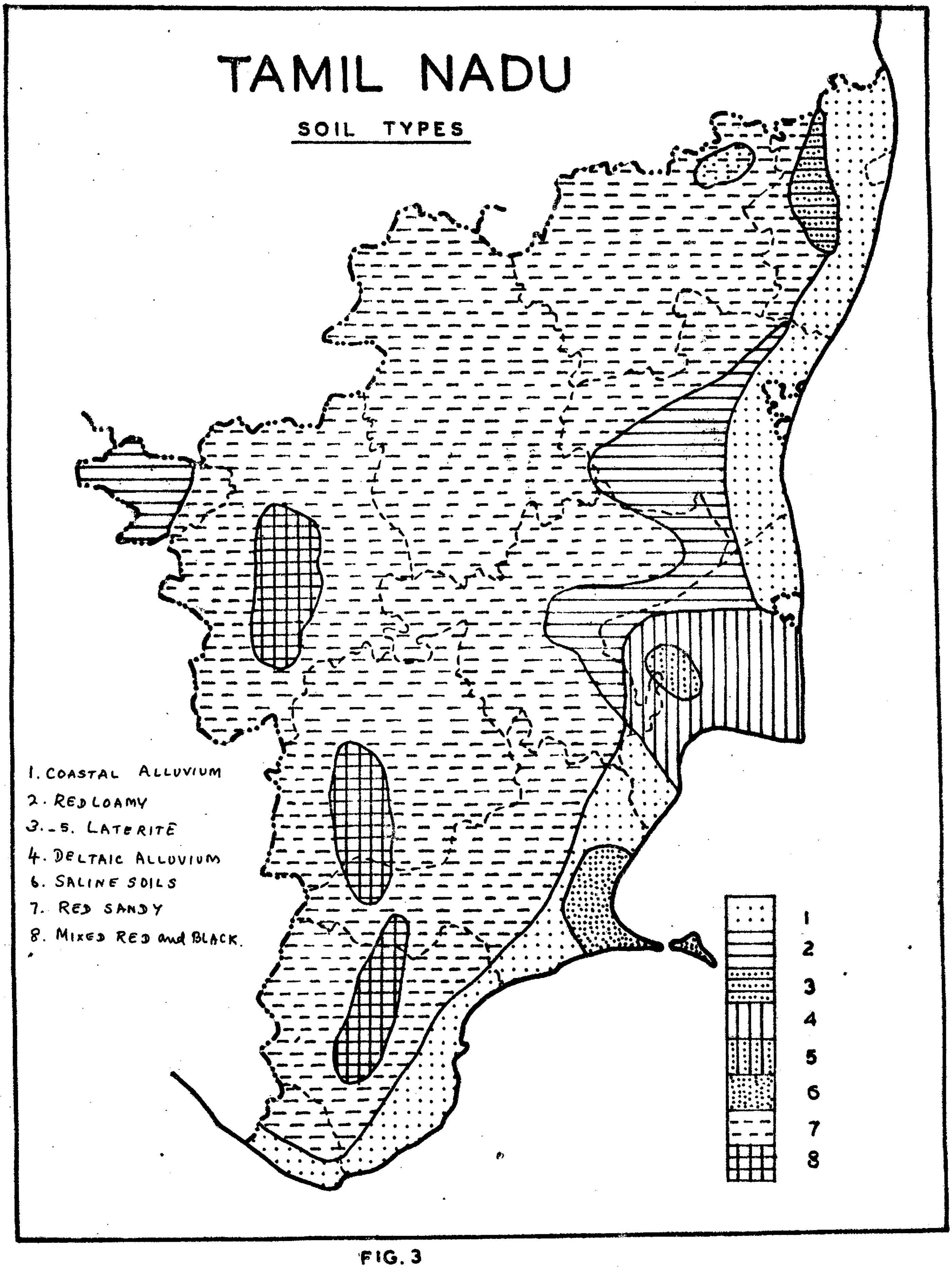
TAMIL NADU
SOIL TYPES
1. COASTAL ALLUVIUM
2. RED LOAMY
3._5. LATERITE
4. DELTAIC ALLUVIUM
6. SALINE SOILS
7. RED SANDY
8. MIXED RED and BLACK.
1
2
3
4
5
6
7
8

FIG. 3

nitrogen, organic matter and phosphoric acid. However, the loamy structure of the soil makes it suitable for cultivation of a larger variety of crops than the black soil.

Black soils cover less than one-fourth of the state and are found chiefly in Ramanathapuram, South Arcot, Tirunelveli and Tanjavur. Three-fourths of the cultivated area in Ramanathapuram and one-third in South Arcot have black soils. On the whole it is fertile. However, it is poor in organic matter and phosphoric acid as well as deficient in nitrogen.

Almost all alluvial soils in the state are concentrated in the Cauvery delta. The deltaic alluvial soil which is well supplied with lime, potash and magnesium is the most fertile soil in the state. It is, however, deficient in phosphoric acid and its nitrogen content is low.[8]

Laterite soil is found mainly in the Nilgiris and some parts of Chingleput and Tanjavur districts.

2.3 Agriculture

Nearly 50 per cent of total area in Tamil Nadu is under cultivation. The scope for bringing additional area under plough is highly limited; the cultivable waste as per the land utilization records is

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8. Fertilizer Association of India, Op.cit., pp.252-256.

is only 4 per cent of the total area in the state. The area sown more than once is of 20 per cent of the net sown area. Only 40 per cent of the net sown area is irrigated. Three-fourths of the total sown area are under food crops among which paddy, cholam and cumbu dominate. Among the non-food crops, groundnut is the only important crop which occupies 12.5 per cent of the total area sown.

Agriculture accounts for nearly 43 per cent of the state income and supports 73 per cent of the rural population in Tamil Nadu.[9] The prosperity of the state is thus dependent on the achievements in the agricultural sector. Hence a high priority is assigned in the plans to achieve higher targets of farm production.

Tamil Nadu was a deficit state in 1950 in the agricultural production but has been a surplus state since 1960, with occasional setbacks. The growth rate of agricultural production in Madras State during 1952-53 to 1964-65 reflects this quick recovery. Compared with the all-India increase of 3.42 per cent per year in crop production, Madras State increased its crop production during this period by an average increase of 4.91 per cent per year. The rate of increase displayed by Madras State was exceeded only by two states, i.e. Punjab and Gujarat. Although third in the rate of in-

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9. Department of Finance, Government of Tamil Nadu, Tamil Nadu - An economic appraisal, (1970), p.8.

crease of all crops and fourth for all non-foodgrains, it ranked first among the states in the growth rate of foodgrain output. Further, much of the increase in its crop production was achieved through yield increases. It ranked second among the states in the rate of growth in crop productivity.[10]

This quick achievement is mainly due to three factors: (a) the early and continued use of improved seeds; (b) the massive increase in tube-well irrigation in Chingleput and South and North Arcot districts and irrigation facilities made available for second crop in Tanjavur district; and (c) good rainfall since 1960.[11]

The past decade thus saw the transformation of agriculture in Tamil Nadu. This tempo of production has to be maintained and improved to compete with the higher rate of growth of population, on the one hand and limited resources on the other. Towards this goal, government has taken a number of steps which paved the way for Tamil Nadu to become a surplus state. As it has been found that the Tamil Nadu farmers readily started utilizing technological inputs, it seems that the main problems of Tamil Nadu's agricultural development stem from the following factors:

(a) The irrigation is pre-requisite for the application of technological inputs. In Tamil Nadu,

10. USAID, Op.cit., pp.2-10.

11. Joan P. Mencher, "Conflicts and contradiction in the Green Revolution: the case of Tamil Nadu", Economic and Political Weekly, Annual Number, (February, 1974), p.309.

only 40 per cent of the net area sown is irrigated, while 60 per cent of area sown still depends on rainfall for successful agriculture. This problem can be solved by using the ground water. In this context, it may be noted that Tamil Nadu is now using only 50 per cent of the ground water available in the state.[12]

(b) Three-fourths of the gross cropped area are under foodcrops in Tamil Nadu. As it is too imbalanced to bring in economic prosperity to the state, it has to be readjusted with proper changes in cropping pattern.

(c) Many High Yielding strains of paddy have been introduced so far. Still, good strains of drought-resisting and pest-resisting are to be evolved.[13] This is essential, as rice occupies a pre-eminent position in crop production in Tamil Nadu. The percentage of rice production to total cereal production in Tamil Nadu was 77 per cent in 1970-71.

(d) Financial resources are not sufficiently available to the farmers to purchase improved seeds, fertilizers and pesticides. And also the non-availability of these inputs in adequate quantities and in proper time poses a problem.[14]

2.4. THE NILGRIS : The hilly district, the Nilgiris, has been excluded from the study, as its agricultural production is mainly of plantation origin. However, the variables pertaining to it are depicted on all maps.

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12. S. Panchanathan, Working Paper on Irrigation, (Madras: State Planning Commission, 1972).

13. State Planning Commission, Op.cit., p.14.

14. Ibid., p.4.

CHAPTER THREE

THE CHOICE OF VARIABLES

The present study aims at explaining the spatial variations in the agricultural productivity in Tamil Nadu with the help of seven independent variables, i.e., soil, rainfall (environmental), irrigation, fertilizer, farm mechanisation (technological) and the concentration of agricultural labourers and of Scheduled Castes and Scheduled Tribes (institutional). The agricultural productivity has been computed by taking into consideration the production figures for twenty eight crops. They include paddy, cholam, wheat, cumbu, maize, ragi, korra, varagu, samai, green gram, Bengal gram, red gram, horse gram, black gram, potatoes, onions, ginger, chillies, pepper, groundnut, gingelly, castor, cotton, tobacco, coffee, tea, sugarcane and rubber. An attempt has been made in this chapter to explain the choice of variables.

3.1 Productivity: The Explained Variable

Productivity, as a general concept, may broadly be defined as 'the efficiency with which resources are converted into goods and services.[1] In the sphere of agriculture, it is generally expressed

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1. National Productivity Council, Productivity trends in iron and steel industry in India, (1974), p.1.

in three ways: (a) output per unit area (yield), (b) output per man-hour, and (c) input-output ratio.

Yield is found to be defective as it considers only land which is just one factor of production.[2] Returns per man-hour of work may considerably be a good indicator of productivity but could not be applied in agriculture, as adequate data are not available.[3] Theoretically speaking, the input-output relationship affords the best possible way of measuring the productivity,[4] as it alone can effectively measure the efficiency of production. But the development of production functions - input-output ratios - for a very large category of soil types, enterprises and systems of farm management presents an operational problem which cannot easily be solved. Even if we are able to build-up a model, it is still impossible to have input-output ratios, as relevant data are not at all available.

These preliminary remarks about the different expressions of productivity make it clear that from the angle of practical possibility, productivity is sought to be measured by the yield alone.

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2. S.B. Tambad, "Spatial and temporal variations in agricultural productivity in Mysore state", Indian Journal of Agricultural Economics, Vol.XX, No.4, (1965), p.39.

3. M.A. Oommen, "Agricultural Productivity in Kerala", Agricultural Situation in India, Vol.XVII, No.4, (1962), p.333.

4. J.G. Anand, "Measurement of the actually realised Agricultural Productivities per acre and per worker in the different crop regions of India", Journal of

3.1.1 Productivity by Yield

Yield may be an easy way of measuring the productivity, if the productivity is to be measured for a single crop. But the agricultural productivity of a large area, say a district, cannot easily be measured by yield, mainly due to: (a) the range and variety of crops being grown in a large area; and (b) the fact that the importance of crops with reference to hectarage highly varies in an area due to various reasons. To overcome these difficulties in measuring the productivity by yield, various methods have been attempted. They may be grouped into four: (a) Index method, (b) Ranking method, (c) Standard Nutrition Unit (SNU) method, and (d) Value of production per unit area.

E. Huntington and Samuel V. Valkenburg (1935) first tried the index method and built up index values,[5] taking the yield per acre of each crop for Europe as a whole as 100 and calculating the yield in each country accordingly. Many modifications are attempted for this method.[6]

Indian Society of Agricultural Statistics, Vol.XVII, No.2, (1965), p.257.

5. L. Dudley Stamp, Our Developing World, (1960), pp.105-107.

6. S.B. Tambad, Op.cit., pp.39-45; S.S. Bhatia, "A New Measure of Agricultural Efficiency in U.P.", Research Paper, Department of Human Geography, University of Delhi, (1965); and J.G. Anand, Op.cit., pp.257-264.

M.G. Kendall (1939) employed the ranking method.[7] The areas are ranked in the order of output per acre for each of the selected crops. Then the ranks, i.e., the places occupied by each region in respect of selected crops, are averaged to obtain ranking coefficients of each region. L.D. Stamp[8] (1960) and M. Shafi[9] (1960) tried Kendall's method. S.G. Sapre and V.D. Deshpande[10] (1964) modified this procedure, by taking a weighted average of ranks.

M.G. Kendall himself devised another method[11] by which the productivity is measured in terms of starch equivalent or energy. The conversion of production into Nutrition Calorie facilitates that 'one can compare directly, say, a wheat diet with a rice diet or a mixed diet of almost any source'.[12] L.D. Stamp[13] (1958) and M. Shafi[14] (1967) tried this method more elaborately.

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7. L. Dudley Stamp, Op.cit., pp. 105-107.
8. Ibid., p.108.
9. M. Shafi, "Measurement of Agricultural Efficiency in U.P.", Economic Geography, Vol.36, No.4, (1960), pp.296-305.
10. S.G. Sapre and V.D. Deshpande, "Inter-district Variations in Agricultural Efficiency in Maharashtra State", Indian Journal of Agricultural Economics, Vol.XIX, No.1 (1964), pp.242-252.
11. L. Dudley Stamp, Op.cit., p.108.
12. Ibid., p.108.
13. L. Dudley Stamp, "The Measurement of Land Resources", Geographical Review, Vol.XLVIII, (1958), pp.1-15.
14. M. Shafi, "Measurement of food production Efficiency and Nutrition in India", The Geographer, Vol.XIV, No. (1967), p.23-27.

Agricultural economists, however, favour the value productivity method. In this method, output per hectare is expressed in money value. By this method, the aggregation of the yields of the different crops - which is a major problem in measuring the agricultural productivity of an area - can easily be done. In fact, price is the best among the common units to express the output for the agricultural sector as a whole.[15]

The procedure of computing agricultural productivity in money value is stated below:

The 1954-55 crop-wise prices at the state-level have been taken from the Madras Government Season and Crop Reports of 1954-55, (Appendix II). Considering 1954-55 price as constant, agricultural productivity for 1964-65 and 1969-70 have been computed. This method facilitates a comparison between the three points of time chosen for this study.

The agricultural productivity of a district has been worked out as follows:

(a) Value of the total output for each crop in a district has been worked out; (b) the values, thus obtained for 28 crops, have been aggregated in order to obtain the total value of agricultural output of the

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15. J.S. Sharma, "Measurement of Agricultural Productivity - Concepts, Definitions, etc." Journal of the Indian Society of Agricultural Statistics, Vol.XVII, No.2, (1965), p.253.

district; and (c) the total value of agricultural output of the district has, then, be divided by the total hectareage under crops in that district in order to get the value of per hectare productivity. This procedure has been repeated for each district for the three points of time.

3.2 Choice of Explanatory Variables

The growth of crops is primarily a function of mutual interaction between nature and man. The natural environment exercises its influences through the variations in relief and soil and in the whole set of climatic parameters. The human effort which makes crop growth possible is constrained by the institutional frame and the level of technology. These three factors interact between themselves, affecting fundamentally agricultural productivity and generating variations in space as well as time. Thus the regional differences in agricultural productivity mirror the magnitude and the nature of interply among these three factors.

Each element of the natural environment affects crop-growth in its own way. The form of land exerts a direct influence on land use, particularly through elevation, ruggedness and slope. Soil sets the very stage for the plant growth. Climate, especially temperature, rainfall and variations in both affect the plant growth. Among the environmental factors, generally soil and rainfall are the only crucial factors.

In the broad sense, "a technology is the employed, or operative, knowledge of means of production of a particular group of goods or services. A change in technology is effected by means of additions to the sets of inputs employed in production".[16] Some of the technological changes in agriculture are irrigation, fertilizers, new seeds, pesticides and insecticides, farm machineries and credit and marketing facilities. Irrigation, fertilizers and new seeds are the basic inputs. Among these three, only first two variables have been taken, since data for the actual pattern of consumption of new seeds are not available. The latest innovation introduced to augment the agricultural production is the mechanisation. Mechanisation includes large number of agricultural machines and implements. However, due to paucity of data, only tractors and water-lifting oil engines and electrical pumps have been consideredas indicators of the process of mechanisation of agriculture.

A sustained increase of production and an increase of production per man-hour, in the agricultural sector, which are more important indices, will depend significantly on the institutional factors. For example,

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16. Montague Yudelman, et al, Technological Change in Agriculture and Employment in Developing Countries, (1971), p.36.

the technological factors may even fail, when the cultivators are reluctant to adopt the innovations. The importance of institutional factors have very well been established by the recent diffusion studies. The social background of a farmer involving the prevailing socio-economic and political perspective as evident in land-tenure system, average size of land-holding and the caste-tribe affiliation, credit facilities and the educational level affect his performance in the efficiency of agricultural production. However, necessary data for most of the institutional variables is not available. So the present study takes only the agricultural labourers and population of Scheduled Castes and Scheduled Tribes to represent the institutional factors. Agricultural labour force may be of both economically and institutionally important one. As it supplies the labour-demand in the agricultural sector, it is economically important and may be directly related with the agricultural productivity. On the other side, as agricultural labourers are generally either landless or uneconomic size of land-holders, they become institutionally important and their larger proportion in an area may be a constraint in the agricultural development. The proportion of Scheduled Castes and Scheduled Tribes in a rural population may be treated as an index of the level of social deprivation operating as an institutional constraint on the effective exploitation of agricultural resource base.

Thus, in a nutshell the explanatory variables chosen in the present study to explain the variations in agricultural productivity include soil, rainfall, irrigation, fertilizers, level of mechanisation, the proportion of agricultural labourers and the proportion of Scheduled Castes and Scheduled Tribes in the rural population.

3.2.1 Soil Fertility

Soil provides two services fundamental to the productive processes: (a) it acts as a source of plant nutrients and (b) it provides the matrix within which plant roots extend and soil moisture is stored and into which additional nutrients and moisture may be placed.[17] The yield of a fully-grown crop depends on the strength of these services available in the soil. The quantities and proportions of the factors of growth present in the soil are expressed as the fertility of the soil.

Soil fertility is an extremely complex property, as it results from physical and chemical conditions of the soil. So it widely varies spatially. Consequently, its exact measurement in quantitative terms is a difficult problem. However, a soil productivity rating method has been evolved which, although a fairly satisfactory method, is not a perfect one.

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17. Dent and Anderson, Systems Analysis in Agricultural Management (1971), p.154.

R. Earl Storie of the California Agricultural Experimental Station developed a soil rating index. His rating index known as Storie Index, results from the multiplication of four factors: A x B x C x X. It is based on soil characteristics that govern the land's potential utilization and productive capacity. It is independent of other physical or economic factors that determine the desirability of growing certain plants in a given location. S.P. Ray Chaudhuri[18] (1965) calculated the soil rating index for the Indian districts based on Storie's method. His soil rating indices have been used here as an explanatory variable.

The underlying hypothesis in this study id that the higher the soil rating index the higher is the agricultural productivity.

3.2.2 Rainfall

Seasonal variations in the yield rate depend also on weather factors, the effects of which on the plants are quite obvious, as it is never static in its physical character but always in a state of dynamism. It may influence production directly through characteristics of the crops and indirectly through its effects on the incidence of pests and plant diseases.

Of the various factors affecting the weather balance of the crop, those affecting moisture supply and

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18. S.P. Ray Chaudhuri, Op.cit.

moisture requirements are probably the most important ones. The rainfall becomes by far the most crucial. It is especially so in India where 80 per cent of the total cropped area is unirrigated.

The influence of rain on output cannot easily be quantified, because: (a) Rain affects all phases of crop-growth; (b) The total amount of rainfall and its variability are the two important characteristics of rainfall. It is the distribution of rainfall during a season rather than its total amount which influences the crop yield. That is why it is sometimes seen that production is even more high in a year of substandard rainfall than in a year of good rainfall.[19] Thus, the incidence of sufficient rainfall in the crucial phases of plant growth is an important matter; (c) The influence of rainfall on crops differ from crop to crop; (d) Another difficulty in the quantification of rainfall is the allowances to be made in the rainfall data. The recorded average rainfall cannot be used directly for analytical purposes, as a portion of it is lost through run-off, drainage and evaporation.[20]

Various methods have been evolved to relate the rainfall with yield.[21] However, it is almost impossible to evolve a perfect method by which an average

19. Ralph W. Cummings, Jr. and S.K. Ray, "1968-69 Foodgrain Production: Relative Contribution of Weather and New Technology", <u>Economic and Political Weekly</u>, (September 1969), p.A163.

20. <u>Ibid</u>., p.A174.

21. S.G. Sapru and D. Dashpande, "Inter-district

relationship can be established between the overall agricultural productivity (in this study, agricultural productivity involves the yields of 28 crops planted and harvested in the different periods of an year) and rainfall of a large area, say district. Confronted with these difficulties, the total amount of rainfall of a district in a particular year has been taken as an explanatory variable. The hypothesis here is that the rainfall has a positive relationship with agricultural productivity.

3.2.3 Irrigation

Farming without irrigation may be possible, when rainfall ranges between 30 cm. and 50 cm. It is, however, impossible when it falls below 30 cm. and irrigation becomes a necessity.[22] The existing rainfall situation in this country emphasises the need for irrigation. The monsoon regime is characterised by an erratic behaviour of rainfall having high variations both in time and space. S.K. Rao[23] (1971) notes that

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variations in Agricultural Efficiency in Maharashtra State", Indian Journal of Agricultural Economics, Vol.XIX, No.1, (1964), p.252; Ram Dayal, "Impact of Rainfall on Crop Yield and Acreage" Indian Journal of Agricultural Economics, Vol.XX, No.3 (1965), p.49; Ralph W. Cummings, Jr. and S.K. Ray, Op.cit., p.167; and A. Ahmad and Aslam Mahmood, "Determination of Critical Drought Limits to Crop Production in the Indian Desert" Mimeograph, 1972.

22. Jasbir Singh, An Agricultural Atlas of India: A Geographical Analysis, (1974), p.13.

23. S.K. Rao, "Inter-regional variations in agricultural growth 1952-53 to 64-65: a tentative analysis in relation to irrigation", E&PW., (July 3, 1971), p.1337

irrigation is like a technological constraint in Indian agriculture and once this is removed, the farmers tend to apply modern inputs and adopt changes in crop pattern that bring them the highest yield. Irrigation leads to increased output in various ways: (a) through enhancing yields from regular watering, (b) through changes in crop pattern in favour of high yielding crops, and (c) by allowing multiple cropping.

Quantification of benefits from irrigation is not easy, as: (a) crop response to irrigation is dependent largely on weather conditions, and (b) the timing of irrigation is often more crucial than the total quantity of water applied. Because of these limitations, the percentage of gross irrigated area to the gross cultivated area has been taken here as an explanatory variable. The hypothesis here is that irrigation is directly related with the agricultural productivity.

There are many studies which relate the irrigation and productivity and get positive results.[24]

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24. A.J. Rupchand and M.S. Ravi Varma, "Agricultural Progress of Madras State between 1949-50 and 1959-60 - A distiictwise analysis" Indian Journal of Agricultural Economics, Vol.XIX, No.1 (1964) pp.227-236; Bashir A. Desai and N.K. Thingalaya, "Irrigation Factor and Yield Variability in Rice-Growing Districts in India", Ibid, Vol.XX, No.3 (1965), p.65; R. Thamarajakshi, "Growth of Agriculture in Madras State, 1949-50-1962-63", Agricultural Situation in India, Vol.XXII, No.9 (1967), p.1006; and S.K. Rao, Op.cit., p.1337.

3.2.4 Fertilizers

Soil acts as a source of plant nutrients. The nutrients are prone to be exhaustible due to cultivation. It may not be possible even for fertile soils to supply the plant nutrients in sufficient quantity for long without becoming impoverished.[25] For the optimum plant growth and maximum crop yields, it is necessary that all the essential nutrients must be present in optimum condition in the soil during the cultivation. So the depleted soil has to be restored with the necessary nutrients at the required amount; otherwise the productivity of the soil will decline.

The fertility of the soil can be restored and maintained at the required level by both organic and inorganic manures. Organic manures are not available abundantly and cannot be prepared fully to our needs, due to certain natural limitations; further they alone cannot fulfil the complete nutritional needs of the plants. So the restoration and maintenance of the soil fertility depend largely on the availability of the inorganic manures. Inorganic manures, popularly known as fertilizers, include nitrogen, phosphatic and potassic elements or their mixture (NPK). The use of fertilizers, apart from

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25. Department of Agriculture, Government of Tamil Nadu, Report of the Committee on Agricultural Production, (1966), p.125.

irrigation, is regarded as one of the quickest ways of increasing productivity of crops.[26]

Fertilizer doses which maximize the profit or the net return to the farmer vary with natural environment, the levels of other agricultural inputs such as irrigation, seeds and other technological advances, and the input-output price ratios. So the additional yield obtained by the application of fertilizers cannot easily be estimated. The per hectare application of fertilizer is commonly considered to measure its impact on the crop yields. This measurement has its own limitations, as the response to fertilizer varies from crop to crop and over time and space.

In the present study, fertilizer supply has been calculated for the irrigated area and so the chosen variable is the fertilizer consumption per hectare of irrigated area of a particular district. This has been taken on the assumption that farmers in the dry tracts do not go for application of fertilizers. This assumption has cropped up from the facts: (a) response to fertilizer, to a greater extent, depends on the assured supply of water, and (b) assured irrigation facilities would

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26. D. Singh, S.K. Raheja and S.R. Bapat, "Returns from fertilizers on farmers' yields", Indian Journal of Agricultural Economics, Vol.XXV, No.4 (1970), p.29.

greatly prompt the farmer in adopting fertilizer practices.

The hypothesis here is that there is a direct relationship between the fertilizer consumption and the productivity. There are many studies[27] observing high correlation between these two variables.

3.2.5 Mechanisation

"Mechanisation in its broad sense, can be defined as the use of improved types of hand-tools, animal driven implements and power-driven equipments."[28] It is not a direct input but is instrumental in raising the yields. It is desirable even in a country like India[29] which has a surplus labour force: (a) Purely from a technical angle, the power requirements of Indian agriculture are estimated about 112 million h.p. or 0.8 h.p. per hectare; as against this estimated

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27. P.P.I. Vaidyanathan, A Critical Survey of the Food Production Programme in Madras State, (1958), p.54; Tamil Nadu Planning Commission, Op.cit.; Robert W. Herdt, "The effect of purchased inputs on paddy yields of selected cultivators in Tanjavur district, 1961-62", Indian Journal of Agricultural Economics, Vol.XIX, No.3&4 (1964) p.211; and A.K. Chaudhari and A.S. Sirohi, "Allocation of fertilizers among crops and regions in U.P." Indian Journal of Agricultural Economics, Vol.XXVIII, No.3 (1974), p.47.

28. Indian Society of Agricultural Economics, Seminar on Problems of Farm Mechanisation, (1972), p.3.

29. Ibid., p.156.

requirement, the available power for use in Indian agriculture has been estimated at 28 million h.p. or 0.2 h.p. per hectare. Of this available power, 75 per cent is supplied by draught animals in the country. This gap of power requirements can be filled up only through mechanisation.[30] (b) As agriculture is a biological process, weather conditions and timeliness of operations are important for the growth of the crop. In such a situation, mechanisation leads to less weather-risk and wastage, thereby indirectly increasing the yield. (c) Mechanisation can often qualitatively improve the operation and significantly raise its productive capacity. This happens, for example, through greater precision both in the timing of the operation and its execution through deeper ploughing in certain soils and so on. (d) Mechanisation influences the cropping pattern and helps in increasing crop intensity, both of which increase land and labour productivity. For example, assured supply of water made available by the water-lifting pumpsets induced the cultivation of cash crops like cotton, sugarcane and chillies in many parts of the once-rain-fed areas of TamilNadu.

The present study considers oil engines, electrical pumpsets and tractors only to represent mechanisation, as complete data are available only for these three. The oil engines and electrical

30. W.B. Donde, "Tractors in Indian Agriculture", Agricultural Situation in India, Vol.XXIV (April 1969), p.891.

pumpsets are treated separately to build up an index, as the efficiencies of these two differ much. These three machineries are put together and expressed in an index, called mechanisation index. The mechanisation index is worked out by 'Division by Mean' method[31] which is as follows:

The absolute data of these machineries were first standardised by working out oil-engines and electrical pumpsets available per 1000 hectare of cultivated area and of the tractors per 10,000 hectare of cultivated area. Then the proportion of the standardised value to the mean for each machinery was found out. Mechanisation index of a district was calculated by adding this proportion of three types of machineries available in that district.

