AN APPRAISAL OF WATER AVAILABILITY AND AGRICULTURAL DEVELOPMENT — A CASE STUDY OF PUNJAB

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To

By Parents

We certify that the dissertation entitled, "An appraisal of Water Availability and Agricultural Development - A Case Study of Punjab", submitted by Rabinder Kaur in partial fulfilment for the Degree of Master of Philosophy (M.Phil) of the university, is to the best of our knowledge, a bonafide work and may be placed before examiners for evaluation.

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TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENT		i
LIST OF MAPS AND DIAGRAMS		vii
LIST OF TABLES		ix
LIST OF APPENDICES		xi
CHAPTER 1		
1.1	Introduction	1
1.2	Statement of the Problem	2
1.3	Objectives	2
1.4	Hypothesis to be tested	3
1.5	Data Base	4
1.6	Area of Study	5
1.7	Coverage of the Study	6
1.8	Methodology	6
1.8.1	Volume of Canal Water V.C.W.	7
1.8.2	Volume of Ground Water V.G.W.	7
1.8.3	Volume of Rain Water V.R.W.	10
1.8.4	Cartographic Techniques	12
1.9	Frame of the Study	12

CHAPTER 2

2.1.0 Physical Setting 14
2.1.1 Climatic Features 15
2.1.2 Soils 16
2.2.0 General Cropping Pattern 17

CHAPTER 3

3.0 Parameters of Water in Punjab Agriculture 23
3.1 Surface Water Resources 25
3.1.1 The Sutlej 27
3.1.2 The Beas 28
3.1.3 The Ravi 30
3.2 Development of Surface Flow Irrigation 30
3.3 Availability of Water for Irrigation from the Surface Water Sources 36
3.4 Groundwater Resources 43
3.4.1 Assessment of Ground Water Potential in the State 45
3.4.2 Use of Ground Water Sources for Irrigation 46
3.4.3 The Development of Well Irrigation Since 1960-61 47
3.4.4 Availability of Ground Water Resources 49
3.5 Rainfall as a Source of Water 50
3.5.1 Annual Rainfall 51
3.5.2 Availability of Water from Rainfall 52
3.5.3 Water Availability as per Hectare of Gross Cropped Area 53

3.6.0	Importance of Irrigation	55
3.6.1	Growth of Irrigation in Punjab	55
3.6.2	Growth of Irrigation in Punjab since 1850-56	56
3.6.3	Growth of Irrigation since 1960-61	58
CHAPTER	4	
4.0	Agricultural Profile	
4.1	Cropping Pattern	
4.1.1	Temporal Pattern of Area under Cereals	
4.1.2	Temporal Pattern of Area under non-Foodgrains	
4.2	Trend of Area Under Selected Crops in Punjab	67
4.2.1	Trends in Area under Wheat	62
4.2.2	Trends in Area under Maize	69
4.2.3	Trends in Area under Rice	70
4.2.4	Trends in Area under Cotton	71
4.2.5	Trends in area under Sugarcane	73
4.2.6	Trends in Area under Rape/Mustard	75
4.2.7	Trends in Area under Groundnut	76
4.3	Behaviour of Productivity of Selected Crops 1960-61 to 1974-75	77
4.3.1	Productivity of Wheat	78
4.3.2	Productivity of Rice	80
4.3.3	Productivity of Maize	82
4.3.4	Productivity of Cotton	03
4.3.5	Productivity of Sugarcane	85
4.3.6	Productivity of Groundnut	86
4.4	Intensity of Cropping	87

CHAPTER 5	CORRELATES OF PRODUCTIVITY	
5.1.0	The Variables Considered	91
5.1.1	The Value Productivity	92
5.1.2-5	The Water Parametres	62
5.1.6	Consumption of Fertilizers	93
5.1.7	The number of Agricultural Workers to per hectare of Cultivated Land	102
5.1.8	High Yielding Varieties of Wheat, Rice and Maize	104
5.2.0	Correlation Matrix	109
5.2.1	Step-wise Regression Analysis for Temporal Variations in Individual Districts	112
5.3.0	Correlation Matrices for the years 1961-62 - 1966-67	126
5.3.1	Step-wise Regression Analysis for Inter-District Variations in Productivity	136
CHAPTER 6	SUMMARY AND CONCLUSIONS	140
APPENDICES		149
BIBLIOGRAPHY		xiii

List of Maps and Diagrams

No.	Title	Page
1	Location and Administrative Divisions	
2	Discharge of Water of Ravi, Beas and Sutlej, 1961-75	
3	Irrigation Canals, 1975	
4	Variability of Volume of Water Available from Canals	
5	Sub-soil Water Depths, June 1970	
6	Sub-soil Water Depths, October 1970	
7	The Distribution of Wells/Tubewells, 1961-1975	
8	Variability of Volume of Water Available from Ground Water	
9	Rainfall Distribution	
10	Variability of Volume of Water Available from Rainfall	
11	Variability of Volume of Water Available (All Sources)	
12	Well Irrigated Area as Percentage to Net Irrigated Area (1961-75)	
13	Canal Irrigated Area as Percentage to Net Irrigated Areas (1961-75)	
14	Cropping Pattern (1961-75)	
15	Trends in Area under Selected Crops, 1961-75	

16	Trends in Yield of Selected Crops, 1961-75
17	Intensity of Cropping (1951, 75)
18	Trends in Intensity of Cropping, 1961-75
19	Trends in Consumption of Fertilizers, 1951-75
20	Value Productivity, 1962, 1975

***

List of Tables

Table No.	Title	Page No.
2.1	Production of Crops, 1870-71	20
2.2	Cropping Pattern, 1919-20	22
3.1	Yearly Discharge of Water of the Rivers of Punjab	29
3.2	District-wise Length of Canals	37
3.3	The Volume of Water Available from Canals	39
3.4	Contribution of Various Parametres of Groundwater Recharge	45
3.5	District-wise Number of Wells and Tubewells in Punjab	48
3.6	The Volume of Groundwater	51
3.7	The Volume of Rain Water	52
3.8	Volume of Total Water Available	54-a
3.9	Water Availability as per hectare of Gross Cropped Area (in terms of rainfall equivalents)	54.b
4.1.1	Percentage of Area under Cereals as Percentage to Gross Cropped Area	
4.1.2	Percentage of Area under non-foodgrains as Percentage to Gross Cropped Area	
4.4.1	Intensity of Cropping	

contd....

5.1	Value Productivity, 1961-62 to 1974-75	93
5.2	Value Productivity Categories and Districts in each Category, 1961-62	95
5.3	Value Productivity Categories and Districts in each Category, 1974-1975	
5.5	Number of Tractors to per hectare of Gross Cropped Area	
5.6	Number of Agricultural Workers	103
5.7	H.Y.V. area under six Crops as percentage to Area under Six Crops	107
5.8	Step-wise Regression Analysis District-wise (A-L)	114-129
5.9	Step-wise Regression Analysis Year-wise (A-O)	129-139

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Appendices

No.	Title
1	The Utilization of Canals
2	Area Irrigated by Canals, 1961-1975
3	Area Irrigated by Wells and Tubewells, 1961-1975
4	Districtwise Average Annual Rainfall in Punjab, 1961-1975.
5	Net Area Irrigated in Punjab, 1961-1975
6	Irrigated Area Under Six Crops as Percentage to total area under Six Crops, 1961-1975
7	Area under Wheat 1960-61 - 1974-75
8	Area under Maize 1960-61 - 1974-75
9	Area under Rice 1960-61 - 1974-75
10	Area under Cotton 1960-61- 1974-75
11	Area under Sugarcane 1960-61 - 1974-75
12	Area under Rape/Mustard 1960-61 - 1974-75
13	Area under Groundnut 1960-61 - 1974-75
14	Yield of Wheat 1960-61 - 1974-75
15	Yield of Maize 1960-61 - 1974-75
16	Yield of Rice 1960-61 - 1974-75
17	Yield of Cotton American 1960-61 - 1974-75

contd...

18	Yield of Cotton Desi 1960-61 - 1974-75
19	Yield of Sugarcane 1960-61 - 1974-75
20	Yield of Groundnut 1960-61 - 1974-75
21	Percentage of area under High Yielding Variation of Wheat to the Total area under Wheat, 1963-1975
21	Percentage of area under H.Y.V. Rice to the total area under Rice 1960-75
22	Percentage of area under H.Y.V. Maize to the total area under Maize, 1960-1975
23	Correlation Matrices Districtwise Analysis (A-L)
24	Correlation Matrices Yearwise Analysis (A-G)

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CHAPTER I

INTRODUCTION

Indian agriculture is often described as 'gamble with the rains'. It indicates that water is a crucial parametre for any meaningful agricultural activity. Prior to a point in the history of agriculture development, when people became aware of and learnt the method of irrigation, the art of growing of crops depended either on rainfall or the surface flow. In spite of great technological breakthrough in seed, fertilizers and farm mechanisation, water still persists to remain one of the most crucial components of the whole package of technologies available for agricultural development. Punjab is a typical case where water has transformed the agriculture to a large extent over time. Agriculture, being the backbone of the economy of Punjab, contributes over 60 per cent of its net domestic product. 'Not less than 80 per cent of its population is dependent in one way or the other upon it.'[1] The socio-economic development of the state and the standard of living of the people mainly hinges on the agricultural development.[2] Since independence, Punjab

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1 Government of Punjab, Punjab on the March (Chandigarh: Planning Department, 1977), p. 1.

2 Government of Punjab, Draft Annual Plan, 1978-79 (Chandigarh: Planning Department, 1979), p. 13.

agriculture has made rapid progress and the state has emerged as the richest agricultural state in India both in terms of growth and development. The state of Punjab occupies the first place among the states as far as economic development is concerned as indicated by one of the most objective measure i.e. per capita income.

1.2 Statement of the Problem

The present study attempts to analyse the spatial and temporal development of agriculture in Punjab and examines the contribution made by the availability of water and its various parametres coupled with some other important technological inputs. Punjab, being a deficit state in respect of rainfall, has to depend on the other sources of water to meet out the water requirement of crops. An institutional effort has been made to compensate for the lack of rainfall by the development of means of irrigation. The state possesses a rich-surface water resource besides the ground water acquifers which have been utilized for growing crops since a long time back. It would be interesting to find out as to how the various parametres of water influenced the agricultural productivity both spatially and temporally.

1.3 Objectives

The main objectives of the study are:

(i) To examine the temporal and spatial pattern of cropping in Punjab.

(ii) To examine the spatial and temporal behaviour of area

and yield of wheat, rice, maize, sugarcane, oil seeds (rape/mustard and groundnut) and cotton, which account for about 75 per cent of the gross cropped area.

(iii) To analyse the spatial and temporal pattern of composite productivity of the above mentioned crops in value terms and its determinants.

(iv) To examine the irrigation facilities in Punjab over time.

(v) To analyse the availability of water from various parametres over time and space.

(vi) To examine as to how parametres of water have contributed to productivity along with other inputs over time and space.

a.4 Hypothesis to be tested

The study attempts to test the following hypotheses:

(i) Productivity is the function of availability of water to the crops.

(ii) The water parametres become neutral after the attainment of a certain level of water technology and the variance in productivity is explained by other technological inputs e.g. fertilizer and seeds.

(iii) The spread of area under H.Y.V. and fertilizers consumption is a function of the parametres of water available through irrigation.

1.5 Data Base

The entire work is based on the secondary data obtained from various published sources. The basic data for production, area and yield of the crops has been taken from the Statistical Abstract of Punjab, Government of Punjab, for the years 1960-61 to 1974-75. The area under high yielding varieties of rice, wheat and maize, the number of tractors, the availability of land per worker; average annual rainfall for years 1966 to 1975 have also been taken from the Statistical Abstract of Punjab, Government of Punjab for the various years. The data pertaining to average annual rainfall from 1960-61 to 1965-66, for the districts, the number of wells and tube wells, crop-wise as well as source-wise area irrigated have been taken from the "Irrigation Floods and Waterlogging Statistics of Punjab, for the years 1969 and 1971-75. The consumption of fertilizers in all the districts of Punjab has been taken from two sources: firstly, for the period covering 1961 to 1968, from "Effective Demand for Fertilizers in India", May 10, 1970, prepared by V.B. Donde, Government of India, New Delhi, and from Dorris D. Brown's International Bank for Reconstruction and Development, New Delhi, for the years 1968-69 to 1974-75, and secondly from 'Fertilizer Statistics, 1971-72, 1975-76, 1976-77' published by the Fertilizer Association of India, New Delhi.

The data for discharge of rivers - Ravi, Beas and Sutlej - have been obtained from the tables 'Yearly Discharge, Data of River Ravi, Beas, and Sutlej', prepared by Irrigation

Department, Government of Punjab. The utilization of canal water for various canal systems has been procured from 'Utilization of Different Canals in Punjab during kharif and rabi' (unpublished), Irrigation Department, Punjab. The number of canals, and the year-wise length for each district have also been taken from the same source.

1.6 Area of Study

The area chosen for the present study is Punjab, agriculturally a very advanced state of the country. Punjab, lying in a semi-arid environ had depended for a considerably long time on rainfall for its agriculture and the cropping pattern prior to the introduction of the irrigation bears testimony for that. The rapid development of agriculture owes much to the development of canal irrigation which not only replaced the old persian wheel technology but ushered a new era of agricultural transformation. The state of Punjab as selected for the present study emerged as a result of the state's reorganisation and separation of the Haryana state. For the period 1960-61 to 1964-65 there were only 10 districts and from 1966 onwards district of Ropar has been added to the list of districts. The districts of Faridkot and Ferozepur have been clubbed together, because of the recency of the creation of Faridkot, a tehsil of Ferozepur district, for which data for the period of the study is not available. The district has been chosen as the unit of study due to the fact that productivity figures below district

level are not available and productivity being the most potent indicator of agricultural development could not be substituted by any other indicator. Productivity is more susceptible also to respond to the changes in inputs, particularly water accompanied by other bio-chemical inputs.

1.7 Coverage of the Study

The study covers a period of 15 years spreading from 1960-61 to 1974-75. An assessment of water availability for crops in Punjab has been done for fourteen years from 1961-62 to 1974-75, while the behaviour of area and yield of some selected crops has been analysed for the years 1960-61 to 1974-75. It is aimed that this temporal study for a continuous period will give a clear picture of Punjab agriculture in the pre- and post-green revolution periods which is associated with the high growth rates of agricultural productivity because of the impact of new technological inputs. The availability of water is calculated only for the years from 1962-1975 as the canal discharge data was not available, because the regulation Department got established separately only in 1960-61. This shows that an attempt has been made to cover a period of roughly 15 years, or less for certain indicators due to data constraints.

1.8 Methodology

In order to interpret the data and to test the hypotheses a number of techniques and methods have been used.

The water availability has been computed for all the districts for each year with the help of the volume of water available from different sources. The assessment of the volume of water is based on a number of assumptions, and of course, has certain limitations. The volume of water available for crops from various sources has been calculated as follows:

1.8.1 Volume of Canal Water (VCW)

The canals are the main source of utilizing the surface water for irrigation in most of the districts. The availability of water from canals in each district depends upon the discharge and the length of canals. The data for utilization of canal water for rabi and kharif is available for each canal. It is assumed here that the water of canals will be distributed proportionate to the length of that particular canal and the distributaries. Hence the volume of total utilized water is divided proportionately according to the length of the canals in the respective districts which receive water from that canal. The water utilization data is available in cusec days which is converted into cubic metres to maintain the uniformity of scale.

1.8.2 Volume of Ground Water

Since there is no standardised method to assess the ground water and it is also difficult to measure the volume of water available from underground sources by any direct method, an attempt has been made to determine the volume of

ground water on the basis of area irrigated by wells and tubewells and with the help of the potential evapotranspiration data. For the purpose of calculation following assumptions have been made:

(i) Water available from the wells and tube wells should be sufficient to meet the water requirement of the crops.

(ii) The water requirement of the crops is equivalent to the potential evapotranspiration of the area.

(iii) The area irrigated by wells and tube wells is normally double cropped and gets irrigation in both the crop seasons.

(iv) Since water from rainfall will be available for all the areas equally and it will be available for the use of crops it has been reduced from the water required for evapotranspiration purposes.

(v) The potential evapotranspiration data used to calculate the volume of ground water is same for all the years as there is not much variations in the temperature over the period.

Hence, the data for area irrigated by wells and tubewells provides only the net irrigated area so as to compute gross irrigated area by wells and tubewells the following methods is used:

GIA - NIA = Area irrigated more than once Assumed that all the area irrigated by wells is irrigated more than once.

(i) If the area irrigated more than once is less than the net area irrigated by wells, then the whole thing is added in the well irrigated area to obtain the gross irrigated area by wells.

(ii) If the area irrigated more than once is more than the area irrigated by wells then to obtain gross irrigated area by wells the net area irrigated by wells is doubled and it is further assumed that the excess area has been irrigated more than once by other source.

EXAMPLE:

Gross irrigated area in Amritsar is 589,700 hectares in 1974-75

Net irrigated area is 372,900 hectares

Net area irrigated by wells = 159,000 hectares

Area irrigated more than once = 589,700 - 372,900
= 216,800 hectares

Since net irrigated area by wells is less than 216,800 hectares, it is presumed that the gross irrigated area by wells will be (159,000 hectares + 159,000 hectares) = 318,000 hectares (as per our assumption).

Thus the volume of water available in the district from Ground water is -

GAI = 318000 hectares

PET = 1501 mm

Rainfall = 543 mm

VGW = GAI by wells X PET - Average annual rainfall

$$VGW = 318000 \times 10{,}000 \times \left(\frac{1501 - 543}{1000} \right)$$

$$= 318000 \times 10 \times 958$$

$$= 3046{,}440{,}000$$

= 3046 million cubic metres

1.8.3 Volume of Rain Water

Since rainfall is distributed over all the cultivated area, the volume of the water available from rainfall in the district will be equal to net cropped area x average annual rainfall of the respective districts.

Example of the method of Calculation of volume of rain water in Amritsar

Net sown area during 1974-75 was 396,000 hectares and the average annual rainfall was recorded to be 543 mm.

Available Volume of rain water = NAS x average annual rainfall

$$\text{Hence } VRW = \frac{396000 \times 543 \times 10000}{1000}$$

VRW = 396000 x 10 x 543 cubic metres

VRW = 2,149,880,000 cubic metres

i.e. VRW = 2150 million cubic metres

With the help of the above computation it is easy to work out the availability of the total volume of water which will now be as under:

$$VTW = VCW + VGW + VRW$$

In order to know the total water availability in terms of rainfall equivalents in the district the total volume of water has been divided by the gross cropped area.

Besides the volume of water and the availability of water per hectare, the coefficient of variability for the total water availability, rainfall and the discharge of river water has also been computed in percentage by using the following method:

$$\text{Coefficient of variation or CV} = \frac{\sigma}{\bar{X}} \times 100$$

Value productivity has been worked out taking the constant prices of respective crops for the year 1974-75. Intensity of cropping has been computed by working out the ratio between net and gross cropped area in terms of percentage.

$$\left(\text{Intensity of cropping} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100\right)$$

The step-wise regression has been computed with the help of computer, taking value productivity of crops as dependent and the water parametres, viz. (VCW, VGW, VRW and VTW) and other major inputs viz. fertilizer per 1000 hectares, labour proportion of HYV area under six crops, tractors as independent variables.

In the first instance the correlation matrices have been obtained for the purpose of analysing the relationship between the dependent variable (productivity) and the other independent variables and their relationship with each other.

1.8.4 Cartographic Techniques

The statistical information used in the study has been depicted on maps and diagrams through suitable cartographic techniques. Chropleth maps have been prepared to show the spatial pattern while the graphs have been prepared to depict the temporal trends in the yield and areas of selected crops.

1.9 Frame of the Study

The present study is divided into six chapters. The first chapter spells out the objectives, hypotheses to be tested, data base, and the methodology of the study. The second chapter provides the environmental setting and salient features of the agricultural economy of Punjab. The third chapter gives a detailed appraisal of the water parametres and their spatial pattern overtime. It also examines the development and spread of irrigational facilities in the state. The fourth chapter is devoted to examine the trends in area production and yield of six selected crops, (wheat, maize, rice, cotton, sugarcane, rape and mustard) which

account for about ? per cent of the gross cropped area during 1974-75. In the fifth chapter an attempt has been made to analyse the relationships between the value productivity computed for the six crops and various parametres of water and also some supporting and complimentary biochemical inputs. It also includes the results of the regression analysis. The last chapter presents a brief summary of the study and the findings by way of conclusion. It also presents the results of the tests of hypotheses.

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CHAPTER 2

PHYSICAL SETTING AND AGRARIAN ECONOMY

2.1.0 Physical Setting

Punjab is situated in the north-western part of the Indian Union. In its present form, it came into existence on November 1, 1966 as a result of re-organisation of the erstwhile state of Punjab which included the present state Haryana and Union Territory of Chandigarh. It is bounded by Jammu and Kashmir from the north, Himachal Pradesh in the east, Haryana and Rajasthan in the south and Pakistan in the west. Sprawling over an area of 50,376 sq. kms, it accounts for about 1.64 per cent of the total area of the Indian Union and accommodates 2.5 per cent of population.[1]

The state is situated between 24° and 32° in North latitude and 73 degrees and 77 degrees east longitude. Punjab is divided into three physical regions viz. (i) The sub-mountaiφn strip; (ii) The central alluvial plains, and (iii) The south western dry zone and these have great effect

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1 Government of Punjab, Economics of Agricultural Production and Farm Management in Punjab, 1967-68 (Chandigarh: Economic and Statistical Organisation, 1968), p. 3.

PUNJAB

LOCATION AND ADMINISTRATIVE DIVISIONS

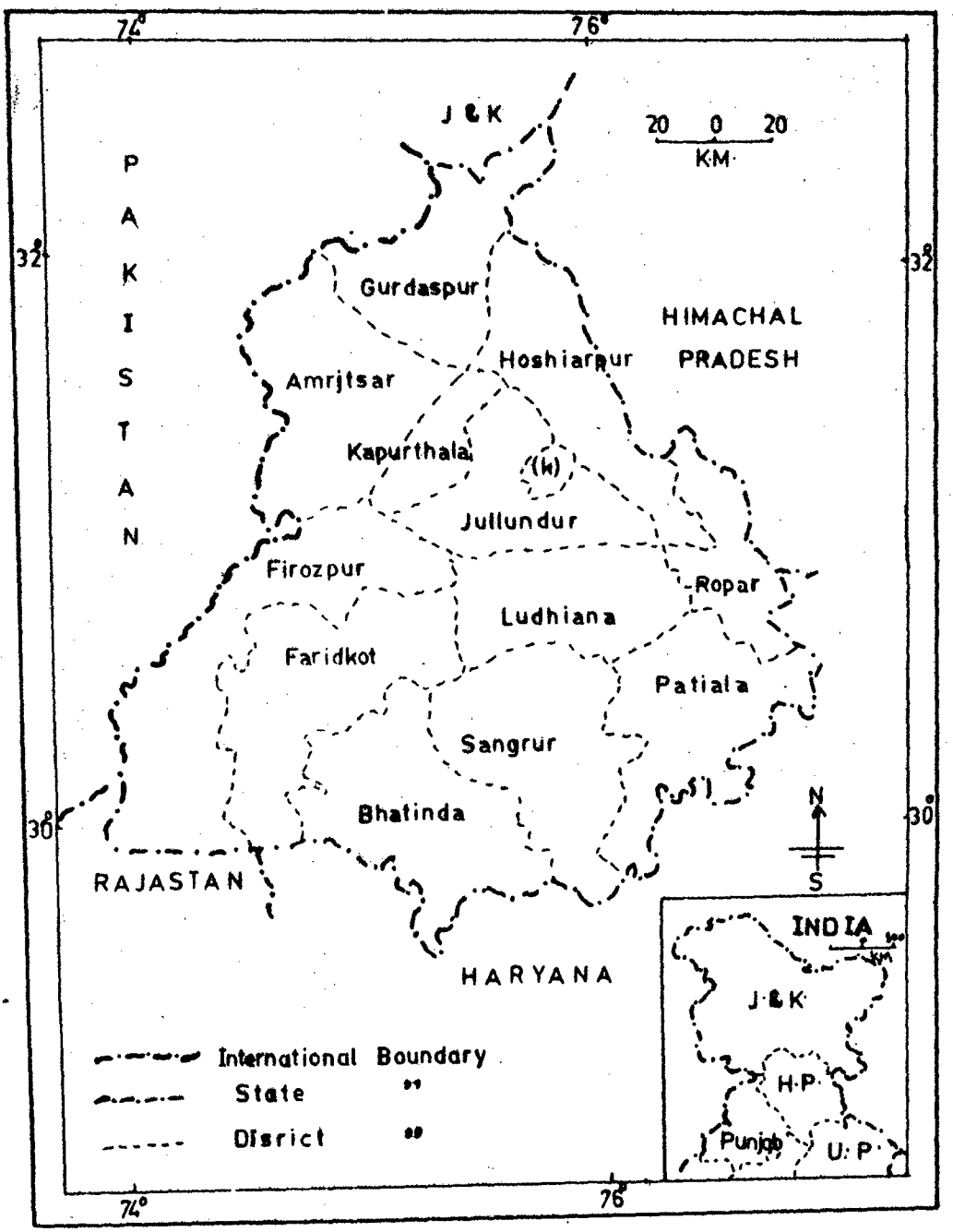

Fig. 1.

on the agricultural practices in the state.[2] The sub-mountain region is a narrow strip of territory lying between the Himalayas and the plains. The northern portions of Hoshiarpur, Ropar and Gurdaspur (except Batala Tehsil) lie in this strip. Districts of Amritsar, Kapurthala, Jullunder, Ludhiana, Patiala, and Sangrur and (Batala Tehsil of Gurdaspur district) lie in the plains of Sutlej, Beas and Ravi rivers. This region has a large resource of underground water suitable for the purpose of irrigation. Bhatinda Ferozepur, Faridkot and Barnala tehsil of Sangrur district are located in the south western dry region, which is drier part than the northern districts of the state.