The index thus developed suffers from the following limitations: (a) there may be a double-counting between the availability of water-lifting devices and the percentage of irrigated area (of course, as seen from the correlation matrix - Appendix-XIV, XVI and XVIII, the inter-correlation between mechanisation index and the percentage of irrigated area is not so high); (b) Number of tractors available are not much, so it may be doubtful to find a marked influence over the productivity, when the study is on a macro-level; and

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31. A. Kundu, "Construction of indices for Regionalization: An enquiry into methods of Analysis", Geographical Review of India, Vol.37, No.1 (1975), p.23.

(c) Many other mechanical implements like tillers, reapers, sprayers and threshers which are also widely being used, are not included in the formulation of index, as no data is available.

The underlying hypothesis here is that the higher the mechanisation index, the higher is the agricultural productivity. There are various studies[32] relating to mechanisation with agricultural productivity and showing significant correlation.

3.2.6 Percentage of Agricultural Labourers to the total Work-force in Agriculture

Land and labour are the principal inputs of a traditional agriculture. Labour is the primary instrument for increasing production within the framework of traditional agriculture. Even in this modern times, labour is a crucial factor, where agriculture is undertaken through small-sized holdings where mechanisation is not economical. Here, it is appropriate to take note of the fact that in the study area - Tamil Nadu, eighty per cent of the total cultivated area is owned by small-and medium-sized land holders.[33] The farm management studies conducted in

32. Indian Society of Agricultural Economics, Op.cit., p.148; and National Council of Applied Economic Research, Impact of Mechanisation in Agriculture on Employment, (1973), p.46.

33. P.S. Sharma, "Pattern of Land Concentration and Elasticity of per acre Composite Crop Elasticity" Agricultural Situation in India, Vol.XX, No.5, (1965), p.330.

Tanjavur district during 1966-67 place the additional demand for labourer at 26 per cent due to the introduction of new paddy variety, ADT-27. The same studies estimate that the labour requirement for irrigated crops is about three times the labour-input for the unirrigated crops.[34] If the labour-force is not available at the required level and at the required time, the transformation of agriculture may be adversely affected. Thus in the existing level of technology, there is a direct relation between agricultural development and extent of utilization of the available labour. Some[35] even feel that leaving aside the other inputs, efficient use of human labour itself can accelerate agricultural growth to a greater extent.

The present study takes up the proportion of agricultural labourers in the total agricultural work-force as an institutional factor. The hypothesis laid down here is that there is a direct relationship between the agricultural productivity and this variable. There are various studies[36] proving this hypothesis. The variable taken here suffers from the facts: (a) the age structure of the labour force is not taken into

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34. C. Muthiah, "The Agricultural Labour Problem in Tanjavur and the New Agricultural Strategy", Indian Journal of Agricultural Economics, Vol.XXV No.3, (1970), p.20.

35. P.C. Goswami and C.K. Bora, "Demand for Labour in Rural Areas of Assam: A Case Study in Nowgong District", Ibid., Vol.XXI, No.1 (1966), p.37.

36. P.S. Sharma, "Impact of Selected Aspects of Labour and Land on per acre Productivity", Ibid., No.1, (1966), p.37; and T.P. Abraham and S.D. Bokil, "Resource Productivity in Agriculture with Special

consideration, due to paucity of data; and (b) the optimum level[37] of labour requirement is also not considered.

3.2.7 Percentage of Scheduled Castes and Tribes to the total rural population

The Indian social system is inconceivable without caste, which is still the foundation of the Indian social fabric. It is especially so in the villages. Caste differences determine the differences in modes of domestic and social life, types of houses and cultural patterns, and occupational characteristics of the people.[38] As such, it is no wonder that this social stratification based on caste influences the agricultural development to a greater extent. This influence can well be noticed when the proportion of rural Scheduled Castes and Tribes to the total population of an area are considered along with the agricultural development. Scheduled Castes represent those communities which suffer or have suffered from untouchability in one form or other chiefly by birth or caste or by the profession which they practice and have been subjected to social disabilities. Scheduled tribes are a category in themselves. They live in isolated areas in more or less seclusion.[39] As the

reference to labour", Ibid., p.92.

37. Optimum being used here to mean the labour required to get the maximum yield from the farm with other inputs at the required level.

38. A.R. Desai, Rural Sociology in India (1969), p.38.

39. Census of India, Scheduled Castes and Tribes (Report and Tables) Vol.IX Madras Part V-A(1) (1961), p.1.

1931 census[40] notes that "it is they who furnish the backbone of agricultural labour", the main occupation of Scheduled Castes and Scheduled Tribes is agriculture. Though they play a large and important role in the agricultural activities in the country, they are socially much backward.

Many of the recent diffusion[41] (of agricultural innovations) studies have shown that adoption of agricultural innovations is not rapid among the Scheduled Caste and Scheduled Tribe, thereby hindering agricultural development. The high caste people being in an advantageous position in the social hierarchy may readily adopt the innovations. But the case is different with the lower caste people, especially Scheduled Castes and Scheduled Tribes, who may not take risk in adopting the new innovations, as they are financially poor and are more tradition-oriented. With these considerations, it is here hypothesed that areas with good percentage of Scheduled Castes and Tribes may not show a relatively better agricultural development.

The present study expresses the rural Scheduled Castes and Tribes in terms of percentage to the total rural population. According to 1971 census, only 19 per cent of total population is constituted

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40. Ibid., p.7.

41. P. Roy et al, Agricultural Innovations Among Indian Farmers, (1968), p.49; and Sachchidananda, Social Dimensions of Agricultural Development, (1972), p.66.

by Scheduled Castes and Scheduled Tribes. Though this is a small percentage, they play an important role in the agriculture because: (a) More than 85 per cent of the total Scheduled Castes and Scheduled Tribes live in rural areas and do farming, either as cultivators or labourers; and (b) There are seven districts in the state, having more than 20 per cent of its rural population as Scheduled Castes and Scheduled Tribes. The variable considered here suffers from the fact that the age structure of Scheduled Castes and Scheduled Tribes, number of cultivating people among them and the size of land-holdings owned by them are not taken into consideration, due to non-availability of data.

CHAPTER FOUR

AREAL PATTERN OF THE VARIABLES

It is intended to provide here a comprehensive picture of the pattern of spatial distribution of both the explained and the explanatory variables in order to be able to build-up the frame for the analysis of their mutual inter-relationships.

4.1 Areal pattern of Productivity

(a) 1954-55

The agricultural productivity among the twelve districts of Madras Province varied largely in 1954-55. It ranged from Rs.861.13 per hectare (South Arcot) to Rs.281.84 per hectare (Salem), the coefficient of variation being 35.55 per cent. Only four districts - two on the eastern coast and two on the western coast (Fig.5) show productivity above the state's mean (448.06). South Kanara, the adjoining district of Malabar, has a productivity (442.18), just below the mean. South Arcot and Coimbatore districts with their high values stand completely isolated from other districts in terms of productivity. This might be due to a good share of cash crops in the total crop production of these districts. Because of these high values only, mean for the state becomes high and the standard deviation gets inflated. All the southern districts, which are in a dry tract and

Table No.II

AGRICULTURAL PRODUCTIVITY

	1954-55	1964-65	1969-70
Range	579.29	308.24	397.80
Mean	448.06	410.54	405.33
Standard Deviation	157.47	86.77	95.92
Coeff. of variation-%	35.55	21.13	23.66
No.of districts above mean	4	5	7

Salem, another dry district, are with low productivity level. As seen in Fig.5, barring Salem, agricultural productivity is generally seen decreasing southward.

(b) 1964-65

The productivity variations among the districts in 1964-65 are less pronounced than those of the previous time-period (Fig.13). The coefficient of variation comes down to 21.13 per cent. The productivity varies from Rs.595.95 per hectare (Kanyakumari) to Rs.287.71 per hectare (Ramanathapuram).

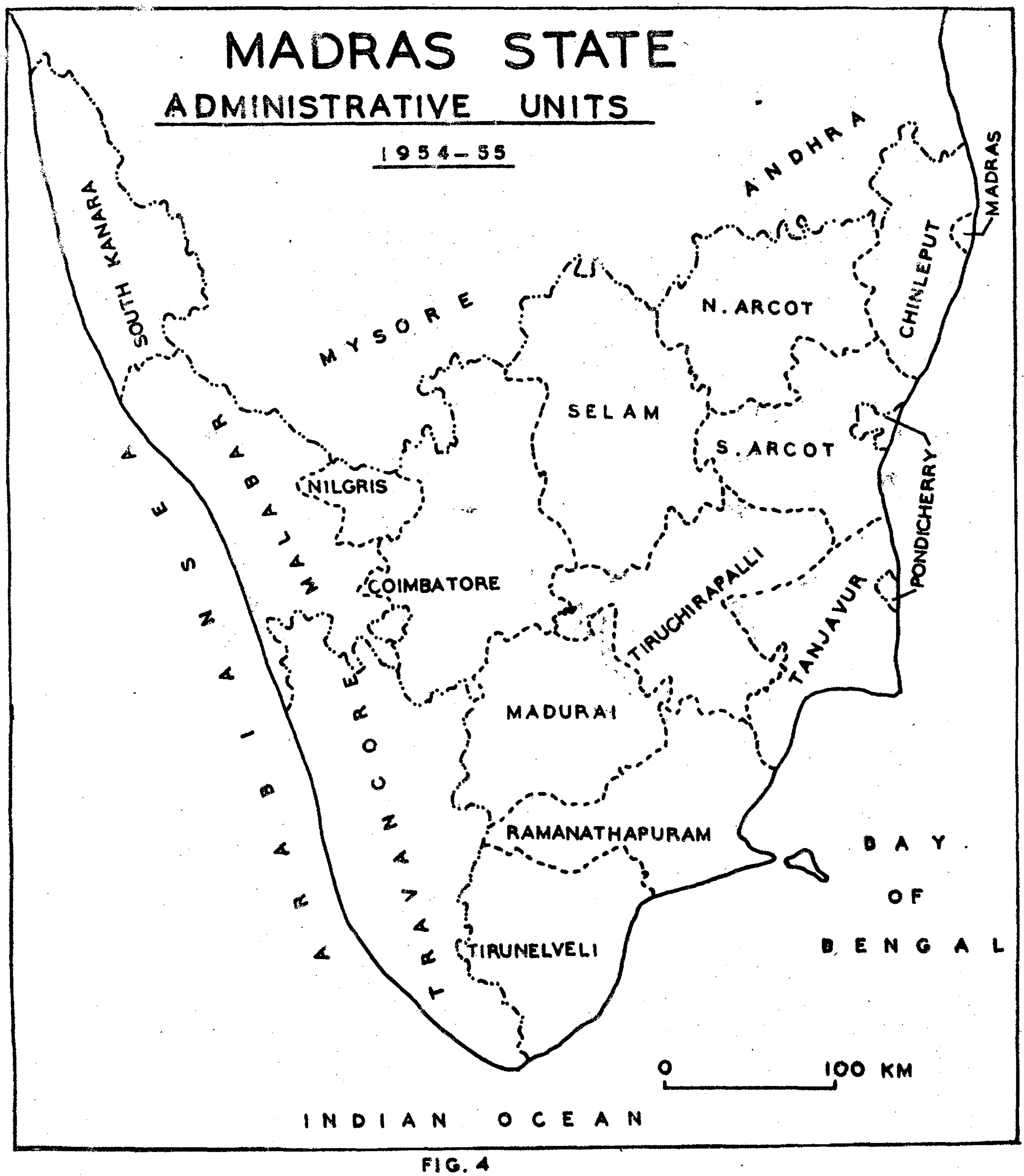

MADRAS STATE
ADMINISTRATIVE UNITS
1954-55
ANDHRA
MADRAS
CHINLEPUT
SOUTH KANARA
MYSORE
N. ARCOT
SELAM
S. ARCOT
PONDICHERRY
MALABAR
NILGRIS
COIMBATORE
TIRUCHIRAPALLI
TANJAVUR
ARABIAN SEA
TRAVANCORE
MADURAI
RAMANATHAPURAM
TIRUNELVELI
BAY OF BENGAL
0 100 KM
INDIAN OCEAN

FIG. 4

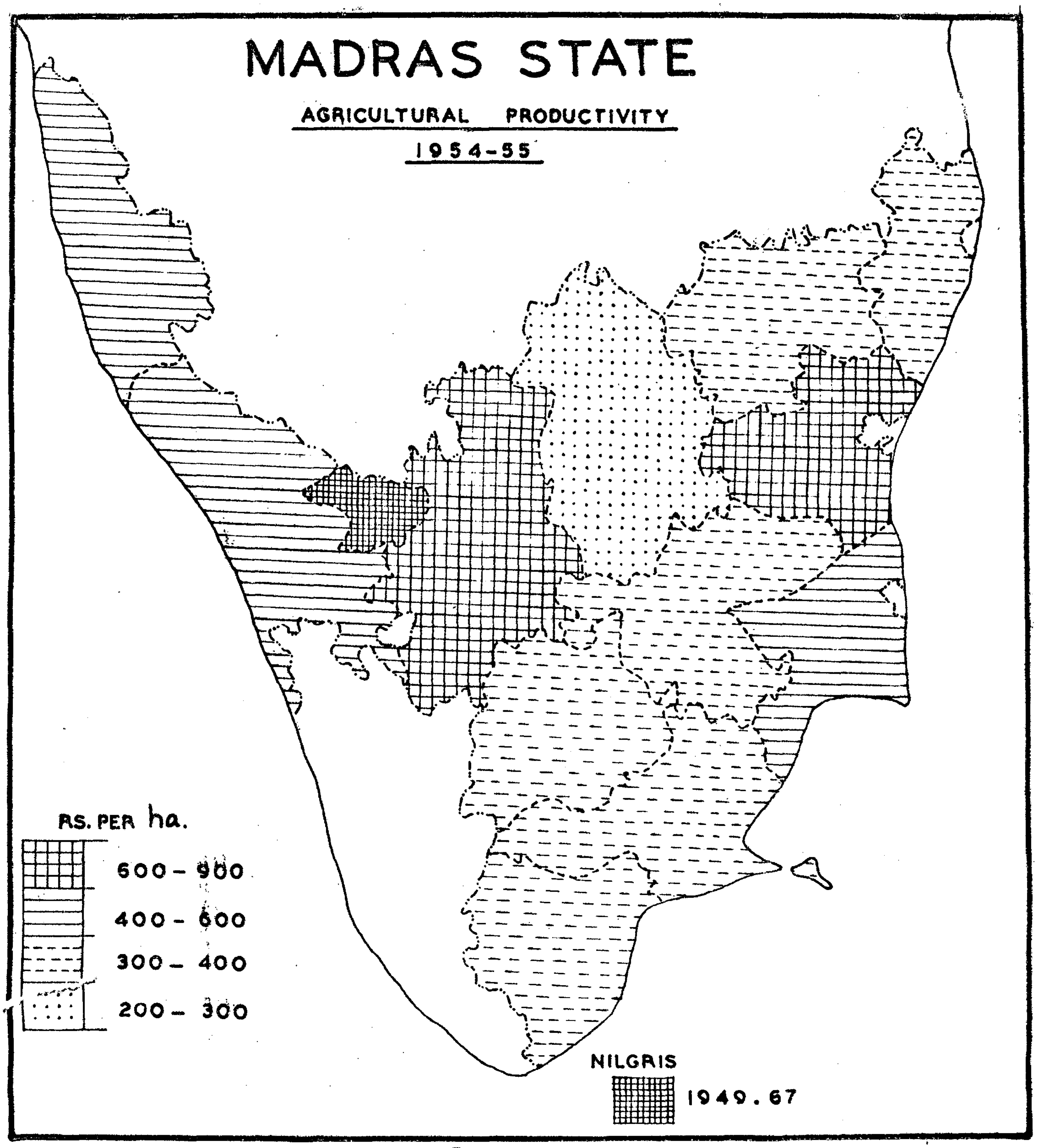

MADRAS STATE
AGRICULTURAL PRODUCTIVITY
1954-55
RS. PER ha.
600 - 900
400 - 600
300 - 400
200 - 300
NILGRIS
1949.67

FIG. 5

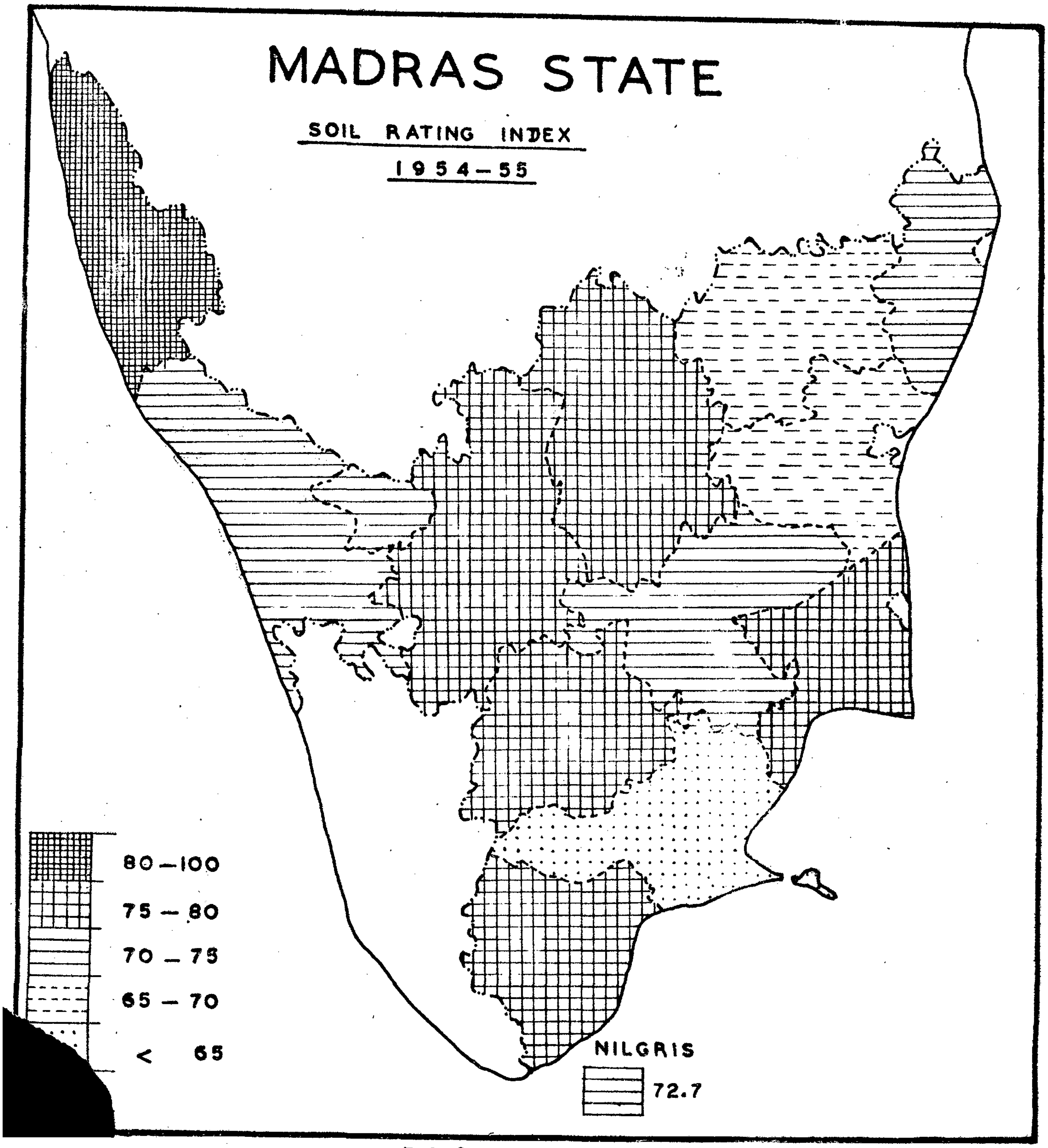

MADRAS STATE
SOIL RATING INDEX
1954-55
80-100
75 - 80
70 - 75
65 - 70
< 65
NILGRIS
72.7

FIG. 6

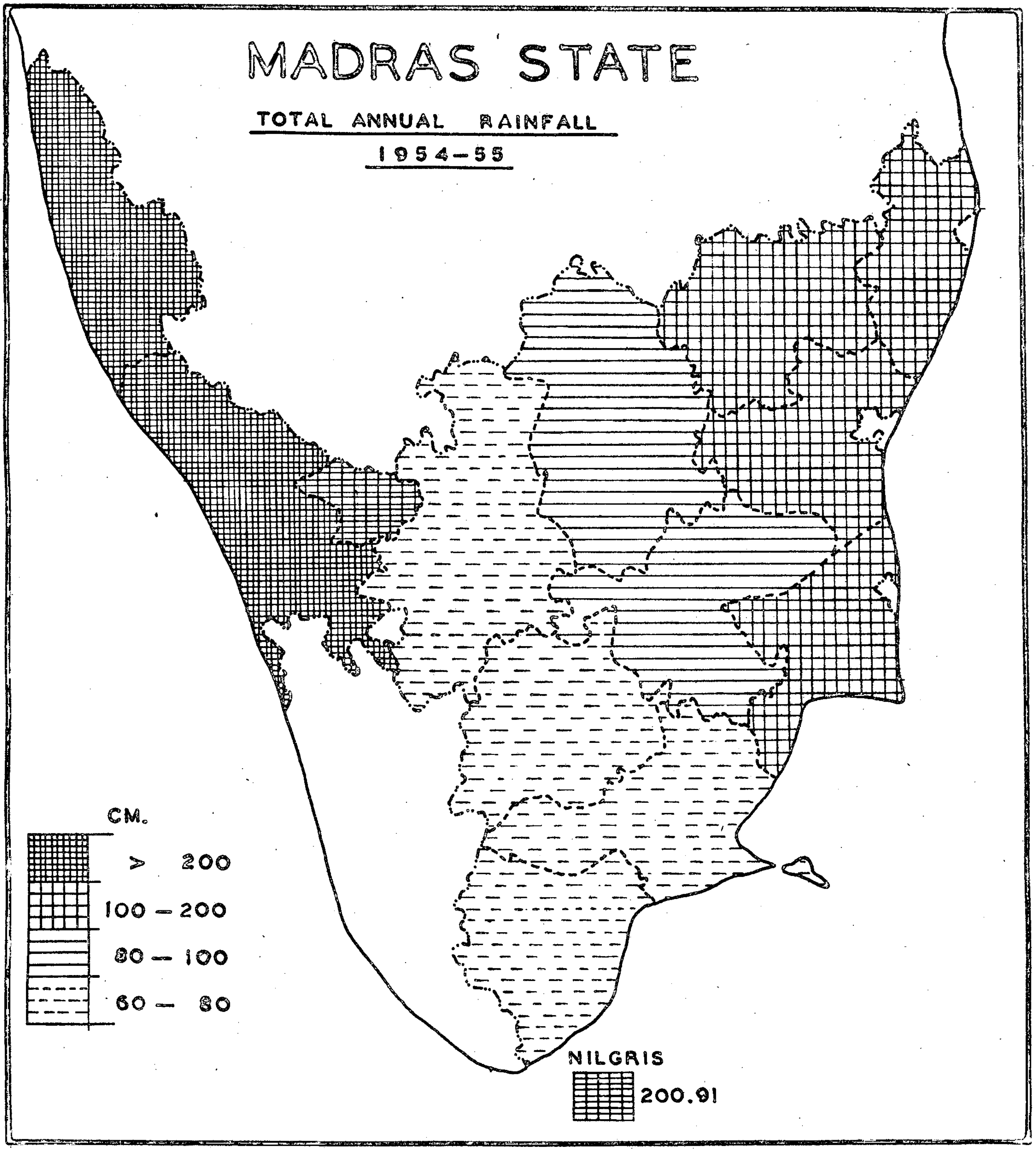

MADRAS STATE
TOTAL ANNUAL RAINFALL
1954-55
CM.
> 200
100 — 200
80 — 100
60 — 80
NILGRIS
200.91

FIG. 7

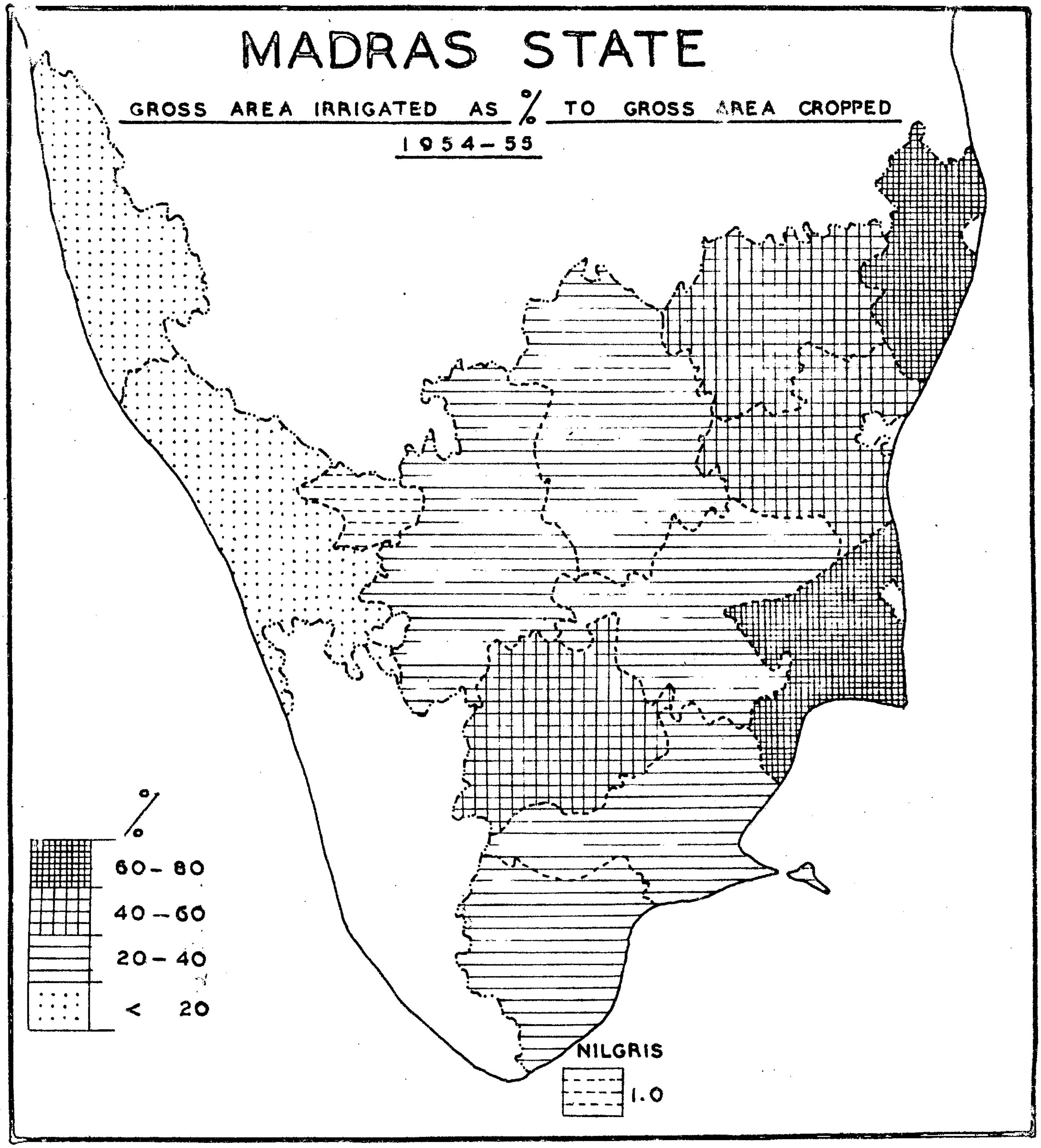

MADRAS STATE
GROSS AREA IRRIGATED AS % TO GROSS AREA CROPPED
1954-55
%
60- 80
40 - 60
20- 40
< 20
NILGRIS
1.0

FIG. 8

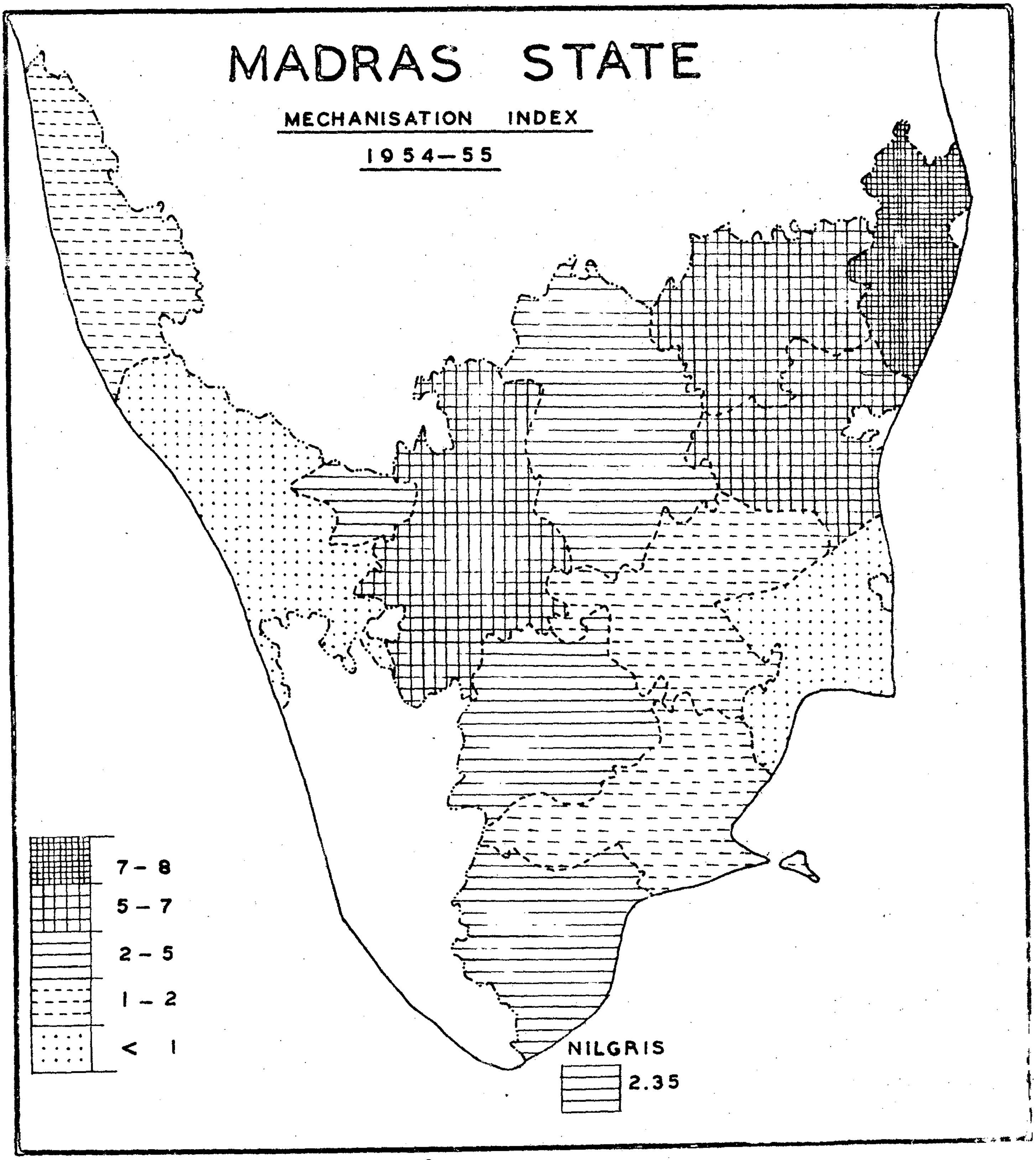

MADRAS STATE
MECHANISATION INDEX
1954—55
7 - 8
5 - 7
2 - 5
1 - 2
< 1
NILGRIS
2.35

FIG. 9

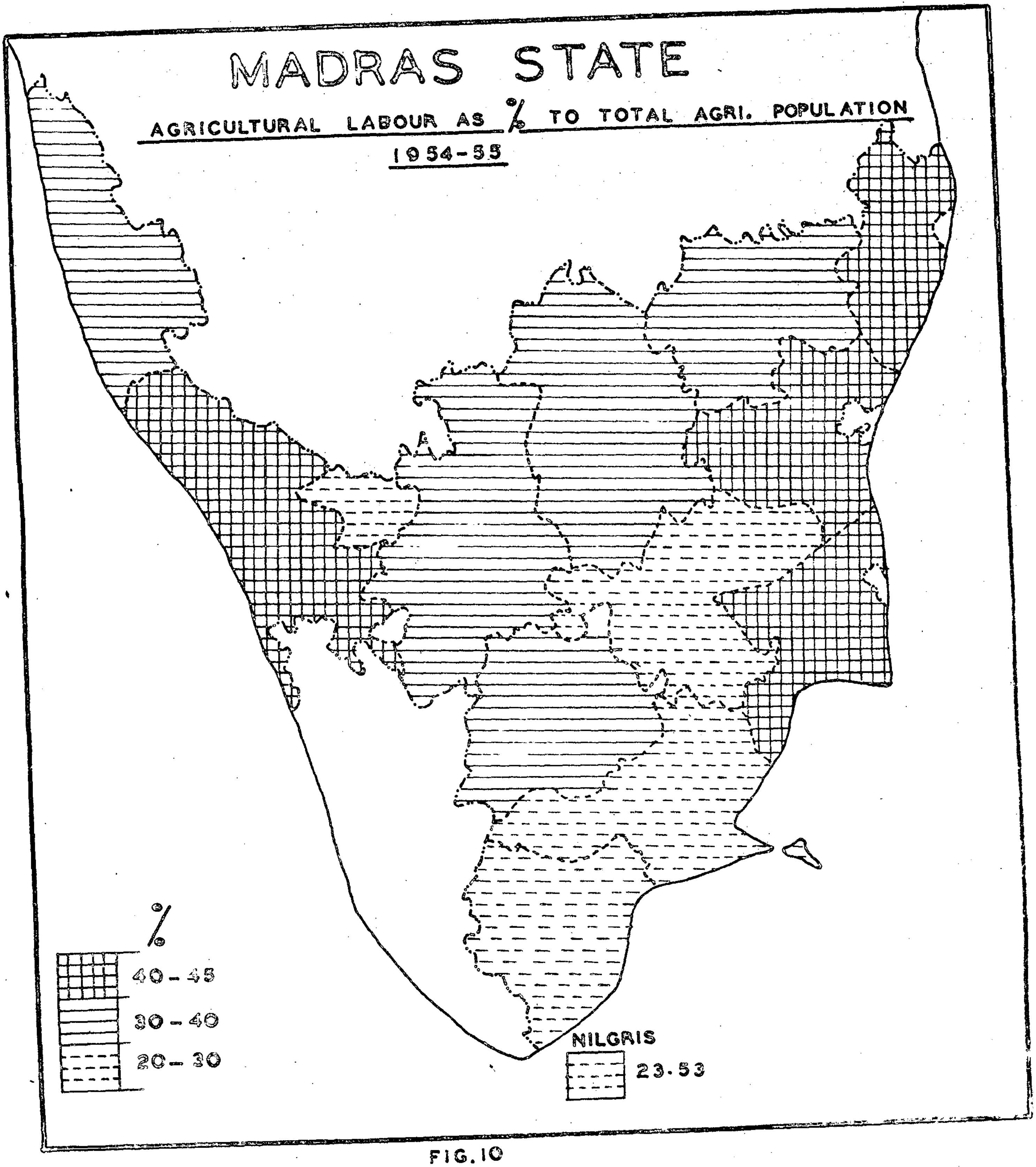

MADRAS STATE
AGRICULTURAL LABOUR AS % TO TOTAL AGRI. POPULATION
1954-55
%
40 - 45
30 - 40
20 - 30
NILGRIS
23.53

FIG. 10

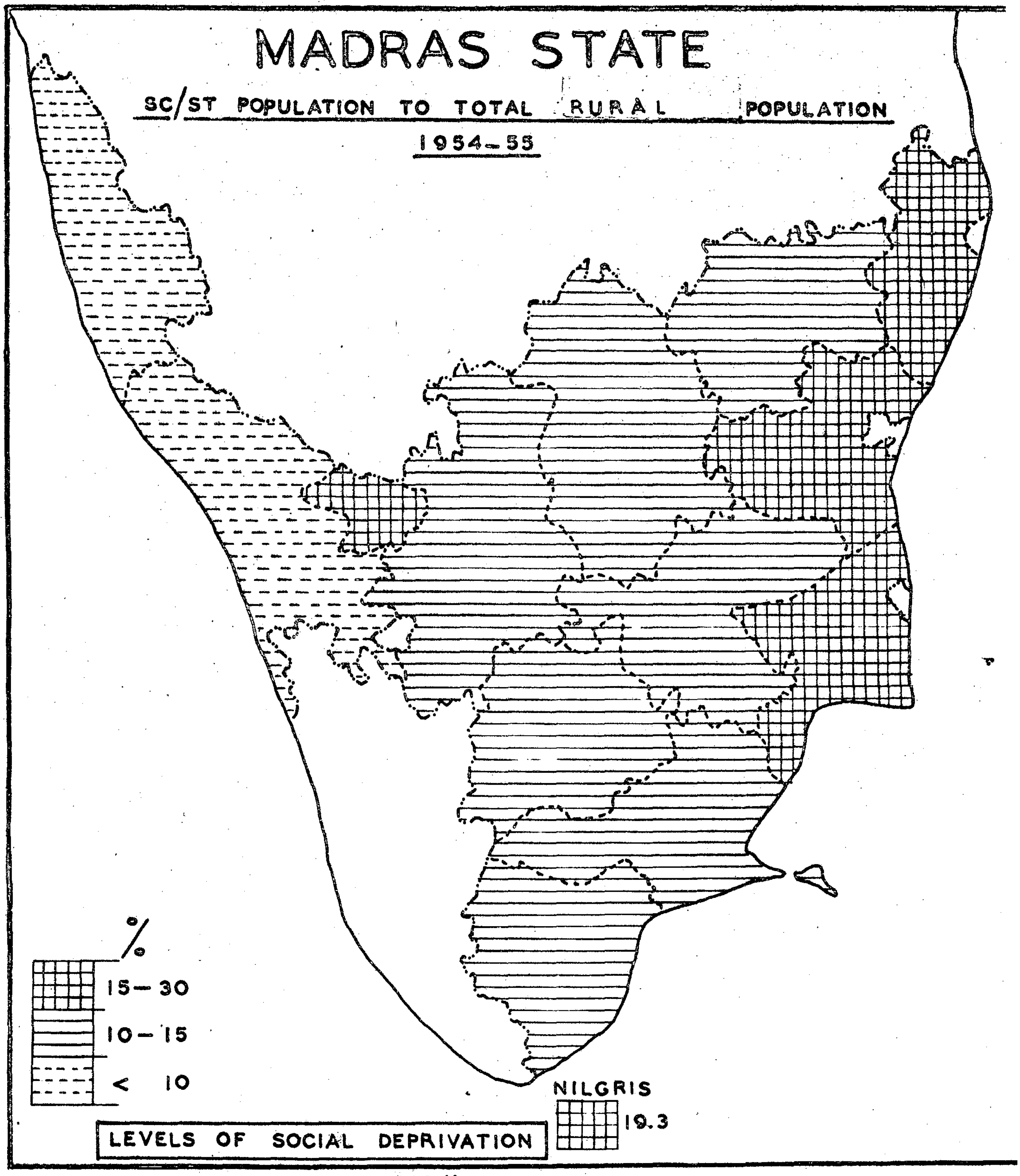

MADRAS STATE
SC/ST POPULATION TO TOTAL RURAL POPULATION
1954-55
%
15-30
10-15
< 10
NILGRIS
19.3
LEVELS OF SOCIAL DEPRIVATION

FIG.11

There are five districts with productivity above the state mean (410.54). South Arcot, which ranked first in 1954-55, grades down to the sixth place in this period. Salem and Ramanathapuram maintain their low level of productivity. Coimbatore, Tanjavur, North Arcot and Tiruchirappalli remain almost in the same level as in 1954-55. Madurai improves its status.

(c) 1969-70

The Fig.21 clearly shows that the productivity variations among the districts remain almost the same. Barring Coimbatore, which tops the list with a productivity of Rs.626.76 per hectare, the productivity gradually falls down from Rs.481.29 (Kanyakumari) to Rs.228.96 (Dharmapuri). Kanyakumari and Coimbatore have alternated their places between 1964-65 and 1969-70. The newly-formed Dharmapuri district takes the place of Ramanathapuram to get the last place. Six districts lie above the state's mean. The dry districts - Salem, Ramanathapuram and Dharmapuri, are, as expected, having a low level of productivity.

On the whole, no distinct pattern of productivity distribution emerges from the maps in any one of the time-periods. However, generally the well-known dry districts of the state have low productivity. Coimbatore and Tanjavur maintain a high level of productivity at all the three points of time.

4.2 Soil Rating Index

The Soil Rating Index adopted in this study represents a normal fertility of the soil in an area and so the same index value is used for all the three points of time. As seen in Fig.6, major portion of the state is placed with a fairly high soil fertility.

Table No. III

SOIL RATING INDEX

	1954-55	1964-65	1969-70
Range	22.60	22.60	22.60
Mean	72.98	72.61	72.95
Standard Deviation	6.91	6.55	6.38
Coeff. of Variation-%	9.58	9.02	8.74
No.of dts. above mean	6	7	7

The Soil Rating Index ranges from 77.00 to 54.40, except the single case of South Kanara, which has an index of 81.20 in 1954-55. The coefficient of variation is fairly low, below 10 per cent in all the years. South Kanara, Coimbatore, Tanjavur, Madurai, Tirunelveli, Salem, Kanyakumari and Dharmapuri districts show a fertility above the state mean. Chingleput, Tiruchirappalli and Malabar have just the

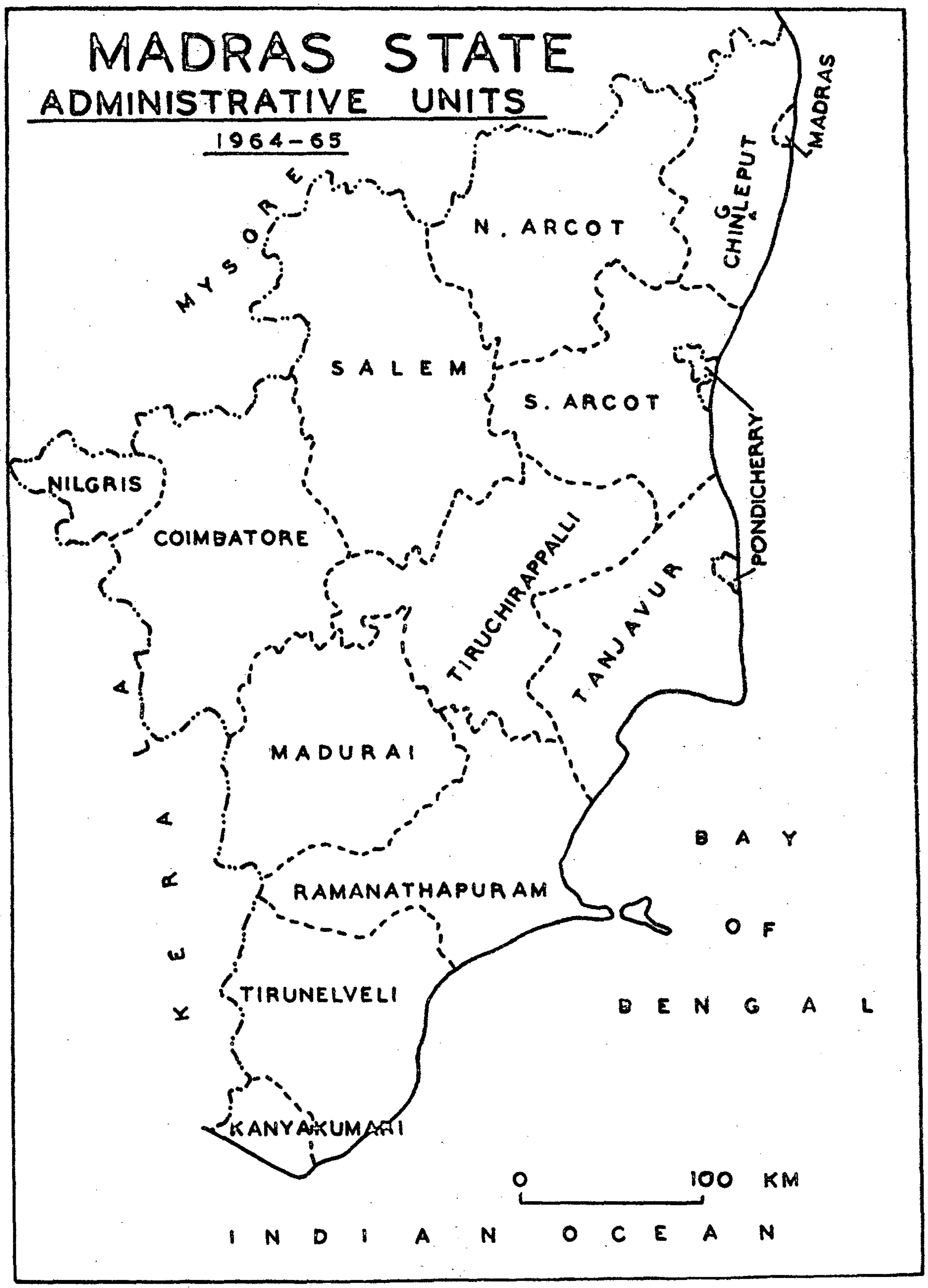
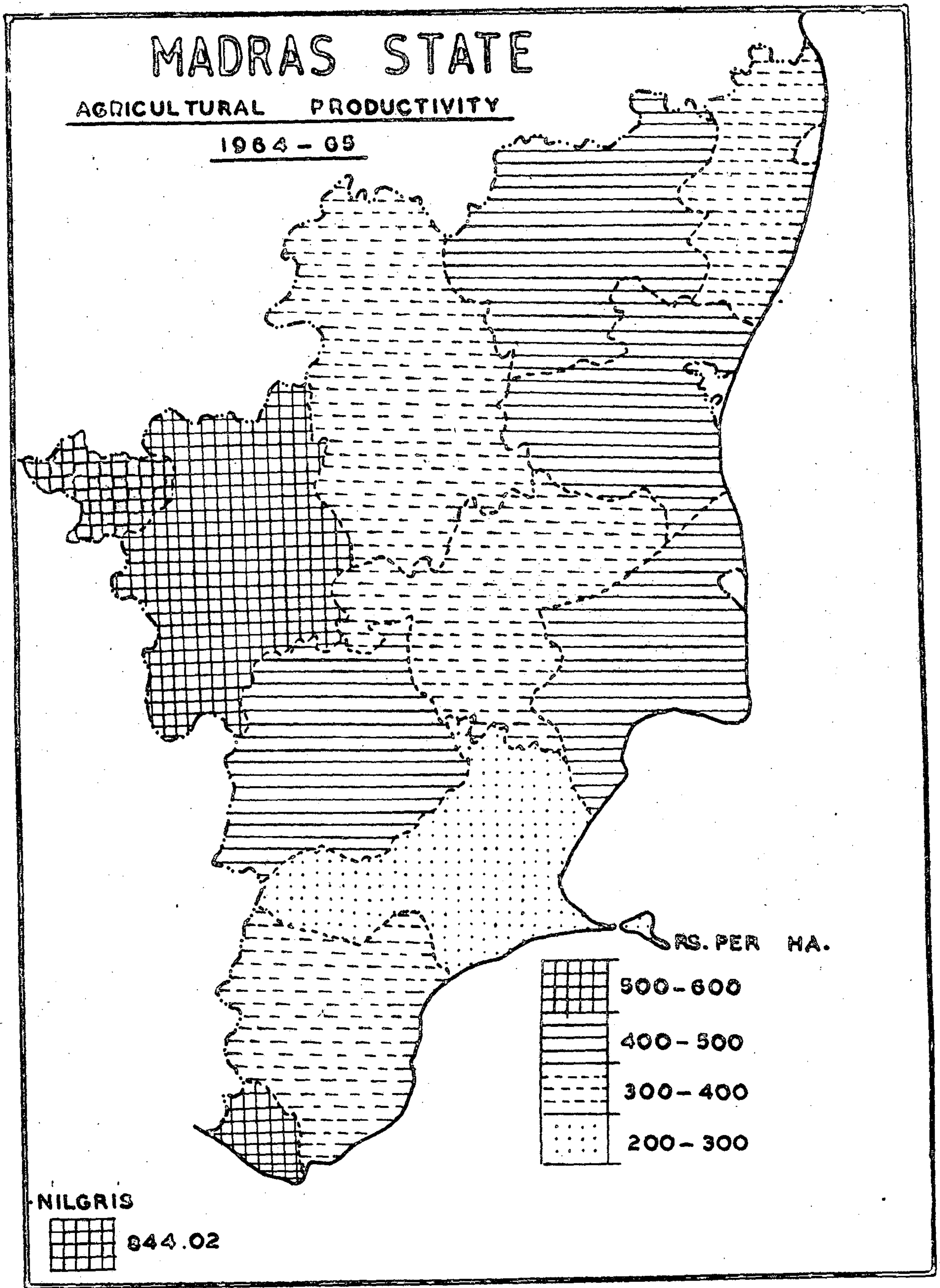

MADRAS STATE
ADMINISTRATIVE UNITS
1964-65
MYSORE
N. ARCOT
CHINGLEPUT
MADRAS
SALEM
S. ARCOT
PONDICHERRY
NILGRIS
COIMBATORE
TIRUCHIRAPPALLI
TANJAVUR
MADURAI
KERALA
RAMANATHAPURAM
TIRUNELVELI
KANYAKUMARI
BAY OF BENGAL
0 100 KM
INDIAN OCEAN