2.1.1 Climatic Features

The climate of Punjab, over most of the year is of a pronounced continental character, extremely hot in summer and severely cold in winter.[3] Climatically, Punjab comes under the sub-humid and semi-arid, agro-climatic region. The northern portions of Punjab lie in the sub-humid region. While the southern portions of states lie in the semi-arid climatic zone.

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2 Government of Punjab, The Third Decennial World Agricultural Census, 1970-71 : Report for Punjab (Chandigarh: Agricultural Census Ding Development Department, 1971), Part I and II, p. 61.

3 Report of the National Council of Applied Economic Research, Techno Economic Survey of Punjab (New Delhi, 1961), p. 3.

The continental position of state has resulted in extremes of temperature conditions. Though the mean daily temperature throughout the year is never below 0°C., the maximum temperature recorded in the months of May and June goes as high as 45°C. The temperature falls to the lowest in January when generally frost is recorded during nights.

The rainy season in Punjab commences in July and lasts in September. There is a little rainfall in the state during winters. The winter rains are highly beneficial for the crops of rabi season. January is the raniest month during winters. November is the driest month of the year. The northern and north eastern districts of Punjab receive about 750 mm of rainfall annually, while southern districts i.e. Sangrur, Bhatinda, Faridkot, and Ferozepur are comparatively dry and receive only about 400 to 550 mm rainfall annually.

2.1.2 Soils

The soils of Punjab are coarse and sandy. The following four main types of soils are found in Punjab.

(1) Alluvial Soils

In the districts of Jullunder, Kapurthala, larger part of Amritsar, Gurdaspur, Hoshiarpur, Ludhiana, Patiala, and parts of Sangrur, the soils are of alluvial type. These are deficient in phosphoric acid, nitrogen and humus, but

rich in lime and potash, noted for quick renewal of nitrogen, responsive to manuring and irrigation. This is the most important and most fertile among the Indian soils for producing a variety of crops.

(ii) Chestnut Brown Soils

Bhatinda, larger parts of Ferozepur, Sangrur and parts of Amritsar, Ludhiana and Patiala are mostly covered by chestnut Brown soils, which have similar characteristics to those of Alluvial soils.

(iii) Desert Soils

These are found in parts of Ferozepur district. These are mostly sandy, often with high soluble salt contents, low organic matter and generally suitable for millets. The soils have low humus content.

(iv) Hilly Brown Soils

Hilly brown soils, deficient in potash, phosphoric acid and lime generally suitable for orchards are found in the parts of Gurdaspur and Hoshiarpur districts.

2.2.0 General Cropping Pattern in Punjab

There are two major crop seasons, rabi and kharif. The rabi crops in the state are mainly wheat, Gram, Barley, Rape and Mustard. Wheat is the dominant crop among the rabi

crops, accounting for 50 per cent of gross cropped area in all the districts. Up to the mid-sixties gram was second ranking crop in most of the districts, but now its growth has decreased tremendously and replaced by wheat and oil seeds. A variety of crops are grown in Punjab in the kharif season. Dominant crop of this season is maize in terms of hectareage. But recently the trend has changed and rice has become as the first ranking crop in most of the districts. In Ferozepur and Bhatinda, cotton is the first ranking crop in the kharif season, while maize occupies the second place. Groundnut is the other important kharif crop which is gaining strength in terms of hectareage in most of the districts of the state. Cotton and sugarcane are the crops which have registered some increase in area. The other crops grown in kharif are Jowar, Bajra, Linseed, Seasamum and some pulses (moong, mash and masoor), but the proportion of area under all these crops is very small and there has been a rapid decline in their area during the recent years.

The cropping pattern in Punjab, today differs to a great extent from that of the 19th century. However, the general trend has not changed too much, but still in terms of areal spread in the wake of new technology accompanied with better irrigational facilities, some major changes have taken place. Though in the 19th century also the major portion of cropped area was under foodgrains only, and the share of commercial crops was very little, even today state

mainly produces foodgrains, but the inferior grains are replaced by superior grains like rice, wheat and maize and the proportion of area under pulses has decreased to a much larger extent.

During the second half of 19th century, when the agriculture in Punjab was dependent on monsoon and irrigation facilities were limited, the main source of irrigation was wells worked by persian wheels. As it is shown in the table 2.1 that during 1870-71 in Punjab the main crops grown in the rabi season were wheat, barley and gram. Toria and sirson, tobacco were some other important crops of rabi harvest. All these crops need less of water. Wheat was only fine cereal which can be grown without the help of irrigation. In terms of acreage coverage wheat was the first ranking crop in all the districts of Punjab. Gram was the second important crop, during the rabi season, followed by barley. During the kharif season, maize, jowar and the spiked millet pulses like moth, mash and mausur were important crops. Rice was grown in only two districts in a limited areas. Jowar was the first ranking crop in Amritsar, Ludhiana, Ferozepur and Hoshiarpur districts, while in Jullunder district maize was the dominant crop. Maize was the important crop in all other districts during the kharif season. Area under pulses was considerably high in all the districts. Cotton and sugarcane were grown only in Amritsar and Jullunder districts where well irrigation was well developed. The district of

TABLE 2.1

Area* under Crops in the Districts of Punjab - 1870-71

District	Wheat	Barley	Gram	Maize (Indian Corn)	Rice	Jowar	Cotton	Sugarcane	Pulses (moth, mash & moong)
Jullunder	287020	25855	39739	115617	31906	81275	34341	30121	22804
Amritsar	240928	48243	88780	48130	22832	68209	24551	21197	79457
Gurdaspur	165766	90389	24615	47535	67599	19465	18066	27024	25902
Ludhiana	217677	43134	94514	60765	-	142259	14284	-	60224
Ferozepur	183346	93723	38335	45452	-	140325	5196	-	20646

* Area in acres.

Source: Punjab Gazetteer, vol. 2, 1874.

Ludhiana grew only cparse grains and pulses. It can be well understood by the following statement: "Much of the district entirely dependent upon rainfall for its cultivation. Years have been known when the whole face of the country, east and west alike, has presented the uniform appearance of a barren expanse of sand like suggestive of the capabilities which timely rains develop...."[4]

During the second half of the 19th century, a little effort was done by the British to improve the irrigation facilities in the state. The first efforts of the British engineers were directed to the improvement of existing indigenous works rather than the construction of new irrigation projects. Of these the most important was western Jamuna Canal. Except this, the effort had been made to complete the upper Bari Doab and the Sirhind canal during 1860s. The history of colonization may be said to have commenced in 1882 with the formulation of the lower Sohag and Para canal project from the Sutlej.[5]

With the result of all these efforts by the British Government there was a great improvement in the irrigation facilities in the beginning of the 20th century. Even then the wheat remained the dominating crop during the rabi

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4 Punjab Gazetteer, vol. 2, 1874, p. 62. vol. I

5 Punjab, Administration Report (Annual), 1921-22 "The Land of the Five Rivers" (Lahore: Government Printing Press, 1923), pp. 160-203.

covering more than 50 per cent of the cropped area. In most of the districts, gram was the second most important crop and barley was often sown mixed with barley. Maize, Jowar and Bajra were the important crops of kharif. Pulses, oil seeds were also grown on large area. The only important change was in the terms of area increased under cotton and sugarcane in all the districts. Sugarcane became a most valuable crop among the kharif crops in all the districts during 1903-4. (Table 2.2)

The most important crops of the state in the second decade of twentieth century were wheat, barley, rice, bajra, jowar, gram, oilseeds, cotton and sugarcane. As it is stated in the Administration report, Annual vol. 1, 1921-22, 'Wheat is the most important Punjab crop both in value and acreage. It is the staple food of most Punjabis, and is also the chief crop for sale and export. The area is generally over 9 million acres of which half is irrigated and half is barani. As the total area under all crops is generally 28 million acres, it will be seen that wheat constitutes from 30 to 35 per cent of the total area of crops. The next important rabi crop is barley.'

At the same time rice while occupying 40 per cent of the net cropped area of foodgrains in India is unimportant in Punjab.[6] In addition to rice, maize, jowar

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6 Ibid., p. 258.

Table 2.2

The Area and Production of Important Crops in Punjab (1919-20)

Crops	Harvest	Sown Area Million acres Irrigated	Sown Area Million acres unirrigated	Total	Production in million tons	Approximate value in crores of Rs.
Wheat	Spring	5.0	4.0	9.0	2.8	16
Barley	Spring	.4	.7	11.0	.3	1
Rice	Autumn	.6	.2	.8	.4	2
Bajra	Autumn	.5	.6	1.1	.4	2
Jowar	Autumn	.4	2.0	2.4	.3	1
Gram	Spring	.2	.8	1.0	.1	½
Oilseeds	Spring	1.0	2.9	3.9	.8	1
Sugarcane	Autumn	.4	.7	1.1	.1	1
Cotton	Autumn	.35	.05	.4	.3	3

Source: Punjab, Administration Report, "The Land of Five Rivers", 1921-22, Annual, vol. 1, p. 258.

and bajra was the staple autumn cereals. Of the pulses most important was gram. During the period 1920-21, Punjab was having largest area under sugarcane among provinces of India. 'American cotton was introduced in the state in 1913, and it gained importance among the fibre crops. The area under cotton reached to its peak in the year 1919-20 due to consequent rise in prices in years 1917-19.'[7]

After this, with the help of canal irrigation the area under cotton and sugarcane had shown a constant rise. While the general cropping pattern of the state had not shown any important change, the state remained a major producer of foodgrains only.

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7 Ibid.

CHAPTER III

PARAMETRES OF WATER IN PUNJAB AGRICULTURE

The water rather than land is the leading limiting factor in the Punjab agriculture. Water is the key input for agricultural development and its assured supply is the prerequisite for agriculture in the state. Thus the evaluation of water resources, irrigation and its development bears great significance. The story of transformation of barren lands of Punjab to the granary of India is the story of the development of irrigation in the state. Irrigation farming gave much greater crop yields than dry land farming. The states which have shown faster growth rates in productivity have better irrigation facilities. The growth in productivity in different states is found to be significantly associated with the increase in the proportion of irrigated area.

Irrigation helps to increase the productivity in different ways. On the one hand it protects crops against droughts, on the other hand, it allows an efficient land use which enables multiple cropping to achieve the optimum production. Irrigation facilities make it possible to adopt

the new technology e.g. use of fertilizers, pesticides etc., and transform primitive subsistence agriculture to commercial and more cash oriented. It is the single most important factor which facilitates a proper utilization of scarce farm land resources in modernizing the agriculture.

Another advantage of irrigation is that it enables a much greater variety of crops to be grown than is possible under natural conditions. It also helps to increase the employment opportunities, and can support more people on the same land than the dry farming.

In the present chapter, an attempt has been made to analyse the different aspects of water resources available in the state. The assessment of water available for the irrigation purposes has been made for each district from 1961-62 to 1974-75. The total volume of water available to rainfall has been worked out, from all the sources namely, surface water, ground water and rainfall. A brief history of the spread of irrigation in Punjab has also been discussed in order to understand the utilization of water in the state.

3.1 Surface Water Resources

In Punjab where the rainfall is scanty the surface water has played an important role in the development of state's agriculture. In the absence of mineral resources, water is the key for the future development of both agricultural and industrial economy of the state. Luckily Punjab's

position is satisfactory from the view point of availability of surface water.

The three rivers, the Sutlej, the Beas and the Ravi flow through the re-organised state of Punjab. All the three rivers are perennial and snow-fed. The longest river of the state is the Sutlej which has its main tributaries, the Ravi and the Beas and the Chenab.[1] These rivers traverse the alluvial plains of Punjab in a generally south westerly direction. The river Ghaggar flows from some distance along the boundary of Punjab and Haryana, in a south-westerly direction and disappears in the Rajasthan desert. There are many small hill torrents and choés which spill over the plains during the rainy season.

3.P.1 The Sutlej

The Sutlej rises in the distant highland of Tibet at a height of about 4,570 metres from the famous Mansarowar lake. It traverses a very long course through the mountain ranges, which rise to heights of 6100 metres on either side. The river flows through Himachal Pradesh and emerges from Siwalik hills at the Bhakra Gorge. It then flows as a narrow deep stream between low hills for about 16 kms and widens into the alluvial plain of Hoshiarpur district. It receives the

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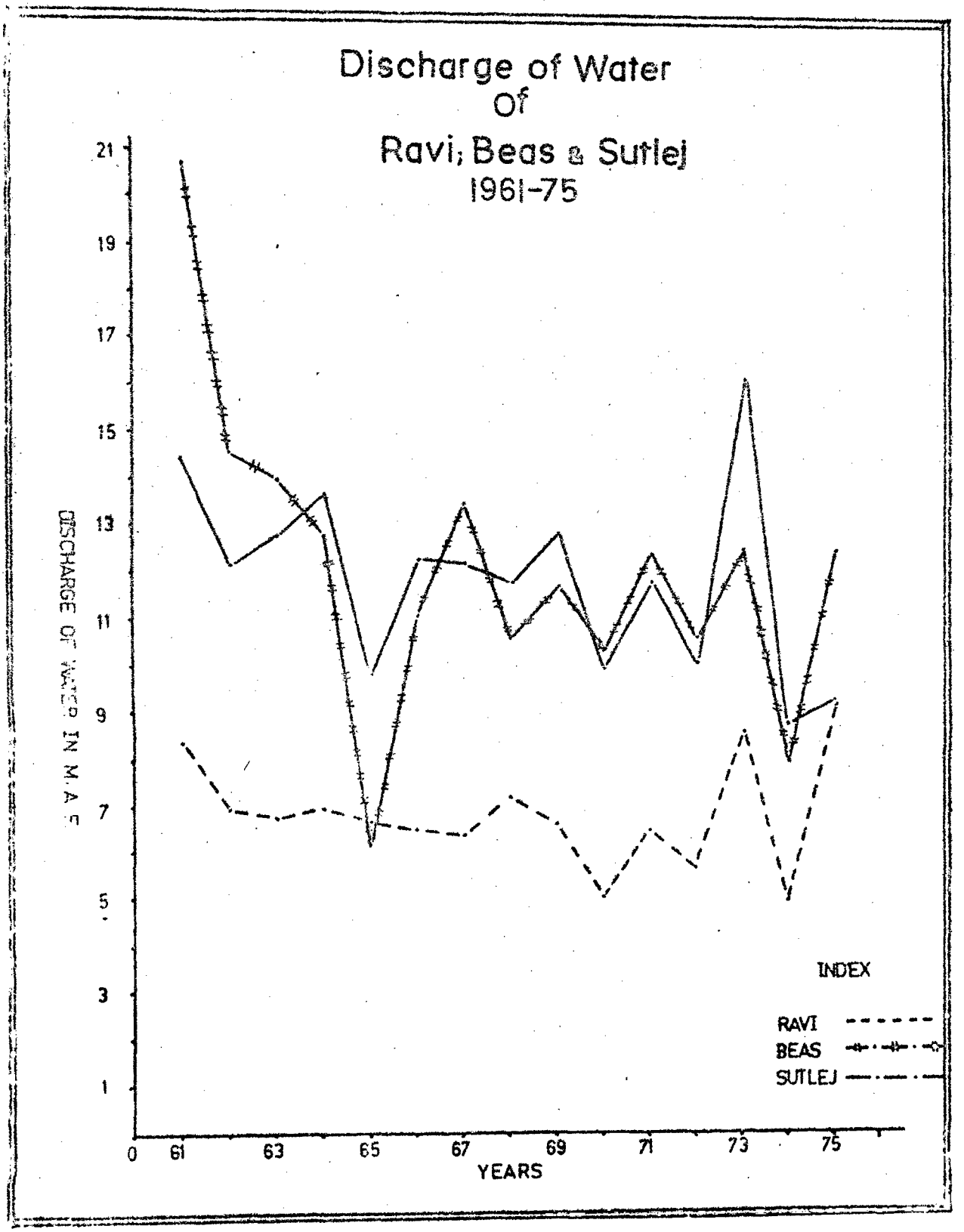
1 Ministry of Irrigation and Power, Report of the Irrigation Commission (New Delhi, 1972), vol. II, p. 314.


Discharge of Water
Of
Ravi, Beas & Sutlej
1961-75
DISCHARGE OF WATER IN M.A.F
21
19
17
15
13
11
9
7
5
3
1
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61
63
65
67
69
71
73
75
YEARS
INDEX
RAVI
BEAS
SUTLEJ

Fig. 2.

Beas at Harike above Ferozepur and Chenab at Madwala in Pakistan. The maximum discharge recorded at Bhakra since 1960-61 was 16.070 M.A.F. during 1973. The discharge of water at Bhakra varied from a minimum of 8.834 M.A.F. to 16.070 M.A.F. from 1960-61 to 1975. The discharge of Sutlej was recorded to be 9.862, 8.834 and 9.286 M.A.F. during 1965, 1974 and 1975 respectively. These years have recorded rainfall less than the normal, and were drought years, for the country as a whole. The river discharge data is presented in table 3.1, and the yearly fluctuations in the river discharge at Bhakra have also been shown in the graph (fig.). The C.V. for the Sutlej is 16.33 per cent and it is more consistent as compared to Beas.

3.1.2 The Beas

The Beas rises in the Pir Panjal range at the Rohtang pass at a height of about 3,960 metres. A number of tributaries combine to flow across the Dhauladhar range and Larji and join the Beas just below Mandi in Himachal Pradesh. From its source to its confluence with the Sutlej the river has a length of about 467 kms.

The maximum discharge observed at Mandi plain was 20.687 M.A.F. in 1961. Otherwise the discharge of Beas at Mandi ranges from 8 to 15 M.A.F. The minimum discharge of 6.263 M.A.F. was recorded in 1965. (Table 3.1) The water potential of the Beas is next to the Sutlej. The fluctuation in discharge of the Beas can be seen from the graph, which

Table 3.1

Yearly Discharge of Water* of the Rivers of Punjab

Year	Ravi	Sutlej	Beas
1961	8.385	14.448	20.687
1962	6.986	12.195	14.589
1963	6.781	12.796	14.020
1964	6.986	13.718	12.766
1965	6.716	9.862	6.263
1966	6.505	12.267	11.106
1967	6.411	12.192	13.488
1968	7.266	11.836	10.653
1969	6.694	12.849	11.720
1970	5.103	9.960	10.375
1971	6.535	11.789	12.437
1972	5.722	10.139	10.650
1973	8.610	16.070	12.497
1974	5.094	8.834	8.023
1975	9.249	9.286	12.474

* River Discharge in Million Acre Feet.

Source: Government of Punjab, Yearly discharge Data of River Ravi, Beas and Sutlej (unpublished).

Note: The discharge site of River Ravi is at Madhopur, Sutlej at Bhakra, Beas at Mandi plain. The discharge of Beas at Mandi is balance of Beas waters only (excluding water transformed from Ravi).

shows a greater variation in it from year to year. The C.V. is 22.814 which shows that the flow of Beas is more variable as compared to the Sutlej and the Ravi. The data also depicts that discharge was highest during 1961 as it was flood year with heavy rains and it was lowest during 1965 and 1974 in the years of less rainfall.

3.1.3 The Ravi

The Ravi rises near the Rohtang Pass in Kangra district and draining the southern slopes of Dhauladhar and crossing the Siwaliks it enters the Punjab Plains at Madhopur. From its source to the India Pakistan border the river has a length of 370 metres.

The discharge of the river varies from 5 to 10 M.A.F. only. The maximum discharge observed at Madhopur during 1975 was 9.249 M.A.F. and minimum was 5.095 (table 3.1) during 1974. The C.V. for the Ravi is 16.49 which shows that the annual discharge of the Ravi is more consistent as compared to the Beas and the percentage of variation is just equal to the Sutlej.

3.2 Development of Surface Flow Irrigation in Punjab

Before 1858 the irrigation in Punjab was mainly provided by the wells. The canal irrigation was practically absent in the state. There were no government canals. Very little area was irrigated by the inundation canals, in the district of Hoshiarpur, because the well irrigation in a

large portions of the district was out of question due to very deep water table. "There was an old cut dating from the imperial times passed through the northern portion of the district. This draws its supply from the Beas from a point located north of Hajipur and was constructed by Rae Murad, a chief of an important family of Muhamedan Rajputs, who held this portion of the district."[2]

The Western Jamuna canal (at present in Haryana) is said to be the oldest perennial canal of Punjab which was started during the fourteenth century in the time of Ferozeshah and was rennovated by Akbar in 1568 and remodelled by Ali Mardan Khan in 1628.[3] But it was done indeed for their own enjoyment rather than the public benefit. The work of remodelling the canal was taken in hand in 1873 and it was in operation in 1919-20.

The canal now known as Hasli or Shahi canal was originally constructed in the year 1633 under the orders of the emperor Shahjahan by Ali Mardan Khan, the famous architect and engineer.[4] Its original object was to supply the fountains and water works of the Royal Gardens and conservatories near Lahore and especially those of famous

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2 Punjab Gazetteer (Gazetteer of the Hoshiarpur District), vol. II, 1874, p. 18.

3 Report of the Royal Commission on Agriculture in India, 1928, pp. 324-66.

4 Punjab Gazetteer (Gazetteer of the Hoshiarpur District), vol. II, 1874, p. 18.

gardens of Shalimar. It was however at certain points undoubtedly used as a means of irrigation. No attention was paid to develop the irrigation works during the Sikh regime also.

The improvement of Hasli canal was among the first projects launched by the Resident and after the occupation of Lahore in 1846, Colonel Napier, who had three lakhs of rupees at his disposal for public works.[5] In 1850 Lieutenant Dyas of Bengal Engineers was instructed to frame plans in general for the remodelling of the old Hasli canal. The scheme was completed by the end of the year and work upon it commenced in 1851. The new canal was ready to be used by the end of 1859-60 and irrigation commenced in the following year. The headworks, however, at that time was of temporary nature, and the present permanent weir and other regulating works were not completed till 1872-73. This prennial canal was 212 miles long at that time and the length of Rajbhahas was 692 miles. It provided water to the districts of Amritsar, Gurdaspur and Lahore. It took off from the left bank of the river, Ravi at the village Madhopur, about 11.2 km north-west of Pathankot. At that time canal was known as Bari Doab Canal. And it was renamed as upper Bari Doab canal after the construction of Lower Bari Doab canal during 1907-1913.