FIG. 12


MADRAS STATE
AGRICULTURAL PRODUCTIVITY
1964 - 65
RS. PER HA.
500-600
400-500
300-400
200-300
NILGRIS
844.02
FIG. 13

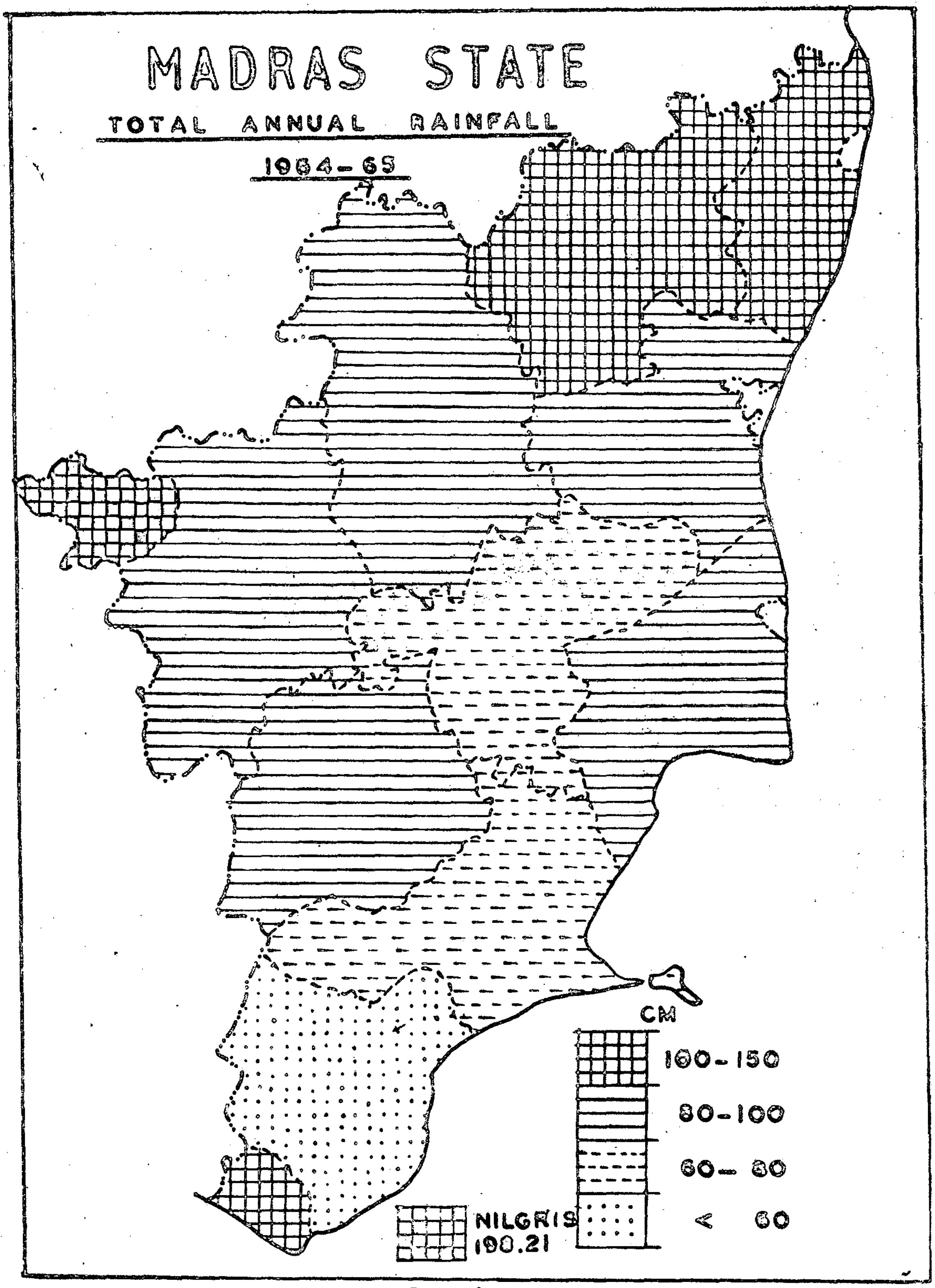

MADRAS STATE
TOTAL ANNUAL RAINFALL
1964-65
CM
100-150
80-100
60-80
< 60
NILGRIS
190.21

FIG.14

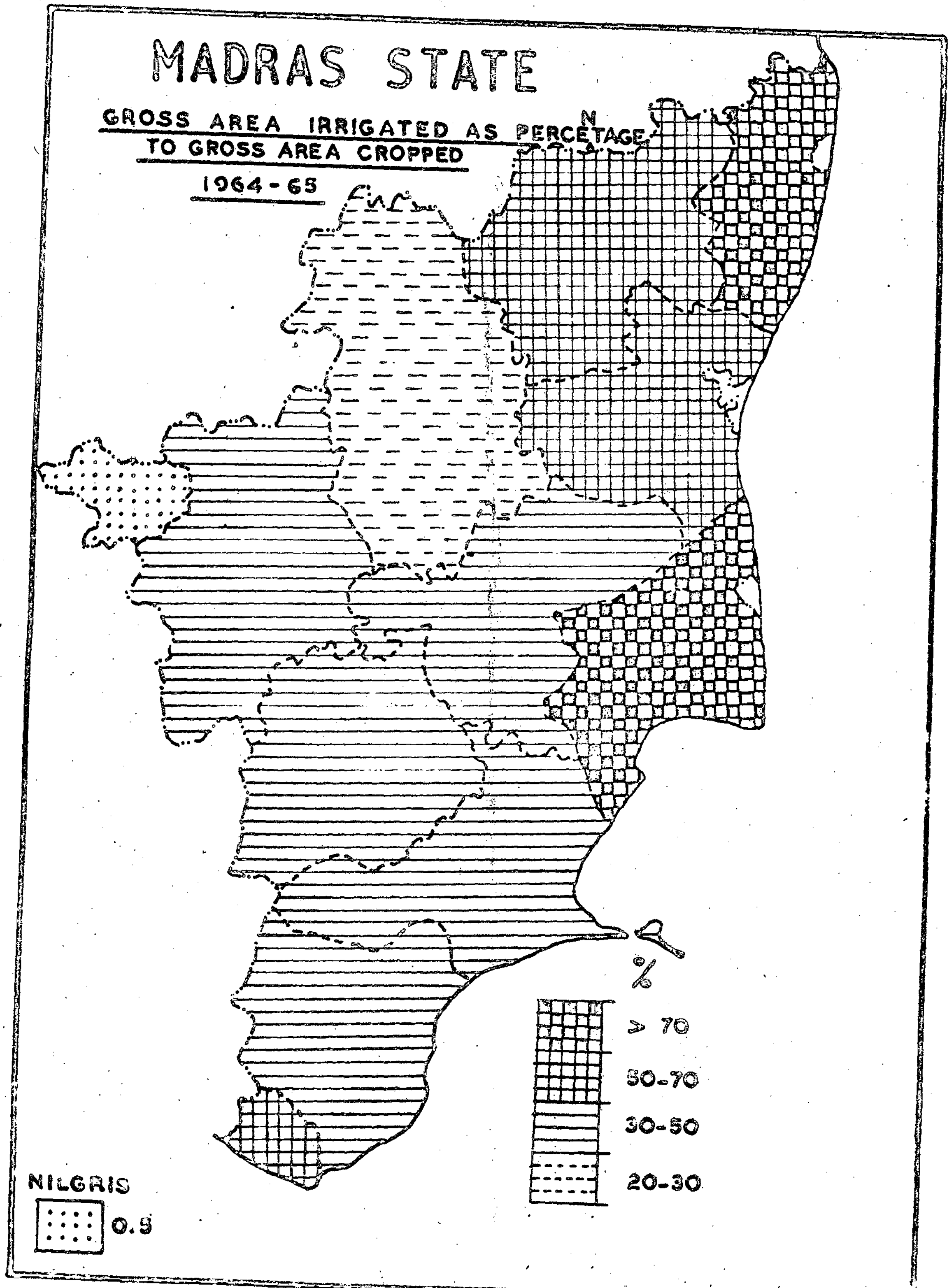

MADRAS STATE
GROSS AREA IRRIGATED AS PERCETAGE TO GROSS AREA CROPPED
1964-65
N
%
> 70
50-70
30-50
20-30
NILGRIS
0.5

FIG.18

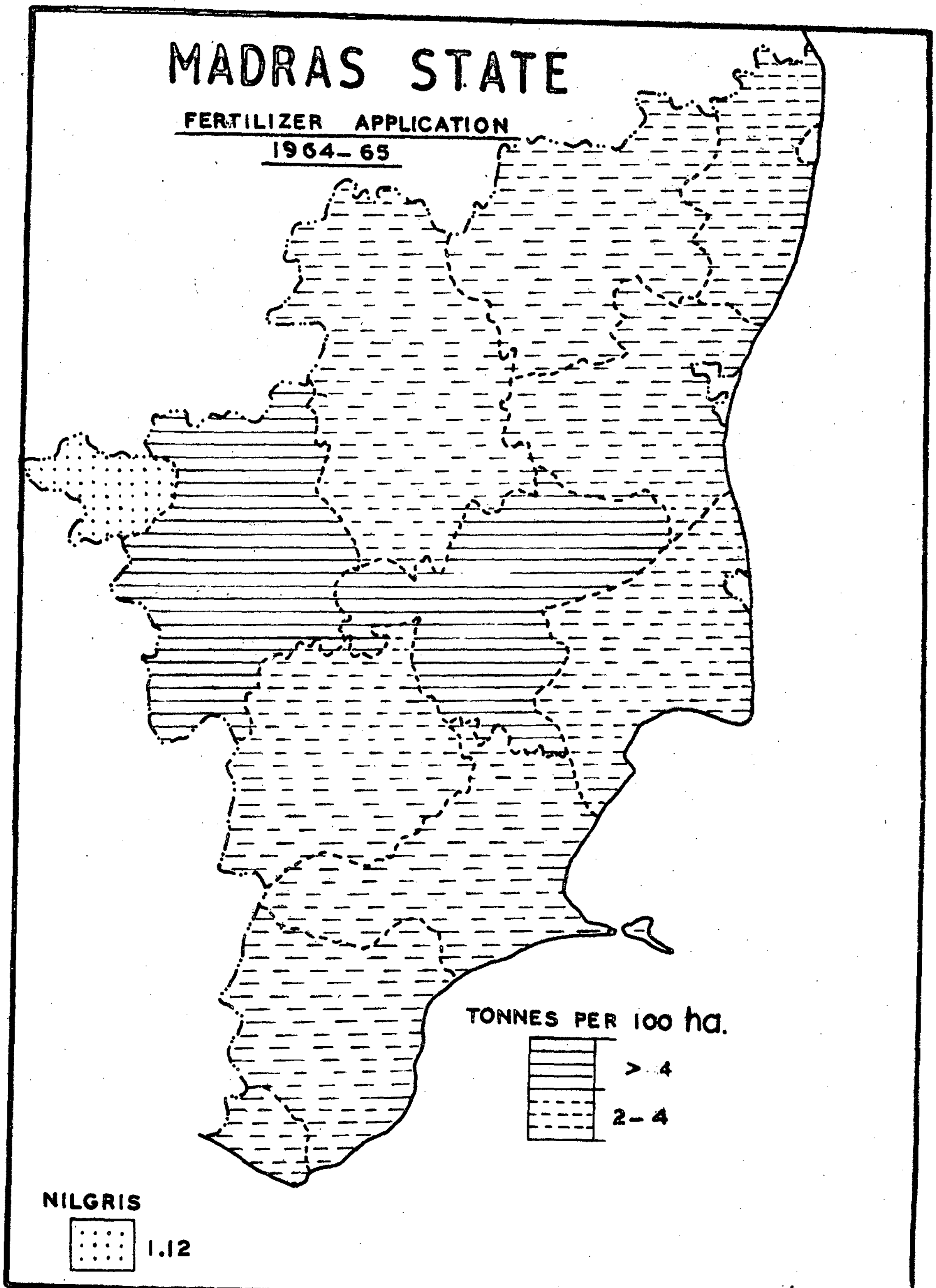

MADRAS STATE
FERTILIZER APPLICATION
1964-65
TONNES PER 100 ha.
> 4
2-4
NILGRIS
1.12

FIG.16

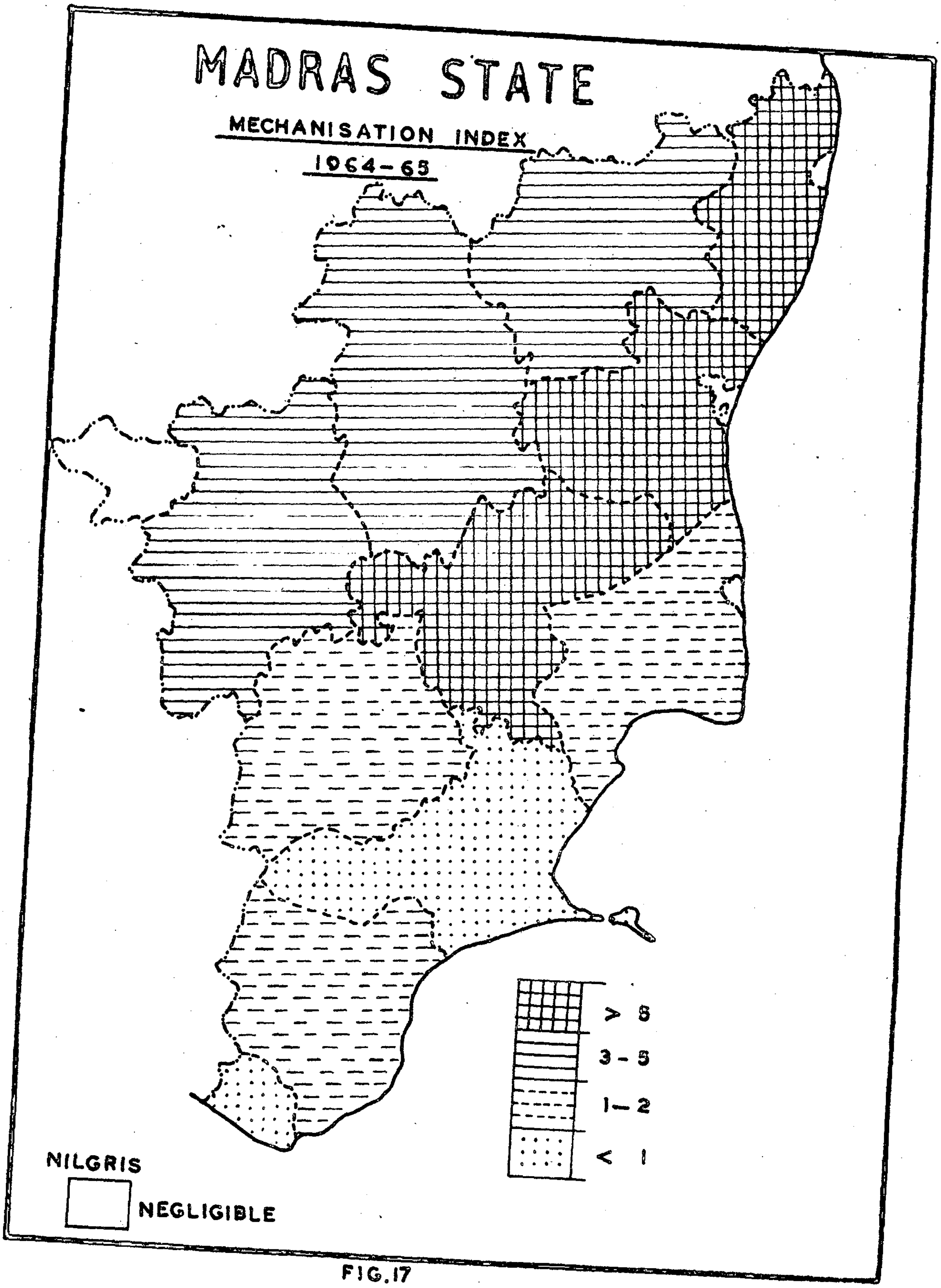

MADRAS STATE
MECHANISATION INDEX
1964-65
> 5
3 - 5
1 - 2
< 1
NILGRIS
NEGLIGIBLE

FIG. 17

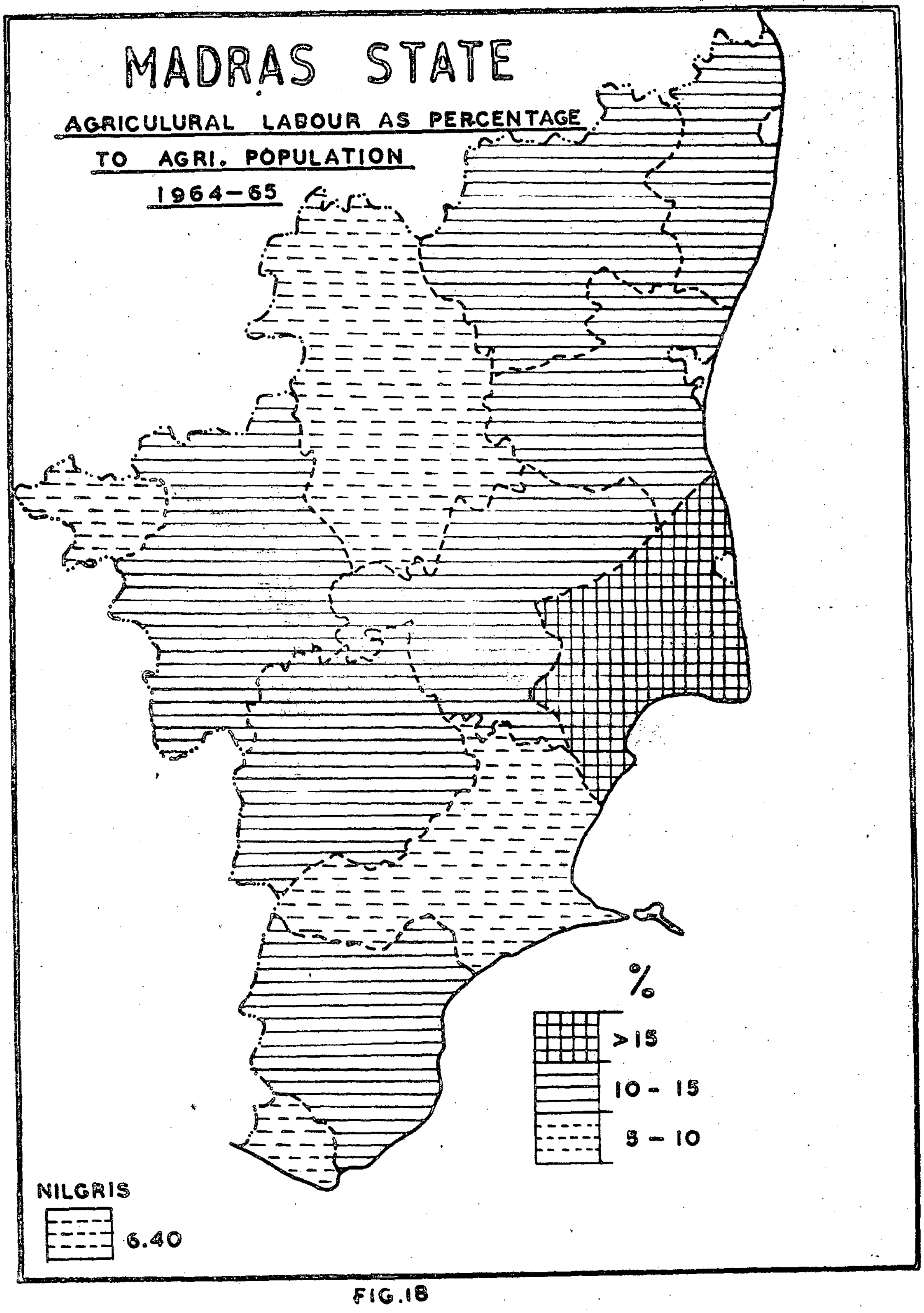

MADRAS STATE
AGRICULURAL LABOUR AS PERCENTAGE
TO AGRI. POPULATION
1964-65
%
>15
10 - 15
5 - 10
NILGRIS
6.40

FIG.18

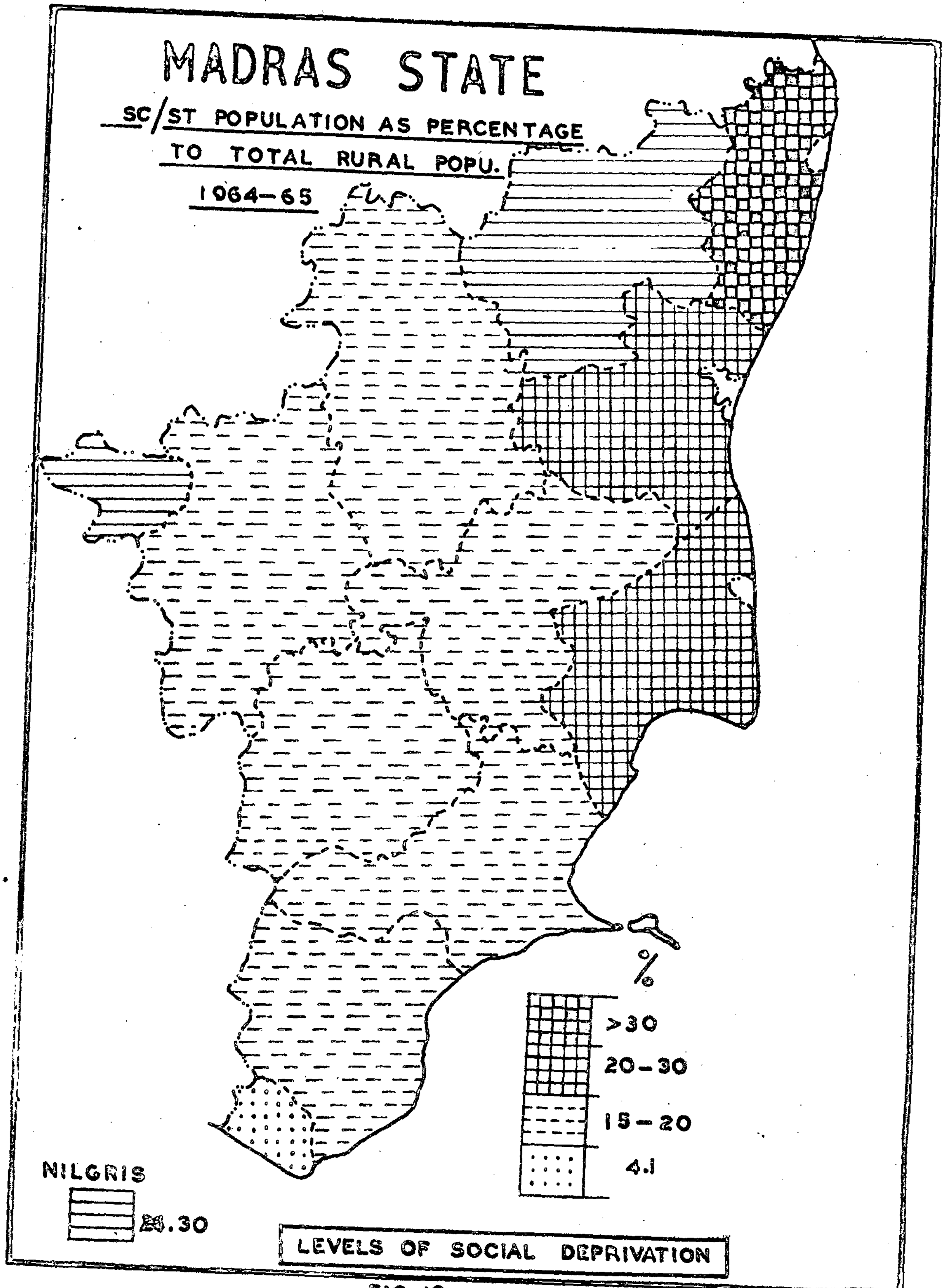

MADRAS STATE
SC/ST POPULATION AS PERCENTAGE
TO TOTAL RURAL POPU.
1964–65
%
>30
20–30
15–20
4.1
NILGRIS
.30
LEVELS OF SOCIAL DEPRIVATION

FIG. 19

mean index. Coimbatore, Madurai and Tirunelveli, with red soil as predominant one which is better placed in the content of chemical nutrients, are seen with high index values. Salem, with its red sandy soils and Tanjavur, with deltaic alluvial soil, also have a high rating index. For the high values noted above, soil fertility alone cannot be thought to be responsible, but other factors, involved in building up the index, also might have helped.

4.3 Total Annual Rainfall

(a) 1954-55

During 1954-55, annual rainfall highly varies from district to district. It ranges from 471.42 cm. (South Kanara) to 67.31 (Madurai). The western coastal districts, South Kanara and Malabar, get extremely high rainfall. South Kanara receives more than three times the state mean rainfall and Malabar, more than twice the state mean. As a matter of fact, these are the only districts getting rainfall more than the mean. Because of this high value, the coefficient of variation gets inflated to as high as 85.33 per cent. Omitting these two districts, the coefficient of variation calculated for the rest of ten districts comes down as low as 26.80 per cent.

It is just one-third of the coefficient of variation obtained with the inclusion of South Kanara and Malabar. Based on the mean for the last ten districts (97.40), northeastern coastal districts, as seen in Fig.7, Chingleput, North Arcot, South Arcot and Tanjavur fare well. All the southern districts, the districts in the western plateau and Tiruchirappalli get rainfall less than the mean.

Table No.IV
TOTAL ANNUAL RAINFALL

	1954-55	1964-65	1969-70
Range	404.11	83.29	67.45
Mean	149.69	87.92	106.67
Standard Deviation	127.52	20.80	24.98
Coeff. of Variation-%	85.33	23.66	23.42
No.of dts. above mean	2	5	5

(b) 1964-65

During this period rainfall varies from 135.43 cm. (Kanyakumari) to 52.14 cm. (Tirunelveli). The coefficient of variation is 23.66 per cent. Six districts experience rainfall more than the mean (87.92). South Arcot (86.88) and Tanjavur (85.27) get little less than the mean. The southern two districts, Ramanathapuram and Tirunelveli, get low rainfall. In this year, along with the northeastern coastal districts, the plateau region also has fairly

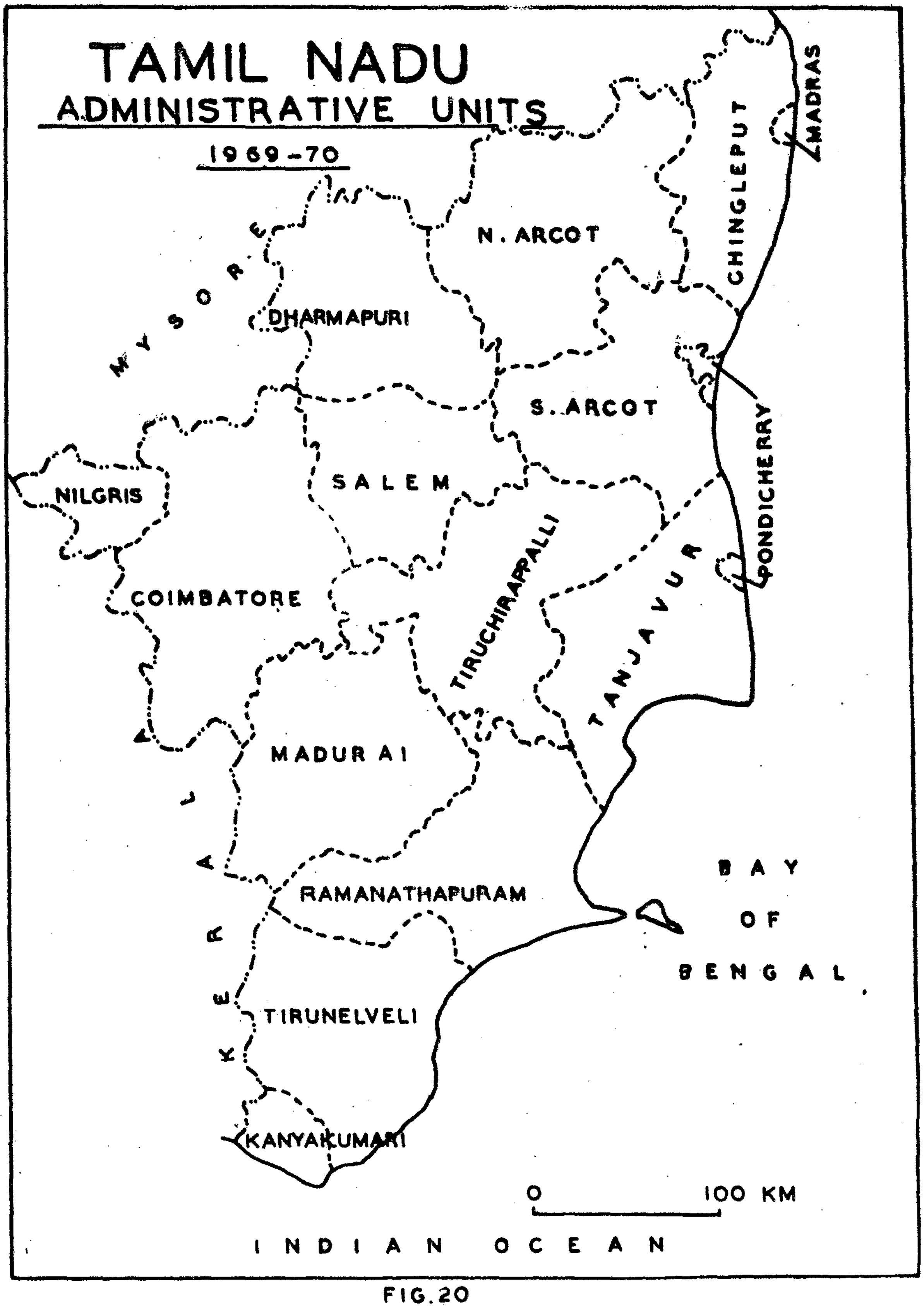

TAMIL NADU
ADMINISTRATIVE UNITS
1969-70
MADRAS
CHINGLEPUT
N. ARCOT
MYSORE
DHARMAPURI
S. ARCOT
PONDICHERRY
SALEM
NILGRIS
TIRUCHIRAPPALLI
TANJAVUR
COIMBATORE
MADURAI
KERALA
RAMANATHAPURAM
BAY OF BENGAL
TIRUNELVELI
KANYAKUMARI
0 100 KM
INDIAN OCEAN