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5 Punjab Gazetteer (Gazetteer of the Gurdaspur District), vol. II, 1874, p. 15.

The old inundation canal of Hoshiarpur known as Shahi Nehar starting from the Beas in the north-west of the district was reopened in 1846 by a number of local landlords at their own expenses. Government acquired the management of the canal in 1890 by an agreement. And it was utilised for irrigating lands in Hoshiarpur district.

Though the construction of Bari Doab canal was motivated by some political reasons, the second important work for the development of irrigation was the construction of Sirhind canal. The preliminary survey work began in 1867 and the canal was formally opened in 1882 though the water for irrigation was available only in 1883. The canal was constructed by government in collaboration with the native states of Patiala, Nabha and Jind. It starts from the river Sutlej at Ropar and provided water mainly to Ludhiana, Bhatinda, Sangrur and Ferozepur districts.

In fact the history of colonization may be said to have commenced in 1882 with the formulation of the Lower Sohag and Para land projects from Sutlej.[6] A number of canals have been constructed one after the other during the latter half and the beginning of 20th century. The great eastern canal from the Sutlej was constructed in Punjab between the years 1927-33. It benefited the Ferozepur district. A vast irrigation scheme was sanctioned in 1905

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6 Punjab Administration Report, The Land of Five Rivers 1921-22 (Government Printers, 1923), vol. 1, p. 163.

for three new canals i.e. the upper Jhelum, upper Chenab and the lower Bari Doab canals. The work on Chenab, lower Jhelum, lower Shahpur inundation canal, grey canals and Ghaggar canals was already going on.

The Punjab system was perhaps the biggest irrigation system in the world; of the total cultivated area of about 30 million acres under all kinds of crops, about 50 per cent got irrigation from canals, wells, tanks and other sources. The canals, however, are the largest source of irrigation supplying water to more than 70 per cent of the land.

After the partition of the country only 20 per cent of the vast net-work of canals in the united Punjab came as a share to eastern Punjab with the result that agricultural economy suffered heavily for lack of irrigation facilities.[7] The state as well as the union Government laid great emphasis on irrigation and power development and a number of works were taken up immediately after independence, including the Bhakra-Nangal project, the Harike project, the Beas project unit I (Beas Sutlej Link) and unit II (Pong Dam).

Actually the idea of building a Dam across Bhakra was first conceived in 1908 by Sir Louis Dane, Governor of Punjab but the work was started later on during (1946-47).

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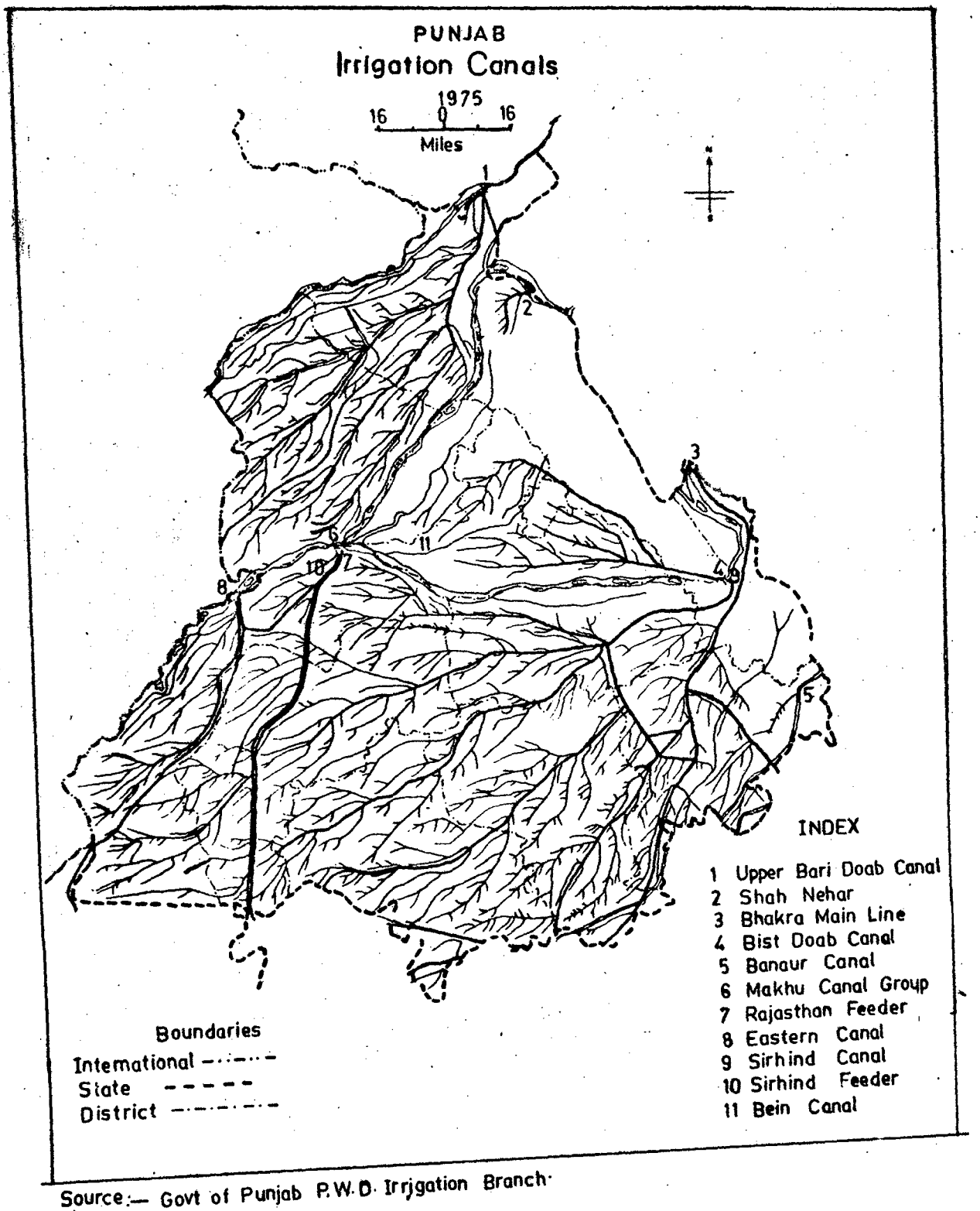
7 Government of Punjab, Punjab on the March, 1967, p. 1.

The water from Bhakra was first released for irrigation purposes in the kharif season of 1952-53. The 64.4 kms lined channel taking off from the left bank of the river serves as feeder for Bhakra canal system below Ropar, and for power generation at the power stations of Ganguwal and Kotla. The Bhakra canal system has been planned to serve the arid and scarcity tracts of Punjab, Haryana and Rajasthan. Since independence special attention has been given to develop a better irrigation system in the state during the plan periods by remodelling the old works. The multi-purpose project Beas Unit I, Beas Project Unit II, Thein Dam, Diversion Weir of Shahnehar canal, Dholbha Check Dam are some of them. Except this the work of remodelling of UBDC channel is proposed to be done in the present plan. To utilise the additional waters from Beas and Ravi rivers according to the treaty and for the extension and remodelling of Bhakra and Sirhind canals has been started during 1975-76. Lining of unlined channels is also going on to overcome the seepage problem and to increase the irrigation potential in the state.

There are ten main canal systems at present in Punjab namely the Upper Bari Doab Canal, Sirhind canal system, Eastern canal, Makhu group, Sirhind Feeder, Shahnehar, Bist Doab, Bhakra main line, Bein canal and Banaur canal. Bein canal is an inundation canal which irrigates a very small area in Jullunder district. Shahnehar irrigates the



Source:— Govt of Punjab P.W.D. Irrjgation Branch.

Fig. 3.

Hoshiarpur district, and the Banaur canal supplies water to parts of Patiala district, while Upper Bari Doab canal provides water to Amritsar and Gurdaspur districts. The 100 per cent water supply of ~~Feroze~~ Sirhind Feeder, Makhu group and Eastern canal goes to Ferozepur district. And Sangrur, Bhatinda, Ludhiana and Patiala receive water from Sirhind canal system and Bhakra mainline. Some water from Sirhind canal is also used for irrigation in Ropar and Ferozepur districts.

The total length of canals in Punjab at present is 2248 kms. of main canals and branches. And the length of distributaries and minors is 11050 kms. The total length of canals and distributaries was maximum in Ferozepur district as it was 3551 kms. The canal length is minimum in Kapurthala. In respect of canal length and area irrigated by canals Bhatinda comes second after Ferozepur with canal length of 1928 kms. during 1972-73. (Table 3.2)

3.3 Availability of Water for Irrigation from the Surface Water Resources

The river water is utilised for irrigation mainly through the canals drawn from dams constructed across the rivers. A number of perennial and imundation canals serve the different parts of the state. Utilization of surface water resources for irrigation started over a century back with the construction of diversion headworks on the perennial rivers of Sutlej, Beas and Ravi. During the last 20 years

Table 3.2

District-wise Length* of Canals

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1962	864	1697	129	689	235	-	924	3624	1906	2850	1668	14586
1963-65	868	1700	124	689	238	-	1188	3431	1958	2782	1521	14538
1964-66	881	1700	124	689	267	-	1188	3431	1955	2782	1521	14500
1967-68	943	1808	124	689	217	87	828	3573	2053	1657	1325	13303
1969	944	1808	123	685	216	150	1002	3596	1855	1701	1461	13514
1972	944	1808	123	685	216	150	1002	3596	1855	1701	1461	13741
1973	1370	1797	117	653	212	90	1024	4164	1928	1685	1452	14395
1974	1372	1798	88	670	216	134	628	3551	1685	1690	1473	13304

* Length in kms.

Source: Length of Canals and Distributaries (unpublished Tables) prepared by Irrigation Department, Government of Punjab, Chandigarh.

the multi-purpose storage schemes such as Bhakra and Beas were taken up for harnessing flood flows of Sutlej and Beas respectively. The transfer of surface supplies from one river basin to be used in the other basin has been achieved by interlinking the sub-systems of surface water. Ravi is interlinked with Beas through Madhopur-Beas Link and with the Beas Sutlej Link (Beas Project unit I). Beas and Sutlej will be interlinked. In this manner the water of these rivers will be used for better management of irrigation and power development.

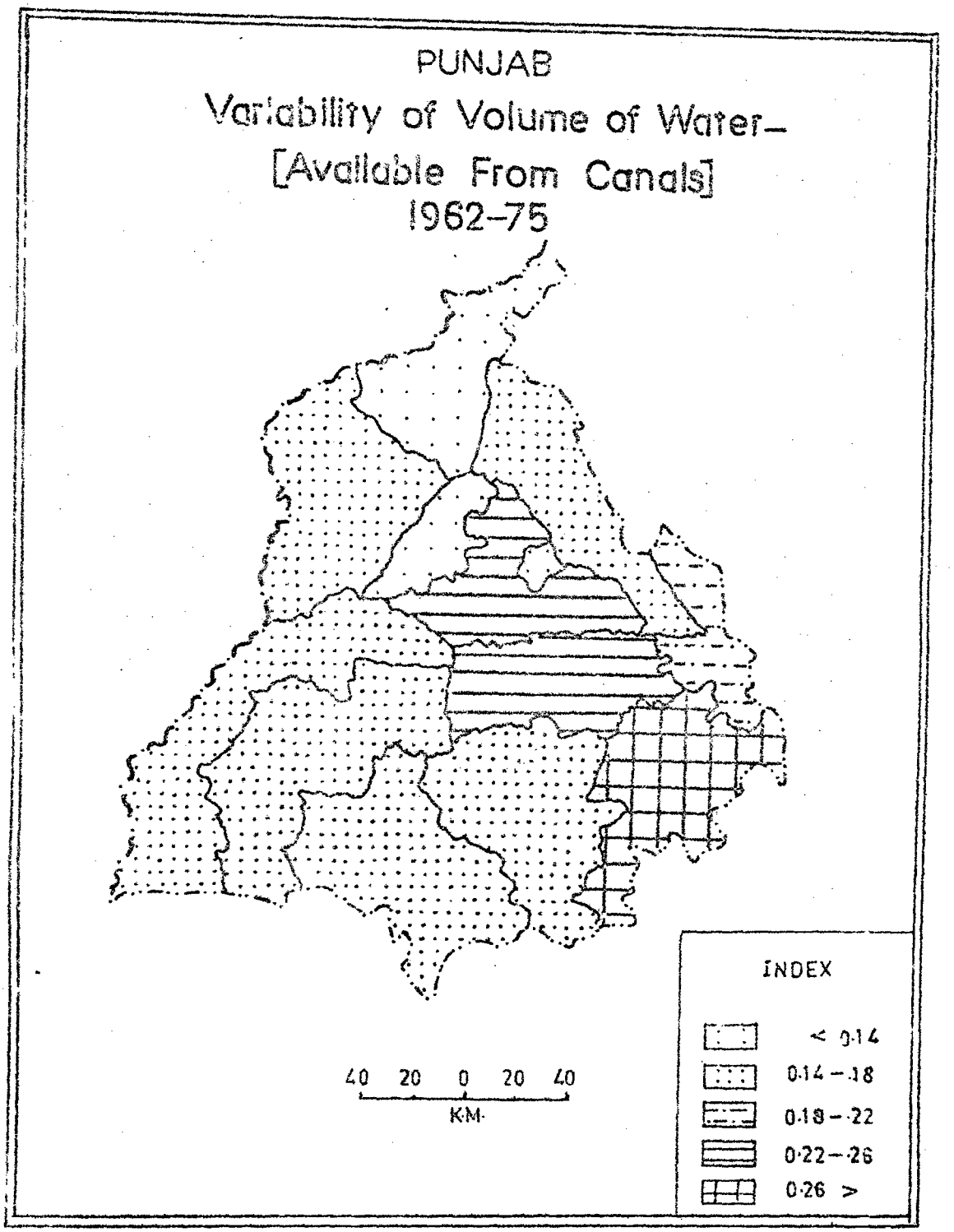
The water of the canals is available for irrigation in both the seasons i.e. rabi and kharif. However, the discharge of various canals is less for rabi as compared to kharif season. The authorised full supply of water from each canal is given in the Appendix. The authorised discharge from all the canals ranges from 10 to 12 M.A.F. during the different years. The annual discharge from Sirhind canal is maximum 2,384,656 cusecs days during 1969-70. The Upper Bari Doab canal comes second after Sirhind canal with the total annual discharge 1,462,519 cusecs days. The discharge from Bein is lowest, i.e. only 635 cusecs days annually.

For the purpose of comparison the volume of canal water available district-wise has been calculated in cubic metres. (Table 3.3) The Feorzepur district accounts for the largest volume of canal water available for the irrigation.

Volume of Water available from Canals in million cubic metres
1961-62 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1961-62	519.6	2078.4	35.0	359.0	251.0	168.0	1021.0	4065.0	1858.0	1580.0	2298.0	14233.0
1962-63	576.4	2305.6	41.0	418.0	327.0	95.0	915.8	4427.0	1557.0	1248.0	643.0	12553.8
1963-64	654.5	2618.0	55.9	565.5	282.8	119.8	1097.9	5374.3	1879.0	1516.0	804.6	14968.3
1964-65	504.6	2018.5	53.9	545.6	297.0	120.7	1017.4	5196.3	1759.9	1433.5	795.9	13743.3
1965-66	593.3	2373.3	50.4	509.5	357.5	165.6	1023.9	4486.2	1856.6	1574.0	1029.7	14020.0
1966-67	569.8	2279.3	55.3	540.9	278.6	133.5	1041.4	4745.1	1820.8	1497.1	887.9	13872.0
1967-68	569.8	2279.3	53.2	519.8	285.2	143.0	1121.0	5452.9	1927.8	1561.9	880.7	14794.6
1968-69	644.5	2578.1	66.5	663.4	339.7	151.5	1086.3	5021.4	1923.2	1598.3	1026.9	15099.8
1969-70	721.9	8887.6	64.7	644.6	392.4	135.7	1110.2	5323.4	1928.5	1578.0	931.9	15718.9
1970-71	940.7	3763.0	47.8	473.5	401.2	134.1	998.1	5565.0	1757.3	1453.4	257.8	14791.9
1971-72	389.0	2756.2	45.2	446.7	364.7	145.4	1080.0	5675.7	1901.7	1573.2	2617.8	17295.6
1972-73	845.8	3431.0	46.4	459.0	393.4	147.5	1040.6	4159.8	1846.6	1537.7	2396.2	16256.0
1973-74	821.1	3284.3	52.6	521.7	389.2	150.2	1215.1	5511.4	2113.7	1730.0	2464.3	18253.6
1974-75	666.6	2666.6	45.0	444.5	400.2	124.0	911.4	6009.7	1607.4	1331.5	2253.3	16460.2

Source: Computed from the data, Irrigation Department, Government of Punjab (India), Utilization of Different Canals in Punjab During Kharif and Rabi (unpublished), 1962-1975.


PUNJAB
Variability of Volume of Water–
[Available From Canals]
1962–75
INDEX
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0·18 – ·22
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40 20 0 20 40
KM.

Fig. 4

The volume of water available in Ferozepur was 6009.7 million cubic metres. Patiala comes second in respect of total volume of canal water available in the district as it was 2253.3 million cubic metres during 1974-75. The canal water availability is lowest for the Kapurthala as it only receives 45 million cubic metres of water annually. The important point to note is that the volume of water from canals, available in the various districts does not differ very much over the period. Minor fluctuations are there because of variable rains over the time period. But the proportion remains almost the same as the length of canals is not changed very much over the same period.

3.4 Ground Water Resources

The surface water resources in the state have already been exploited to a reasonable extent, the importance of ground water for irrigation and also for domestic and industrial uses is increasing day by day. The further development of irrigation in the state will have to depend on the tapping of ground water resources.

Underground water occurs in a zone of saturation of permeable rocks under the hydrostatic pressure. Water moves down from the surface by gravity to enter into this zone, the upper surface of which is called the water table, or pluratic, sub-surface or substerrancan water. All the pores and spaces within the zone of saturation are filled with water and its depth depends upon local geology. The

lower limit of the zone is the point at which the underlying rock formation becomes so dense that the water cannot penetrate. It may vary in depth from few metres to hundreds of metres. This zone of saturation is very important because it supplies water to all wells and maintains the normal, relatively uniform flow of streams. Ground water has been laid down very unevenly below the surface and moves towards the oceans like surface water. It flows through cracks or fissures in rocks or through water bearing strata called aquifers.[8] Some hydrologists prefer defining aquifers as natural zones below the surface that yield water in sufficiently large quantity to be important economically.[9]

The ground water resources have been built up in alluvial plains of Punjab through infiltration of rainfall, seepage from the rivers, other streams and sprawling network of unlined canals which carry vast quantities of river waters to the irrigated fields. As per preliminary estimate, nearly 28 per cent of the state area consisting of southern districts bordering Rajasthan (Ferozepur, Bhatinda and Sangrur) is having saline alkaline ground water.[10]

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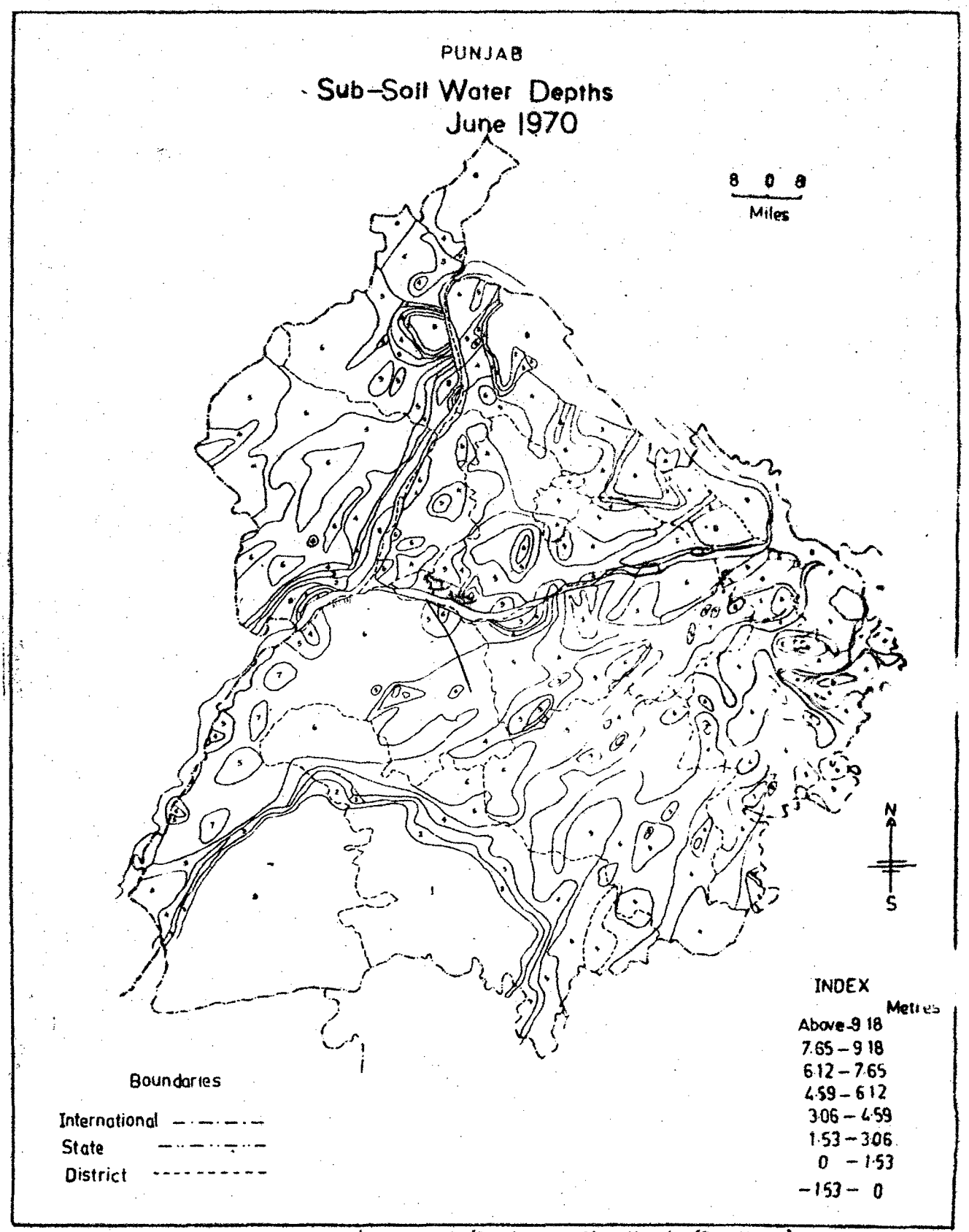
8 Leonard M. Cantor, A World Geography of Irrigation (London: Oliver and Blyd Tweeddale Court, 1967), p. 7.

9 S.N. Davis and R.J.M. Dewiest, Hydrogeology (John Wiley, 1967), p. 463.

10 R.K. Sabbarwal and N.V. Potdar, Planning for Consumptive use of Surface and Ground Water Resources, Proceedings of International Symposium on Development of Ground Water Resources, Madras (India), November 26-29, 1973, vol. 3, p. 5.

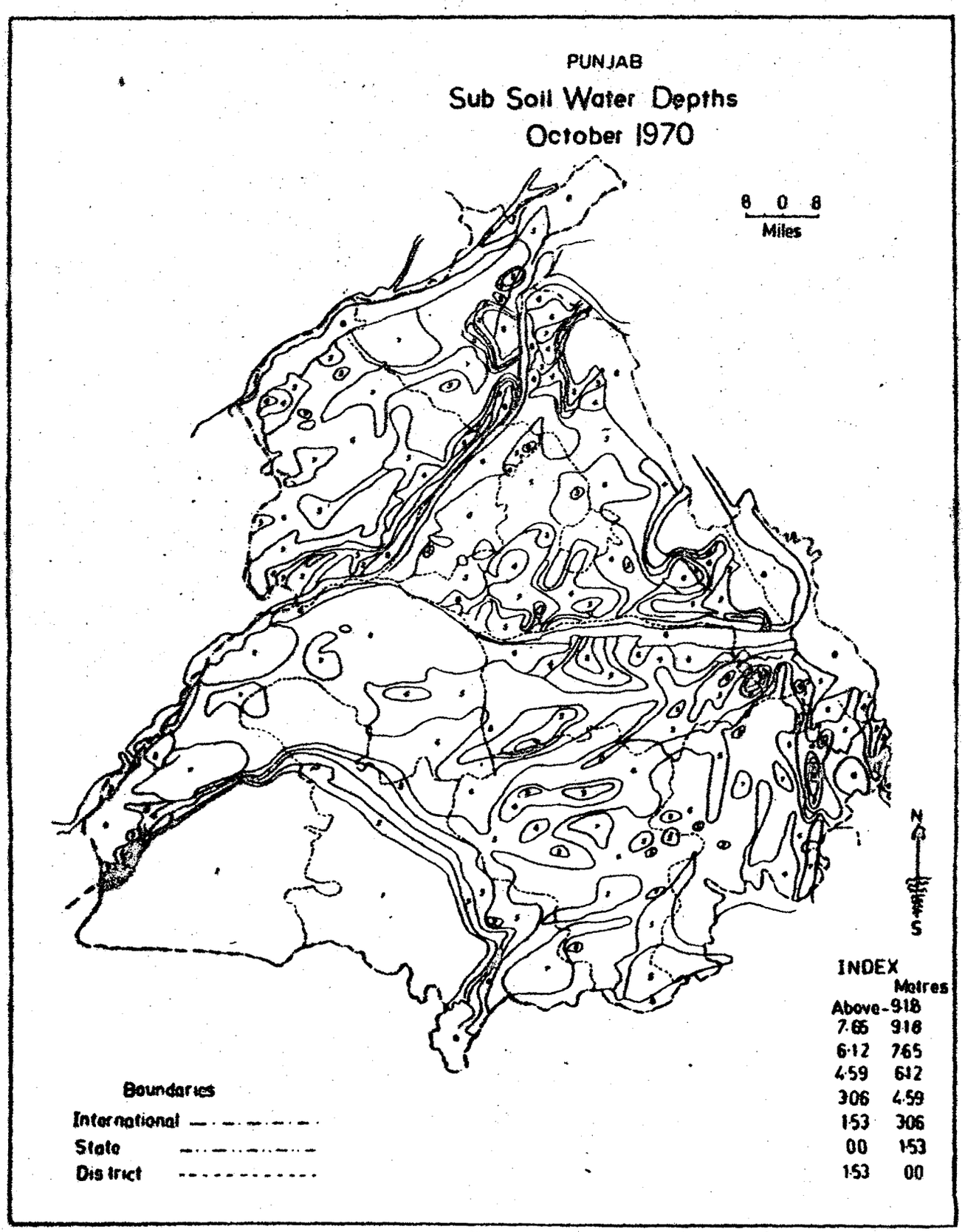
The water in the state is available near the surface in most of the districts. The quality of water is also good. The water table in the different districts has been shown in the map (fig. 5.6). One can see from the map that in Punjab during the month of October 1970, the depth of sub-soil water near the banks of all the three rivers, the Ravi, the Beas, and the Sutlej, is 0-1.52 metres. The area under sub-soil water depth of 1.52 metres is located in Gurdaspur and Amritsar districts in the vicinity of Ravi, and in parts of Ludhiana and Jullunder districts because of the Sutlej. The water table up to 1.52 metres is found in the parts of Hoshiarpur and Kapurthala districts where the river Beas flows along the boundary between Gurdaspur and Hoshiarpur, Amritsar and Kapurthala. A little patch of area with 1.52 metres water table is also found in Ferozepur district near Harike headworks. In general the water table is high in the northern plain than the southern districts. The water table in Batala Tehsil of Gurdaspur, Ajnala and Tarntaran Tehsils of Amritsar and near Dasuya in Hoshiarpur is between 0 to 1.52 metres.

A few patches with water table from 1.5 metres have been located in the districts of Ludhiana, Jullunder, Patiala and Ropar. The water table is very low in the southern parts of Bhatinda and Ferozepur districts, where it is located about 9.14 metres below the surface. The water table in Zira tehsil of Ferozepur generally ranges from 1.52 to 3.1 metres. The ground water table is also low in the northern parts of Ropar district, i.e. more than 9.14 metres. While in other



Source :- Superintending Engineer Project Circle (I.B.) Pb Chandigarh (S.A.Nagar)

Fig- 5



Source.- Superintending Engineer Project Circle (I·B·) Pb Chandigarh (S·A·Nagar)

Fig. 6.

districts water table ranges from 1.52 metres to 6.08 metres.

In fact there is no constant water table for the state, as it is subject to change due to a number of factors every year under natural conditions the ground water system is in an 'approximate hydrologic equilibrium';[11] the long term recharge, although on occasions, equals the long term discharge. In Punjab, the introduction of canal irrigation by diverting the river waters into the basin becomes potent factor of recharge in the system. The impact of these changes can be seen from the rise of the water table in canal command areas. However, in certain areas the ground water table has also shown decline after 1965 due to continuous pumping of ground water through deep bore wells.

3.4.1 Assessment of Ground Water Potential in the State

The amount, quality and depth of underground water is of great significance for irrigation. The development of small irrigation schemes, undertaken by the individual entrepreneur is related directly to the depth of sub-soil water. The scarcity of water in the aquifers can cause some serious problems for the future development. Although the ground water has been located at a number of places, but no systematic quantitative assessment has, so far, been made. The assessment

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11 S.R. Sehgal and A.D. Gulati, Hydrological Consequences of Irrigation and Drainage Projects in the Punjab (I), in Proceedings of the International Symposium of the Development of Ground Water Resources, 26-29 November 1973, Madras (India), vol. 3, p. 2.

of ground water potential involves (a) estimation of ground water recharge, (b) estimation of present level of extraction, and (c) determining the potential available for further extraction.[12] The main factors contributing to the recharge of ground water are, rainfall, return flow of water from irrigation, water spread areas of water bodies, surface flow like canals rivers and streams etc.

The assessment of quantity of ground water needs a vast sets of data on sub-surface geology, rainfall, evapotranspiration, run off, percolation zone and extent of saturation hydraulic gradient, aquifer characteristics, geochemicals of water etc. However, recently a very rough assessment has been attempted by Dr. K.V. Raghava Rao and his colleague of the Central Ground Water Board. The occurrence of ground water, according to their assessment, has been given for all the states, and India as a whole. The following table presents the contribution of various parametres.

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12 S.A. Radhakrishnan, "Formulation of Minor Irrigation Schemes, Data Requirements and Problems", Indian Journal of Agricultural Economics, vol. XXXII, no. 4, October-December 1978, pp. 191-203.

Table 3.4

Contribution of Various Parametres to Ground Water Recharge

Parametres	Recharge in (million acre feet)
1. From rainfall	5.1
2. From canal irrigation	4.0
Total recharge	9.1
1. Evapotransporation and sub-surface run off	2.5
2. Annual draft	3.3
Net ground water recharge for future	3.3

Source: Report of the Irrigation Commission, Ministry of Irrigation and Power, vol. I, 1972, pp. 54-55.

According to another study made by Sehgal and Gulati, it is estimated that the total water discharge from the tube-wells in state is about 8.2 M.A.F. annually and the total utilization from wells is of 1.7 M.A.F. Thus, 8.2 M.A.F. of water is being pumped out from sub-soil reservoir every year.[13]

13 Sehgal and Gulati, n. 11.

The study of assessment of ground water resources need much attention in the state for the future developments of minor irrigation works.

3.4.2 Use of Ground Water Sources for Irrigation

The use of underground water for the purposes of irrigation is not new in the history of irrigation. The use of wells as an 'instrument of irrigation',[14] to extract water from the ground is very old in Punjab. Actually, wells of one sort or of the other have been in use for many centuries, as a source of year round irrigation. The bullocks and camels were main draught power for operating persian wheels. However in recent years pumping sets run by diesel oil and hydro-electric power have replaced the traditional source of energy. One of the most common of the primitive lifting devices is the Dhenkli. Persian wheel is a more elaborate device of lifting water used in Punjab from early times.

Before the construction of Upper Bari Doab canal in 1859 the irrigation in Punjab was entirely done by wells. The irrigation by wells was mainly important in Jullunder, Patiala, Ludhiana, Ferozepur and Amritsar districts. The number of wells in Punjab rose from 246,000 in 1911 to 267,000 in 1920.[15] The spread of canals also increased the possibilities

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14 Punjab Administration Report Annual, 1921-22, vol. 1, p. 160.

15 Ibid. Also see Water Logging Statistics of Punjab, 1969 and 1974-75.

of well irrigation by adding through seepage to the store of sub-soil water.

3.4.3 The Development of Well Irrigation since 1960-61

Wells remained an important source of irrigation in Punjab in all the times as water is near the surface and suitable for irrigation. The total number of wells used for irrigation purposes both masonary and non-masonary, private and government owned in the state during 1960-61 was 168,566 which rose to 168,872 during 1969 but the number of wells has shown decline during the seventies and it came down to 125,263 during 1974-75. (Table 3.5) The number of wells in the state are on the decrease and these are being replaced by tube-wells and pumping sets with the advancement of irrigation technology. The electrification of villages in Punjab is mainly responsible for the replacement of ordinary wells by power operated tube-wells. The cheaper hydro-power is an additional reason to encourage the tube-well irrigation in the state.

During 1974-75 the district Jullunder had the maximum number of wells, i.e. 31,732 used for irrigation purposes followed by Sangrur, Amritsar, Ludhiana, Patiala and Hoshiarpur with 14,978, 13,459, 12,419, 11,384 and 9,412 wells respectively. The number of wells was lowest in Bhatinda where only 1,144 wells were used for the irrigation purposes.

Tube well irrigation was not very common till the 1950s. The tubewells were first installed in Amritsar under

Table 3.5

District-wise Number of Wells and Tubewells in Punjab

District	1960-61		1974-75	
	Wells	Tubewells	Wells	Tubewells
Gurdaspur	9012	520	7973	7251
Amritsar	17624	1047	13450	13221
Kapurthala	12476	329	9166	15119
Jullunder	37392	1020	31732	10392
Hoshiarpur	12338	393	9412	18599
Ropar	-	-	8593	8642
Ludhiana	21347	1268	12419	31948
Ferozepur	11897	384	4977	24527
Bhatinda	2204	147	1144	9960
Sangrur	18793	353	14978	24668
Patiala	25454	733	11384	39839
Punjab	168537	6194	125228	204161

Source: Government of Punjab (India), Irrigation, Floods and Waterlogging Statistics of Punjab, 1969, 1971-72, 1974-75.

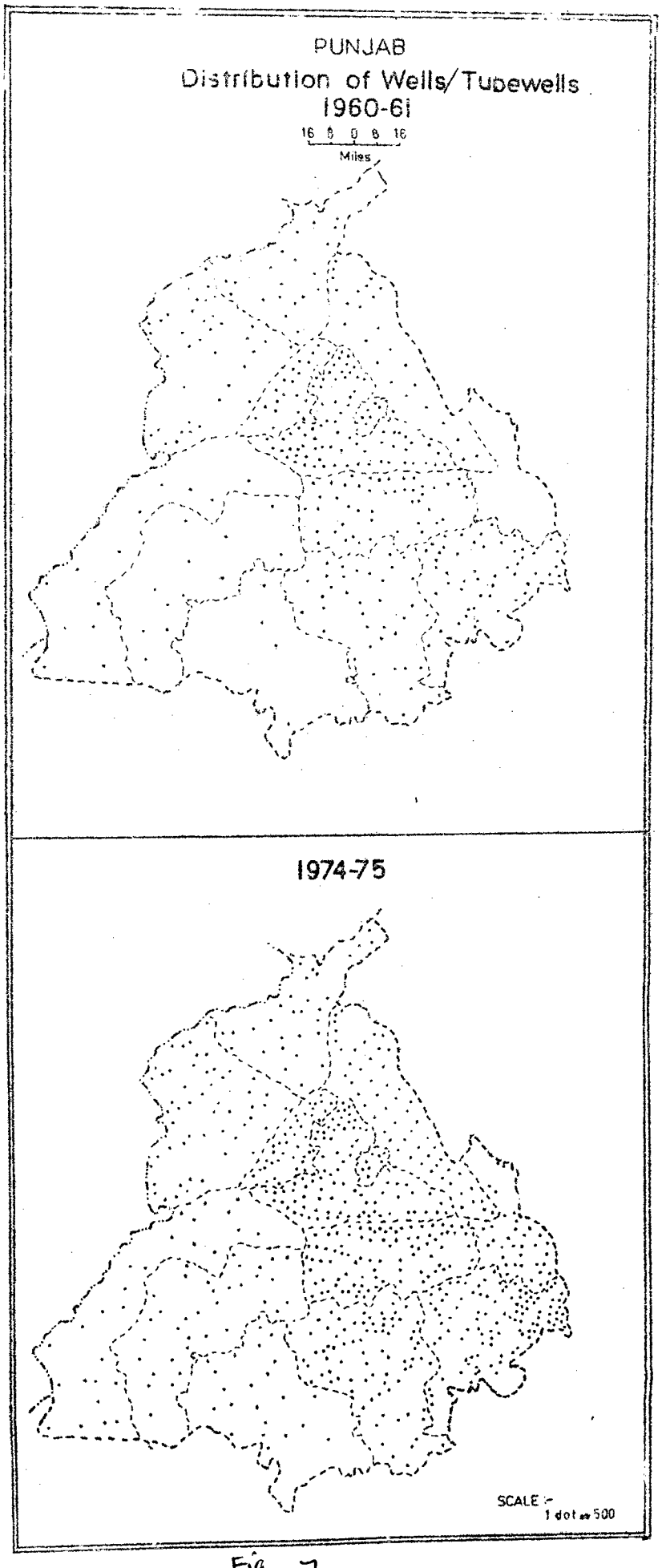
PUNJAB
Distribution of Wells/Tubewells
1960-61
16 8 0 8 16
Miles
1974-75
SCALE
1 dot = 500

Fig. 7

the scheme known as 'Amritsar Scheme - 1910'.[16] And it was intended to lower the water table near Amritsar, but it was closed in 1936. Indian irrigation scheme was introduced in 1934, but the number of tubewells did not increase till 1951. The number of tube-wells/pumping sets has increased very rapidly after 1961. The rapid increase in the number of tube-wells/pumping sets during this period was due to the heavy water requirements from the H.Y.V. crops.

The number of tube wells/pumping sets in the state was 204,161 during 1974-75 as against 6,194 during 1960-61 and 460 in 1951. Patiala ranked first in respect of total number of tube wells/pumping sets, with 39,839 tube wells/ pumping sets and Ludhiana and Sangrur comes second and third with 31,948 and 24,668 tubewells respectively. The number of tubewells has been lowest in Ropar and Bhatinda, 8,642 and 9,960 only during 1974-75. Tube wells are best suited for irrigation in the areas where the water table is low.

3.4.4 Availability of Water from Ground Water Resources

Nearly 55 per cent of the irrigated area in the state gets water from wells and tube wells. The water available from ground water sources is calculated for the purpose of the present study to know the total volume of water

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16 K.R. Sharma, Irrigation Engineering (Jullunder: India Printers, Booksellers, Publishers and Printers, 1959), vol. 1, p. 3.

Appendix

Volume of Water Available from Groundwater in million cubic metres

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Julian-der	Hoshiar-pur	Ropar	Ludhia-na	Ferozo-pur	Bhatin-da	Sang-rur	Patia-la	Pun-jab
1961-62	256.9	483.6	335.6	762.5	91.4	82.2	1320.8	557.9	23.0	702.8	820.5	5457.2
1962-63	412.8	1223.4	502.4	1241.7	192.8	103.0	818.6	782.7	54.3	1095.8	696.5	7129.0
1963-4	353.3	1035.9	862.8	936.3	189.9	52.7	738.2	649.0	51.6	590.9	960.4	6406.0
1964-65	463.2	1253.6	643.7	1379.8	181.8	179.3	629.9	842.6	80.8	1009.5	627.1	7291.3
1965-66	237.1	733.8	603.1	787.6	179.3	147.4	813.7	654.8	161.2	898.6	965.8	6182.4
1966-67	124.0	894.4	960.7	1149.1	149.7	182.5	920.5	656.8	353.4	911.3	849.1	7168.5
1967-68	220.1	1019.4	1016.7	1293.9	159.5	145.7	1462.3	566.0	366.6	1278.6	1187.3	8716.1
1968-69	462.9	1372.6	1118.6	1723.0	283.6	242.3	1761.4	1215.8	1339.5	2253.3	1487.2	13265.2
1969-70	376.2	1292.0	927.1	1155.0	156.0	122.1	1228.9	2440.7	877.8	2152.2	1836.3	12564.3
1970-71	18.9	952.4	971.2	1496.7	248.9	69.2	1647.0	2455.3	1024.1	2246.2	1581.0	12707.5
1971-72	16.7	403.3	893.0	1559.8	174.4	280.7	1581.1	1473.6	669.1	1771.5	1235.7	10063.9
1972-73	285.4	1123.3	820.7	1034.2	314.5	211.8	1620.4	1851.1	664.8	2270.7	1620.6	11817.5
1973-74	692.1	1761.5	1172.5	2154.6	550.0	367.0	2455.7	2668.0	968.0	2830.8	2234.4	17904.6
1974-75	639.0	1523.2	915.4	1631.0	422.7	251.0	1837.1	2458.5	303.6	2593.9	1871.4	14493.4

Source: Government of Punjab (India), Irrigation, Floods and Waterlogging Statistics of Punjab, 1969, 1971-72, 1974-75.

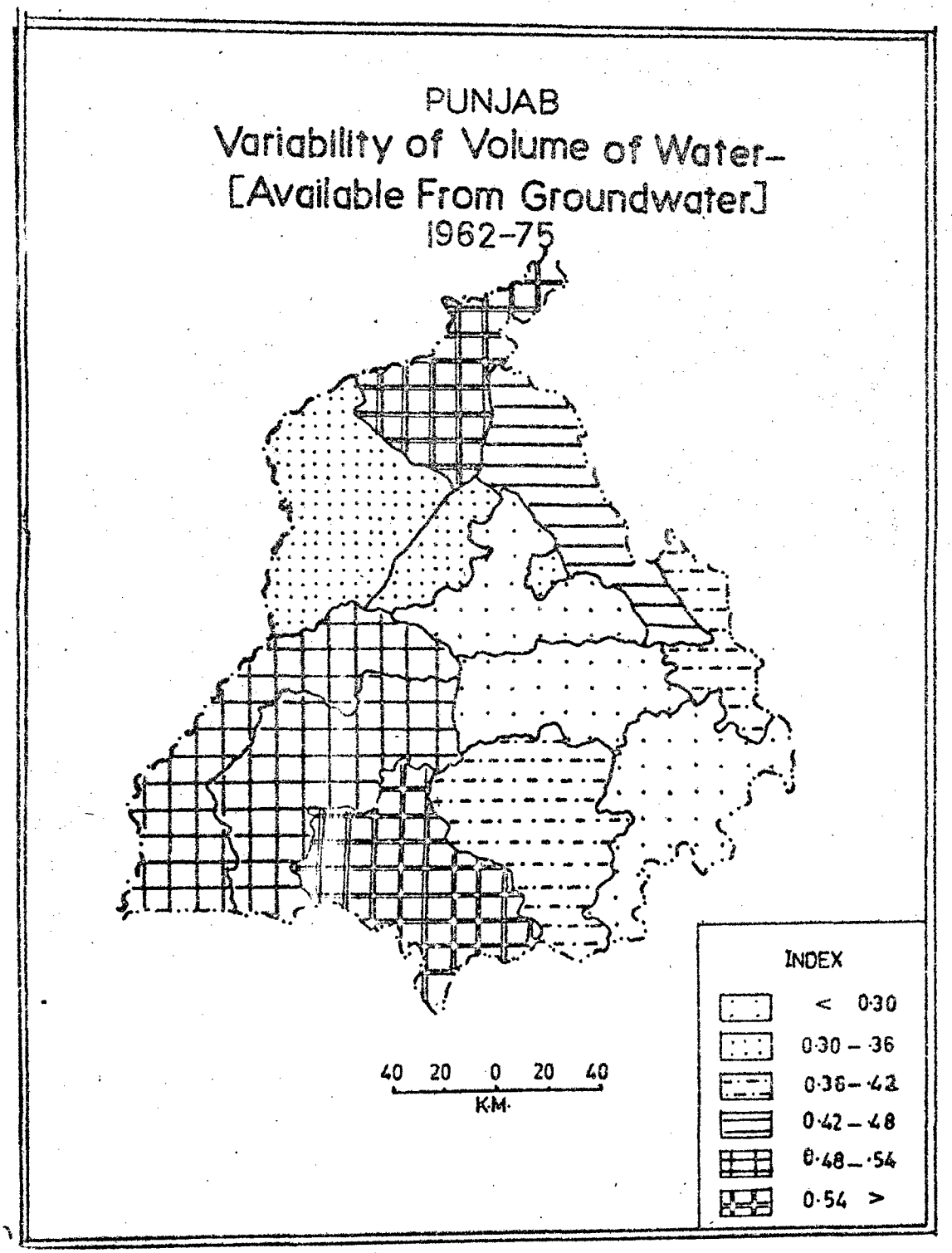

PUNJAB
Variability of Volume of Water-
[Available From Groundwater]
1962-75
40 20 0 20 40
KM.
INDEX
< 0·30
0·30 – ·36
0·36 – ·42
0·42 – ·48
0·48 – ·54
0·54 >

Fig 8

available to be used for irrigation purposes in each district of the state. The figures for year-wise volume of water available from ground sources has been given in table below. The volume of water from ground water sources available to the state was 5,457 million cusec metres in 1961-62, and it rose to 13,265 million cusec metres during 1968-69, and reached to 17904.6 mc.metres in 1973-74. The total annual draft of water from ground sources has rapidly increased since 1967-68. It has increased rapidly during the green revolution period because the H.Y.V. varieties require more water than the indigenous ones. The cropping pattern of the state has also undergone drastic change. The ground water volume is less in Ropar, Bhatinda and Hoshiarpur districts where tube wells irrigation is not widely used because of deep water table, high cost of installation and low water yields. The deep and saline water in Bhatinda is not usable for the irrigation. Lack of public investment and security of power and oil are the other factors which contribute to the slow development of the tube well irrigation in these districts.

3.5 Rainfall as a Source of Water

Rainfall is the single most important source of water though the geographical location of the state does not favour a heavy rainfall, as the most of its parts lie in the semi-arid zone. The rainfall in the state normally varies from 200 to 1000 mms annually. It occurs during the South West monsoon months, i.e. from July to September.

3.5.1 Annual Rainfall

About 80 per cent of the average annual rainfall in Punjab occurs in the monsoon period. The state does receive a little rainfall during the winter months from the Western disturbances. The rainfall during these months is scanty but it is highly beneficial for the rabi crops especially for the wheat. The rainiest month during the winter is January. Normally the northern sub-hill districts get higher amount of rainfall during the winter than the semi-arid districts of south. The November is the driest month of the year. The state gets a little amount of rainfall during the pre-monsoon months, but the amount of rainfall during these months never exceeds 5 cms and even in the northern districts where rainfall is comparatively higher than the south.

Rainfall is generally higher in the northern sub hill districts of Ropar, Hoshiarpur and Gurdaspur and decreases towards the semi-arid districts of Bhatinda and Ferozepur. Ropar, Gurdaspur and Hoshiarpur districts get rainfall of 900 to 1000 mm annually, while the southern districts receive annual average rainfall of 300 to 500 mm.