FIG.20

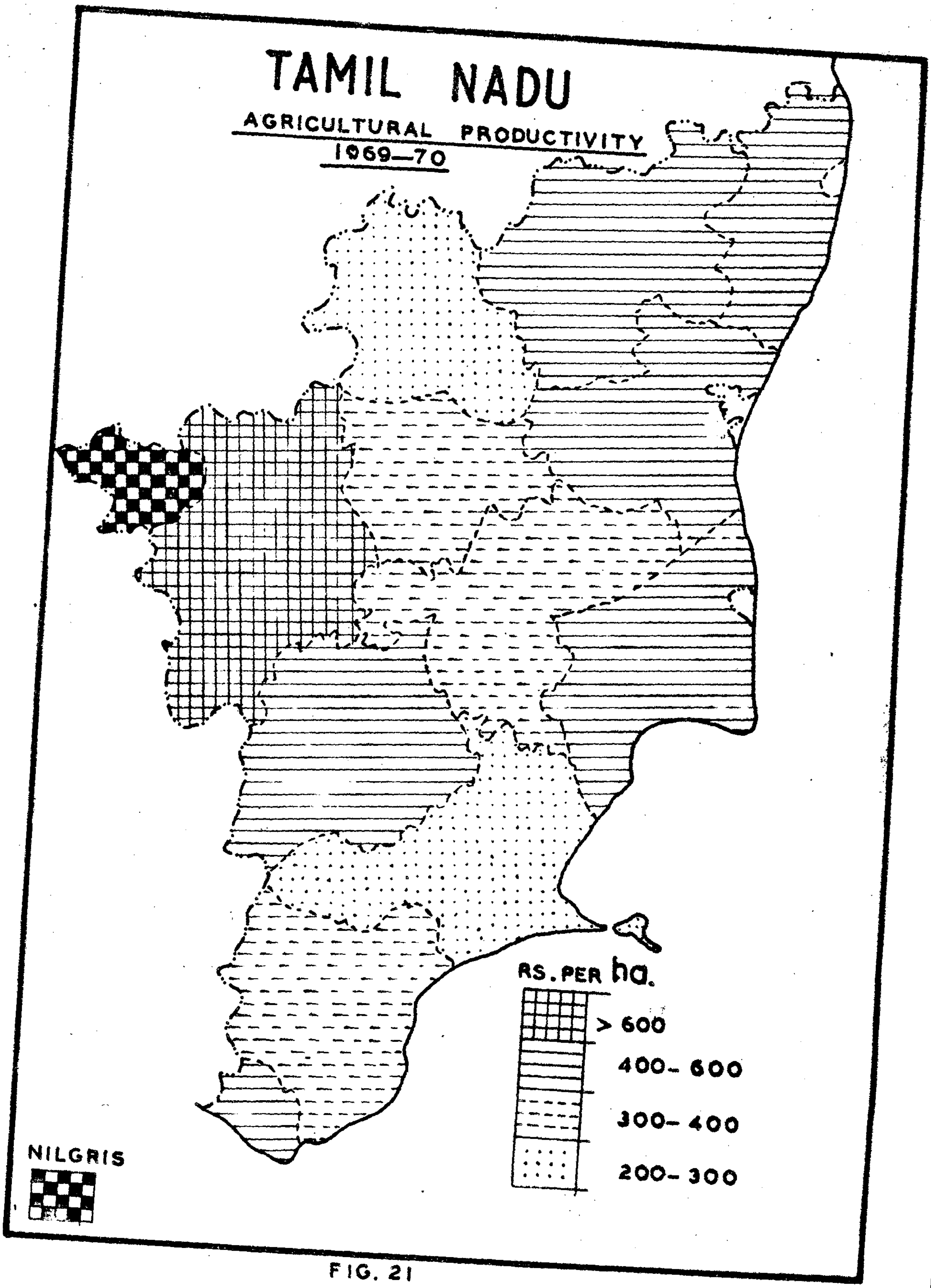

TAMIL NADU
AGRICULTURAL PRODUCTIVITY
1969—70
RS. PER ha.
> 600
400- 600
300- 400
200- 300
NILGRIS

FIG. 21

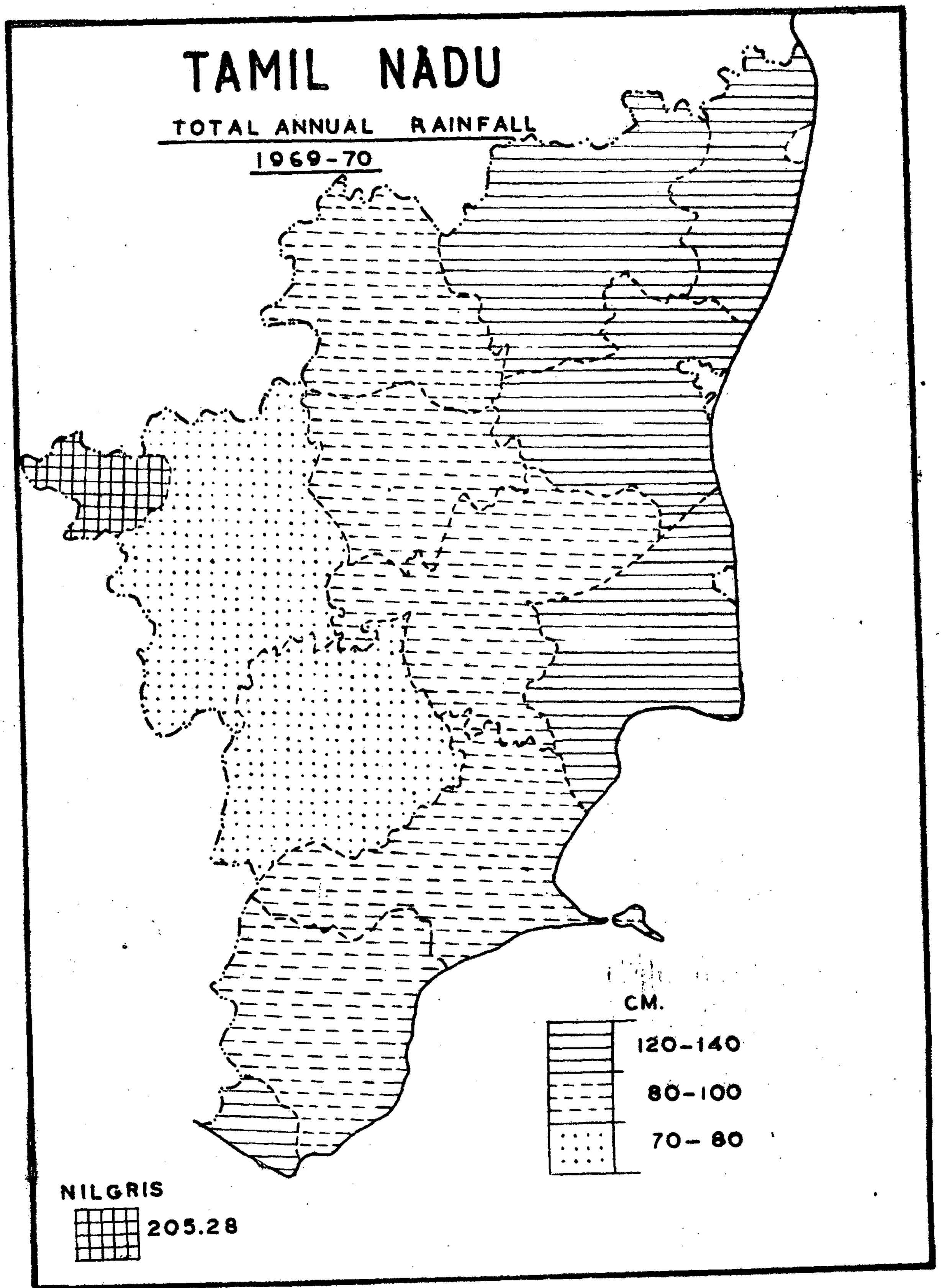

TAMIL NADU
TOTAL ANNUAL RAINFALL
1969-70
CM.
120-140
80-100
70-80
NILGRIS
205.28

FIG. 22

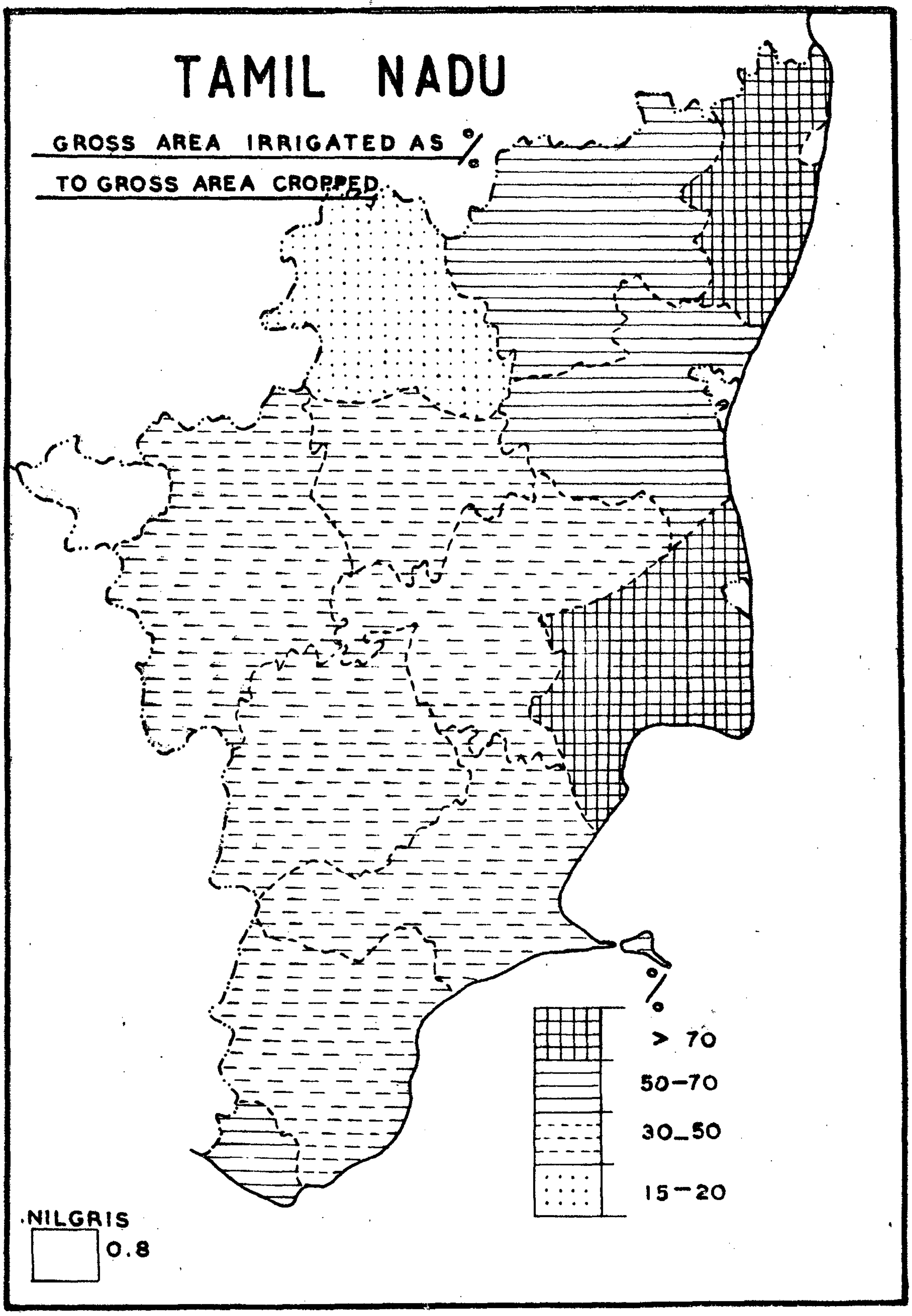

TAMIL NADU
GROSS AREA IRRIGATED AS %
TO GROSS AREA CROPPED
%
> 70
50-70
30_50
15-20
NILGRIS
0.8

FIG.23

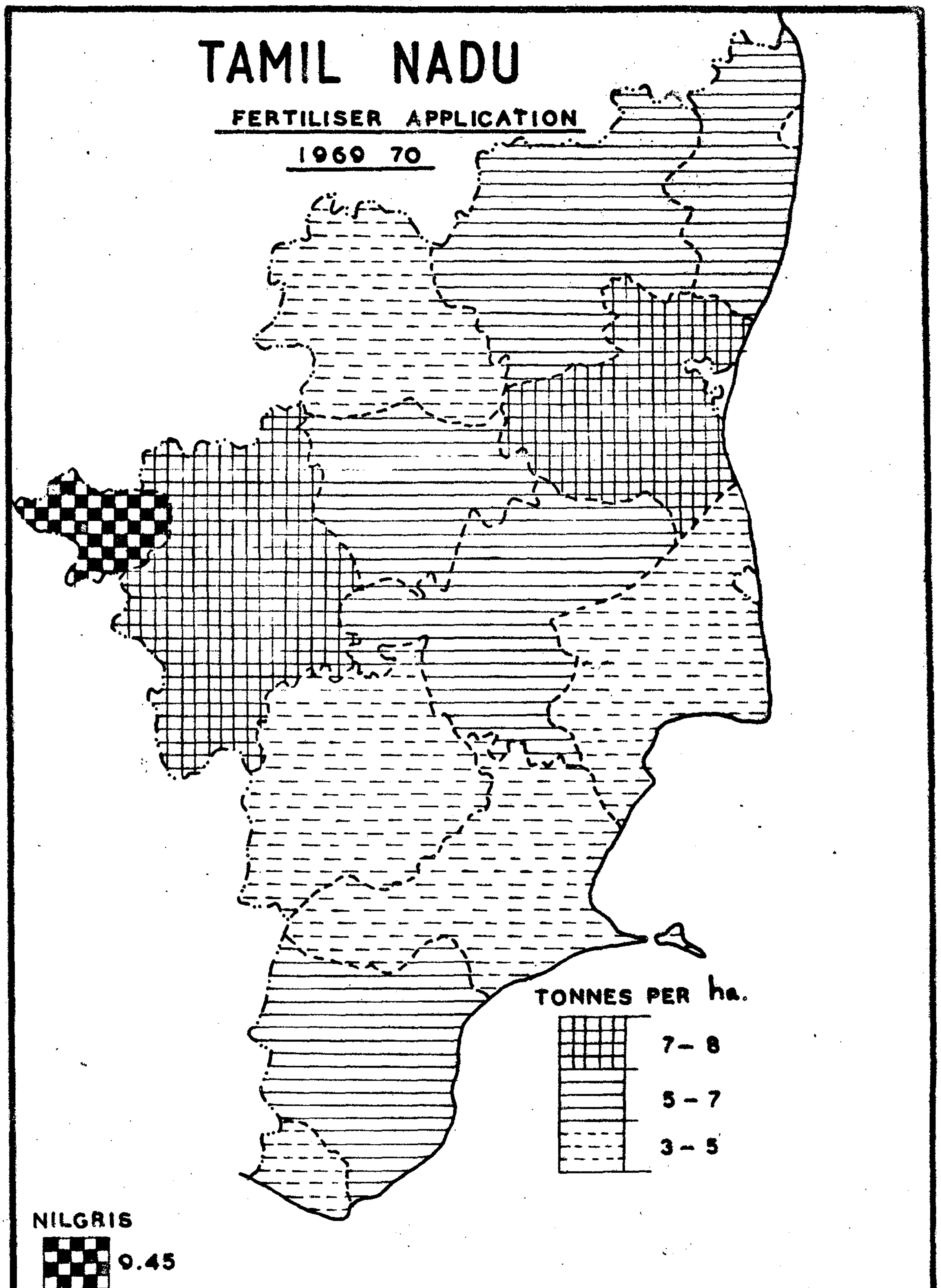

TAMIL NADU
FERTILISER APPLICATION
1969 70
TONNES PER ha.
7 – 8
5 – 7
3 – 5
NILGRIS
0.45

FIG. 24

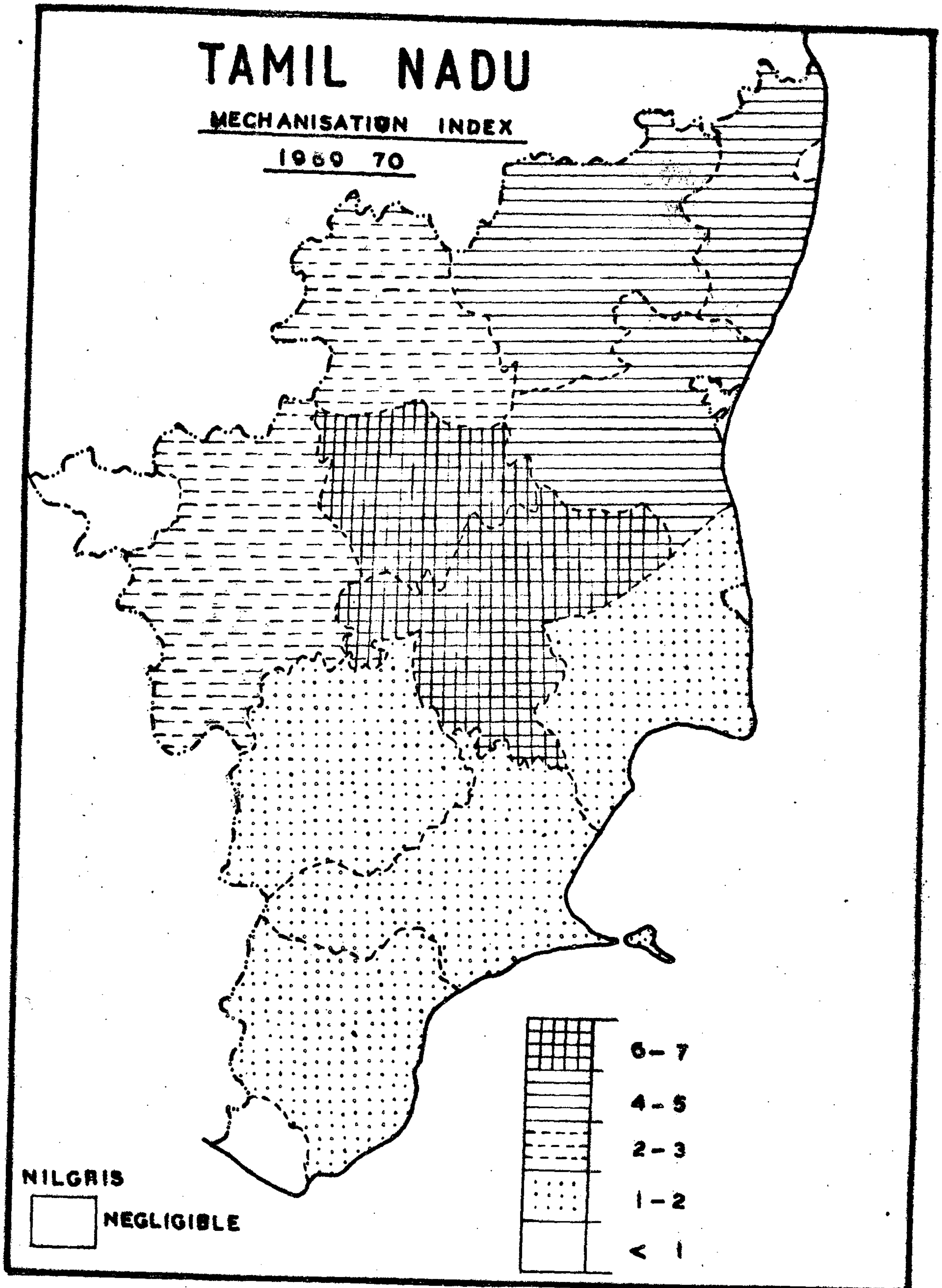

TAMIL NADU
MECHANISATION INDEX
1960 70
6 - 7
4 - 5
2 - 3
1 - 2
< 1
NILGRIS
NEGLIGIBLE

FIG. 25

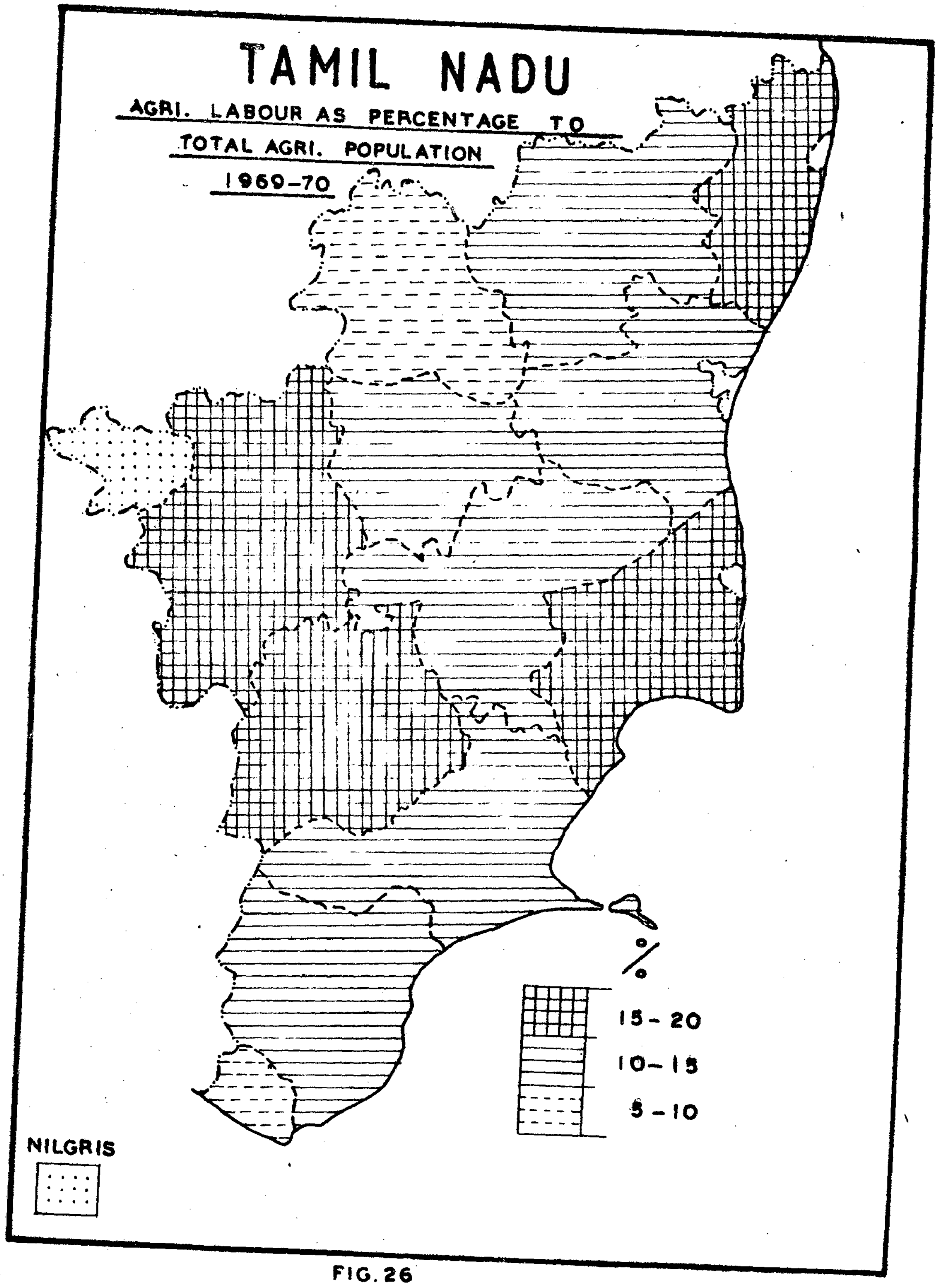

TAMIL NADU
AGRI. LABOUR AS PERCENTAGE TO
TOTAL AGRI. POPULATION
1969-70
%
15- 20
10- 15
5 - 10
NILGRIS

FIG. 26

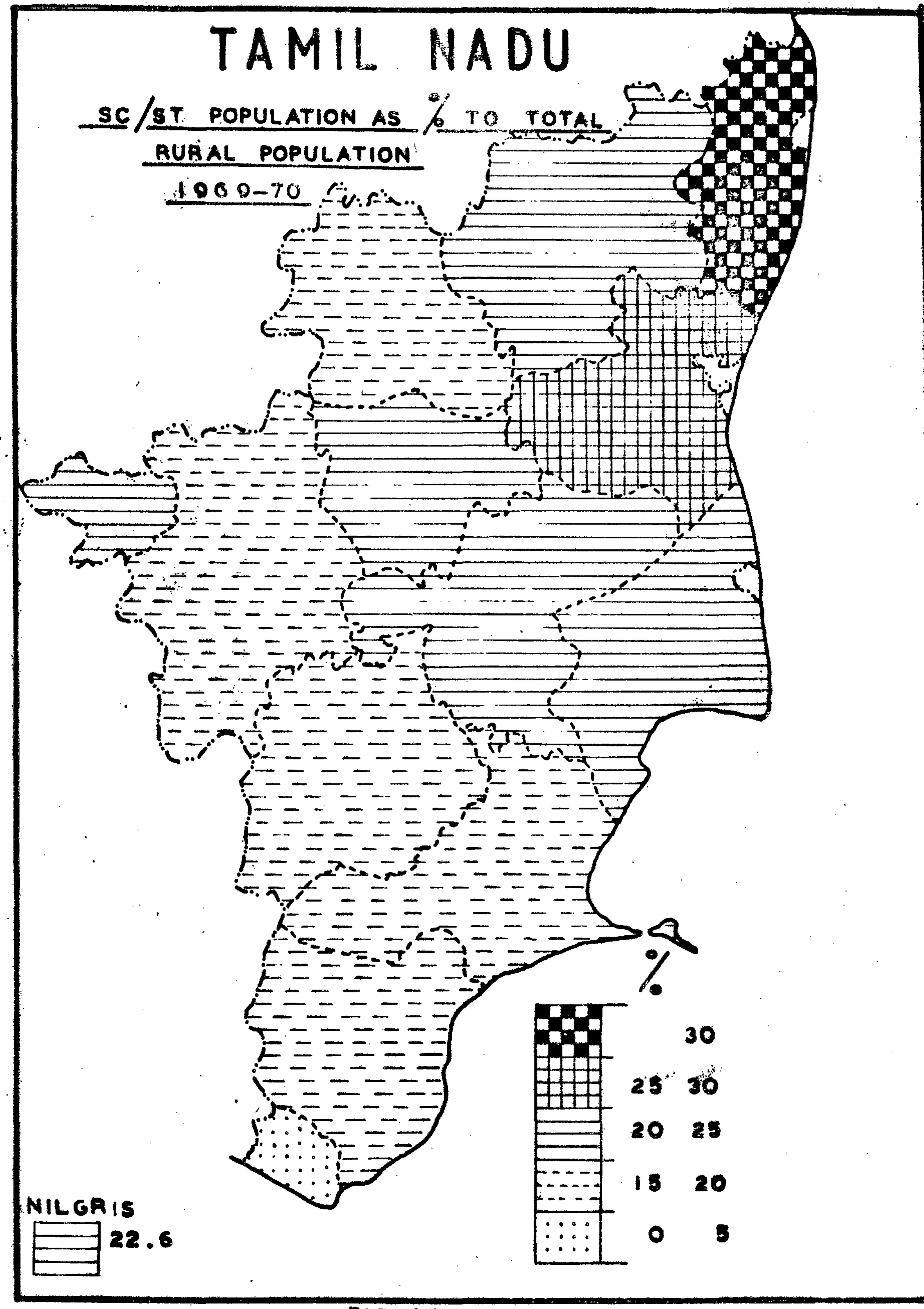

TAMIL NADU
SC/ST POPULATION AS % TO TOTAL
RURAL POPULATION
1969-70
%
30
25 30
20 25
15 20
0 5
NILGRIS
22.6

FIG. 27

heavy rainfall. On the whole, it can be noticed from the Fig.14, that rainfall decreases southward, with an exception of Kanyakumari district, which tops the list and Madurai. Compared to 1954-55, rainfall is less in South Arcot, Tanjavur and Tiruchirappalli, Tirunelveli and Ramanathapuram remain in the same position. Coimbatore, North Arcot, Chingleput and Madurai better their positions.

(c) 1969-70

The coefficient of variation in this period (23.42) almost remains in the same as that of 1964-65. Tanjavur, which finds eigth place in 1964-65, gets first place in 1969-70 with a rainfall of 142.25 cm. Coimbatore gets the lowest rainfall (74.79). Five districts, northern coastal districts and Kanyakumari, receive rainfall above the mean and the remaining seven districts, below the mean. Generally, as the Fig.22 indicates, rainfall decreases westward and southward (excluding Kanyakumari). In this period too, Tirunelveli and Ramanathapuram are in the lower category. Compared to 1964-65, South Arcot, Tanjavur and Tiruchirappalli fare better. Coimbatore and Madurai are worst hit.

4.4 Percentage of Irrigated Area

(a) 1954-55

Percentage of irrigation among districts varies much from 79.10 per cent to 2.50 per cent. Irrigated area is more than the average in six districts. It is very near to the mean in Tirunelveli district. Northwestern districts and Tiruchirappalli are with low percentage. Tanjavur, as expected with its well-spread canal irrigation, tops the list with the percentage of as high as 80 per cent. Malabar shows the lowest percentage (2.5%). As rainfall is usually certain and sufficient in the two western coastal districts, the percentage of irrigated area is very low. It can be summarised from the Fig.8, that irrigated area generally decreases towards the northwest.

Table No.V

PERCENTAGE OF IRRIGATED AREA

	1954-55	1964-65	1969-70
Range	76.60	54.60	60.80
Mean	38.32	47.65	45.57
Standard Deviation	20.28	15.15	16.67
Coeff. of Variation-%	52.63	31.81	36.59
No. of dts. above mean	6	5	5

(b) 1964-65

With the exclusion of South Kanara and Malabar, the variations get reduced in this time-period. The coefficient of variation comes down to 31.80 per cent from 52.63 as in 1954-55. The percentage of irrigation varies from 78.40 (Tanjavur) to 23.80 (Salem). Five districts, including the newly-formed district of Kanyakumari, are above the mean and the remaining six districts are below the mean. The high percentage is found in the north-eastern coastal districts and the southernmost district (Fig.15). It is generally found where canal and well irrigations are dominant. Low percentage is found where generally rainfall is low and tank irrigation, that depends on rainfall, is either dominant or shares considerably.

(c) 1969-70

The variations are slightly increased in 1969-70. The coefficient of variation is 36.59 per cent. The 1964-65 pattern continues in this period too (Fig.23). The same five districts, four north-eastern coastal districts and the southern-most Kanyakumari district continue to be in the above mean category. Dharmapuri, newly carved out from Salem district, reads the lowest. It is in the northern part of Salem of 1964-65, where the rainfall is meagre and well-irrigation is also highly limited as the water table is very low.

4.5 Fertilizer Consumption

(a) 1964-65

The variations in the fertilizer consumption among the districts are fairly high. The fertilizer consumption ranges from 4.56 tonnes (Coimbatore) to 1.93 tonnes (Tanjavur), average being 3.78 tonnes per 100 hectare. The coefficient of variation is 25.14 per cent. Only two districts, Coimbatore and Tiruchirappalli apply fertilizer more than the state mean. Coimbatore, where cultivation of cash crops like cotton, sugarcane and tobacco, is considerably in larger area and the average land-holding

Table No.VI
FERTILIZER CONSUMPTION

	1954-55	1964-65	1969-70
Range		2.63	4.27
Mean	No	3.78	5.71
Standard Deviation	Data	0.80	1.37
Coeff. of variation-%		25.14	24.07
No. of dts. above mean		2	6

per a cultivating household is fairly high (of course, highest in the state), tops the list. Tanjavur is at the bottom of the list. This low consumption is mainlydue to the large percentage of irrigated area. The percentage of irrigated area in Tanjavur is almost twice that of Coimbatore. South Arcot, Salem and Kanyakumari have a consumption level very near to the mean. Excluding Kanyakumari, as seen in Fig.16, South Tamil Nadu where irrigation is also low, consumes less dosage of fertilizer.

(b) 1969-70

Fertilizer consumption has increased considerably - almost doubled - from that of 1964-65. But the variations in it among the districts almost remain the same, the coefficient of variation being 24.07 per cent. The fertilizer application ranges from 8.09 tonnes per 100 hectare (South Arcot) to 3.82 tonnes (Dharmapuri), with a mean of 5.71 tonnes per 100 hectare. The number of districts above the mean have increased to six including all the northern districts (Fig.24), except Tanjavur and Dharmapuri. Coimbatore is pushed down to the second place by South Arcot, which tops in the fertilizer consumption. It is interesting to note that North Arcot, which comes last but one in 1964-65, gets third place in 1969-70. Tanjavur district fares better and Kanyakumari comes down to ninth place. Dharmapuri and Ramanathapuram, the two dry districts of Tamil Nadu, show low consumption of fertilizer.

4.6 Index of Mechanisation

(a) 1954-55

The mechanisation index widely varies among districts. It ranges from 7.71 (Chingleput) to 0.66 (Malabar), with a mean of 3.04. The coefficient of variation is as high as 66.66 per cent. Five districts, northeastern coastal districts of Chingleput and

and Arcots and the interior districts of Coimbatore and Madurai (Fig.9), stand above the mean. All the southern districts, except Madurai, the north central districts and Tanjavur and the western coastal districts are less progressive in mechanisation. As the cultivation is assured with canal irrigation and

Table No. VII
MECHANIZATION INDEX

	1954-55	1964-65	1969-70
Range	7.05	5.73	6.77
Mean	3.04	3.16	3.25
Standard Deviation	2.32	1.89	2.19
Coeff. of variation-%	66.66	60.01	67.65
No.of dts. above mean	5	6	6

tenant-cultivation is dominant,[1] Tanjavur comes out to be the last but one in mechanisation. South Kanara and Malabar are also poor in mechanisation, as they are assured with rainfall.

(c) 1964-65

The variations in mechanisation is still high among the districts, the coefficient of variation being 60.01 per cent. The mechanisation index varies from 6.19 (Chingleput) to 0.46 (Kanyakumari) with a mean of 3.16. Six districts get more than

1. According to 1961 Census General Report, Vol.IX, Part IA.II, p.469, 33.6% of rural households do cultivation in the lands of others in Tanjavur district. It is highest in the state. (For details, see Appendix-X)

the mean index value. Chingleput keeps its first place. Salem and Tiruchirappalli are entered into this above-mean category and Madurai gets down to eigth place. Generally, the mechanisation index decreases southward, as seen in Fig.17. All the southern districts and Tanjavur are poor in mechanisation. Dry Ramanathapuram and agriculturally developed Kanyakumari districts show a very low mechanisation index.