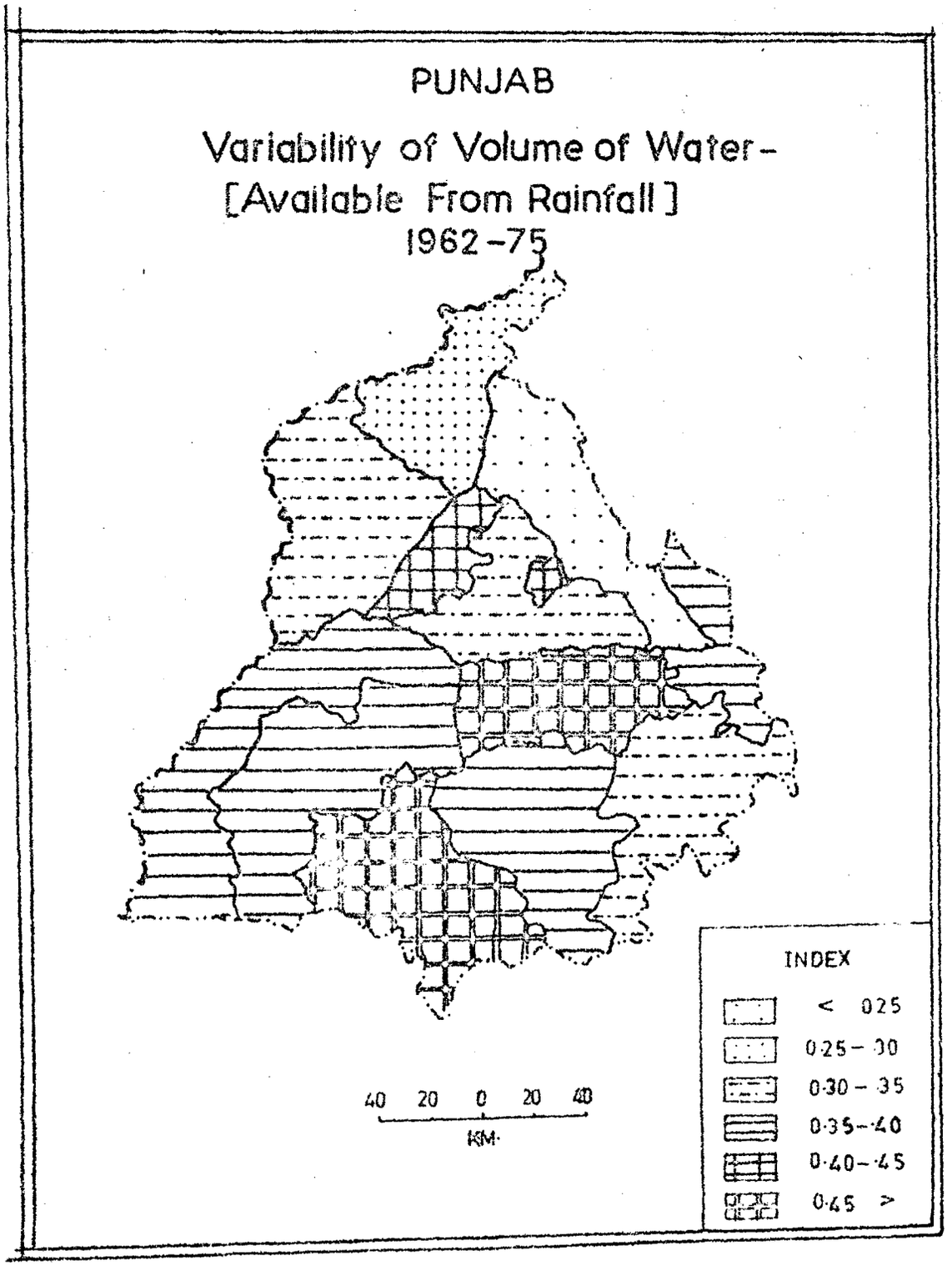
3.5.2 Availability of Water from Rainfall

The total volume of water available from rainfall in the state depends upon the total amount of rainfall received annually. It varies with the amount of precipitation. In the north where the rainfall is high the water available for the

Volume of Water available from Rainfall in million cubic metres
1961-62 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1961-62	2019.9	2336.0	960.4	2390.5	2289.3	1041.3	3348.7	4696.0	4373.0	3062.4	2735.0	29252.5
1962-63	1514.9	1155.0	853.3	1659.9	1440.3	921.1	1827.0	2432.1	2473.4	858. 5	3279.9	18375.4
1963-64	1224.3	2197.7	352.5	2092.7	1519.3	1235.2	2030.1	2813.3	3803.6	3787.9	2042.8	23104.4
1964-65	1536.8	1103.3	791.2	1477.2	1334.4	692.7	2600.6	2624.0	1626.9	3830.8	533.11	21024.0
1965-66	2552.9	2795.1	935.6	2404.2	2066.0	831.1	2123.7	3876.0	2773.8	2211.2	1840.9	24410.5
1966-67	2931.0	2234.6	365.4	1817.4	2048.8	668.1	2103.3	3330.5	1101.1	1230.5	2222.8	20103.5
1967-68	2642.8	1881.4	309.1	1697.1	1894.2	1047.3	1521.9	2393.6	2500.6	2368.8	1625.8	19332.6
1968-69	1943.8	1536.3	315.7	1255.7	1552.6	674.3	1073.9	2345.3	1946.0	1749.7	2337.0	16330.3
1969-70	2371.3	2301.1	726.9	2159.9	2408.3	1160.4	2376.0	1923.4	3194.8	2338.1	2133.5	23093.7
1970-71	4005.5	3282.9	685.2	1856.2	1969.3	1646.8	1985.4	2149.0	2267.5	2159.2	2654.4	24662.4
1971-72	3536.2	4834.1	782.1	1780.7	2508.5	741.9	2210.5	5672.5	2719.3	2814.8	3412.2	31003.0
1972-73	2725.5	3029.0	904.0	2547.0	2200.9	1021.1	2242.9	5255.8	2175.8	2510.6	2706.3	27938.9
1973-74	1946.7	1500.4	447.3	1066.9	1292.6	683.4	1179.0	2027.5	1226.4	1238.0	1625.3	15833.5
1974-75	2462.1	2149.9	824.1	1893.6	2001.0	991.6	2044.3	7356.8	3064.2	2193.1	2350.0	27535.7

Source: (1) Computed from the data Government of Punjab (India), Irrigation Floods and Waterlogging Statistics of Punjab, 1969;
(2) Government of Punjab (India), Statistical Abstract of Punjab, 1966-1975.


PUNJAB
Variability of Volume of Water-
[Available From Rainfall]
1962-75
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40 20 0 20 40
KM.

Fig. 10

crop growth is also more than the southern districts. The amount of water available in the Punjab was 27,535 million cubic metres in 1974-75. The rainfall water is important from the viewpoint of the onset of the rain e.g. early or late rains south-west monsoon upset the whole agricultural operations. The availability of water from rainfall is given in table 3.7 As the computation of volume of water available from rainfall depends upon the net cropped area of the districts and amount of rainfall, it varies from district to district and from year to year accordingly.

3.5.3 Water Availability as per hectare of Gross Cropped Area (in terms of rainfall equivalents)

The availability of water per hectare of gross cropped area in each district depends upon the total volume of water available from all sources of water, i.e. surface water, ground water and water from rainfall. The average availability of water for the state as a whole varies from 77 to 102 cms per hectare. But one can note from the table 3.8 that availability of water is not uniform for all the districts in all the years. And it also follows the rainfall regime in general and its distributions also follows the distributional pattern of rainfall. Even then the total water availability is much more higher than the water available from only rainfall in the semi arid districts of southern Punjab and it is enough to meet the requirements of the crops grown in those areas. It shows how the irrigation can transform

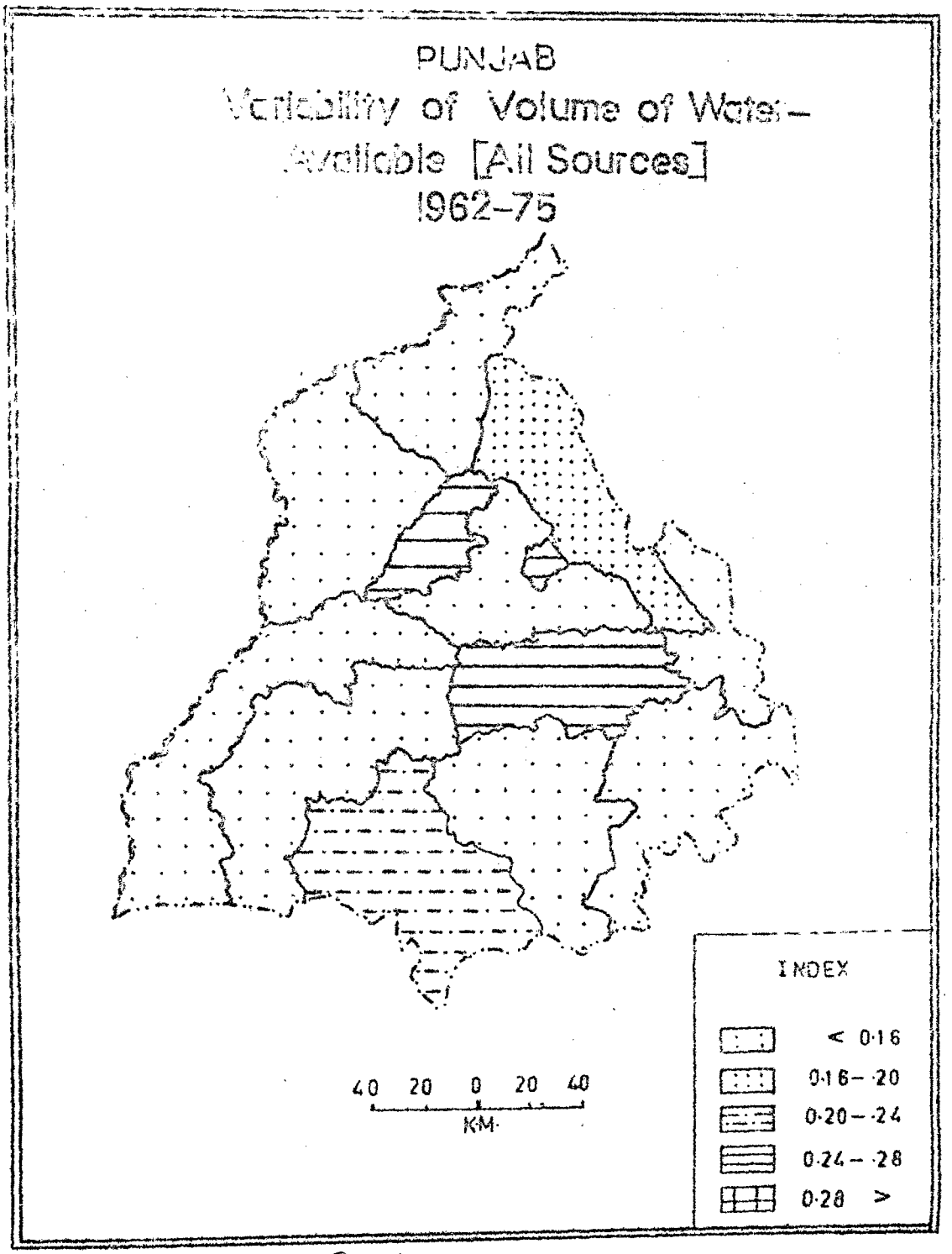
PUNJAB
Variability of Volume of Water
Available [All Sources]
1962–75
INDEX
< 0·16
0·16 – ·20
0·20 – ·24
0·24 – ·28
0·28 >
40 20 0 20 40
KM.

Fig. 11

Volume of Water available from All Sources* in million cubic metres 1961-62 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1961-62	2796.4	4898.0	1351.0	3512.0	2631.7	1291.5	5690.9	9318.9	6254.0	5345.2	5853.5	48942.7
1962-63	2504.1	4689.0	1396.7	3299.6	1960.1	1119.1	3561.4	7641.8	4084.7	3182.3	4619.4	38058.2
1963-64	2217.1	5851.6	1271.2	3594.5	1992.0	1407.7	3866.2	8836.6	5739.2	5894.8	3807.8	44478.7
1964-65	2524.6	4380.4	1488.8	3402.6	1813.2	992.7	4460.6	8662.9	3467.6	6323.8	5686.2	42058.6
1965-66	3383.3	5902.2	1589.1	3701.3	2602.8	1144.1	3961.3	9017.0	4791.6	4683.8	3836.4	44612.9
1966-67	3647.8	5408.3	1381.4	3507.4	2471.1	984.1	4065.2	8382.4	3275.3	3638.9	3959.8	41144.0
1967-68	3432.7	5180.1	1379.0	3510.8	2338.9	1336.0	4105.2	8412.5	4795.0	5209.3	3693.8	43393.3
1968-69	3051.2	5487.0	1500.8	3642.1	2180.9	1068.1	3921.6	8525.5	4808.7	5601.3	4851.1	44695.3
1969-70	3469.4	6480.7	726. 9	2159.9	2408.3	1160.4	2376.0	1923.4	3194.8	2338.1	2133.5	23093.7
1970-71	4965.7	7998.3	1704.2	3826.4	2616.4	1850.1	4630.5	10169.3	5048.9	5858.8	4493.2	52161.8
1971-72	4241.9	7993.6	1725.3	3787.2	3047.6	1168.0	4862.6	12821.8	5290.1	6159.5	7265.7	58363.3
1972-73	3856.7	7583.3	1771.1	4040.2	2908.8	1380.4	4903.9	11266.7	4687.2	6319.0	6803.1	56012.4
1973-74	3059.9	6546.2	1672.4	3743.2	2231.8	1200.6	4849.8	10206.9	4308.1	5798.8	6374.0	49991.7
1974-75	3817.7	6339.7	1784.5	3969.1	2823.9	1366.6	4792.8	15825.0	4975.2	6120.1	6679.7	58494.3

Source: Computed from the data, Irrigation Department, Government of Punjab (India), Utilization of Different Canals in Punjab During Kharif and Rabi (unpublished), 1962-1975.

SM A

Table 3.8

Water Availability* as per hectare of Gross Cropped Area (in terms of rainfall equivalents)

District	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Gurdaspur	99	84	73	79	103	105	99	88	97	137	116	102	81	99
Amritsar	101	88	116	81	120	99	96	96	114	136	136	129	104	103
Kapurthala	104	96	85	94	101	86	87	97	111	110	111	116	103	108
Jullunder	110	97	113	93	106	98	98	96	103	97	91	95	86	90
Hoshiarpur	91	65	65	58	84	77	72	68	90	75	82	74	55	76
Ropar	87	77	93	63	81	64	73	61	81	93	65	74	63	70
Ludhiana	151	93	96	106	95	95	92	84	98	94	95	94	92	90
Ferozepur	98	80	90	86	98	82	76	86	92	93	116	85	75	122
Bhatinda	82	53	79	45	66	44	58	62	71	58	65	66	63	82
Sangrur	90	52	102	106	82	63	83	90	72	92	93	94	85	89
Patiala	128	95	83	119	84	87	74	100	98	82	132	117	110	111
Punjab	102	77	91	82	91	80	80	85	91	92	102	94	83	99

* Water available in cms.

area that would otherwise be classified as drought affected area, but now these areas have been transformed into the green fields, by making the plenty of water available from other sources.

3.6.0 Importance of Irrigation

The development of agriculture in the state like Punjab, where the rainfall is not only inadequate but also highly variable in time and space, is entirely dependent upon the assured supply of water through irrigation. The necessity of irrigation arises from a number of factors. Major function of irrigation is to mitigate the impact of irregular, uneven and inadequate rainfall with wide fluctuations from year to year. "Irrigation in many countries is an old art - as old as civilisation but for the whole world it is a modern science - the science of survival".[17]

3.6.1 Growth of Irrigation in Punjab

The precise origin of irrigated agriculture is not known, but there is no doubt that it has been in existence for many thousands of years in Asia and Africa.[18] Irrigation in India has been practised since time immemorial. Frequent

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17 B.C. Punmia and Brijbasilal Pande, Irrigation and Water Power Engineering (Delhi: Standard Publishers, 1969), p. 2.

18 Reonard M. Cantor, A World Geography of Irrigation (London: Oliver and Boyd Tweeddale, 1967), p. 11.

references are found in the Vedas and Smrities and other ancient literature to wells, tanks, canals and dams.[19] From the early Vedic times up to the Moghul period, the rulers have initiated irrigation works to counteract famine and in recognition of its value in agriculture. Evidences of old storage and canal systems can be found in many parts of the country, some of these old systems have been improved for modern use also. But the systematic development of irrigation in the country has taken place only in the end of the 19th century and in the beginning of 20th century.

3.6.2 Growth of Irrigation in Punjab since 1850

Though the wells were the oldest means used for the purpose of irrigation, but inundation canals and waters from streams and tanks were also used for the similar purpose. Till 1850 wells were the only most important means of irrigation. There were no government canals to irrigate the vast lands of Punjab. The irrigation was based on the dug wells and the bullocks and camels provided the main source of draught power for running the Persian wheels. The well irrigation was the mainstay for the districts of Jullunder, Ferozepur and Ludhiana. The Upper Bari Doab canal was constructed in 1859 and some of the cultivated areas in Amritsar and Gurdaspur were irrigated from this canal,

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19 K.L. Rao, "Utilization of Irrigation Resources", Agriculture Situation in India, 1966-67, pp. 265-7.

33,377 hectares of land was irrigated by Upper Bari Doab canal in Amritsar during 1870-71. And 24,956 hectares of land in Gurdaspur received water from the Sabraon and Kasur branches of Upper Bari Doab canal. In Hoshiarpur district irrigation was partially done by wells along with an old inundation cut. But the situation somewhat improved with the opening of Upper Bari Doab Canal, and Sirhind canal system.

According to the Imperial Gazetteer of India, 1908, of the total area cultivated in Amritsar, 189,847 hectare (60%) was classed as irrigated and out of this area 53 per cent was irrigated from wells and 47 per cent from canals. Similarly in Gurdaspur 89,096 hectares (26%) of the total cropped area of the district was classified as irrigated and 55,685 (62.5%) hectares were irrigated from wells and canals, 31,339 (35.17%) hectare from canals and 1,275 (1.4%) hectares from streams and tanks. Also, 325,563 hectares (27%) of the cultivated area of the then Patiala statewas irrigated and out of this 88,578 hectares (27%) was irrigated by wells and the rest from canals. There were 12,696 wells in use in the state. In Hoshiarpur only 23,569 hectare (8%) of the total cultivated area was irrigated in 1903 and of that 14,649 hectare (63%) was irrigated by wells and 5,957 (25%) from canals and only 2,849 hectares (12%) by streams. The important source of irrigation in Jullunder and Ludhiana was well. And 124,061 hectares in Jullunder and 56,721 hectares in Ludhiana was irrigated by wells. 203,051 hectares of land was irrigated by canal in Ludhiana.

Of the total area cultivated in 1903-4, 417,249 hectares (47%) were classified as irrigated in Ferozepur district. Of this area, 44,030 hectares (10.55%) were irrigated from wells, 20,461 (4.9%) from wells and canals, 352,499 (84.48%) hectares from canals, and 210 hectares from streams and tanks.

Thus the report shows that the irrigation in most of the districts was mainly by the wells, the proportion of irrigated area was high only in Amritsar and Gurdaspur where the water was available from Upper Bari Doab canal since 1859. In the first half, of 20th century, the development of sources of irrigation both canals and wells was going on side by side. The net work of canal irrigation also increased the possibilities of well irrigation. The most of the investment was done on the irrigation works in the state during this period. When British left the country the irrigation system in the undivided Punjab was one of best irrigation systems of the world. The position of state in respect of irrigation was much better than the remaining parts of the country.

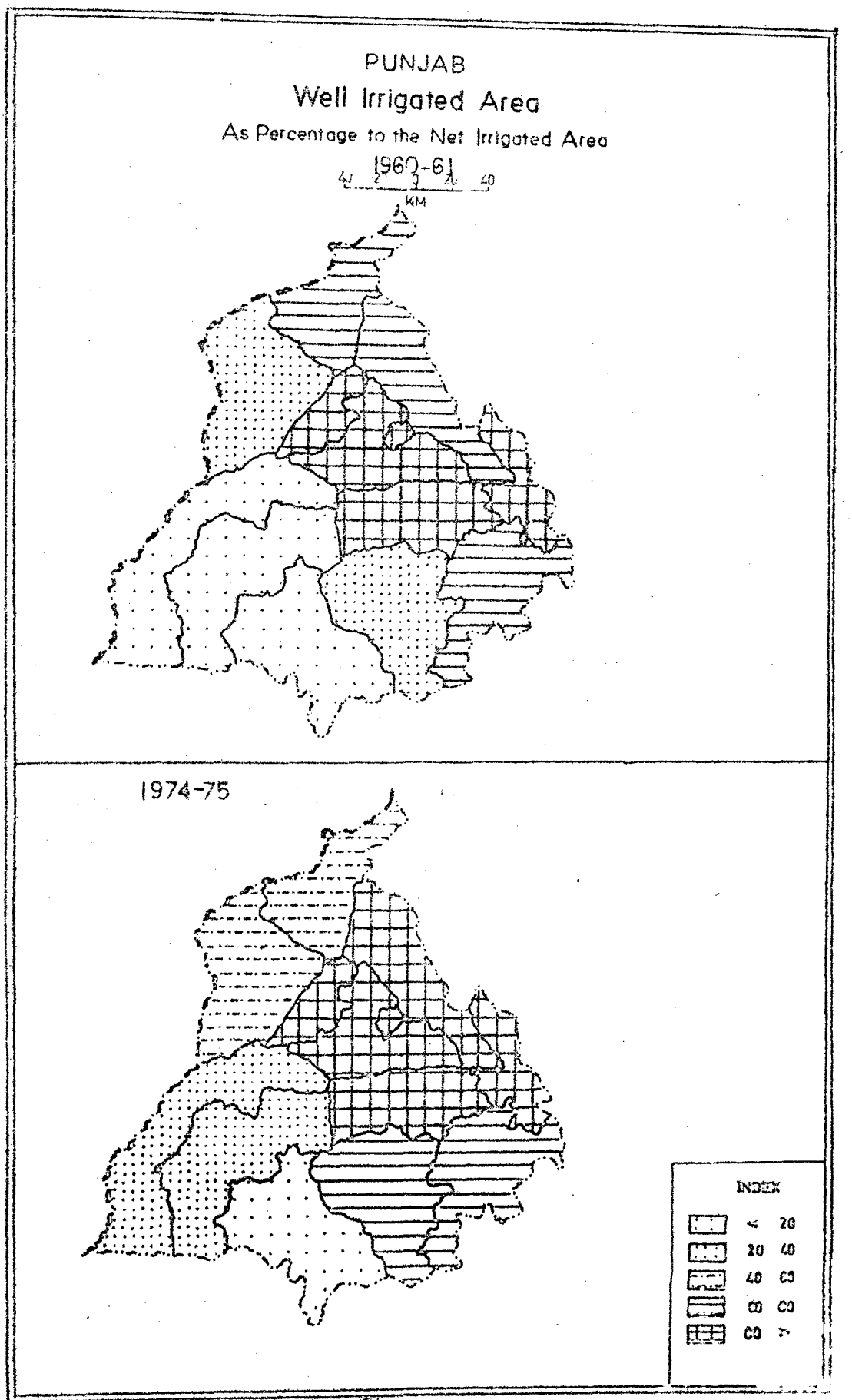
3.6.3 Development of Irrigation since 1960-61

Despite the small size, the state occupied the second position next to UP in terms of its gross area irrigated which was 4,377 thousand hectares during 1971-72. As regards the percentage of net irrigated area to net area sown, Punjab occupied the second position in 1971-72 with 72.5 per cent of its net area sown being irrigated, first place being occupied

by Pondicherry with 81.3 per cent of its net area sown. It also occupied the second place in the country in irrigation through tubewells during 1971-72 with an area of 1,186 thousand hectares while Uttar Pradesh recorded the highest with 2,330 thousand hectares irrigated by tube wells.

During 1974-75, the gross area irrigated by all sources was 80.9 per cent of the gross cropped area against 56.0 per cent in 1960-61. Amritsar district was the leading district in terms of percentage of gross area irrigated to the gross cropped area in the state in 1974-75, with 96 per cent of it being irrigated. It was followed by Sangrur 90.2 per cent, Jullunder 89.3 per cent and Ludhiana 88.3 per cent respectively.

The net area irrigated in the state by all sources was 3,183 thousand hectares as against the 1,985 thousand hectares in 1960-61. Out of 1,985,500 hectares of area irrigated during 1960-61, 116,600 hectares was irrigated by the canals alone, which accounts for 58.75 per cent of the net area irrigated by all sources and 798,500 hectares (40.21%) was irrigated by wells and tubewells. During 1974-75, out of the net area irrigated of 3,183 thousand hectares, 1,447,800 hectares (45.5%) was irrigated by canals and 1,723,900 hectares (54.2%) was irrigated by wells and tubewells. The percentage of area irrigated by canals has declined slightly from 1960-61 to 1974-75, but the use of underground water for the purposes of irrigation has gained importance since then.


PUNJAB
Well Irrigated Area
As Percentage to the Net Irrigated Area
1960-61
0 20 40
KM
1974-75
INDEX
< 20
20 40
40 60
60 80
80 >
Fig. 12

Canals are the important source of irrigation in Bhatinda, Ferozepur, Amritsar and Sangrur districts where 98.11 per cent, 88.02 per cent, 67.46 per cent, and 60.52 per cent area was irrigated by canals during 1960-61 respectively. The proportion of irrigated area by canals to the net area irrigated in these districts during 1974-75 has declined as compared to the 1960-61, as it was 86.54 per cent in Bhatinda, 74.52 per cent in Ferozepur, 57.15 per cent Amritsar, 31.52 per cent in Sangrur. In fact 87 per cent of canal irrigated area in the state is located in these four districts. The canal irrigation is best suited for the Ferozepur and Bhatinda districts because the water table is very low and tubewell irrigation is costly and the saline waters obtained from the underground aquifers are not suitable for the proper growth of crops.

The tubewell irrigation is important in the Jullunder, Kapurthala, Ludhiana, Ropar and Patiala districts. It is clear from the map (fig.) that 96.72 per cent, 95.48 per cent, 82.97 per cent and 92.70 percent, 74.22 per cont area to the net area irrigated of the respective districts was irrigated by wells and tubewells during 1960-61. Area irrigated by wells/tubewells in these districts has shown an increase and it was above 90 per cent in Jullunder, Kapurthala, Ropar and Ludhiana during 1974-75. The tubewell irrigation is also important in Hoshiarpur, Gurdaspur and Sangrur districts where it accounted for 84.87 per cent, 56.33 per cent and

PUNJAB

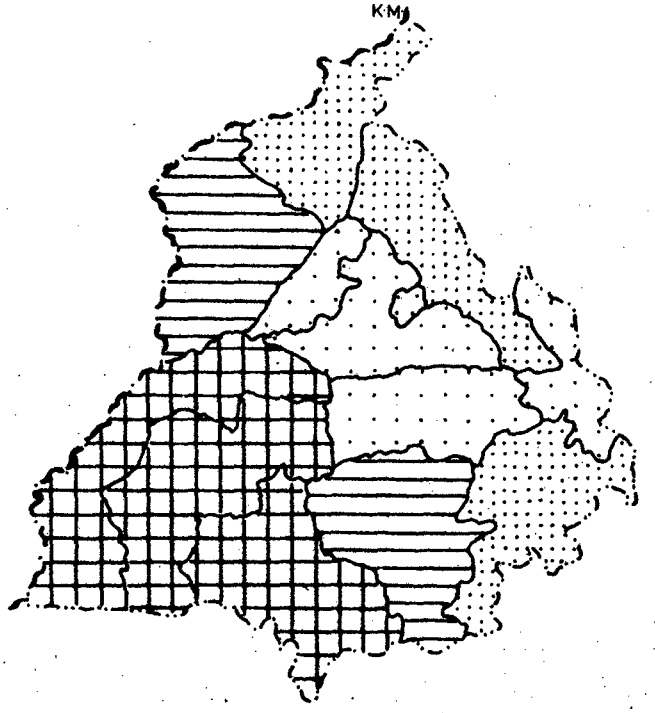
Canal Irrigated Area

As Percentage to the Net Irrigated Area

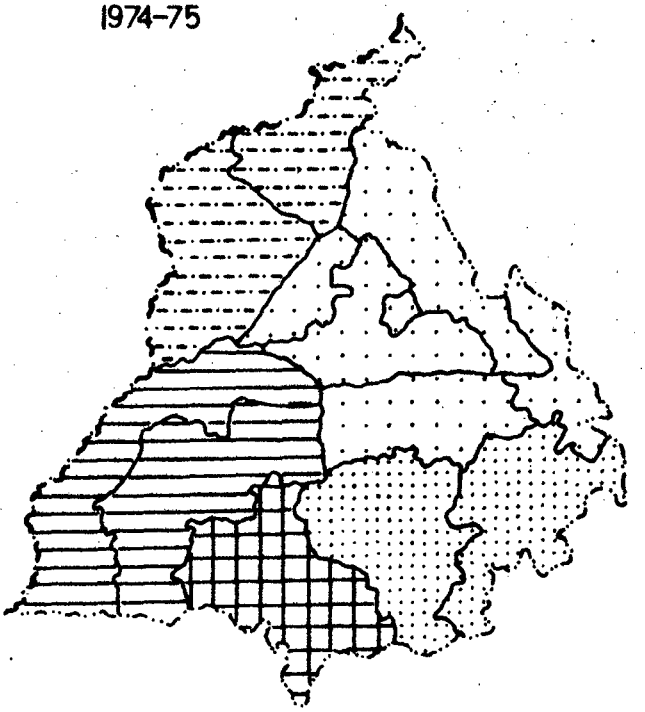
1960-61

40 0 40

K·M



1974-75



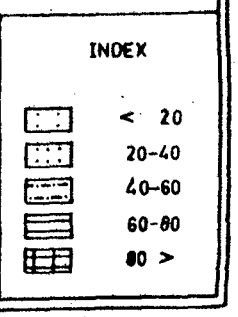


Fig. 13

68.47 per cent respectively of the net irrigated area of districts during 1974-75.

The irrigated area by wells/tubewells has shown a substantial increase in the state over the time period with the result of rapid expansion of minor irrigation schemes. However, the proportion of irrigated area by wells and tubewells has shown a comparatively rapid growth, in Sangrur and Hoshiarpur districts where it rose to 68.47 per cent and 84.87 per cent during 1974-75, as compared to 39.48 per cent and 66 per cent during 1960-61 in the respective districts. The wells and tubewells are generally important for providing assured irrigation in the northern parts of the state and in the central plains where the ground water is within easy reach. In spite of increasing importance of tubewell irrigation canals are still the important source of irrigation in southern districts of state.

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CHAPTER 4

AGRICULTURAL PROFILE

4.1 Cropping Pattern

Punjab, virtually the grainary of India, has a varied cropping pattern which includes cereals e.g. wheat, maize, rice, bajra and jowar, pulses e.g. moong, masoor, mash and gram, and commercial crops e.g. cotton and sugarcane. Rape and mustard and groundnut are important oil seeds, besides these linseed and castor seed, chillies, potatoes and tobacco are the other crops. But now a days the agriculture in the state has become predominantly cereal oriented.

In the following paragraphs an attempt has been made to see the spatial and temporal changes in the cropping pattern in the state. In the first instance the cropping pattern in terms of foodgrains and non-foodgrains has been analysed. Secondly, an analysis has been made to see the behaviour of area and yield of the crops included in study over the time period from 1960-61 to 1974-75. The trend in the spread of area under high yielding varieties, consumption of fertilizers in NPK units and use of agricultural machinery

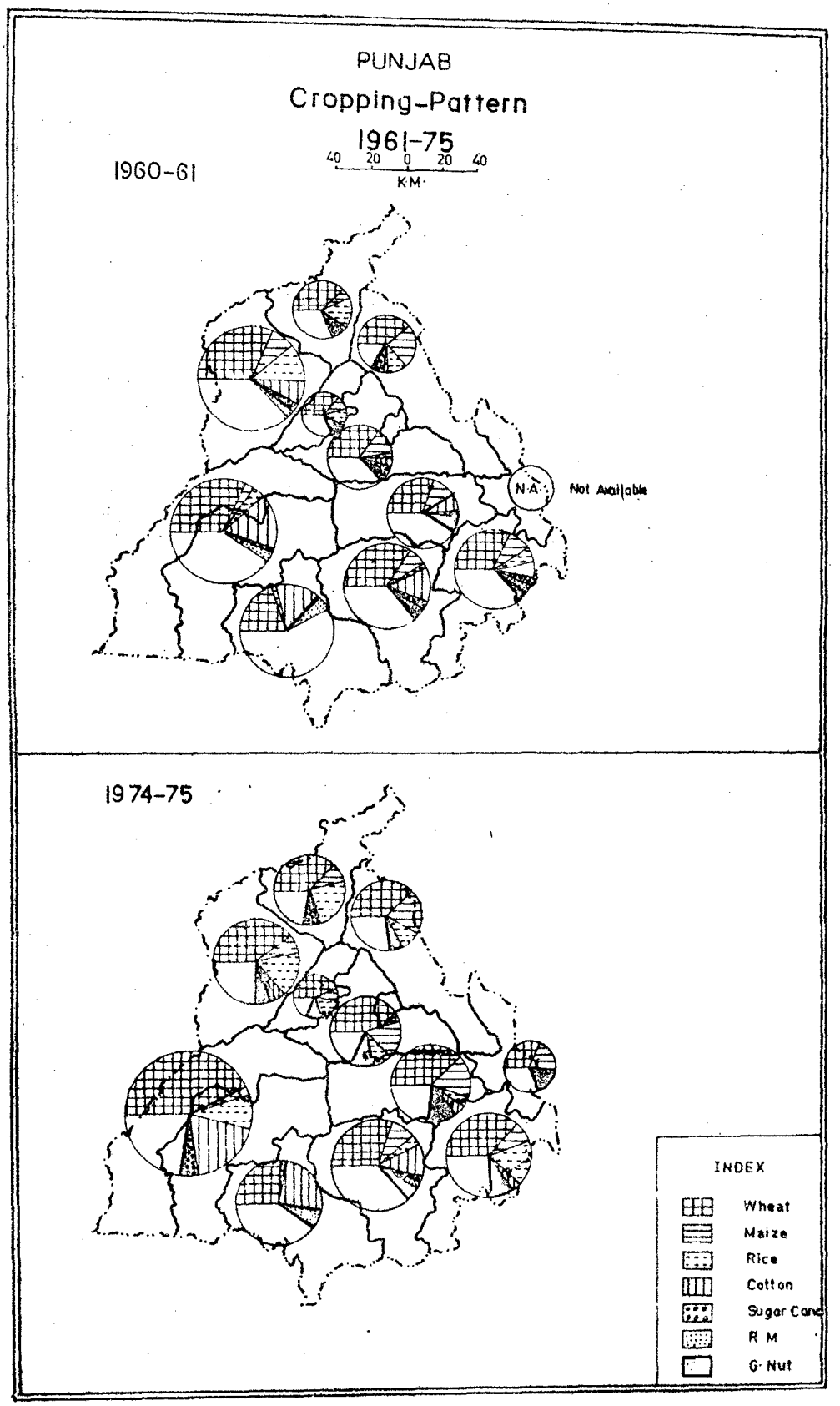

PUNJAB
Cropping-Pattern
1961-75
40 20 0 20 40
KM.
1960-61
N.A.
Not Available
1974-75
INDEX
Wheat
Maize
Rice
Cotton
Sugar Cane
R M
G. Nut

Fig. 14.

has been also analysed to see its effect on productivity.

Although the cropping pattern of an area is dependent upon many factors such as growing season, fertility of soil, moisture factor and price policies, the irrigation facilities are one of the most crucial factor which influences it in the areas of scarce rainfall. Other modern inputs e.g. fertilizers and high yielding varieties of seeds are dependent on the moisture factor particularly assured supply of water. The cropping pattern, in fact, represents a constantly shifting equilibrium between physical, economic and institutional forces. It has, however, a tendency to get stabilized through time in different homogenous type of farming areas.

4.1.1 Temporal Pattern of Area under Cereals

In the present study only seven crops have been analysed which cover ? per cent of gross cropped area. Among the foodgrains only three cereal crops i.e. wheat, rice and maize have been considered while rape/mustard and groundnut (oilseeds), cotton and sugarcane are the non-foodgrains included in this study.

In the case of cereals (rice, wheat and maize) the percentage of area has shown tremendous increase. In the year 1960-61, the area under these crops in the state was only 42.36 per cent of the gross cropped area which rose to 56.95 per cent in 1970-71 which was the highest during this period. Before this the area under these crops has shown a

fluctuating trend up to 1966-67, rising at a slow rate and in a few years it has registered a little decrease also, but the general trend was towards the increase. After1966-67, with the advent of green revolution and introduction of new technology alongwith high yielding varieties of seeds, especially in wheat, the percentage of area under cereals has shown a sudden rise, and it reached to the level of 58.24 per cent during 1971-72 from 45.19 per cent in 1966-67. But in the very next year the percentage of area under cereals slightly declined i.e. from 58.24 to 58.02 per cent and came down to 53.52 per cent in 1974-75.

The district-wise analysis of the patterns shows the same type of ups and downs. In the district of Gurdaspur the percentage of area under cereals was fairly high in 1960-61 when 59.65 per cent of the gross cropped area was devoted to these three crops. It had shown an increasing trend up to 1969-70, with only minor fluctuations. It attained its maximum level in 1969-70 when 75.90 per cent of total cropped area of the district was devoted to these crops. After 1969-70 it had shown a decrease as it fell down from 75.90 to 70.8 per cent in 1970-71, and became almost stagnant after 1970-71 with only a little increase of 1 per cent in the 1972-73 from the previous year.

During 1960-61 about half of the total cropped area area of Amritsar was under these cereals. In the pre-green revolution period the area under cereals in Amritsar has shown a rising trend with only one trough in 1963-64 when the percentage of area fell down from 51.38 to 43.33 per cent.

Percentage of Area Under Cereals (Wheat, Rice and Maize) to Gross Cropped Area - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Roper	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	59.65	50.34	58.26	50.34	74.38	-	41.52	38.45	21.52	42.82	46.97	42.36
1961-62	61.72	47.45	61.53	51.72	74.29	-	41.79	36.52	21.99	42.71	48.58	42.08
1962-63	63.86	51.58	56.54	55.59	76.56	-	39.26	39.43	46.86	45.11	46.61	44.76
1963-64	58.60	42.25	43.33	54.09	76.78	-	46.88	39.68	23.10	46.56	45.74	43.13
1964-65	62.99	50.69	54.09	56.15	76.42	-	48.56	39.51	24.37	48.30	45.29	44.89
1965-66	65.03	53.76	54.43	56.55	61.57	47.37	50.42	39.56	23.94	41.67	47.50	45.60
1966-67	64.45	52.80	56.31	55.58	58.26	46.37	52.29	38.59	24.42	40.53	48.33	45.19
1967-68	66.36	55.60	58.47	58.87	63.18	48.07	53.68	39.86	28.89	43.37	49.98	47.37
1968-69	68.10	59.59	69.42	63.57	67.37	51.71	61.23	50.29	36.47	52.87	57.96	54.79
1969-70	75.90	62.10	70.96	66.30	67.87	51.98	65.34	48.09	35.87	53.77	61.20	54.98
1970-71	70.80	62.44	72.24	68.01	68.87	55.68	66.46	49.62	35.01	55.26	65.15	56.95
1971-72	70.56	64.84	71.59	70.42	71.11	56.97	67.89	48.68	36.83	56.75	65.39	58.24
1972-73	71.79	64.00	72.54	71.22	70.05	57.52	69.02	48.15	33.52	56.46	66.02	58.02
1973-74	70.88	65.94	72.82	70.96	67.55	56.83	66.66	46.48	30.01	53.63	65.85	56.72
1974-75	70.04	63.84	71.07	70.09	67.47	54.85	59.17	53.97	27.97	42.89	62.68	53.52

Source: Computed from the Data obtained from Statistical Abstract of Punjab (1961-75), Government of Punjab.

The percentage of area under cereals in Amritsar was highest during 1971-72 (64.84%) and the general trend was towards the increase.

In general the percentage of area under cereals has shown an increasing trend throughout the period. In Gurdaspur cereals occupy the highest percentage of GCA as compared to other districts. Bhatinda recorded the lowest percentage of area under cereals (21.52% of the GCA of the district in 1960-61). It rose to its highest level in 1971-72 with 36.83 per cent of GCA under cereals. Since 1971-72 the area under cereals in Bhatinda has again been showing a serious decline continuously up to 1974-75.

Hoshiarpur is another case in the state where percentage of area under cereals was highest in the state in 1960-61 (74.30% of its total cropped area). It rose up to 76.42 per cent in 1964-65. After this it has shown a decreasing trend, in a few years it has shown a little rise also but in 1974-75 the percentage of area remained only 67.47 per cent.

4.1.2 Temporal Pattern of Area under non-Foodgrains

The area under non-foodgrains, i.e. cotton, sugar-cane, rape and mustard and groundnut accounted for 16.3 per cent of the GCA in the state during 1960-61 and it rose to 17.1 per cent during 1974-75, as compared to the 53.52 per cent of area under cereals (i.e. wheat, rice and maize). The proportion of area under non-foodgrains was highest in

the state during 1965-66 (17.43%). It has shown minor ups and downs up to 1967-68, but afterwards it has shown a continuous decline and came down to 14.11 per cent during 1970-71. But again it picked up and attained the level of 17.1 per cent during 1974-75. The district-wise proportion of area under non-foodgrains has also been given in table which reveals that the highest proportion of area under non-foodgrains was recorded in Ferozepur (20.84 per cent) during 1960-61 and in Bhatinda (31.75%) during 1974-75. The lowest proportion was recorded in Hoshiarpur (8.03 per cent during 1960-61 and 5.29 per cent during 1974-75).

Among the non-foodgrains, sugarcane and cotton both are more important in all the districts of state, as the proportion of these crops is more than the oilseeds. Taking state as a whole area under cotton and sugarcane accounted for 12.50 per cent during 1960-61. It has shown minor fluctuations during the period, 1960-61 to 1974-75. After 1967-68 it has almost stabilised around 10 per cent. The table shows that Bhatinda, Ferozepur and Sangrur are the only districts where proportion of area under commercial crops is quite high and is above the state average. Bhatinda and Ferozepur have shown the increase in proportion of area under these crops on the base of 1960-61 while all other districts have shown decline. It was lowest in Hoshiarpur (7.62%) during 1960-61, and in Kapurthala (2.04%) during 1974-75. The proportion of area under these crops ranged

Percentage of Area under Non-Foodgrains (Cotton, Sugarcane and Oilseeds) to Gross Cropped Area - 1960-1 to 1974-5

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-dar	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	8.65	13.14	10.10	12.18	8.03	-	17.33	20.84	20.81	20.94	15.79	16.30
1961-62	7.37	14.81	10.58	12.19	8.50	-	18.55	20.20	22.40	22.53	15.77	16.84
1962-63	7.60	11.82	7.47	12.10	8.01	-	19.21	19.30	18.24	23.49	14.79	15.24
1963-64	6.94	13.68	11.32	13.19	7.48	-	24.79	22.02	21.04	24.35	15.11	17.31
1964-65	7.52	14.17	11.94	12.67	5.73	-	24.04	19.90	19.42	22.73	15.66	16.63
1965-66	9.26	12.57	13.34	14.40	5.07	18.78	24.34	21.85	22.44	17.33	17.16	17.43
1966-67	8.99	11.12	14.11	15.77	5.84	15.68	26.26	19.52	20.60	13.66	17.49	16.80
1967-68	8.27	12.66	13.83	15.30	6.43	16.99	24.29	20.27	22.67	16.77	15.95	17.21
4968-69	9.09	10.76	14.90	14.69	6.13	16.54	23.58	18.35	20.26	15.06	16.05	15.91
1969-70	8.81	12.16	12.76	13.83	6.31	15.07	20.37	18.38	16.38	12.18	14.34	15.24
1970-71	7.90	10.03	12.43	12.98	4.72	16.73	19.12	17.60	17.67	14.05	12.11	14.11
1971-72	7.82	10.28	11.90	11.53	4.00	13.13	18.77	20.36	23.98	15.94	10.79	15.22
1972-73	7.67	10.34	11.69	10.34	4.16	12.03	17.67	20.9	26.99	17.55	10.63	15.90
1973-74	7.45	10.23	10.85	10.24	5.22	13.13	17.10	22.88	27.07	13.89	11.25	16.23
1974-75	7.49	11.26	10.17	10.68	5.29	14.40	17.98	23.45	31.75	20.56	12.19	17.10

Source: Government of Punjab (India), Statistical Abstract of Punjab, 1961-1975.

from 2 to 7 per cent only in all the other districts except Bhatinda, Ferozepur and Sangrur during 1974-75.

The proportion of area under oilseeds (rape/mustard and groundnut) was recorded to be only 3.80 per cent during 1960-61 and it has increased very slowly and reached to its highest level during 1967-68 when it accounted for 7 per cent of the total cropped area in the state. Afterwards it has declined again and fell down to 5.51 per cent during 1968-69 and since then it has almost stabilised. The proportion of area under oilseeds has been high in Ludhiana since 1960-61 as compared to the other districts in the state. It was very low in Hoshiarpur and Gurdaspur (1.96% and 1.27% during 1974-75 respectively). It also witnessed great fluctuations over the time period in all the districts, but it has shown an increase in the area during 1974-75 as compared to 1960-61 in all the districts.

4.2 Trend of Area under Selected Crops in Punjab (1960-61 to 1974-75)

In Punjab, maize, rice, cotton and groundnut are some of the important kharif crops which are sown with the onset of monsoons in July and harvested in the late September and early October. The rabi crops e.g. wheat, barley, rape and mustard are sown in late October and early November and harvested in April.

4.2.1 Trend of Area Under Wheat

Wheat is the leading food crop in Punjab. In terms of its acreage Punjab occupies second place after UP with an

area of 24.39 lakh hectares during 1975-76, accounting for about 10.2 per cent of the total area under wheat in the country. The area under wheat accounted for about 30.44 per cent in the state during 1960-61 which rose to 40.81 per cent during 1971-72. The wheat acreage has shown a very slow rate of growth from 1960-61 to 1966-67, but after the introduction of HYV seeds and new technology the wheat acreage has increased rapidly up to 1968-69. Its proportion to total cropped area was the highest during 1971-72, and since then it has shown a little decline in the area.

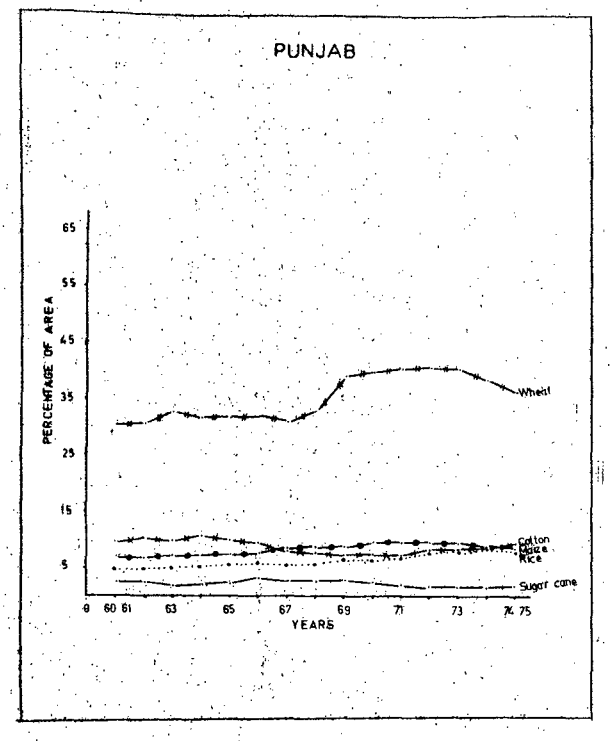
The wheat is a leading crop in all the districts in terms of area since 1960-61, however, the area has shown some variations over time. During 1960-61 the area under wheat ranged from 30 to 38 per cent in all the districts except Bhatinda, where it was lowest in the state (20.11%). The highest area under wheat was recorded in Hoshiarpur (38.75%).