(c) 1969-70

The variations in mechanisation get increased in this time-period. The coefficient of variation increases to 67.65 per cent. The index ranges from 6.78 (Salem) to Kanyakumari (0.01), giving out a mean of 3.25. The same six districts, as come out during 1964-65, remain to be above the mean and the remaining six districts, below the mean. But the positions are much changed. Salem rises to first place and Chingleput goes down to third place. There is no change in the positions of districts of low level of mechanisation (Fig.25). The newly-formed Dharmapuri district finds a place just above Tanjavur.

4.7 <u>Proportion of Agricultural Labourers</u>

(a) 1954-55

The percentage of agricultural labourer varies from 45.36 (Malabar) to 19.54 (Ramanathapuram)

Six districts are above the mean (29.51%) and the remaining six districts below the mean (Fig.10).

Table No. VIII

PROPORTION OF AGRICULTURAL LABOURERS

	1954-55	1964-65	1969-70
Range	25.82	24.22	34.63
Mean	29.51	37.16	45.92
Standard Deviation	8.18	7.73	9.84
Coeff. of variation-%	26.66	20.80	21.43
No.of dts. above mean	6	7	6

Large percentage is generally found in the agriculturally intensive areas, which show high productivity too.

(b) 1964-65

The pattern of 1954-55 continues in this time-period too. The variations among the districts go down; the coefficient of variation is 20.80 per cent. Seven districts have agricultural labour-force above the mean (37.16%). The central belt of the state (Fig.18) including North Arcot, Salem, Tiruchirappalli and Ramanathapuram is below the mean. Tirunelveli improved its percentage and ranks in the above-average category.

(c) 1969-70

The variations among the districts get slightly increased; the coefficient of variation is

21.43 per cent. Six districts fare above the mean (45.92%) and other six districts below the mean. South Arcot ranks down to the below mean category, yet it is just near to the mean. Kanyakumari gets the first place with 60.91 per cent of the agricultural labour force and the newly-formed Dharmapuri district attains the last place with 26.28 per cent; much below the mean. Dry districts like Ramanathapuram, Salem, Dharmapuri (Fig.26) are found with low percentage. At the same time, the intensive agricultural districts of North Arcot and Tiruchirappalli too get low percentage.

4.8 Proportion of Scheduled Castes and Tribes

(a) 1954-55

The variations in the percentage of Scheduled Castes and Scheduled Tribes among the districts are fairly high, the coefficient of variations being 35.29 per cent. The percentage of Scheduled Castes and Tribes ranges from 7.10 per cent (South Kanara) to 28.60 per cent (Chingleput). As seen in Fig.11, five districts, northeastern coastal districts and Tiruchirappalli, are bestowed with the Scheduled Castes and Tribes above the state mean (16.81). All the western and southern districts are in the below-average category.

(b) 1964-65

The variations are still strong. The coefficient of variations is 34.31 per cent. The percentage of Scheduled Caste and Scheduled Tribe varies from 32.30 (Chingleput) to 4.10 (Kanyakumari), with a mean of 20.46 per cent. Only four districts,

Table No.IX
PROPORTION OF SCHEDULED CASTES AND TRIBES

	1954-55	1964-65	1969-70
Range	21.50	28.20	28.80
Mean	16.81	20.46	20.20
Standard Deviation	6.03	7.02	6.84
Coeff. of variation-%	35.29	34.31	33.89
No. of dts. above mean	5	4	5

northeastern coastal districts (Fig.19), show the percentage above the mean. Tiruchirappalli is very near to the mean. All the southern districts and western districts of Salem and Coimbatore show the percentage less than the mean. Kanyakumari, which ranks first in the productivity gets the last place in the percentage of Scheduled Caste and Tribe population.

(c) 1969-70

The Scheduled Caste and Scheduled Tribe percentage variations continue to be strong, ranging from 32.80 (Chingleput) to 4.00 (Kanyakumari). The coefficient of variation is 33.89 per cent. As seen in Fig.27, northeastern coastal districts and the interior Salem district, have Scheduled Caste and Scheduled Tribe population above the mean percentage (20.20). Tiruchirappalli with its Scheduled Caste and Tribe percentage of 20.10, is very near to the mean. All the southern districts, Coimbatore and the newly-formed Dharmapuri district form the below-mean category. Kanyakumari continues to be the lowest.

CHAPTER FIVE

DETERMINANTS OF AGRICULTURAL PRODUCTIVITY IN TAMIL NADU - A MULTIPLE REGRESSION ANALYSIS

A step-wise regression procedure - a special type of multiple regression analysis - is employed here to get the best possible predictors by which larger part of the variations in productivity can be explained. In the stepwise procedure, a series of intermediate regression equations are obtained, one for each addition of variable, until all variables are added and the final regression equation is reached. The variables are added in order of their improvement to the overall goodness of fit and the intermediate regression equations provide the best values of the coefficients for the specific variables included in the equation. Thus at each step, a regression equation is provided, which is the optimum for the included variables.[1] The cumulative sum of squares of the multiple 'R' and the standard error of the estimate are also provided at each step, thus indicating the variance

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1. D.P. Hauser, "Some Problems in the Use of Stepwise Regression Techniques in Geographical Research," The Canadian Geographer, Vol.XVIII, No.2 (1974), p.148.

included and the confidence limits. The standard error of the estimate for the equation can be treated as a standard deviation and there is a 95 per cent possibility that actual values will differ from the regression values by not more than twice the standard error of the estimate.

5.1 Step-wise Regression Analysis: 1954-55

Six predictors are added and related with the agricultural productivity one by one in the step-wise regression procedure. They are:

X_1 = Soil Rating Index

X_2 = Annual Rainfall in cm.

X_3 = Percentage of Gross Irrigated Area to the Gross Cultivated Area

X_4 = Mechanisation Index

X_5 = Percentage of Agricultural Labourers to the Total Agricultural Population

X_6 = Percentage of Scheduled Castes and Tribes to the Total Rural Population

Y = Agricultural Productivity

The first predictor introduced is the percentage of agricultural labourers to the total agricultural population with which the criterion variable gets the highest correlation of 0.42 (Appendix-XIV). The least important variable that is added lastly is the soil rating index. The order by which the independent variables are added is given in the following table X (for details, see Appendix-XX). The third column shows the variables in order of their goodness of fit; the fourth, the cumulative multiple correlation coefficient. The fifth column gives the square of the multiple correlation coefficient which is equivalent to the proportion of total variance accounted for by the equation. The R^2 is

Table No.X

ORDER OF VARIABLES ADDED

Included Variables	V-	R	$R^2 \times 100$	Increase in $R^2 \times 100$	Std. Error
X_5	1	.419*	17.5	-	149.94
X_5 X_4	2	.529	28.0	10.5	147.65
X_5 X_4 X_3	3	.558	31.2	3.2	153.13
X_5 X_4 X_3 X_6	4	.595	35.4	4.2	158.61
X_5 X_4 X_3 X_6 X_2	5	.598	35.8	0.4	170.76
X_5 X_4 X_3 X_6 X_2 X_1	6	.601	36.1	0.3	186.59

* Significant at 20% level

V- = Variable newly added

1 = Percentage of Agricultural Labourer

2 = Mechanisation Index

3 = Percentage of Irrigated Area

4 = Percentage of Scheduled Castes and Tribes

5 = Total Annual Rainfall

6 = Soil Rating Index

expressed for convenience as a percentage. The sixth column lists the increament of total variance, also expressed in percentage. The last column lists the standard error of the estimate for the equation in that step.

The initial variable accounted for 17.5 per cent of the total variance, the first four together 35.4 per cent and the remaining two add some 0.7 per cent only. Thus only 36.1 per cent of the areal variations in the agricultural productivity over 12 districts is explained by the six independent variables considered here. The overall square of the multiple correlation coefficient is not significant even at 20 per cent level and so also the regression coefficients, except that of percentage of agricultural labourers which is significant at 20 per cent level. Further the standard error of the estimate is fairly high and decreases at the second step only by very small amount. From third step onwards, it starts increasing rapidly. ✓With this overall result, it can well be concluded that the functional relationship between the productivity and the explanatory variables considered here is very weak. This may be due to the following facts: (a) The explanatory variables might not have been sensitive enough to explain the variations in a period (here in the year 1954-55) when the agricultural activities were almost traditional with all social impediments. So, if some of the institutional factors, like size of holding, land-tenure system and farmers' indebtedness and credit facilities, are included in the regression model, the result would have been an encouraging one, (b) The result might have also been affected by the high intercorrelations between irrigation and Scheduled Castes and Tribes (0.83) and between mechanisation and Scheduled Castes and Tribes (0.71); and by the moderate intercorrelations between rainfall and irrigation (-0.52) and between rainfall and Scheduled Castes and Tribes (-0.51).

Thus, no variable add significantly to the R^2; no regression coefficient is significant even at 20 per cent level, except that of agricultural labourer. So, choosing the best set of variables and further analysis are not attempted for the year 1954-55.

5.2 Step-wise Regression Analysis: 1964-65

A step-wise regression is attempted with seven explanatory variables to measure the strength of each variable in explaining the variation in the agricultural productivity. The seven predictors are listed below:

X_1 = Soil Rating Index

X_2 = Total Annual Rainfall in cm.

X_3 = Percentage of Gross Irrigated Area to the Gross Cultivated Area

X_4 = Fertilizer Consumption per 100 hectare of Irrigated Area

X_5 = Mechanisation Index

X_6 = Percentage of Agricultural Labourers to the Total Agricultural Population

X_7 = Percentage of Rural Scheduled Castes and Tribes to the total Rural Population.

The regression procedure starts with the predictor rainfall and ends with the inclusion of fertilizer. Thus rainfall becomes the most important predictor. This fact can be strengthened by the fact that the correlation between the rainfall and the productivity is the highest (0.69) and between the fertilizer and productivity, the lowest (0.13) as seen from the correlation matrix (Appendix-XVI). Further, the partial correlation matrix also shows the least relationship between the latter too (Appendix-XVII).

All the seven independent variables put together explain 88.8 per cent of the areal variations in the productivity among the eleven districts of Madras State. The table (No.XI) gives the results step by step (for details, see Appendix-XXI), as obtained from the step-wise regression procedure.

Table No. XI

ORDER OF VARIABLES ADDED

Included Variables	V-	R	R^2x100	Increase in R^2x100	Std. Error
X_2	X_2	.690*	47.6	-	69.39
X_2 X_1	X_1	.779*	60.8	13.1	63.70
X_2 X_1 X_7	X_7	.825@	68.1	7.3	61.37
X_2 X_1 X_7 X_6	X_6	.896@	82.3	14.2	51.98
X_2 X_1 X_7 X_6 X_5	X_5	.930@	86.6	4.3	47.09
X_2 X_1 X_7 X_6 X_5 X_3	X_3	.941£	88.5	1.9	48.65
X_2 X_1 X_7 X_6 X_5 X_3 X_4	X_4	.942	88.8	0.3	55.57

* Significant at 2.5% level;
@ Significant at 5% level;
£ Significant at 10% level.

V- = Variable newly added.

It is interesting to note in the order of variables added that the first two variables are the environmental factors; the second two variables, the institutional factors; and the last three, the technological factors. The R^2 reveals that the environmental and institutional factors dominate in explaining the variations in the agricultural productivity. The first predictor emplains 47.6 per cent of the total variance, nearly half the variations explained. The first four variables put together account for 82.3 per cent and the remaining three, only 6.5 per cent. The 'R' is highly significant upto fifth step but in the sixth step with the inclusion of irrigation, it is significant only at 10 per cent level. In the last step which includes fertilizer, the result gets insignificant.

Rainfall is positively related, as expected and its regression coefficient is significant at 5 per level. 'R' is significant at 2.5 per cent level. Soil Rating Index is the second predictor added and raises the R^2 to 60.8 per cent. 'R' is still significant at 2.5 per cent level. When rainfall exerts a dominant influence on the productivity, it is quite natural for the soil to follow it, as generally rainfall affects the crop through soil. The third and fourth predictors account for 21.5 per cent of total variations. Though proportion of agricultural labourers is the fourth variable added, its addition to the R^2 of the third step is twice the value by which the third predictor adds to the R^2 of the second step. 'R' is significant at 5 per cent level in both the steps. The last three predictors add little to R^2.

5.2.1 Overall Picture of Regression Coefficients

The table No.XII can very well show the pattern of regression coefficients, as the variables are added one by one. The rainfall, agricultural labour, mechanisation index, irrigation and fertilizer are all positively related with the agricultural productivity, throughout the steps, since their introduction. The

Table No.XII

REGRESSION COEFFICIENTS OF THE VARIABLES STEP-WISE

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Rainfall	2.88*	2.50**	2.13@	1.52£	1.05	0.59	0.72
Soil		4.94£	4.59£	1.68	- 0.65	0.02	00.73
S.C. and S.T.			- 3.57	- 6.44@	-11.44**	-13.22**	-10.91
Agri. Labourer				5.28@	7.85**	5.69	4.55
Mech. Index					18.78£	21.46£	10.86
Irrigation						1.76	2.24
Fertilizer							19.50

* Significant at 2% level
** Significant at 5% level
@ Significant at 10% level
£ Significant at 20% level

Scheduled Castes and Scheduled Tribes are negatively related throughout the steps. Soil introduced as a positive variable in the second step gets negative relationship in the fifth step when mechanisation index is added in the regression model. No variable is significantly related in the last step. Rainfall is significant only in the first two steps. The Scheduled Castes and Tribes are significant at 5 per cent level in the fifth and sixth steps.

5.2.2 Overall Analysis of Residuals

The Table No.XIII indicates the overall picture of the unexplained variations among the districts in each step. For the first three steps, the districts showing the productivity more than estimated one are more in number; and for the remaining four steps, reverse is the case. South Arcot and Coimbatore districts show positive deviations throughout the seven steps. Negative factors are pulling down the productivity throughout the seven steps in Salem. Based on an assumption that the lowest deviation among the seven steps of a district indicate the best possible equation for that district, it is noticed that seven out of eleven districts of Madras State get the best-fit equation within the three steps, involving rainfall, soil and Scheduled Castes and Scheduled Tribes.

Table No. XIII

DISTRIBUTION OF RESIDUALS AMONG DISTRICTS IN EACH STEP

District	Variable Added	Rain-fall	Soil	SC/ST	Agricul-tural Labourer	Mech. Index	Irriga-tion	Ferti-lizer	No. of Steps	
		PERCENTAGE OF RESIDUALS							Nega-tive	Posi-tive
	Step	1	2	3	4	5	6	7		
Chingleput		-23.17	-21.93	- 8.94	-11.09	-15.37	-15.36	-14.10	~~6~~ 7	~~1~~
South Arcot		1.34	3.11	9.65	9.10	5.47	7.49	5.84	-	7
North Arcot		- 6.82	- 1.35	1.56	10.40	15.17	12.33	13.31	2	5
Salem		-32.14	-38.66	-39.65	-19.33	-11.92	- 7.61	- 9.29	7	-
Coimbatore		19.96	16.36	14.33	11.09	4.09	6.76	6.50	-	7
Tiruchirappalli		6.81	5.10	2.38	12.27	2.88	- 2.31	- 1.90	2	5
Tanjavur		10.19	5.13	9.98	- 0.04	5.93	2.72	1.68	1	6
Madurai		1.51	- 3.53	- 4.89	- 7.42	- 3.64	0.58	2.52	4	3
Ramanathapuram		-25.47	3.56	- 3.58	-10.41	- 7.52	- 5.68	- 5.77	6	1
Tirunelveli		16.01	6.43	1.46	- 4.43	- 1.73	- 2.65	- 2.37	4	3
Kanyakumari		8.15	7.49	0.93	- 1.08	- 1.32	- 3.03	- 3.25	4	3
Range of Residuals		52.10	60.59	53.98	31.60	30.54	27.69	27.41		

5.2.3 Identifying the best set of predictors

The best set of independent variables - having strong relationship with dependent variable, has to be picked out from the step-wise regression analysis, to build a best-fit regression model. This has been decided on five founds: (a) R^2; (b) 'F' and 't' tests; (c) colliniarity and multicolliniarity; (d) the distributional pattern of the residuals; and (e) some personal judgements.

(a) The first four variables explains 82.3 per cent of the variations and the remaining three variables add little to the total R^2, only 6.5 per cent.

(b) 'R' is highly significant upto fourth step; and moderately significant in its fourth and fifth steps. It is not significant at the last step.

(c) There are moderately high intercorrelations between soil and agricultural labourers (0.46); between irrigation and fertilizer (-0.48); between irrigation and Scheduled Castes and Tribes (0.45); and between fertilizer and mechanisation (.58). There are high intercorrelations between irrigation and agricultural labourers (.79) and between mechanisation and Scheduled Castes and Scheduled Tribes (.65).

(d) With the above considerations the first three variables - rainfall, soil and Scheduled Castes and Tribes alone turn out as significant variables.

But thene are some other considerations also to be looked into: (a) The variable, agricultural labourer explains more than the variable, Scheduled Castes and Scheduled Tribes and its regression coefficient and 'R' at the fourth step are also significant. Further, many studies show that agricultural labourer is also more important in influencing agricultural productivity. So the equation at the fourth steo may also be one of the best-fit equations. (b) The Scheduled Castes and Scheduled Tribes variable adds to the R^2 only 7.3 per cent and its regression coefficient is not significant. So it has been left out and a new equation (eigth model),

$$\bar{y} = a + b_2x_2 + b_1x_1 + b_6x_6 + e$$

involving rainfall, soil, and agricultural labourer has been worked out (Appendix-XXIII). This eigth model explains 63.2 per cent of the variations in the agricultural productivity. The 'R' is significant at 10 per cent level. All the variables are positively related with the productivity. The regression coefficient of rainfall alone is significant at 2.5 per cent level.

The arguments so far advocated indicate that there are three possible equations each of which claim to be the best-fit on some grounds:

1. $\bar{y} = a + b_2x_2 + b_1x_1 - b_7x_7 + b_6x_6 + e$
   $R^2 = 82.3$

2. $\bar{y} = a + b_2x_2 + b_1x_1 - b_7x_7 + e$
   $R^2 = 68.1$

3. $\bar{y} = a + b_2x_2 + b_1x_1 + b_6x_6 + e$
   $R^2 = 63.2$

The following table XIV portray the distribution of residuals among the districts for each of the three selected equations. The range of deviations is higher

Table No. XIV
DISTRIBUTION OF RESIDUALS

District	Percentage of Residuals		
	Model 1	Model 2	Model 3
Chingleput	-11.09	- 8.94	-26.62
South Arcot	9.10	9.65	0.95
North Arcot	10.40	1.56	1.05
Salem	-19.33	-39.65	-30.79
Coimbatore	11.09	14.33	15.77
Tiruchirappalli	12.27	2.38	9.60
Tanjavur	- 0.04	9.98	- 0.05
Madurai	- 7.42	- 4.89	- 4.07
Ramanathapuram	-10.41	- 3.58	3.16
Tirunelveli	- 4.43	1.46	5.72
Kanyakumari	- 1.08	0.93	8.70
Range of Residuals	31.70	53.98	46.56
R^2	82.3	68.1	63.2

both in the second and third equations than in the first one.

All these considerations push forward the equation involving rainfall, soil, Scheduled Castes and Tribes and agricultural labourer to become fairly

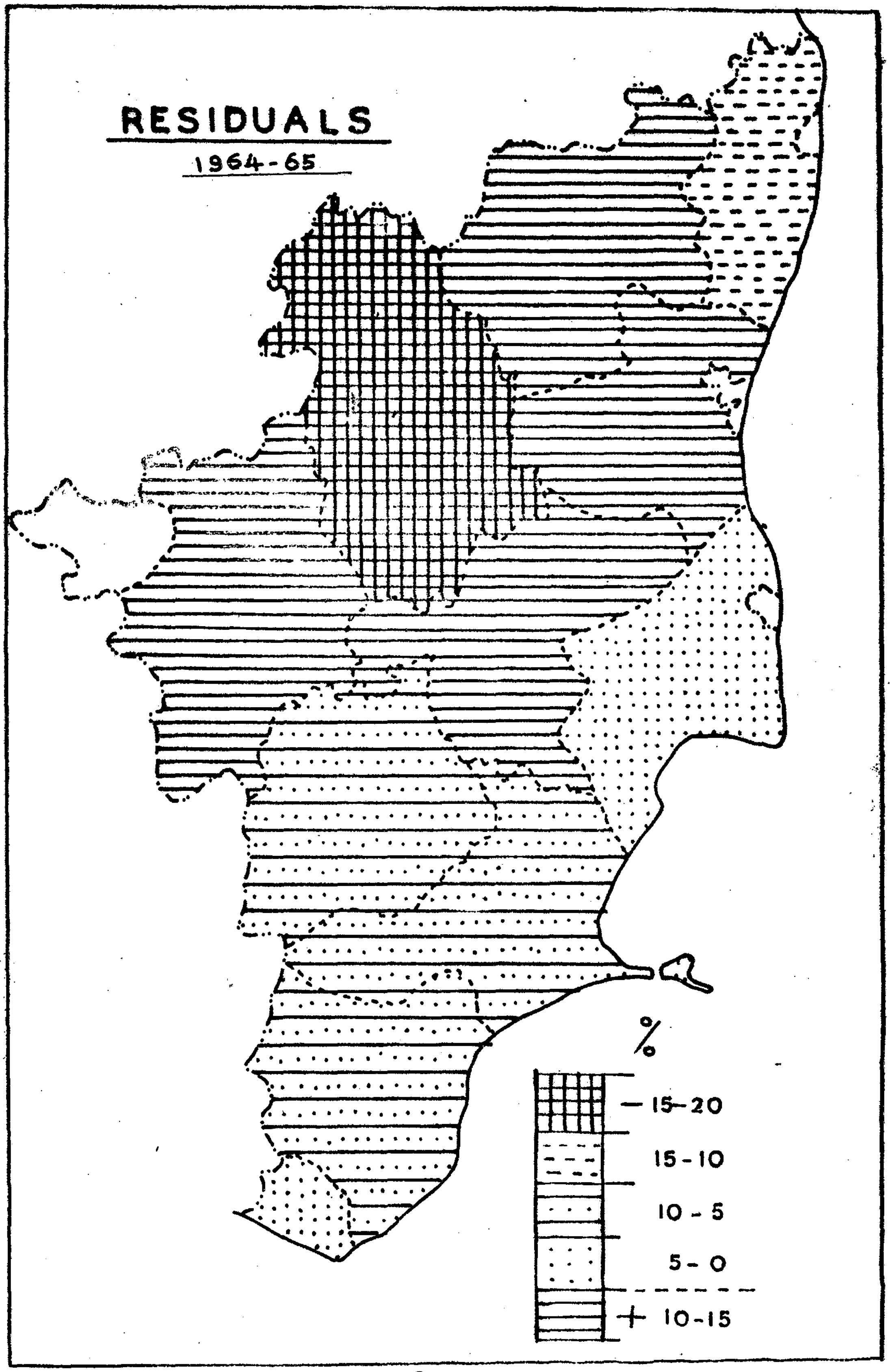

FIG. 28

a best-fit equation. The variables explain more than four-fifths of the variations in the agricultural productivity in Madras State.

The residual map (Fig.28) drawn for this equation shows the areas of positive and negative factors affecting the productivity. In Tanjavur, the deviation is almost nil, thereby pointing out that productivity variations in that district are mostly due to the combined effect of these selected four variables. In Kanyakumari district also, the deviation is negligible. Out of the remaining districts, four districts are with positive factors and five other districts with negative factors. Negative factors are highly active in Salem (19.33%) and Chingleput (11.09%).

5.3 Step-wise Regression Analysis: 1969-70

The steo-wise regression procedure is attempted with the following seven predictors for 1969-70:

X_1 = Soil Rating Index

X_2 = Total Annual Rainfall in cm.

X_3 = Percentage of Gross Irrigated area to the Gross CultivatedArea

X_4 = Fertilizer Consumption per 100 hectare of Irrigated Area

X_5 = Mechanisation Index

X_6 = Percentage of agricultural labourers to the total agricultural population

X_7 = Percentage of rural Scheduled Caste and Scheduled Tribe to the rural population

Y = Agricultural Productivity

All the seven independent variables together account for 91.5 per cent of the areal variations in the agricultural productivity over twelve districts of Tamil Nadu. The first variable added is the percentage of agricultural labourers with which only the dependent variable gets the highest correlation coefficient of 0.72 (Appendix-XVIII). The last variable included in the model is the soil rating index. The following table (XV) lists the results of the step-wise regression procedure (for details, see the Appendix-XXII):

Table No.XV
ORDER OF VARIABLES ADDED

Included Variable	V-	R	R^2x100	Increase in R^2x100	Std. Error
X_6	X_6	.724£	52.5	-	72.39
X_6 X_4	X_4	.891*	79.4	26.9	50.16
X_6 X_4 X_3	X_3	.937*	87.8	8.4	40.99
X_6 X_4 X_3 X_5	X_5	.946@	89.5	1.7	40.68
X_6 X_4 X_3 X_5 X_7	X_7	.949£	90.1	0.6	42.67
X_6 X_4 X_3 X_5 X_7 X_2	X_2	.954+	91.0	0.9	44.38
X_6 X_4 X_3 X_5 X_7 X_2 X_1	X_1	.956#	91.5	0.5	48.44

* Significant at .1% level; £ Significant at 1% level
@ Significant at .5% level; + Significant at 2.5% level
# Significant at 5% level

The initial variable alone accounts for 52.5 per cent of the total variance and the first three variables together explain 87.8 per cent. But the remaining four variables add only 3.7 per cent. 'R' is highly significant throughout the steps. Even with the inclusion of all the variables, it is significant at 5 per cent level. It is interesting to note that the factors responsible for the technological breakthrough in the agriculture and their related input of agricultural labourers dominate in explaining the productivity, in contrast to the period of 1964-65 when the environmental and institutional factors dominated.

The percentage of agricultural labourers, as expected, is positively related and its 'R' is highly significant, at 1 per cent level. The second predictor added is fertilizer consumption, one of the important technological inputs. It explains 27 per cent of variations, and along with the first predictor explains three-fourths of variations. The 'R' is highly significant, at .1 per cent level. The third and fourth variables are also drawn from technological factors and they explain nearly 11 per cent of the variations. 'R' is significant in these steps too. By the remaining steps, little is added to the 'R'.

5.3.1 Overall Picture of Regression Coefficients

The regression coefficients of the percentage of agricultural labourers fertilizer consumption and the soil are positive throughout the steps, since their addition (Table No.XVI). The mechanisation, Scheduled Castes and Tribes and rainfall are negatively related with productivity throughout the steps since their respective introduction. Irrigation is also negatively related but in the sixth step along with rainfall, it gets positively related. All the regression coefficients are highly significant upto the third step. The fertilizer consumption is significantly related with productivity in all steps since its inclusion. The agricultural labourers and mechanisation are also moderately related with productivity.

5.3.2 Overall Picture of Residuals

The table-XVII depicts the pattern of residual distribution among districts in each step. In the first two steps, the districts having negative deviations more in number and in the second two steps, three with positive deviations dominate. In the last three steps (Steps 5, 6 and 7) districts having positive and negative deviations are equal in number. Negative factors are active in Salem and Tirunelveli, Chingleput and South and North Arcots. In Tirunelveli district, deviations are not only negative but also

TABLE No. XVI

REGRESSION COEFFICIENTS OF THE VARIABLES - STEP-WISE

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Agricultural Labourer	7.06**	6.69**	9.57*	8.51**	7.80£	6.34+	4.94
Fertilizer		36.31**	43.48**	54.48**	55.20**	55.35£	57.40£
Irrigation			- 2.48£	- 2.36@	1.68	0.40	1.42
Mech. Index				- 9.78	7.74	6.82	- 9.28
S.C. and S.T.					1.91	3.66	- 4.11
Rainfall						0.91	- 1.22
Soil							1.42

* Significant at 0.1% level
** Significant at 1% level
£ Significant at 5% level
@ Significant at 10% level
\+ Significant at 20% level

Table No. XVII

DISTRIBUTION OF RESIDUALS AMONG THE DISTRICT IN EACH STEP

District	Variable Added:	PERCENTAGE OF RESIDUALS							No.of Steps	
		Agricultural Labourer	Fertilizer	Irrigation	Mech. Index	SC/ST	Rainfall	Soil	Negative	Positive
	Step:	1	2	3	4	5	6	7		
Chingleput		-10.61	-16.30	- 7.49	- 2.96	- 1.36	0.00	1.17	2	5
South Arcot		14.77	- 3.75	- 0.55	- 4.42	- 3.88	- 1.12	- 0.46	1	6
North Arcot		8.73	- 3.43	1.23	- 1.32	- 2.56	- 2.98	- 3.25	2	5
Salem		- 3.85	- 9.56	-16.03	- 9.04	- 9.01	- 7.03	- 5.77	-	7
Dharmapuri		-16.44	10.34	8.09	6.16	6.24	12.62	9.69	6	1
Coimbatore		27.40	17.64	9.32	8.37	8.75	7.45	7.15	7	-
Tiruchirappalli		11.93	2.93	4.12	7.87	5.26	0.90	- 0.19	6	1
Tanjavur		-10.76	- 3.81	7.56	7.61	7.77	6.67	4.31	5	2
Madurai		- 5.61	6.91	0.89	1.91	4.35	4.46	4.32	6	1
Ramanathapuram		-21.45	- 0.72	4.66	0.46	1.61	- 3.12	1.61	4	3
Tirunelveli		-16.48	-11.46	-16.87	-18.86	-17.16	-18.28	-19.83	-	7
Kanyakumari		- 6.21	4.39	1.22	0.61	- 3.14	- 1.47	- 0.60	3	4
Range of Residuals		48.85	33.94	26.19	27.23	25.91	30.90	29.52		

high throughout the steps. On the basis of lowest deviation among the steps two-thirds of the districts in the state get the best-fit equations within the first four steps involving agricultural labourers, fertilizer, irrigation and mechanisation.

5.3.3 Identifying the best set of Predictors

(a) The set of first three variables explain 87.8 per cent of the variations and the remaining variables account only for meagre 3.7 per cent of the variations.

(b) In all the steps 'R' is significant at-least at 5 per cent level. The regression coefficients in the first three steps are highly significant. From fourth step onwards, the variables gradually loose their significance. Fertilizer consumption alone remains significant all through the steps.

(c) The standard error of the estimate goes on decreasing upto the fourth step and then starts increasing. The decrease in the standard error with the inclusion of mechanisation (at the fourth step) is highly marginal.

(d) There are some high and moderate inter-correlations which have to be accounted for (Appendix-XVIII). High intercorrelations are found between rainfall and irrigation (0.8); between irrigation and agricultural labourer (0.7); and between fertilizer and mechanisation (0.7).

The R^2, the regression coefficients and the standard error of the estimate, thus clearly indicate that the first three valuables - agricultural labourers, fertilizer consumption and irrigated area, are significant ones. As the technological factors dominate in explaining the variations in productivity during 1969-70, mechanisation index may also be included in the equation, though it does not add significantly. Thus the fourth equation becomes best-possible one. But the problem arises due to the inter-correlations listed above. So it has been decided to build-up two other different models, one involving agricultural labourers and mechanisation index (eigth regression model) and second one involving fertilizer consumption and irrigated area (ninth regression model) (Appendix XV and XVI).

The eigth model explains 61.8 per cent of the variations. The 'R' is significant at 2.5 per cent level. The regression coefficient of the agricultural labourers is significant at .5 per cent level and that of mechanisation index, at 10 per cent level. All the variables are positively related. The ninth model explains 40.8 per cent of the variations in the productivity. The 'R' is significant at 10 per cent level. The regression coefficient of fertilizer consumption is significant at 10 per cent level and that of irrigation only at 20 per cent level. Both the variables are positively related with the productivity.

As discussed above, there are now three equations from which best-fit equation has to be identified.

$$\bar{y} = a + b_6x_6 + b_4x_4 - b_3x_3 - b_5x_5 + e$$
$$R^2 = 89.5\%$$

$$\bar{y} = a + b_6x_6 + b_5x_5 + e$$
$$R^2 = 61.8\%$$

$$\bar{y} = a + b_4x_4 + b_3x_3 + e$$
$$R^2 = 40.8\%$$

The significance of R^2 and the regression coefficients of these models have already been noted in the preceding paragraph. The following table (XVIII) gives the residuals calculated for the districts for each of the three selected models. The range of deviations is low in the first model, when compared to the other models. In the third model, it is twice the value of the first-model. The total deviation (irrespective of the signs) is pretty high in the second and third models.

All these factors favour towards the equation involving agricultural labourers, fertilizer consumption, irrigated area and mechanisation index.

There are intercorrelations among these variables but this can be tolerated because: (a) omission of any of the intercorrelated variables does not better the results, as found

Table No.XVIII
DISTRIBUTION OF RESIDUALS

District	---Percentage of Residuals		
	Model 1	Model 2	Model 3
Chingleput	- 2.96	-20.44	-13.30
South Arcot	- 4.42	11.76	- 8.16
North Arcot	- 1.32	6.61	-13.25
Salem	- 9.04	-16.24	-14.12
Dharmapuri	6.16	- 1.22	-26.22
Coimbatore	8.37	24.91	27.99
Tiruchirappalli	7.87	2.26	-13.42
Tanjavur	7.61	- 8.44	0.32
Madurai	1.91	-0.96	17.80
Ramanathapuram	0.46	- 6.21	-15.30
Tirunelveli	-18.86	-10.91	- 1.60
Kanyakumari	0.61	- 0.26	21.82
Range of Deviations	27.23	45.35	54.21
R^2	89.5%	61.8%	40.8%

in the eigth and ninth models, and (b) the four variables in the first equation form a best set of variables as they all put together represent a modern trend in the agricultural production and so may explain the productivity variations well in a period (1969-70) which is after some five years since the introduction of various programmes of agricultural development. Thus, proportion of agricultural labourers, fertilizer consumption, percentage of irrigated area and mechanisation index for the best set of variables

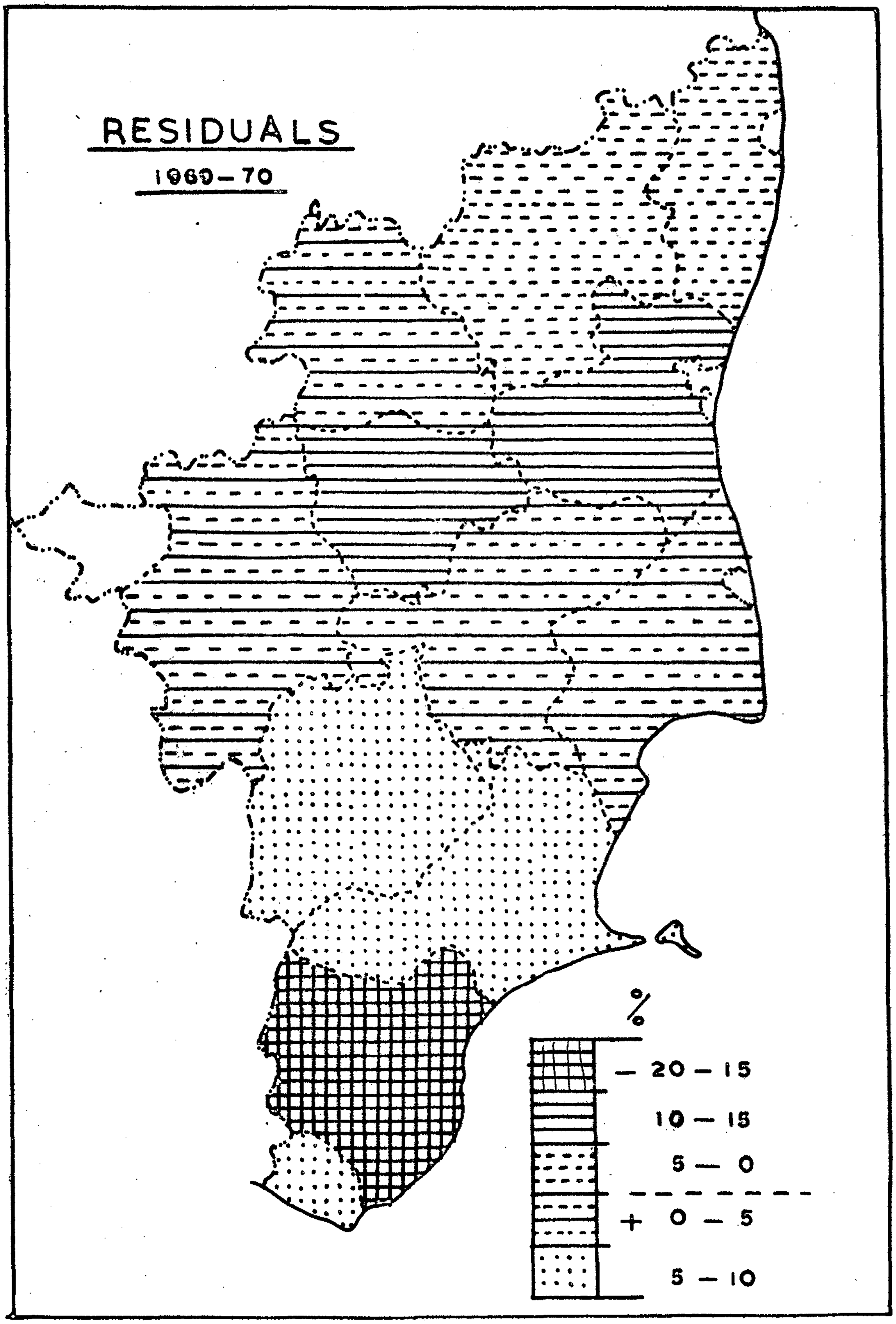

FIG. 29

explaining variations in productivity during 1969-70.

The map (Fig.29) drawn for the residuals indicate the areas influenced by the positive factors as well as the areas affected by the negative factors. Positive factors are acting in the central and southern parts of the state. The exception in the southern region is the district of Tirunelveli which shows exceptionally high negative deviation. The negative factors pull down the potential productivity in the northeastern coastal districts and Salem and Tirunelveli districts.

CHAPTER SIX

CONCLUDING REMARKS

An attempt has been made here to summarize the main conclusions emerging from the foregoing study. Productivity turns out to be the only alternative to raise agricultural production, when area-increasing method is not feasible. By productivity, is meant agricultural output per hectare in terms of money value.

Agricultural productivity varies over space as well as time. Factors responsible for these variations in productivity are numerous and complex. They may conveniently be grouped into three sets of factors: environmental, technological and institutional. The present study takes up seven sensitive predictors - soil and rainfall from the environmental group; irrigation, fertilizer consumption and mechanisation from the technological; and agricultural labourers and Scheduled Castes and Scheduled Tribes from the institutional frame - to explain the spatial productivity variations. While these factors might be largely responsible for the existing variations, it is strongly felt that existing variations in the agricultural productivity are so large and its pattern so conflicting, that it would need a close and thorough examination of the statistics from the primary sources.

The present study concentrates on two aspects: (a) Attempting an areal survey of productivity variations in detail in each time-period; and (b) searching out the causes for the spatial variations in productivity. This analysis may help to formulate ways and means by which regional imbalances can be wiped out and overall productivity level can be raised.

The study is attempted for Tamil Nadu, formerly known as Madras State. However, it excludes the Nilgiris district which is "a category by itself due to its income largely drawn from plantations". Tamil Nadu is one of the advanced states in India. In food production, it was a deficit state in 1950 but a surplus state in 1960. Since 1960, the production has been gradually increasing with only a few set backs.

The main data of the study have been subjected to statistical analysis that includes simple and partial correlations and step-wise regression. The major limitations are: (a) data relate to single agricultural year; and (b) data for institutional variables and mechanisation are computed ones.

6.1 Findings

Main findings are briefly summarised below:

6.1.1 Spatial Pattern of Productivity Distribution

The northern districts except Salem show fairly high productivity level and thus productivity gradient is due southward. But Kanyakumari district which is exceptionally high in the productivity level standa isolated in the south. Coimbatore and Kanyakumari consistently show high productivity. Salem and Ramanathapuram consistently show low productivity. Districts showing productivity above the mean get increased in number, from 4 in 1954-55 to 5 in 1964-65 and to 7 in 1969-70. The coefficient of variation goes down from 35.55 per cent in 1954-55 to 21.13 per cent in 1964-65 and 23.60 per cent in 1969-70. This clearly shows the overall improvement in the agricultural production and the downward trend in the spatial variations.

6.1.2 Validity of the Hypotheses

Seven simple hypotheses relating to productivity with the explanatory variables have been formulated in this study. They are tested by the simple correlation method. The hypotheses are also examined from the results of multiple regression (here the last equation in the step-wise regression procedure is to be followed) which gives the type of relationship between the productivity and each predictor, when all the predictors are together related with the productivity. Table XIX summarises the results of tests of hypotheses by both the methods:

Table No.XIX
TESTS OF HYPOTHESES

Variables	1954-55		1964-65		1969-70	
	r	b	r	b	r	b
Soil	.00	- 1.43	0.52	0.72	0.31	1.42
Rainfall	.12	.13	.69+	0.73	.18	-1.22
Irrigation	.00	- 3.93	.31	2.24	.44	1.42
Fertilizer	No Data		0.13	19.51	.57+	57.4 +
Mechanisation	.38	11.45	-0.20	10.86	.01	-9.28
Agri.Labourers	.42*	6.28	.46	4.55	.73@	4.9
S.C/S.T. Popn.	.27	14.39	-0.52*	-10.91	-0.00	-4.11

* Significant at 10% level
\+ Significant at 5% level
@ Significant at 1% level

During 1954-55, the simple correlation coefficient shows that agricultural productivity is directly related with all predictors, thus confirming all the hypotheses, except the last one which relates the productivity with the Scheduled Castes and Scheduled Tribes. However, all the r-values are highly weak. Looking at the regression coefficient obtained from the multiple regression equation, it is noted that soil and irrigation is inversely related; however, b-values of these two variables are weak. Soil, rainfall and irrigation are highly interrelated and so the absence of detailed data for these variables can very well disprove the logical hypotheses. It is really curious that Scheduled Castes and Tribes is positively correlated with productivity. However, the interrelationship between the agricultural labourers and the Scheduled Castes and Tribes (it is a fact that agricultural labourers are largely drawn from Scheduled Castes and Tribes) might have disproved the hypothesis.

In 1964-65, all the hypotheses except the one relating to productivity with mechanisation hold good, according to the simple correlation analysis. However, it is to be noted that the correlation coefficient of mechanisation with productivity is very weak. The regression coefficients justify all the hypotheses. When considered along with other inputs, mechanisation becomes positive.

The simple correlation coefficients for 1969-70 data lead one to accept all the hypotheses, although those of soil, rainfall, mechanisation and Scheduled Castes and Tribes are insignificant and weak. But the regression coefficients give a different picture. Rainfall and mechanisation, contrary to our hypotheses, are inversely related with productivity. Fertilizer consumption has a very strong relationship with productivity.

6.1.3 Identification of Significant Predictors

Significant predictors are identified from the step-wise regression procedure with the help of 'F' and 't' tests and personal reasoning. The following table gives the total variance (R^2x100) explained by the explanatory variables considered here for each time-period.

Table No. XX
TOTAL VARIANCE EXPLAINED

1954-55		1964-65		1969-70	
Variable	R^2x100	Variable	R^2x100	Variable	R^2x100
X_5	17.5	X_2	47.6	X_6	52.5
X_4	10.4	X_1	13.1	X_4	26.9
X_3	3.1	X_7	7.3	X_3	8.4
X_6	4.2	X_6	14.2	X_5	1.6
X_2	0.4	X_5	4.3	X_7	0.5
X_1	0.3	X_3	1.9	X_2	0.9
		X_4	0.2	X_1	0.4
Total	35.9		88.6		91.2

During 1954-55, all the explanatory variables taken together explain only 36 per cent of the total variations. Agricultural labourers and mechanisation index alone explain 28 per cent out of this 36 per cent. No regression coefficient is significant even at 20 per cent level, except that of agricultural labourers which is significant at 10 per cent level. Further, no 'R' is significant. With these findings in hand, it is concluded that variables considered here are not much helpful in explaining the spatial variations in productivity in Tamil Nadu in 1954-55.

In 1964-65, on the other hand, these variables explain as much as 88.6 per cent of total variations. All the 'R's' and most of the regression coefficients are significant. Rainfall, soil and agricultural labourers which explain 75 per cent out of 88.6 per cent turn out to be significant variables. Due to some other considerations as mentioned in the preceding chapter, the variable Scheduled Castes and Tribes has also been included in the list of leading variables. Thus, rainfall and soil of the natural environmental factors and agricultural labourers and Scheduled Caste and Tribes from institutional factors come out to be more relevant predictors in reasoning out the productivity variations during 1964-65.

In the final time-period considered, all the predictors put together explain 91 per cent of total variations. Agricultural labourers, fertilizer consumption and irrigation alone explain as much as 88 per cent. Based on some relevant weightages, mechanisation index has also been included to form the set of best possible predictors. Thus, to explain the productivity variations in 1969-70, agricultural labourers from the institutional side and the fertilizer consumption, irrigation and mechanisation from the technological side emerge out as the best possible predictors.

6.1.4 Suggestions for the Future

Suggestions are put forth, based on the R^2 of the selected variables, partial correlation coefficients and residuals calculated for each district for the selected equation in the year 1969-70. They are sketching the ways to minimise the spatial variations in productivity. (a) It is already noted that the 1969-70 represents almost a period of technological break-through. As such, spatial variations in productivity can be minimised only by the judicial use of technological inputs and agricultural labourers. (b) The partial correlation coefficient matrix for 1969-70 (Appendix-XIX) shows that there is a very strong correlation (.86) between the productivity and fertilizer consumption. Agricultural labourers moderately (0.47) correlates with productivity. These facts strengthen the earlier contention that the technological inputs are crucial to agricultural productivity. The rainfall, mechanisation and the Scheduled Castes and Tribes are negatively correlated with productivity (though weak) and this has to be carefully looked into.

The residuals - unexplained variations calculated for the equation in step number 4 of 1969-70 - are small in all districts, except in Tirunelveli district where the percentage of deviation is 18.86. Negative deviations are found also in Chingleput, South and North Arcots, and Salem districts. The residuals in the northeastern districts are largely minimised when other variables are also included in the regression model. But the dry districts of Salem and Tirunelveli persistently show a high negative deviation. The reasons for this negative deviation may be identified in the framework of institutional factors and also in the distributional aspects of rainfall, which may be more relevant as these two districts are dry tracts (in fact, 70 per cent of gross cropped area in Salem and 60 per cent of the gross cropped area in Tirunelveli districts are unirrigated).

To sum up, it can briefly be concluded that (a) in the earlier periods, productivity variations were mostly due to traditional inputs and in the latter period, mostly due to technological inputs; (b) the step-wise regression helps much to identify the responsible factors for productivity variations but the results have their own limitations owing to the constraints of data; and (c) if the detailed primary data for small administrative units - say taluks - are available, the results would have been more accurate and precise. The researcher proposes to take up this study at the doctoral level using the primary data generated through field-works.

Appendix-I

Tamil Nadu

Indices of Output, Area and Productivity of all crops

(Base: 1956-57 = 100)

Year	Output			Area			Productivity		
	All Commodities	Food Grains	Non-Food Grains	All Commodities	Food Grains	Non-Food Grains	All Commodities	Food Grains	Non-Food Grains
1952-53	67.9	64.6	74.2	88.4	88.3	88.9	76.8	73.2	83.4
53-54	82.2	84.8	80.2	99.5	104.2	84.2	83.6	81.4	95.2
54-55	95.5	93.3	99.8	100.6	100.0	102.8	94.9	93.3	97.1
55-56	96.0	94.0	99.8	93.3	98.2	102.9	96.7	95.7	97.0
56-57	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
57-58	102.9	102.1	104.5	97.3	96.0	101.4	105.8	106.4	103.1
58-59	102.3	98.8	109.0	99.4	97.5	105.7	102.9	101.3	103.1
59-60	108.5	105.9	113.6	101.1	99.5	106.2	107.3	106.4	107.0
60-61	116.5	111.2	126.8	105.0	103.2	110.8	111.0	107.8	114.4
61-62	119.6	118.6	121.5	104.4	102.9	109.4	114.6	115.3	111.1
62-63	120.1	121.2	118.0	105.8	103.9	112.4	113.5	116.8	105.0
63-64	121.5	118.2	127.7	106.7	104.0	115.8	113.9	113.7	110.3
64-65	123.9	121.4	128.7	107.1	104.2	116.9	115.7	116.5	110.1
65-66	113.4								
66-67	121.1								
67-68	120.7								
68-69	111.4				NOT AVAILABLE				
69-70	130.6								
70-71	141.8								

Source: (1) Ministry of Agriculture: Directorate of Economics and Statistics, Estimates of Area and Production of principal crops in India, 1971-72.

(2) Robert E. Evenson and D. Jha, "The Contribution of agricultural research system to agricultural production in India," Indian Journal of Agricultural Economics, Vol.XXVIII, No.4 (October-December 1973), pp.212-230.

APPENDIX-II

PRICE PER TON OF AGRICULTURAL COMMODITIES, 1954-55

	Price per ton in Rs.
Paddy	271.11
Cholam	244.16
Cumbu	230.28
Ragi	246.61
Korra	218.03
Varagu	173.94
Samai	201.97
Maize	283.63
Wheat	385.98
Bengal Gram	418.37
Horse Gram	276.56
Green Gram	383.80
Red Gram	295.61
Black Gram	486.69
Chillies	1447.29
Onions	138.55
Potatoes	363.66
Sugarcane (Gur)	332.08
Groundnut	349.23
Gingelly	570.80
Castor	342.43
Tobacco	2260.89
Cotton Lint	1974.54
Ginger	643.48
Papper	4133.63
Coffee	3780.31
Tea	6262.51
Rubber	2979.20

Source: Department of Statistics, Government of Tamil Nadu, Season and Crop Report of the Madras State, 1954-55 (1957), p.25.

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Appendix - III

Madras State

Monthly Average Rainfall (in cms.)

1954-55

District	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 1955	Feb.	Mar.	Apr.	May	Grand Total Actual	Grand Total Normal
1	4.06	23.36	10.66	7.62	30.73	0.76	27.68	7.36	0.25	0.12	3.55	13.97	131.82	118.87
2	2.54	15.24	14.73	4.82	42.67	1.77	16.00	3.04	0.25	0.12	6.09	28.70	135.89	118.87
3	3.55	22.60	13.46	3.04	25.40	0.50	10.16	7.11	0.12	0.12	1.77	15.74	103.37	96.26
4	3.30	10.41	14.73	2.04	26.41	0.76	5.58	1.01	-	1.27	5.08	18.54	89.66	82.80
5	1.27	5.84	9.90	1.27	19.55	3.04	4.57	1.27	-	1.52	10.16	15.24	73.66	69.59
6	1.01	4.57	16.00	4.31	21.33	3.04	7.87	1.52	-	1.52	10.66	13.71	84.83	86.86
7	1.77	7.62	18.28	4.57	38.86	8.38	24.89	5.33	0.50	0.25	10.92	15.24	136.65	114.55
8	1.77	3.04	14.22	2.54	20.57	2.79	4.06	2.54	0.12	2.03	7.11	7.11	67.31	82.04
9	2.10	5.58	10.16	1.27	21.84	5.58	7.62	2.28	0.25	0.76	15.74	4.82	76.70	82.04
10	0.70	2.28	4.06	0.50	19.81	4.57	14.22	6.85	0.02	2.54	11.43	6.09	72.89	77.21
11	28.00	76.45	51.30	20.32	23.36	2.28	2.79	-	0.25	0.76	11.43	61.46	352.04	307.59
12	37.10	145.54	77.97	43.43	13.46	-	2.28	-	-	0.76	4.82	48.51	471.42	379.47

(1) Chingleput; (2) South Arcot; (3) North Arcot; (4) Salem; (5) Coimbatore; (6) Tiruchirapalli; (7) Tanjavur; (8) Madurai; (9) Ramanathapuram (10) Tirunelveli; (11) Malabar; and (12) South Canara

Note: Normal based on the actuals for fifty years ending 1950.

Source: Season and Crop Report of Madras State - 1954-55

Appendix-IV

Madras State

Monthly Average Rainfall (in cms.)

1964-65

District	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Grand Total	
													Actual	Normal
Chingleput	2.73	8.94	11.45	14.41	11.14	50.24	1.54	0.87	0.34	-	1.19	-	101.30	121.10
South Arcot	1.07	10.19	10.58	10.55	15.13	20.99	12.79	0.62	0.48	0.17	2.28	2.03	86.88	118.89
North Arcot	2.57	23.80	10.20	13.55	23.88	20.49	1.57	-	-	-	2.71	0.93	99.70	97.11
Salem	2.92	22.74	5.70	6.46	20.18	14.88	3.63	0.01	-	0.66	7.47	3.03	87.88	84.31
Coimbatore	2.42	11.48	5.19	13.07	24.81	13.26	6.85	-	0.13	1.36	8.81	6.99	94.37	71.84
Tiruchirapalli	2.96	16.46	5.34	6.20	13.02	7.23	7.95	0.05	0.07	0.03	3.35	1.60	64.26	87.71
Tanjavur	2.54	13.74	7.56	8.51	10.85	16.60	12.36	0.27	2.28	0.62	5.87	4.07	85.27	114.78
Madurai	3.24	14.74	6.60	4.98	26.02	10.45	9.36	0.10	0.24	1.42	6.86	5.15	89.16	85.48
Ramanathapuram	0.92	15.88	4.10	3.10	12.24	9.18	12.29	0.14	1.71	0.98	6.28	3.90	70.72	83.95
Tirunelveli	1.02	9.96	4.48	2.65	6.83	12.45	1.50	0.13	1.54	1.65	7.13	2.80	52.14	81.48
Kanyakumari	6.80	17.21	9.29	18.36	23.21	24.60	0.32	0.36	0.69	4.00	15.33	15.25	135.43	146.97

Note: Normal based on the actuals for fifty years ending 1950.

Source: Season and Crop Report of Madras State - 1964-65.

Appendix-V

Tamil Nadu

Monthly Average Rainfall (in cms.)

1969--70

District	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Grand Total	
													Actual	Normal
Chingleput	6.04	10.45	10.76	3.26	60.69	32.77	11.97	0.15	0.79	0.08	1.26	1.47	139.69	121.10
South Arcot	2.84	3.55	12.61	3.36	45.66	43.84	15.71	1.19	1.52	0.10	1.64	3.95	135.97	118.89
North Arcot	3.98	9.04	22.10	3.13	41.86	22.76	7.21	0.02	1.40	0.06	1.73	8.42	121.71	97.11
Salem	1.59	3.64	9.88	3.57	25.31	16.40	9.48	0.65	2.16	0.26	5.38	13.15	91.47	84.24
Coimbatore	1.03	2.64	10.80	3.11	21.89	9.63	9.07	0.95	1.64	1.08	2.98	9.97	74.79	71.84
Tiruchirapalli	3.54	1.26	11.39	4.83	18.52	18.72	11.31	1.82	1.16	0.93	6.99	9.33	89.80	87.71
Tanjavur	2.45	1.61	10.63	2.54	26.94	33.55	40.17	7.65	3.27	0.12	4.50	8.81	142.24	114.78
Madurai	0.55	2.70	16.00	4.54	19.79	8.45	9.31	0.74	2.39	1.29	7.52	8.38	81.66	85.48
Ramanathapuram	0.98	1.00	11.10	3.49	19.34	12.61	18.59	1.80	1.95	0.44	10.44	5.55	86.29	83.95
Tirunelveli	0.51	5.12	8.20	1.88	16.52	12.77	16.13	1.72	2.50	3.55	14.32	3.56	86.78	81.48
Kanyakumari	6.60	13.69	11.69	4.39	31.73	15.77	11.04	0.52	3.19	5.66	18.05	14.26	136.59	146.97
Dharmapuri	1.11	3.40	18.35	2.18	27.36	15.18	5.11	0.65	0.82	0.03	3.37	15.48	93.04	84.43

Note: Normal based on the actuals for fifty years ending 1950.

Source: Season and Crop Report of Tamil Nadu, 1969-70.