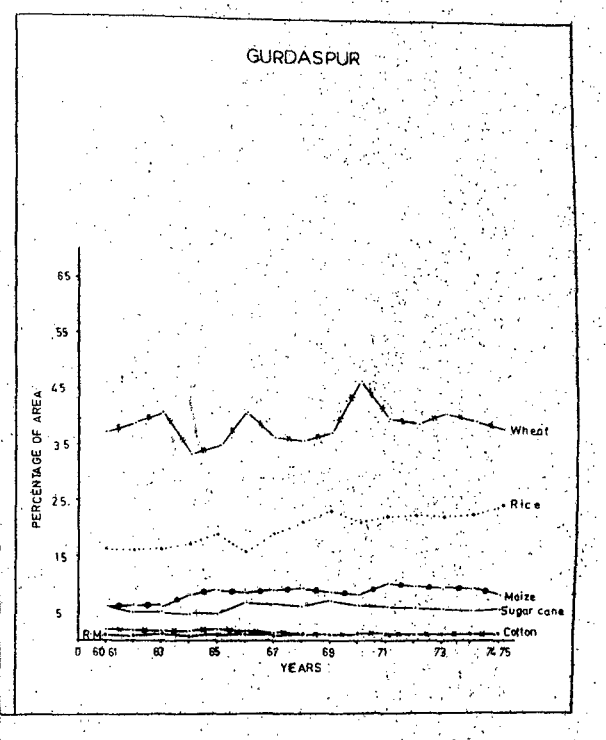
Ludhiana which had been selected for the Intensive Agricultural District programme, is the only district of Punjab which has shown a continuous increase in the area under wheat from 1960-61 to 1971-72, witnessing a slight decline afterwards. It has shown fluctuations in different years in Jullunder and Amritsar up to 1966-67, and onward it has registered rapid increase with the advent of green revolution. The proportion of area under wheat to the total cropped area attained peak during 1971-72 in Jullunder and in 1972-73 in Amritsar. Later the area showed decline in both the districts.

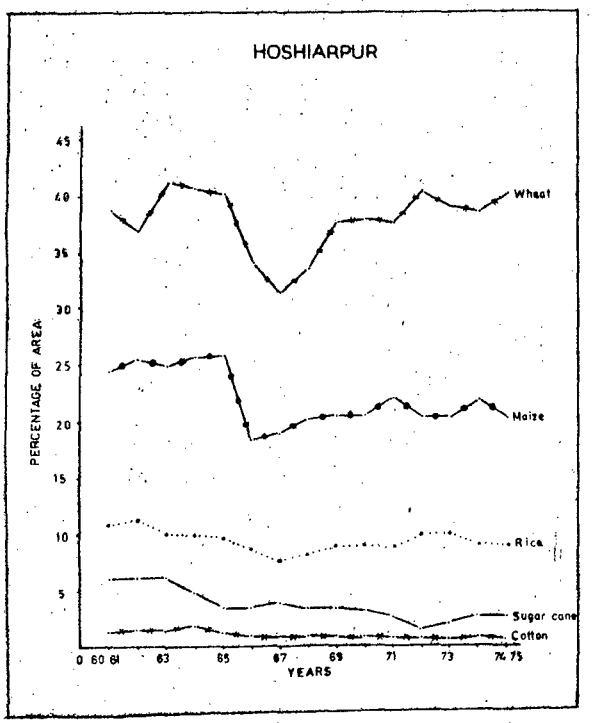
Trends in Area of Some Selected Crops

As Proportion to Gross Cropped Area

1961 –75







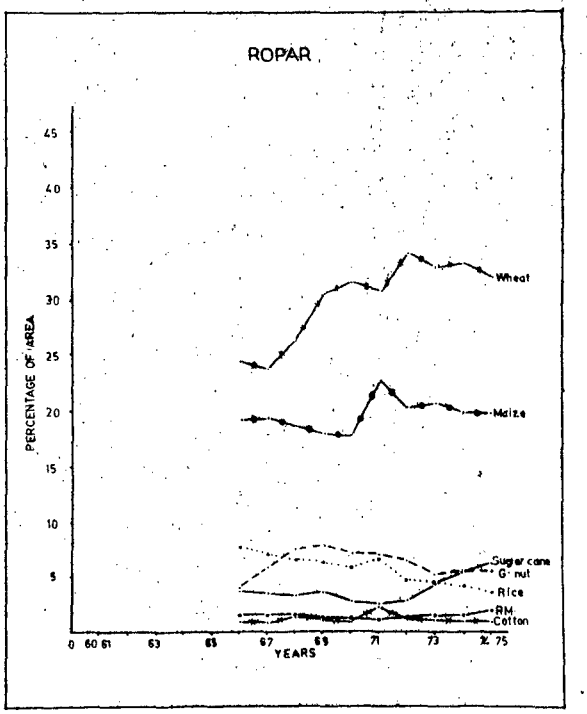


Fig. 15

Patiala and Kapurthala have shown a decreasing trend in the wheat acreage from 1961-62 to 1966. But they registered rapid increase after 1966 which continued up to 1970 in Kapurthala and till 1971 in Patiala, after which it started declining in both the districts. In Hoshiarpur it declined from 1964-65 to 1966-67, but afterwards showed a continuous increase with one or two exceptional years.

It has shown an increasing trend in Bhatinda, Sangrur, and Ferozepur districts also during the late sixties, but it declined after 1971-72.

4.2.2 Trend of Area under Maize

Maize ranks third to wheat and cotton in Punjab. The proportion of area under maize in the state was 7.07 per cent during 1960-61 which rose to 9.60 per cent during 1970-71 and since then it is almost stagnant, rather its area slightly declined during 1974-75. In the pre-green revolution period its area was less than that of cotton, but after 1966-67 it has exceeded the cotton and occupied the second place after wheat from 1966-67 to 1973-74. Maize is the competing crop with rice in the districts of central alluvial plains and with cotton in the south western arid districts.

It ranks second to wheat in the districts of Hoshiarpur, Ropar, Jullunder and Ludhiana. During 1960-61 24.56 per cent of the gross cropped area was devoted to maize in Hoshiarpur, but it started declining after 1970-71. In Ropar its area showed decreasing trend since 1966-67, while

in Ludhiana it rose continuously up to 1973-74 except during 1965. The proportion of area under maize in Jullunder has also shown rising trend with few exceptions, but the rate of increase is slow.

In the districts of the central aluvial plains viz. Patiala, Amritsar, Kapurthala and Gurdaspur the maize is third ranking crop after wheat and rice. In Amritsar the maize area has shown greater fluctuations and general trend has been towards decline. In Kapurthala, it has not shown a rapid change up to 1965-66 but after 1966 it started gradually increasing up to 1970 and afterwards started declining. Gurdaspur accounted for only 7.42 per cent during 1960-61, but it rose up to 9.92 per cent during 1970-71. After attaining this level it has shown a decreasing trend. Maize is losing importance in terms of area in Patiala gradually. In Sangrur also it has shown decreasing trend after 1972-73. In Bhatinda and Ferozepur maize is not very important crop, it ranks fourth in Bhatinda and fifth in Ferozepur.

4.2.3 Trend of Area under Rice

The rice cultivation was earlier confined to a limited area, but with the release of semi-dwarf high yielding varieties and improved cultivation techniques the area under rice has increased tremendously and now rice has become the major kharif crop in Punjab. Only a few crops witnessed a spectacular increase in area as did rice during the period 1965-66 to 1974-75. It accounted for only 4.85 per cent of

Trends in Area of Some Selected Crops

As Proportion to Gross Cropped Area

1960-61 – 74-75

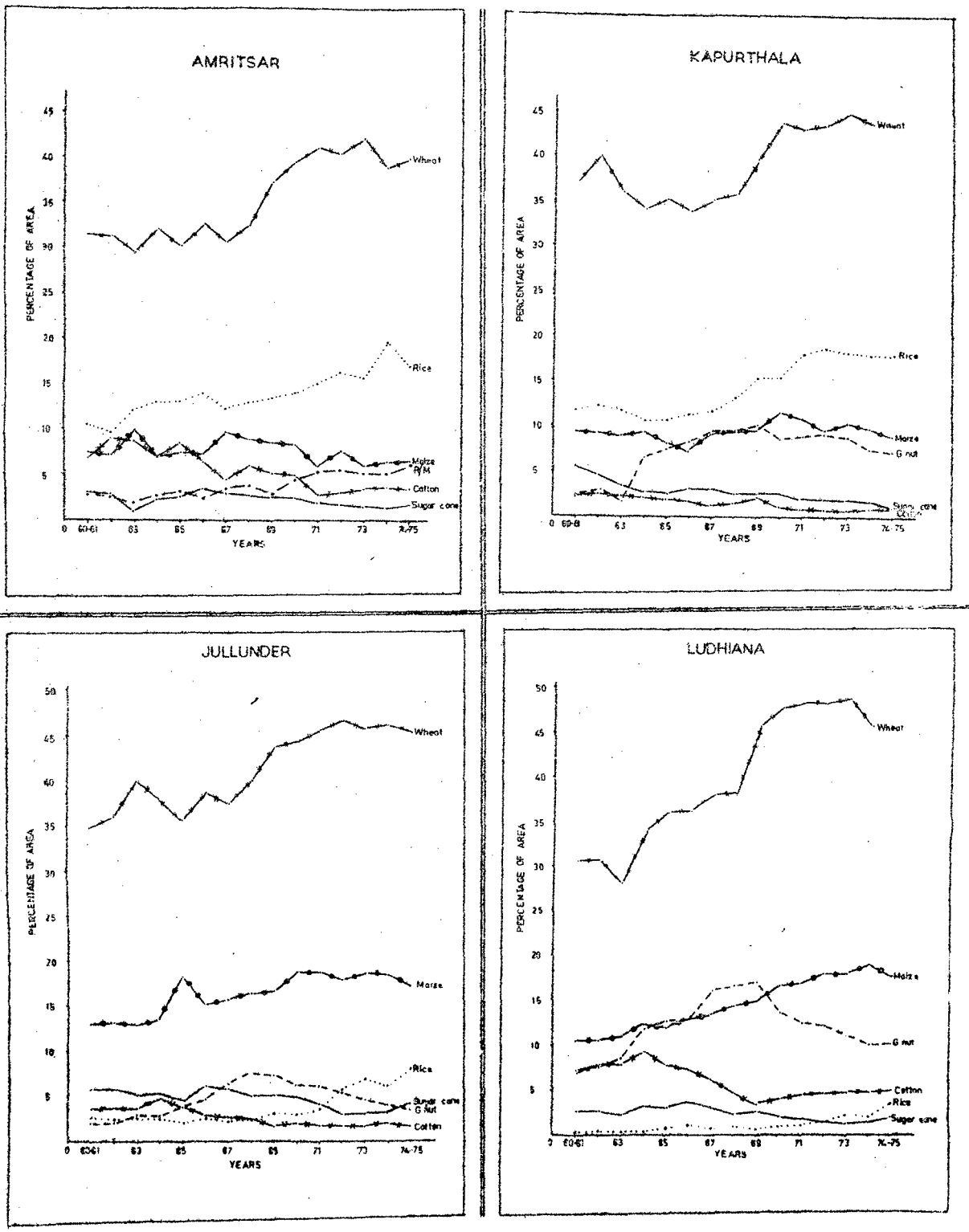


Fig. 1C

the gross cropped area in the state during 1960-61 but rose to 8.07 per cent during 1974-75.

Rice is second ranking crop in Amritsar, Kapurthala, Gurdaspur and Patiala. The acreage under rice has shown sharp increase in all these districts since 1963-64 with one or two exceptions. Gurdaspur recorded the highest area under rice amongst the districts of Punjab during 1974-75 when 24.21 per cent of its gross cropped area was devoted to rice. In Hoshiarpur it is third ranking crop. It attained third rank in Ferozepur after wheat and cotton. It accounted for 3.8 per cent of gross cropped area during 1960-61 but rose to 8.9 per cent during 1974-75. It has shown an increasing trend which continues except for a decline during 1967-68.

In Jullunder it was only 2.66 per cent during 1960-61, but during 1974-75 it recorded 9.14 per cent of gross cropped area. The graph depicts a fluctuating trend, though towards increase, but at a sluggish rate. However, the rate of increase has become rapid after 1969-70.

The area under rice is low in Ludhiana, Sangrur and Ropar districts as it ranges from one to three per cent of the gross cropped area. Ludhiana and Sangrur have witnessed substantial increase under the area of rice in the recent years. In Bhatinda rice cultivation is almost absent.

4.2.4 Trend of Area under Cotton

'India enjoys the distinction of being the earliest country to domesticate cotton and utilize the fibre for

manufacturing fabrics.' Evidence of the antiquity of cotton has been traced to Mohanjodara, the date of which is estimated to be 2500-3000 BC.'[1]

The cotton crop is firmly established in the agricultural system of Punjab. It is a kharif crop and sown generally after the onset of the summer monsoons.

Cotton holds the second position in state in terms of percentage of area. It accounted for 9.69 per cent of the gross cropped area of the state during 1960-61, and has shown an increasing trend up to 1964-65 with minor fluctuations. It has shown decrease from 1964-65 to 1970-71.

In the districts of Bhatinda, Ferozepur, and Sangrur cotton ranks second. In districts of Bhatinda and Ferozepur more than 15 per cent of their gross cropped area is devoted to cotton. The percentage of area under cotton has shown great fluctuations in both the districts from 1960-61 to 1964-65, and hence it witnessed a consistent decrease up to 1971. After 1971 it has recorded sharp increase up to 1974-75 as its proportion was 18.84 per cent in Ferozepur and 24.47 per cent in Bhatinda as compared to only 14.39 per cent in Ferozepur and 13.76 per cent in Bhatinda during 1970-71. The cotton area has shown a sharp decline in Sangrur from 1963-64 to 1968-69, but since then it has shown increase.

In the central plains, Ludhiana, Amritsar and Patiala are the three districts where cotton has occupied

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1 Council of Scientific and Industrial Research, The Wealth of India (New Delhi, 1971), vol. 4.

a significant place. Its area witnessed an increase from 1960-61 to 1963-64 in Ludhiana but after 1963-64 it has declined suddenly as maize gained importance during this period. In 1968-69 the area under cotton shrunk to only 3.38 per cent against 7 per cent during 1960-61. In Amritsar and Patiala its area has shown a substantial decrease from 1961-62 to 1970-71. The proportion of area under cotton was more than 6 per cent in both the districts during 1960-61, but it has come down to 2.78 per cent in Amritsar and 3.25 per cent in Patiala. The overall trend was towards decrease in cotton area in Jullunder also.

In the districts of sub-montane region, Ropar, Hoshiarpur and Gurdaspur, the cotton is not significant crop. It accounted for only less than 2 per cent area in these districts during 1960-61. Its area has shown decline in all the three districts from 1960-61 to 1974-75 and during 1974-75 it came down to only 0.75, 0.64 and 0.82 per cent in Gurdaspur, Hoshiarpur and Ropar respectively.

4.2.5 Trend of Area under Sugarcane

Sugarcane, accounting for 2.28 per cent of the gross cropped area in the state during 1960-61, ranked fifth crop. The proportion of area under sugarcane in the state has not shown much changes over this time period.

A high proportion of area under sugarcane is found in the sub-montane region. It was the highest in Hoshiarpur during 1960-61, and in Ropar during 1965-66 as compared to

the other districts in the state. In Hoshiarpur area under sugarcane has shown continuous decline from 1960-61 to 1971-72 and in Ropar it has declined up to 1969-70. After 1965-66 there has been an increase in sugarcane area, after 1970 in Ropar and after 1971-72 in Hoshiarpur. In Gurdaspur it has decreased from 1960-61 to 1964-65 and increased from 1964-65 to 1969-69 and then again has decreased up to 1974-75 when it accounted for only 5.47 per cent.

Kapurthala and Jullunder are the important sugarcane producing districts among the central alluvial plain. But the percentage of area under sugarcane is decreasing rapidly in Kapurthala since 1960-61 and came down to 1.20 per cent during 1974-75 as compared to its share of 5.51 per cent during 1960-61. The sugarcane area in Amritsar has shown an increase from 1962-63 to 1965-66, but since then it has decreased though the rate of decline is slow as is evident from the fact that it recorded 1.79 per cent of GCA during 1974-75 against 3.14 per cent during 1960-61. It has marginally increased in Ludhiana from 2.70 per cent during 1960-61 to 3.82 per cent during 1965-66. But sugarcane is losing importance since 1965-66. Similarly its area is decreasing since 1965-66 in Patiala (1.82% during 1974-75 as against 3.38% during 196061). Sugarcane is not important crop in south western dry districts of Bhatinda and Ferozepur, where it has to compete with highly remunerative crops like cotton and oilseeds.

4.2.6 Trend of Area under Rape and Mustard

Among the oilseeds rape and mustard are very important in Punjab in terms of area. These are grown during the rabi season as independent crops in dry areas and as interculture with wheat and gram in less dry areas.

The percentage of area under rape/mustard was 2.47 per cent in the state during 1960-61 and was the sixth important crop of the state. It has not shown large variation from year to year, but it showed a decreasing trend from 1960-61 to 1970-71, but since 1970-71 it has shown fast increase.

Rape and mustard is important cash crop in Bhatinda, Ferozepur and Sangrur districts. The area under rape and mustard has shown great fluctuations in Bhatinda, where it experienced a decline in area up to 1968-69, but onwards it has been increasing every year. Similarly in Ferozepur and Sangrur the proportion of area under rape and mustard has shown larger variations from year to year up to 1968-69, but after that it is improving slightly.

In Amritsar rape and mustard is sixth ranking crop and area under this has shown slight increase from 1962-63 to 1964-65, but witnessed a decline during the period from 1965-69, but since then it has been increasing rapidly. The rape and mustard area has shown a continuous decline in Patiala from 1960-61 to 1971-72 with only one exceptional year of 1966-67. Since 1971-72 acreage under rape and mustard

Trends in Area of Some Selected Crops

As Proportion to Gross Cropped Area

1961–75

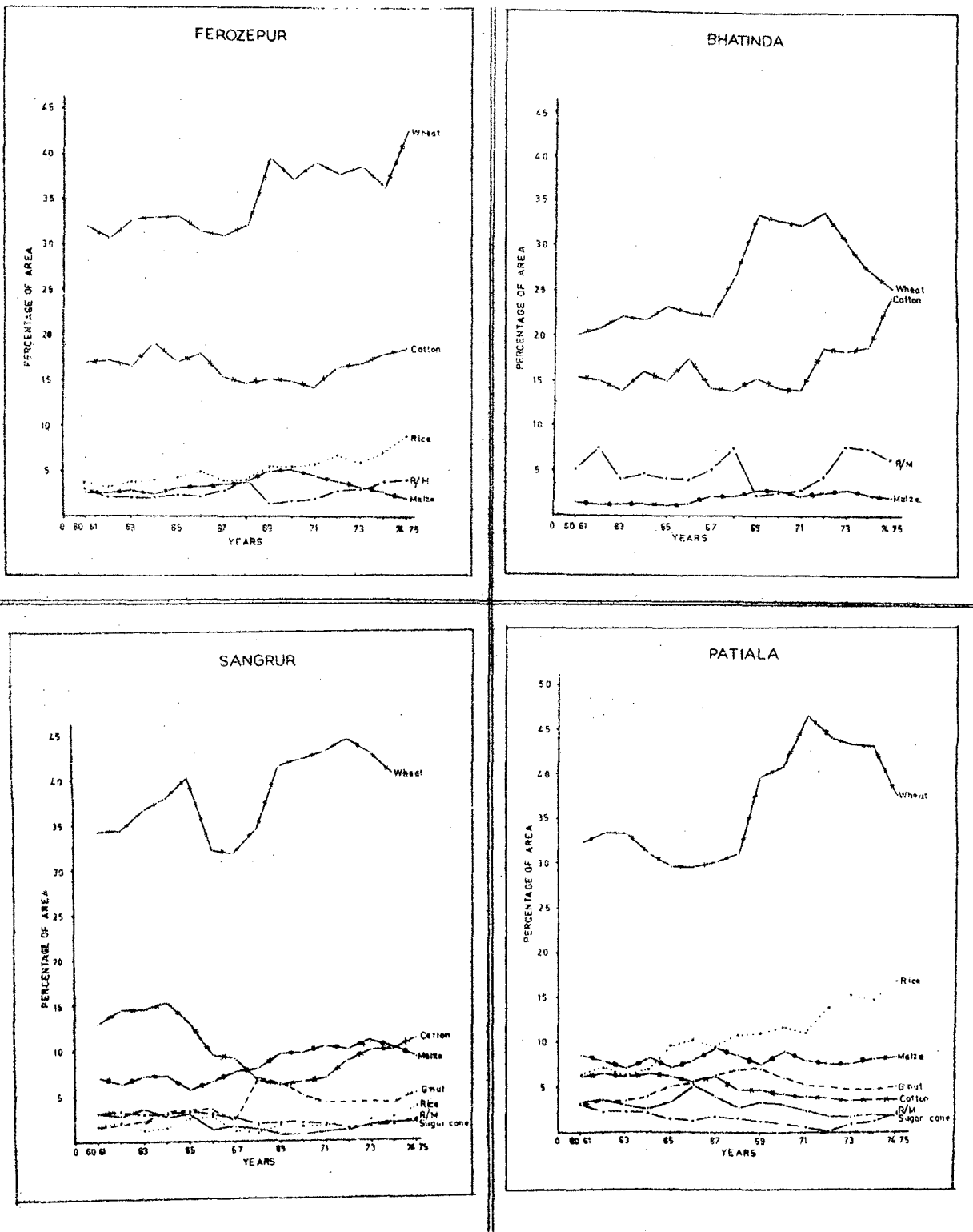

Fig. 15

is increasing in the district. In Ropar the proportion of area under rape and mustard has shown an increasing trend since 1966. In Gurdaspur area under rape and mustard has increased to 1.27 per cent during 1974-75, from 0.84 per cent during 1960-61. In the districts of Jullunder, Ludhiana, Hoshiarpur and Kapurthala the cultivation of rape and mustard is almost absent.

4.2.7 Trend of Area under Groundnut

The groundnut was introduced in Punjab in 1931. Accounting for only 1.33 per cent of the total cropped area in the state, groundnut was not very important crop during 1960-61, but the area under groundnut increased rapidly from 1960-61 to 1968-69, and it rose up to 4.19 per cent during 1969. After 1969 it is losing its importance as rice is becoming more important kharif crop in most of the districts.

During 1960-61 the proportion of area under groundnut was highest in Ludhiana accounting for 7.30 per cent of its cropped area. It was third ranking crop of the district. As the acreage under groundnut increased very rapidly, it became even the second ranking crop in Ludhiana after wheat, and its proportion to the total cropped area rose to 17.19 per cent during 1968-69, but after that the area under groundnut has been decreasing every year. Similarly groundnut acreage has shown continuous increase since 1960-61 to 1968-69 in Patiala district but it also witnessed a declining

trend after 1968-69. In Sangrur, only 1.68 per cent of GCA was under groundnut during 1960-61, but it attained 6.87 per cent during 1967-68. From 1967-68 to 1971 it witnessed declined and afterwards remained stagnant.

Its cultivation is also important in Kapurthala and Jullunder. Starting with 2.36 per cent area in Kapurthala and 2.15 per cent in Jullunder under Groundnut during 1960-61, it increased very rapidly in both the districts up to 1968-69. During 1968, the area under groundnut was 7.74 per cent in Jullunder and 10 per cent in Kapurthala during 1969. Similarly the acreage under groundnut rose up to 7.87 per cent during 1968-69 in Ropar as compared to 4.04 per cent during 1960-61, which declined afterwards. The cultivation of groundnut is practically absent in Amritsar, Gurdaspur and Ferozepur and Bhatinda districts.

4.3 Behaviour of Productivity of Selected Crops (1960-61 to 1974-75)

The state of Punjab has made big strides in agricultural production during the last decade. However, the increase in agricultural production is obtained marginally by the increase in net area sown and substantially by the increase in productivity per unit of land. The modernisation of agriculture with new technology has been responsible for this breakthrough. Yield per hectare is a function of many factor inputs. Some of these inputs are controllable e.g. irrigation, labour, agricultural practices adopted etc. while

some others are uncontrollable factors viz. weather which is most important. There are other economic and institutional factors affecting the yield per hectare viz. cost price relationship, the better price prospects of a crop and size of operational holdings, pattern of land distribution, ownership and tenancy, availability of credit etc. Irrigation or availability of water through rainfall is an important factor as it is the key input for efficient use of fertilizers and high yielding varieties of seeds.