Appendix-VI

Tamil Nadu

Number of Agricultural Machineries

Sl. No.	District	1951			1956			1961			1966		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1.	Chingleput	22	2,990	898	99	4,519	2,386	166	2,788	11,477	534	2,329	19,655
2.	South Arcot	28	3,385	1,499	127	7,800	2,430	137	9,823	7,492	203	10,096	21,251
3.	North Arcot	11	1,648	1,291	57	4,835	3,852	32	4,755	19,519	230	4,129	40,986
4.	Salem	18	1,446	1,343	33	3,678	2,326	37	5,097	13,725	122	7,715	26,348
5.	Dharmapuri	--	-----	-----	--	-----	-----	--	-----	------	52	1,021	3,966
6.	Coimbatore	78	1,826	6,937	205	2,771	7,084	208	3,599	25,534	293	4,804	45,509
7.	Tiruchirapalli	21	893	562	42	2,179	1,192	30	5,177	3,005	1,233	6,647	13,521
8.	Tanjavur	21	472	243	48	812	223	185	1,611	283	444	2,187	789
9.	Madurai	13	548	747	131	14,97	1,668	36	1,814	8,822	68	1,437	18,095
10.	Ramanathapuram	20	227	803	30	566	1,452	10	929	3,569	29	1,230	6,458
11.	Tirunelveli	28	486	419	35	1,048	1,322	43	1,078	5,054	58	1,221	11,882
12.	Malabar	21	428	57	68	529	37	--	-----	-----	--	-----	------
13.	South Canara	11	148	54	16	745	105	--	-----	-----	--	-----	------
14.	Kanyakumari	--	---	--	--	---	---	46	149	1	11	34	22

1. Tractors; 2. Oil Engines for irrigation; 3. Electric pumps for irrigation.
Source: Government of Tamil Nadu, Season and Crop Reports.

Appendix-XII

Madras State

Demographic Aspects - 1951

	District	(1)	(2)	(3)	In 10% Sample (4)	(5)	(6)	(7)
1.	Chingleput	1,845,273	1,532,257	529,660	185,240	79,421	42,249	121,670
2.	North Arcot	2,845,569	2,330,945	521,119	285,851	144,515	48,840	193,355
3.	Salem	3,362,487	2,900,450	498,619	337,258	184,755	50,856	235,611
4.	Coimbatore	3,278,604	2,640,032	490,842	329,107	115,084	57,150	172,234
5.	South Arcot	2,770,491	2,449,304	694,784	277,649	155,503	66,904	222,407
6.	Tanjavur	2,951,098	2,404,774	656,822	298,238	123,632	71,970	195,602
7.	Tiruchirapalli	2,629,616	2,360,607	499,420	294,238	164,741	40,145	204,886
8.	Madurai	2,873,733	2,086,513	436,321	289,568	125,984	51,482	177,466
9.	Ramanathapuram	2,073,775	1,541,966	298,627	208,627	105,352	24,626	129,978
10.	Tirunelveli	2,415,669	1,681,404	371,704	245,161	100,194	27,489	127,683
11.	Malabar	4,749,309	4,250,367	447,956	476,561	126,202	107,220	233,422
12.	South Canara	1,740,131	2,506,806	123,987	174,868	76, 596	26,940	103,536

(1) Total Population; (2) Total Rural Population; (3) Total SC/ST Population; (4) Sample Population (5) Cultivators; and (6) Agricultural Labourer; and (7) Total Agricultural Population.

Source: Census of India, 1951, Madras and Coorg, Part II-B.

Appendix-VIII

Madras State

Demographic Aspects - 1961

District	(1)	(2)	(3)	(4)	(5)	(6)
1. Chingleput	2,196,412	1,740,734	642,967	334,974	241,254	576,228
2. North Arcot	3,146,326	2,515,101	680,007	755,723	250,670	1,006,393
3. South Arcot	3,047,973	2,655,651	815,217	696,928	400,359	1,091,287
4. Salem	3,804,108	3,186,760	653,000	1,067,768	250,440	1,318,208
5. Coimbatore	3,557,471	2,525,302	553,135	515,270	269,294	788,564
6. Madurai	3,211,227	2,195,482	495,643	569,510	292,976	862,486
7. Tiruchirapalli	3,190,078	2,512,007	574,430	862,396	256,875	1,119,271
8. Tanjavur	3,245,927	2,584,407	750,872	494,668	445,975	940,643
9. Ramanathapuram	2,421,788	1,822,307	374,060	615,781	167,686	783,467
10. Tirunelveli	2,730,279	1,882,397	431,853	438,305	200,690	638,995
11. Kanyakumari	996,915	846,836	42,075	72,865	31,267	104,132

(1) Total Population; (2) Total Rural Population; (3) Total SC/ST Population;
(4) Cultivators; (5) Agricultural Labourers; (6) Total Agricultural Population

Source: Census of India, 1961

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Tamil Nadu

Demographic Aspects - 1971

Appendix-IX

District	(1)	(2)	(3)	(4)	(5)	(6)
1. Chingleput	2,907,599	1,896,909	1,035,180	238,790	330, 254	569,044
2. North Arcot	3,755,797	2,972,702	796,612	510,096	416,303	926,399
3. South Arcot	3,617,723	3,104,726	951,999	523,709	464,411	988,120
4. Dharmapuri	1,677,775	1,533,834	257,948	349,768	160,727	510,495
5. Salem	2,992,616	2,197,234	574,700	410,554	331,347	741,901
6. Coimbatore	4,373,178	2,816,936	714,292	417,124	570,330	987,454
7. Madurai	3,938,197	2,614,003	594,581	420,324	526,238	946,562
8. Tiruchirapalli	3,848,816	2,991,808	705,548	631,809	371,131	1,002,940
9. Tanjavur	3,840,732	3,052,694	850,300	374,324	541,919	916,243
10. Ramanathapuram	2,860,207	2,113,545	460,672	371,900	275,045	646,945
11. Tirunelveli	3,200,515	2,171,019	506,570	290,757	360,858	651,615
12. Kanyakumari	1,222,549	1,018,144	50,398	58,120	126,447	184,567

(1) Total Population; (2) Total Rural Population; (3) Total SC/ST Population;
(4) Cultivators; (5) Agricultural Labourers; (6) Total Agricultural Population;

Source: Census of India, 1951-61-71.

Tamil Nadu   Appendix-X

Size of land--holdings

Distribution of 1,000 households under each size-class of land held (in acres)

Sl. No.	Less than 1	1-2.4	2.5-4.9	5.0-7.4	7.5-9.9	10.0-12.4	12.5-14.9	15.0-29.9	30.0-49.9	50+	Unclas-sified
1.	190	394	236	90	28	25	6	20	5	2	4
2.	137	396	273	110	30	25	7	17	3	1	1
3.	191	371	237	98	34	29	8	24	5	2	1
4.	61	304	311	171	55	45	12	33	5	1	2
5.	36	195	251	182	80	92	24	98	27	13	2
6.	139	400	246	118	32	30	7	21	4	3	-
7.	119	344	258	130	42	43	10	38	8	4	4
8.	134	331	259	132	46	42	10	34	7	3	2
9.	158	347	258	122	33	31	12	27	7	3	2
10.	126	328	260	130	46	43	12	41	8	3	3
11.	268	306	191	92	34	35	13	42	11	5	3
12.	551	298	99	31	6	7	3	4	1	-	-
13.	148	332	254	125	42	40	11	35	8	3	2

Sl. No. 1 denotes Chingleput
2 ,, North Arcot
3 ,, South Arcot
4 ,, Salem
5 ,, Coimbatore
6 ,, The Nilgiris

Sl. No.7 denotes Madurai
8 ,, Tiruchirapalli
9 ,, Tanjavur
10 ,, Ramanathapuram
11 ,, Tirunelveli
12 ,, Kanyakumari

Sl. No. 13 denotes State as a whole.

Source: Census of India, Vol.IX, Part I-A-(II) General Report, p.471. Year 1961

Appendix-XI

Statistics of both dependent and independent variables analysed

1954-55

S.No.	District	x_1	x_2	x_3	x_4	x_5	x_6	x_7
1.	Chingleput	377.86	72.70	131.83	66.50	7.71	36.52	28.60
2.	South Arcot	861.13	68.90	135.89	43.50	5.92	32.18	24.80
3.	North Arcot	384.65	68.90	103.38	43.60	4.80	25.16	18.20
4.	Salem	281.84	76.70	89.66	29.40	2.12	20.68	14.80
5.	Coimbatore	627.31	77.00	73.66	29.70	5.23	32.88	14.90
6.	Tiruchirapalli	369.54	72.09	84.84	33.20	1.44	20.49	17.10
7.	Tanjavur	478.04	77.00	136.65	79.10	0.87	39.79	22.10
8.	Madurai	368.99	77.00	67.31	40.60	3.12	30.50	15.10
9.	Ramanathapuram	346.15	54.40	76.71	39.70	1.57	19.54	14.30
10.	Tirunelveli	356.00	77.00	72.90	37.00	2.08	24.52	15.20
11.	Malabar	483.11	72.90	352.04	2.50	0.66	45.36	9.50
12.	South Canara	442.18	81.20	471.42	15.10	1.00	26.49	7.10
	Mean	448.06	72.98	149.69	38.32	3.04	29.51	16.81
	Std. Deviation	157.47	6.91	6.91	20.28	2.32	8.18	6.03
	Coef. varn. %	35.55	9.58	9.58	52.63	66.66	26.66	35.29

x_1 = Agricultural Productivity - output per hectare in money terms

x_2 = Soil Rating Index

x_3 = Total Rainfall (Annual) in cms.

x_4 = Percentage of gross irrigated area to the gross cultivated area

x_5 = Mechanisation Index

x_6 = Percentage of agricultural labour to the agricultural population

x_7 = Percentage of rural SC/ST population to total rural population.

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Appendix-XII

1964-65

S.No.	District	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
1.	Chingleput	364.57	72.70	101.30	70.10	3.09	6.19	46.66	32.30
2.	South Arcot	402.15	68.90	86.88	52.10	3.87	5.19	39.68	28.30
3.	North Arcot	416.08	68.90	99.70	53.20	2.39	3.47	30.90	23.00
4.	Salem	310.58	76.70	87.88	23.80	3.63	3.52	26.79	19.20
5.	Coimbatore	536.17	77.00	94.37	38.80	4.56	4.19	41.34	16.30
6.	Tiruchirapalli	367.46	72.09	64.26	36.20	4.35	5.63	27.15	20.20
7.	Tanjavur	448.65	77.00	85.27	78.40	1.93	1.90	51.01	26.40
8.	Madurai	420.47	77.00	89.16	40.10	2.52	1.85	40.56	18.30
9.	Ramanathapuram	287.71	54.40	70.72	37.00	2.62	0.74	27.70	18.30
10.	Tirunelveli	366.13	77.00	52.14	40.90	2.82	1.61	38.60	18.70
11.	Kanyakumari	595.95	77.00	135.43	53.10	3.18	0.46	38.42	4.10
	Mean	410.54	72.61	87.92	47.61	3.78	3.16	37.16	20.46
	Std. Deviation	86.77	6.55	20.80	15.15	0.80	1.89	7.73	7.02
	Coef. varn. %	21.13	9.02	23.66	31.81	25.14	60.01	20.80	34.31

x_1 = Agricultural Productivity - output per hectare in money terms

x_2 = Soil Rating Index

x_3 = Total Rainfall (Annual) in cms.

x_4 = Percentage of gross irrigated area to the gross cultivated area

x_5 = Fertilizer consumption per hectare

x_6 = Mechanisation Index

x_7 = Percentage of agricultural labour to the agricultural population

x_8 = Percentage of rural SC/ST population to total rural population

Appendix-XIII

1969-70

S.No.	District	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
1.	Chingleput	421.38	72.70	139.69	72.70	6.46	5.43	54.53	32.80
2.	South Arcot	467.89	68.90	135.97	57;40	8.09	4.31	44.99	28.10
3.	North Arcot	405.51	68.90	121.71	51.20	7.02	4.26	40.93	23.00
4.	Salem	346.36	76.70	91.47	30.40	6.19	6.78	39.46	21.20
5.	Dharmapuri	228.96	76.70	93.04	15.20	3.82	2.43	26.28	15.20
6.	Coimbatore	626.76	77.00	74.79	37.80	7.47	3.76	52.95	17.30
7.	Tiruchirapalli	366.28	72.09	89.80	36.00	6.50	6.69	34.20	20.10
8.	Tanavour	434.92	77.00	142.24	76.00	4.99	1.65	56.74	25.40
9.	Madurai	419.01	77.00	81.66	37.50	4.32	1.45	51.19	18.30
10.	Ramanathapuram	289.46	54.40	86.29	38.00	3.98	0.79	38.31	18.80
11.	Tirunelveli	376.16	77.00	86.78	41.40	5.24	1.40	50.57	18.20
12.	Kanyakumari	481.29	77.00	136.59	53.20	4.46	0.01	60.91	4.00
	Mean	405.33	72.95	106.67	45.57	5.71	3.25	45.92	20.20
	Std. Deviation	95.92	6.38	24.98	16.67	1.37	2.19	9.84	6.84
	Coef. varn. %	23.66	8.74	23.42	36.59	24.07	67.65	21.43	33.89

x_1 = Agricultural Productivity - output per hectare in money terms

x_2 = Soil Rating Index

x_3 = Total Rainfall (Annual) in cms.

x_4 = Percentage of gross irrigated area to the gross cultivated area

x_5 = Fertilizer consumption per hectare

x_6 = Mechanisation Index

x_7 = Percentage of agricultural labour to the agricultural population

x_8 = Percentage of rural SC/ST population to total rural population

Appendix-XIV

Correlation Matrix, 1954-55

	y	x_1	x_2	x_3	x_4	x_5	x_6
y	1.00	.00	.12	.00	.38	.42*	.27
x_1		1.00	.32	-.10	-.08	.29	-.18
x_2			1.00	-.52**	-.35	.35	-.52**
x_3				1.00	.38	.11	.82***
x_4					1.00	.14	.71***
x_5						1.00	.19
x_6							1.00

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = Percentage of gross irrigated area to the gross cultivated area
x_4 = Mechanisation Index
x_5 = Percentage of agricultural labour to the agricultural population
x_6 = Percentage of rural SC/ST population to total rural population

Partial Correlation Matrix, 1954-55

Appendix-XV

	y	x_1	x_2	x_3	x_4	x_5	x_6
y	1.00	-.07	.09	-.28	.12	.31	.23
x_1		1.00	.15	.17	.16	.25	-.21
x_2			1.00	-.17	-.10	.42	-.14
x_3				1.00	-.47	.05	.81**
x_4					1.00	-.08	.68*
x_5						1.00	.17
x_6							1.00

**Significant at 1% level
*Significant at 5% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = Percentage of gross irrigated area to the gross cultivated area
x_4 = Mechanisation Index
x_5 = Percentage of agricultural labour to the agricultural population
x_6 = Percentage of rural SC/ST population to total rural population

Appendix-XVI

Correlation Matrix, 1964-65

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7
y	1.00	.52*	.69**	.31	.13	-.20	.46	-.52*
x_1		1.00	.24	.11	.14	.08	.46	-.17
x_2			1.00	.34	-.03	-.09	.26	.33
x_3				1.00	-.49	.08	.79***	.45
x_4					1.00	.58**	-.29	-.14
x_5						1.00	.02	.65**
x_6							1.00	.31
x_7								1.00

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = %age of gross irrigated area to the gross cultivated area
x_4 = Fertilizer consumption per hectare of irrigated area - in tonnes
x_5 = Mechanisation Index
x_6 = %age of agricultural labour to the agricultural population
x_7 = %age of rural SC/ST population to total rural population

Partial Correlation Matrix, 1964-65

Appendix-XVII

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7
y	1.00	.09	.31	.39	.15	.14	.38	-.51
x_1		1.00	-.27	-.52	-.60	.65	.69	-.53
x_2			1.00	.01	-.42	.43	.10	-.36
x_3				1.00	-.61	.41	.53	-.07
x_4					1.00	.90**	.57	-.65*
x_5						1.00	-.71**	.87**
x_6							1.00	.72**
x_7								1.00

** Significant at 1% level
 * Significant at 5% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = % age of gross irrigated area to the gross cultivated area
x_4 = Fertilizer consumption per hectare of irrigated area
x_5 = Mechanisation Index
x_6 = % age of agricultural labour to the agricultural population
x_7 = % age of rural SC/ST population to total rural population

Appendix-XVIII

Correlation Matrix, 1969-70

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7
y	1.00	.31	.18	.44	.57**	.01	.72***	-.00
x_1		1.00	.03	-.02	.02	.07	.33	-.20
x_2			1.00	.83***	.19	-.03	.44	.32
x_3				1.00	.29	-.05	.70***	.50*
x_4					1.00	.69**	.07	.52*
x_5						1.00	-.37	.55*
x_6							1.00	-.04
x_7								1.00

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = %age of gross irrigated area to the gross cultivated area
x_4 = Fertilizer consumption per hectare of irrigated area - in tonnes
x_5 = Mechanisation Index
x_6 = %age of agricultural labour to the agricultural population
x_7 = %age of rural SC/ST population to total rural population

Appendix-XIX

Partial Correlation Matrix, 1969-70

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7
y	1.00	.22	-.37	.16	.86*	-.34	.47	-.41
x_1		1.00	.51	-.55	-.32	.46	.48	.29
x_2			1.00	.88**	.39	-.22	-.42	-.66*
x_3				1.00	-.21	.14	.69*	.76**
x_4					1.00	.63*	-.25	.42
x_5						1.00	-.15	.03
x_6							1.00	-.32
x_7								1.00

** Significant at 1% level
* Significant at 5% level

y = Agricultural Productivity - output per hectare in money terms
x_1 = Soil Rating Index
x_2 = Total Rainfall (Annual) in cms.
x_3 = %age of gross irrigated area to the gross cultivated area
x_4 = Fertilizer consumption per hectare of irrigated area - in tonnes
x_5 = Mechanisation Index
x_6 = %age of agricultural labour to the agricultural population
x_7 = %age of rural SC/ST population to total rural population

Appendix-XX

Results of Step-wise Regression Procedure - 1954-55

Step	Variable added	R	R^2	R^2 x 100	Increase in R^2 x 100	Regression Coefficient - b
1	x_5	0.419	0.175	17.50	-	b_5 = 8.064
2	x_4	0.529	0.280	28.00	10.5	b_5 = 7.209
						b_4 = 22.231
3	x_3	0.558	0.312	31.2	3.2	b_5 = 7.429
						b_4 = 27.110
						b_3 = - 1.494
4	x_6	0.595	0.354	35.4	4.2	b_5 = 6.758
						b_4 = 9.916
						b_3 = - 4.315
						b_6 = 14.641
5	x_2	0.598	0.358	35.8	0.4	b_5 = 5.957
						b_4 = 10.452
						b_3 = - 4.122
						b_6 = 15.404
						b_2 = 0.113
6	x_1	0.601	0.361	36.1	0.3	b_5 = 6.278
						b_4 = 11.448
						b_3 = - 3.935
						b_6 = 13.396
						b_2 = 0.128
						b_1 = - 1.429

x_5 = Percentage of agricultural labour to the agricultural population

x_4 = Mechanisation Index

x_3 = Percentage of gross irrigated area to the gross cultivated area

x_6 = Percentage of rural SC/ST population to total rural population

x_2 = Total Rainfall (Annual) in cms.

x_1 = Soil Rating Index

Standard Error of b	T-Value Estimated	b- significant at the level of %	F-Value Estimated	R- significant at the level of -%	Intercept	Std. Error of Es.
5.522	1.460	20	2.132	2	210.07	149.94
5.489	1.313	N.S	1.756	N.S	167.66	147.64
19.398	1.146	N.S				
5.704	1.302	N.S	1.210	N.S	203.61	153.13
21.671	1.250	N.S				
2.468	-0.605	N.S				
5.991	1.127	N.S	0.960	N.S	137.75	158.61
33.928	0.292	N.S				
4.893	-0.881	N.S				
21.663	0.675	N.S				
7.603	0.783	N.S	0.671	N.S	122.60	170.76
36.625	0.285	N.S				
5.357	-0.769	N.S				
23.636	0.651	N.S				
0.568	0.198	N.S				
8.551	0.734	N.S	0.472	N.S	221.99	186.58
40.510	0.282	N.S				
5.971	-0.658	N.S				
26.599	0.541	N.S				
0.627	0.203	N.S				
9.019	-0.158	N.S				

Note: N.S = Not significant; not significant when the regression coefs. and multiple correlation coefficients remain to be insignificant even at 20% level.

Results of Stepwise Regression Procedure
1964-65

Appendix-XXI

Step	Variable added	R	R^2	R^2 x 100	Increase in R^2 x100	Regression Co-efficient
1	x_2	0.690	0.476	47.6	-	b_2 = 2.879
2	x_1	0.779	0.608	60.8	13.2	b_2 = 2.506
						b_1 = 4.942
3	x_7	0.825	0.681	68.1	7.3	b_2 = 2.131
						b_1 = 4.591
						b_7 = - 3.571
4	x_6	0.896	0.823	82.3	14.2	b_2 = 1.524
						b_1 = 1.678
						b_7 = - 6.445
						b_6 = 5.289
5	x_5	0.930	0.866	86.6	4.3	b_2 = 1.048
						b_1 = - 0.652
						b_7 = -11.438
						b_6 = 7.851
						b_5 = 18.785
6	x_3	0.941	0.885	88.5	1.9	b_2 = 0.594
						b_1 = 0.025
						b_7 = -13.218
						b_6 = 5.688
						b_5 = 21.459
						b_3 = 1.756
7	x_4	0.942	0.888	88.8	0.3	b_2 = 0.723
						b_1 = 0.734
						b_7 = -10.907
						b_6 = 4.544
						b_5 = 10.858
						b_3 = 2.239
						b_4 = 19.509

x_2 = Total Rainfall (Annual) in cms.

x_1 = Soil Rating Index

x_7 = Percentage of Rural SC/ST Population to total rural population

x_6 = Percentage of agricultural labour to the agricultural population

Standard Error of b	T-Value Estimated	b- significant at the level of - %	F-Value Estimated	R- significant at the level of -%	Intercept	Standard Error of Estimate
1.005	2.863	2	8.202	2.5	157.34	69.391
0.951	2.635	5	6.206	2.5	-168.62	63.700
3.019	1.637	20				
0.962	2.213	10	4.996	5	- 37.03	61.374
2.922	1.571	20				
2.808	-1.271	N.S				
0.873	1.744	20	6.164	5	90.06	51.977
2.894	0.579	N.S				
2.802	-2.302	10				
2.727	1.939	10				
0.850	1.232	N.S	6.469	5	248.62	47.095
3.038	-0.214	N.S				
4.152	-2.754	5				
2.991	2.624	5				
12.364	1.519	20				
1.036	0.572	N.S	5.164	10	264.14	48.655
3.243	0.007	N.S				
4.799	-2.754	5				
4.048	1.405	N.S				
13.176	1.628	20				
2.123	0.827	N.S				
1.285	0.562	N.S	3.403	20	144.67	55.571
4.615	0.159	N.S				
10.513	1.037	N.S				
6.384	0.713	N.S				
43.827	0.247	N.S				
3.065	0.730	N.S				
75.749	0.257	N.S				

Note: N.S = Not significant; not significant when the regression coefficients remain to be insignificant even at 20% level.

x_5 = Mechanisation Index

x_3 = Percentage of gross irrigated area to the gross cultivated area

x_4 = Fertilizer consumption per 100 hectare of irrigated area in tonnes

Appendix-XXII

Results of Step-wise Regression Procedure - 1969-70

Step	Variable added	R	R^2	R^2 x 100	Increase in R^2 x 100	Regression Coefficient - b
1	x_6	0.724	0.525	52.5	-	b_6 = 7.062
2	x_4	0.891	0.794	79.4	26.9	b_6 = 6.689
						b_4 = 36.305
3	x_3	0.922	0.878	87.8	8.4	b_6 = 9.569
						b_4 = 43.483
						b_3 = - 2.480
4	x_5	0.946	0.895	89.5	1.7	b_6 = 8.511
						b_4 = 54.479
						b_3 = - 2.363
						b_5 = - 9.779
5	x_7	0.949	0.901	90.1	0.6	b_6 = 7.803
						b_4 = 55.201
						b_3 = - 1.683
						b_5 = - 7.744
						b_7 = - 1.913
6	x_2	0.954	0.910	91.0	0.9	b_6 = 6.338
						b_4 = 55.355
						b_3 = 0.404
						b_5 = - 6.822
						b_7 = - 3.658
						b_2 = - 0.905
7	x_1	0.956	0.915	91.5	0.5	b_6 = 4.940
						b_4 = 57.402
						b_3 = 1.419
						b_5 = - 9.277
						b_7 = - 4.115
						b_2 = - 1.223
						b_1 = 1.418

x_6 = Percentage of agricultural labour to the agricultural popn.

x_4 = Fertilizer consumption per 100 hectares of irrigated area in tonnes

x_3 = Percentage of gross irrigated area to the gross cultivated area

Standard Error of b	T-Value Estimated	b- significant of the level of -%	F-Value Estimated	R- significant at the level of -%	Intercept	Standard Error of Estimate
2.122	3.227	1	11.072	1	81.01	72.387
1.475	4.535	1	17.438	.1	-109.21	50.165
10.559	3.438	1				
1.723	5.553	.1	19.229	.1	-169.45	40.999
9.159	4.747	1				
1.060	-2.339	5				
1.980	4.298	1	14.927	.5	-157.24	40.684
13.788	3.950	1				
1.057	-2.234	10				
9.223	-1.060	N.S				
2.386	3.269	5	10.925	1	-127.79	42.676
14.513	3.803	1				
1.583	-1.063	N.S				
10.249	-0.755	N.S				
3.180	-0.601	N.S				
3.175	1.995	20	8.508	2.5	- 27.65	44.384
15.095	3.666	5				
3.267	0.123	N.S				
10.732	-0.635	N.S				
4.062	-0.900	N.S				
1.224	-0.739	N.S				
4.677	1.056	N.S	6.151	5	- 73.72	48.437
17.104	3.355	5				
4.233	0.335	N.S				
12.947	-0.716	N.S				
4.551	-0.904	N.S				
1.515	-0.807	N.S				
3.186	0.445	N.S				

x_5 = Mechanisation Index

x_7 = Percentage of rural SC/ST population to total rural popun.

x_2 = Total Rainfall (Annual) in cms.

x_1 = Soil Rating Index

<u>Note:</u> N.S = Not significant; not significant when the regression coefficients and multiple correlation coefficients remain to be insiginificant even at 20% level.

Appendix-XXIII

1964-65

Result of forced equation of multiple regression.

$$\bar{y} = a + b_2 x_2 + b_1 x_1 + b_6 x_6 + e$$

	x_2	x_1	x_6
Regression Coeff. - b	2.392***	3.962*	1.969*
Standard Error	0.999	3.453	2.939
T-Values	2.392	1.147	0.670

Intercept = -160.73 Standard Error = 224.02

Standard Error of estimate = 66.014

R = .794** R^2 = .631

F = 4.002 R^2 x 100 = 63.1

x_2 = Total Rainfall (Annual) in cms.
x_1 = Soil Rating Index
x_6 = Percentage of agricultural labour to the agricultural population

***Significant at 2.5% level
**Significant at 10% level
*Significant at 20% level

Appendix-XXIV

1969-70

Results of Forced Equations of multiple regression-I

$$\bar{y} = a + b_6 x_6 + b_4 x_4 - b_3 x_3 - b_5 x_5 + e$$

	x_6	x_4	x_3	x_5
Regression Coefficient - b	8.510****	54.479****	-2.363**	-9.779*
Standard Error	1.980	13.789	1.057	9.223
T-Values	4.298	3.950	-2.234	-1.060

Intercept = -157.24

Standard Error of Estimate = 40.684

R = .946*** R^2 = .895

F = 14.927 $R^2 \times 100$ = 89.5

x_6 = Percentage of agricultural labour to the agricultural population

x_4 = Fertilizer consumption per 100 hectaré of irrigated area - in tonnes

x_3 = Percentage of gross irrigated area to the gross cultivated area

x_5 = Mechanisation Index

****Significant at .5% level
***Significant at 1% level
**Significant at 5% level
*Significant at 20% level

Appendix-XXV

1969-70

Results of forced equations of Multiple Regression-II

$$\bar{y} = a + b_6 x_6 + b_5 x_5 + e$$

	x_6	x_5
Regression Coefficient - b	8.242***	14.305*
Standard Error	2.160	9.682
T-Values	3.815	1.477

Intercept = -19.61 Standard Error = 116.29

Standard Error of Estimate = 68.45

R = .786** R^2 = .618

F = 7.282 R^2 x 100 = 61.8

x_6 = Percentage of agricultural labour to the agricultural population

x_5 = Mechanisation Index

***Significant at .5% level
**Significant at 2.5% level
*Significant at 10% level

Appendix-XXVI

1969-70

Results of forced equations of Multiple Regression-III

$$\bar{y} = a + b_4 x_4 + b_3 x_3 + e$$

	x_4	x_3
Regression Coefficient - b	33.777**	1,727*
Standard Error	18.678	1.540
T-Values	1.808	1.120

Intercept = 133.72 Standard Error = 112.17

Standard Error of Estimate = 85.18

R = .639** R^2 = .408

F = 3.109 R^2 x 100 = 40.8

x_4 = Fertilizer consumption per 100 hectare of irrigated area - in tonnes

x_3 = Percentage of gross irrigated area to the gross aultivated area

** Significant at 10% level

* Significant at 20% level

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