4.3.1 Productivity of Wheat

Excepting Mexico in the case of wheat and Japan and Korea in the case of paddy, the average yields in Punjab are the highest among the wheat and rice growing countries.[2] With average wheat productivity of 2373 kg per hectare, Punjab is the leading state in the country. It is much higher than the national average of 1409 kg per hectare. During 1960-61 the wheat yield was 1237 kg per hectare only, which rose to 1514 kg per hectare during 1965-66. As a result of package inputs the wheat yield has increased rapidly after 1966 and obtained a peak of 2406 kg per hectare during 1971-72. After that it has declined slightly for the state but it has again shown an increase since 1973-74 and rose to 2395 kg per hectare during 1974-75.

Patiala was the leading district in the state with a yield rate of 1533 kg per hectare during 1960-61. It was lowest in Gurdaspur (885 kg per hectare). But since 1961-62

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1 P.S. Hoshiarpuri, The Tribune, July 17, 1979.

Ludhiana leads the state in wheat productivity. During 1960-61, in Amritsar, Kapurthala, Gurdaspur and Hoshiarpur, the yield of wheat was below the state average of 1231 kg per hectare while in the remaining districts it was above the average yield of the state. During the pre-green revolution period, i.e. from 1960-61 to 1965-66, the yield of wheat has shown an increasing trend in general for all the districts. But as evident from the table - the increase in the yield has not been continuous and shown large fluctuations in all the districts. Wheat yield has shown a decline during 1962-63 in Sangrur, Ferozepur and Patiala districts as well as in Bhatinda, Hoshiarpur, Gurdaspur and Amritsar, while in Kapurthala, Ludhiana and Jullunder it has shown continuous increase till 1965. The year 1964-65 was the peak year for all the districts, but a substantial decline in the wheat yield has taken place during the year 1965-66, in all the districts of state.

After 1966-67, with the introduction of high yielding varieties of wheat and with increased consumption of fertilizer a substantial increase in wheat yields has been registered. It increased at a very rapid rate in all the districts in the late sixties. Ludhiana has witnessed continuous increase up to 1971-72. The peak of wheat productivity has been attained during 1968-69, by Patiala, during 1970-71 by Kapurthala, and in 1974-75 by Gurdaspur, Jullunder and Hoshiarpur, while the year 1971-72 was a good crop year in which most of the districts of Punjab attained the maximum yield levels. It was also the peak year for the state as a

Trends in Yield of Some Selected Crops

1960-61--74-75

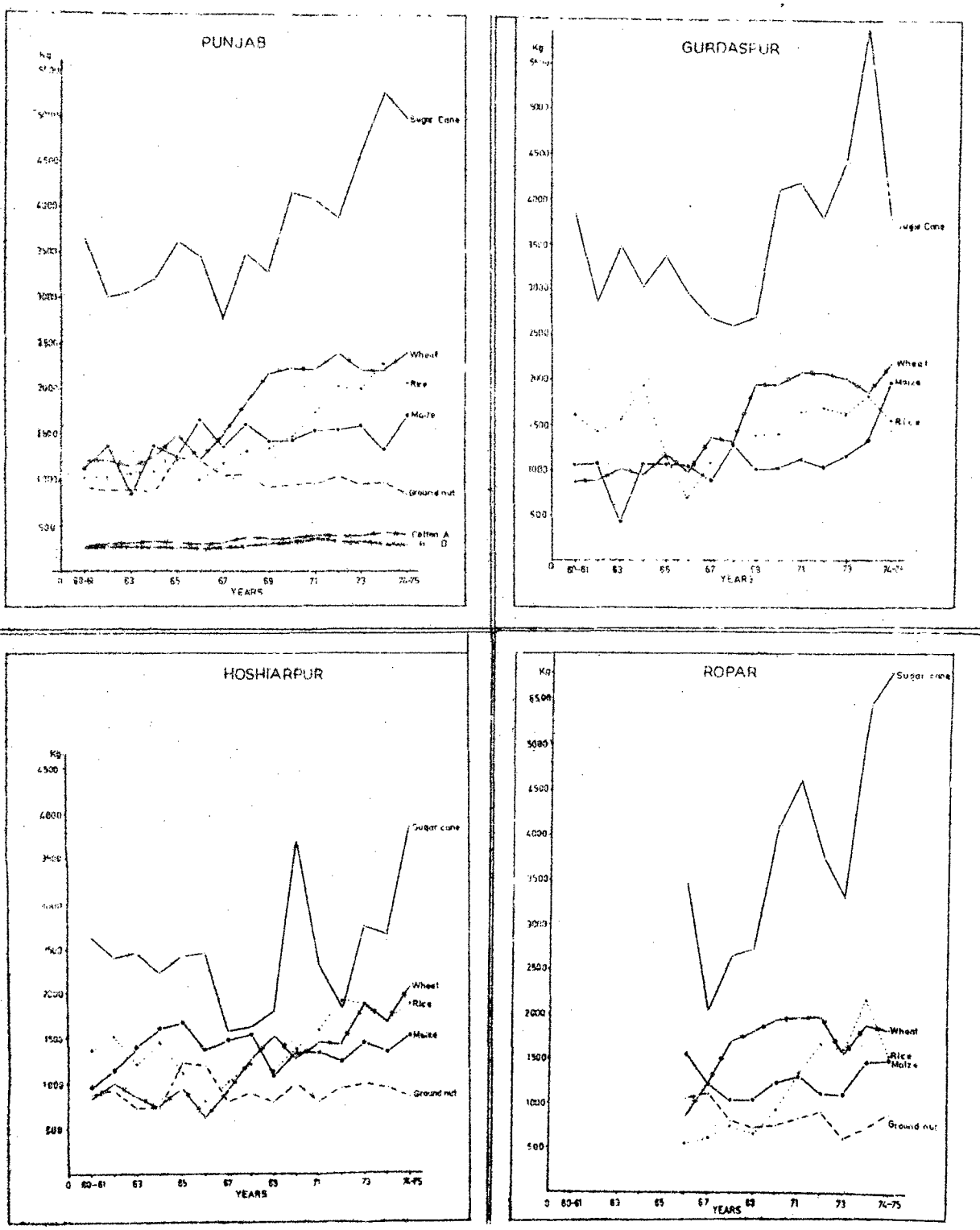

Fig. 16 A

whole and it witnessed a yield of 2406 kg per hectare. After reaching the highest level of yields all the districts have shown a declining trend during the subsequent years. Amritsar, Patiala, Bhatinda, Ropar, Sangrur and Ludhiana during 1973 and Jullunder, Kapurthala, Gurdaspur, Hoshiarpur and Ferozepur during 1973-74 have witnessed lowest wheat yields. But afterwards the trend has changed and it has shown an increase in all the districts of Punjab except Ropar, which has shown a decline.

In general one can conclude that wheat yield has been increasing in the state since 1960-61 and the rate of increase was rapid from 1965-66 up to 1971-72. After a setback during 1972-73, it has shown an upward trend.

4.3.2 Yield of Rice

Punjab which leads the country now in respect of rice yield per hectare and is the largest contributor to the central pool of foodgrains, was not important at all for rice production in the early sixties and yield of race was also low in comparison to other rice growing states. During 1960-61, the average yield of rice in the state was 1035 kg per hectare and highest yield was recorded in Kapurthala (1691 kg per hectare) and lowest in Hoshiarpur (1371 kg per hectare). The yield of rice during the pre-green revolution period has shown a steady and continuous increase up to 1964-65. During 1965-66 it fell down because of drought conditions. It has been increasing continuously at a much faster rate since 1966-67 and attained

Trends in Yield of Some Selected Crops

1960-61-74-75

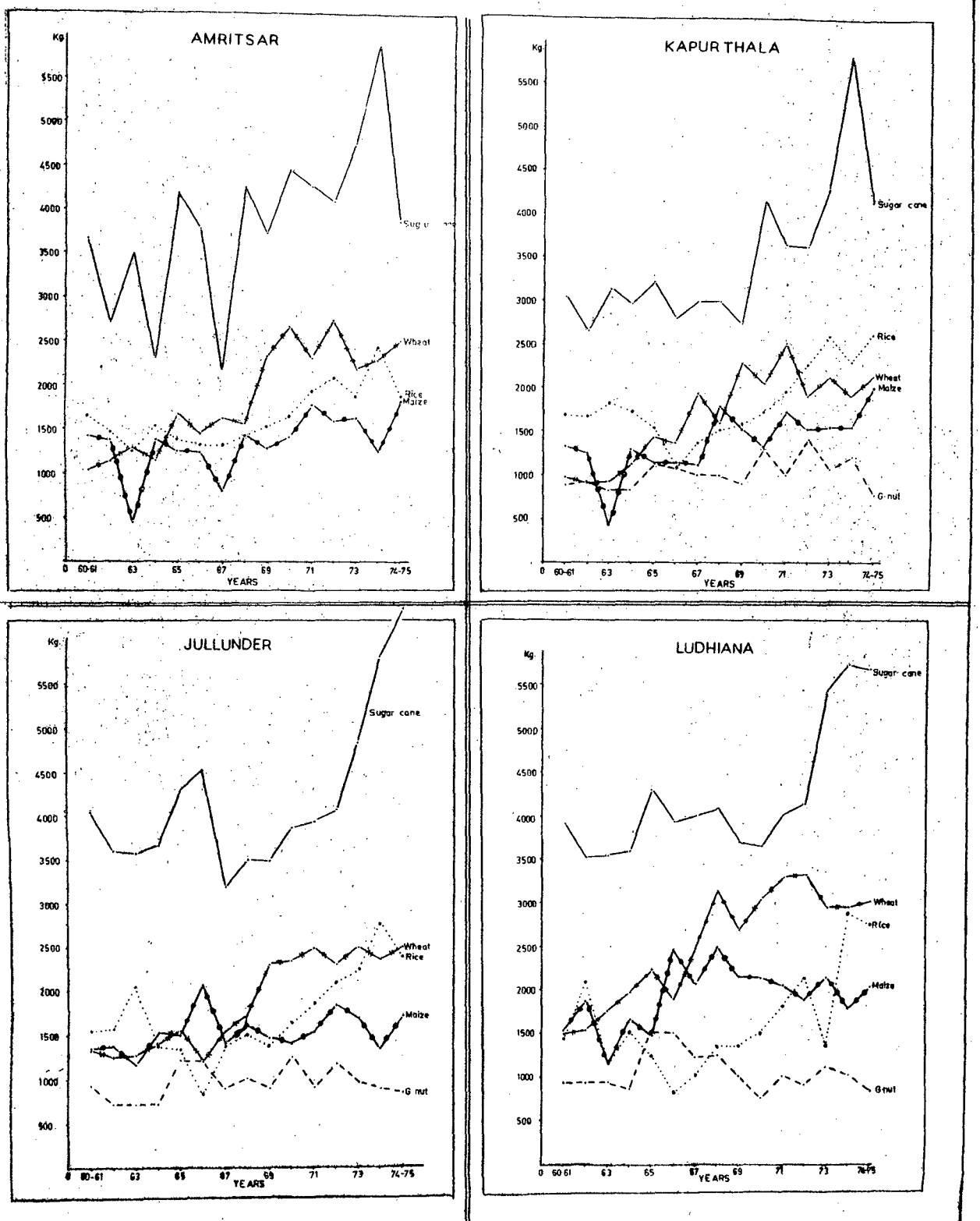

Fig. 16. B

the highest peak during 1973-74, when the state registered an yield of 2287 kg per hectare.

A spatial pattern of the rice yield across the districts reveals (Appendix) that productivity of rice has shown larger yearly variations, but general trend has been of increase in most of the districts. The pre-green revolution yield peak has been attained by Gurdaspur, Amritsar and Ludhiana in 1963-64 and Sangrur, Ferozepur, Jullunder and Kapurthala attained it during 1962-63.

After 1966-67, the rice has become an important crop in the kharif season and has shown rapid increase not only in area and output but also in productivity. Since 1966-67 the productivity of rice has been increasing rapidly in all the districts, because of introduction of high yielding varieties of seeds, heavy doses of fertilizers and improved water facilities. As is evident from the graphs, it has been increasing in every district continuously up to 1973-74, with the only exception of the year 1968-69, when some of the districts namely, Ferozepur, Sangrur, Ropar, Gurdaspur and Jullunder have shown a decline. All the districts except Hoshiarpur, Patiala and Kapurthala recorded the highest rice yields in 1973-74. Hoshiarpur and Patiala registered highest yields during 1971-72, Kapurthala witnessed the peak in 1974-75. Kapurthala has been ahead of the districts of state with respect of rice yield from 1966-67 to 1971-72 with only one exceptional year of 1967-68. Ludhiana has become the leading district from 1973-74 onwards. The lowest yields of rice

has been recorded in Ropar in 1966, where it remained lower than the average. Bhatinda and Gurdaspur are the other districts which have recorded lower yields.

4.3.3 Yield of Maize

The yield of maize in Punjab is lower as compared to the other maize growing states of India. During 1975-76 the maize yield in the state was only 1467 kg per hectare as against the average yield of 1173 kg per hectare in the country, but it was far below that of Karnataka (3036 kg per hectare). During 1960-61 the yield was only 1135 kg per hectare. The productivity of maize in Punjab has shown large yearly fluctuations between 1960-61 and 1968-69. Within this period of eight years, it recorded the highest yield during 1964-65 (1670 kg per hectare) and lowest during 1962-63 (851 kg per hectare). Since 1968-69 it has shown a continuous rise, up to 1974-75, with only one exception of 1973-74. The average yield for the state touched a all time high during 1974-75 (1723 kg per hectare). It is interesting to note that the years of lower yields in rice are the years of higher yields of maize. It is due to the fact that maize needs less water as compared to rice, and the lower yields of rice are associated in most of the years with the shortage of rainfall and inadequate water supply. Ludhiana has been leading district in the maize yield from 1966-67 to 1973-74, and Kapurthala has shown the highest yield in the state during 1975. The yield of maize is low in Bhatinda and Gurdaspur

for most of the years of the study. Ferozepur has recorded the lowest yields during 1973-74.

District-wise trend of maize yield in Punjab is given in the Appendix. It is also evident from the graphs that the maize yield has shown year to year fluctuations up to 1966-67 in all the districts of state. Even after 1966-67, when the high yielding varieties were introduced for maize along with rice and wheat the maize yield has not shown any regular trend. The year of 1965-66 with high maize yield has been followed by decline during 1966-67 in the majority of districts. The maize yield went up in Ludhiana, Kapurthala, Hoshiarpur, Gurdaspur and Ferozepur districts during 1968 and declined in these districts during 1969 except in Ludhiana. It reached its peaks in 1971 in Amritsar, Kapurthala and Ropar, during 1971-72 in Jullunder, Patiala and Bhatinda, and during 1972-73 in Ludhiana, Hoshiarpur and Sangrur. Maize yield has shown continuous rise from 1972 to 1975 in Gurdaspur and slight increase in Ropar during 1973 and 1975, while the remaining eight districts have shown a substantial fall from 1972 to 1974. The year 1975 has again witnessed an increase in maize yield in all the districts.

4.3.4 Yield of Cotton

Punjab grows both the American and desi varieties of cotton. The state leads other states in the productivity of cotton in the country, the average yield in 1975-76 being 362.3 kg per hectare against the national average of 139 kg

per hectare. The average yield of desi cotton was 267 kg per hectare and of American variety 270 kg per hectare during the year 1960-61. The yield of American variety has shown a continuous increase with one or two exceptions since 1960-61, while the yield of desi cotton has shown a slight decline from 1960-61 to 1965-66. The productivity of American variety attained its highest level during 1973-74 (430 kg per hectare) while desi cotton during 1970-71 (378 kg per hectare). The average yield of American variety for the state has remained always a little higher than that of desi cotton.

The yield of desi as well as American varieties found to be highest in Ferozepur district and in certain years Bhatinda became the leading district in the yield of desi cotton. The lowest yield of desi cotton is recorded in Hoshiarpur district throughout the time period except in 1967 when Ropar accounted for lowest yield. In case of American cotton the lowest yield has been recorded in Gurdaspur till 1966 and afterward Ropar and Hoshiarpur have registered the lowest yield in American variety of cotton. The highest yield of American cotton was recorded in all the districts during 1973-74, while the highest yield of desi cotton was recorded during 1971-72 in the important cotton growing districts of Ferozepur, Bhatinda, Sangrur and Ludhiana. The yield of American cotton in these districts has shown fluctuations up to 1965-66 but these variations were very small. After 1965-66, the yield of desi cotton has

Trends in Yield of Some Selected Crops

1960-61—74-75

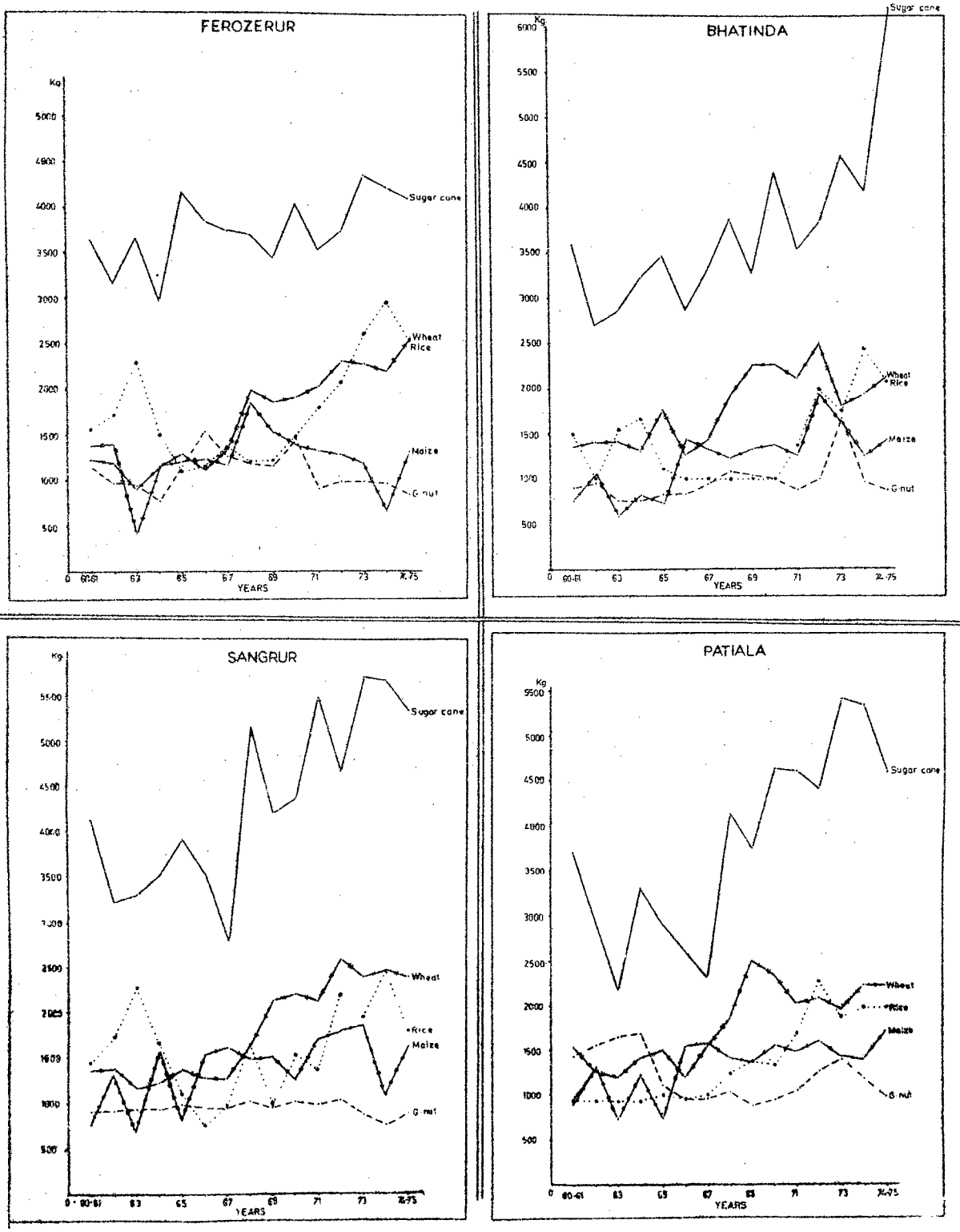

Fig. 16. C

shown a slight steady increase up to 1970-71 and since then it has been declining in the districts of Bhatinda and Ferozepur. In Ludhiana it has shown a slight increase from 1962-63 to 1968-69 and afterwards has shown a decline up to 1971-72 and witnessed a little increase after 1971-72. Sangrur and Patiala have shown continuous and steady increase in the yield of desi cotton from 1965-66 to 1974-75.

4.3.5 Yield of Sugarcane

The yield of sugarcane is low as compared to the other cane growing states in the country. In Punjab it was 3679 kg per hectare during 1960-61 which declined to 3016 kg per hectare during 1961-62. An increase in yield has been witnessed from 1961-62 to 1964-65 regularly, but again it slided down to 2779 kg per hectare during 1966-67. Since 1966-67 the yield has shown a rapid rising trend, except for marginal declines here and there. It attained the peak during 1973-74 (5289 kg per hectare).

The year 1966-67 has been a year of low yield of sugarcane for all the districts in general. Jullunder has shown a continuous increase in cane yield from 1967-68 to 1975. The yield of sugarcane in Ludhiana also has recorded regular increase from 1970-71 to 1974. It registered a decline during 1975 in all the districts except Jullunder, Hoshiarpur, Ropar and Bhatinda.

4.3.6 Yield of Groundnut

Punjab recorded a yield of 925 kg per hectare in 1960-61 for groundnut which attained 1261 kg per hectare during 1964-65. Since then its general trend has been towards decline. However, it has shown minor increase during certain years e.g. in 1971-72 when it registered a yield of 1056 kg per hectare from 970 kg per hectare in 1971. During 1974-75 it declined to 861 kg per hectare.

Ferozepur was the leading district in the state in respect of groundnut yield up to 1969-70, and afterwards Patiala has become the leading district. The districts of Ropar and Hoshiarpur have comparatively lower yield of groundnut as is clear from the appendix table. It was lowest in Hoshiarpur between 1960-61 and 1966-67 and since 1968 Ropar has been relegated to the lowest position as far as groundnut yield is concerned.

The highest yield of groundnut has been recorded in Ferozepur during 1965-66 and then it showed decline up to 1969. After 1970-71 it is almost stagnant and has decreased during 1975. In Bhatinda it has shown general increase after 1963 which continued till 1968. It declined between 1968 and 1971. This district attained the highest yield during 1972-73. The years of 1974-75 have witnessed decline. In Sangrur it has shown only small fluctuations up to 1971-72 and has decreased rapidly from 1972 to 1974.

The groundnut yield has shown a declining trend since 1961-62 with minor increases over certain years. It has shown

decreasing trend in Kapurthala and Jullunder. The groundnut yield has not shown any remarkable changes in Patiala up to 1968, but after 1969 it has increased but again decreased during 1974-75.

4.4. Intensity of Cropping

The intensity of cropping is defined as the extent to which net area sown is cropped or resown. The total cropped area as per centage of the net area sown is a measure of the intensity of cropping. It depends upon many factors in a particular region. Adequate irrigation facilities especially tubewell irrigation, coupled with rotation of short duration crops had helped the farmers of Punjab to cultivate land more intensively.

The intensity of cropping in Punjab was 125.94 per cent during 1960-61, which rose to 131.57 per cent during 1966-67 and 140.09 during 1970-71. It further increased to the level of 146.71 per cent during 1973-74. On the whole intensity of cropping has witnessed fluctuations over the time period but the trend is towards the increase since 1960-61 as is clear from the graph (fig.).

The highest intensity was recorded in Amritsar (137.34%); while the lowest by Kapurthala (113.89%) during 1960-61. It rose to 158.18 per cent in Amritsar during 1966-67, while the lowest intensity during this period was witnessed by Ferozepur (117.00%). During 1970-71 Ropar became the leading district with an intensity of 165.88

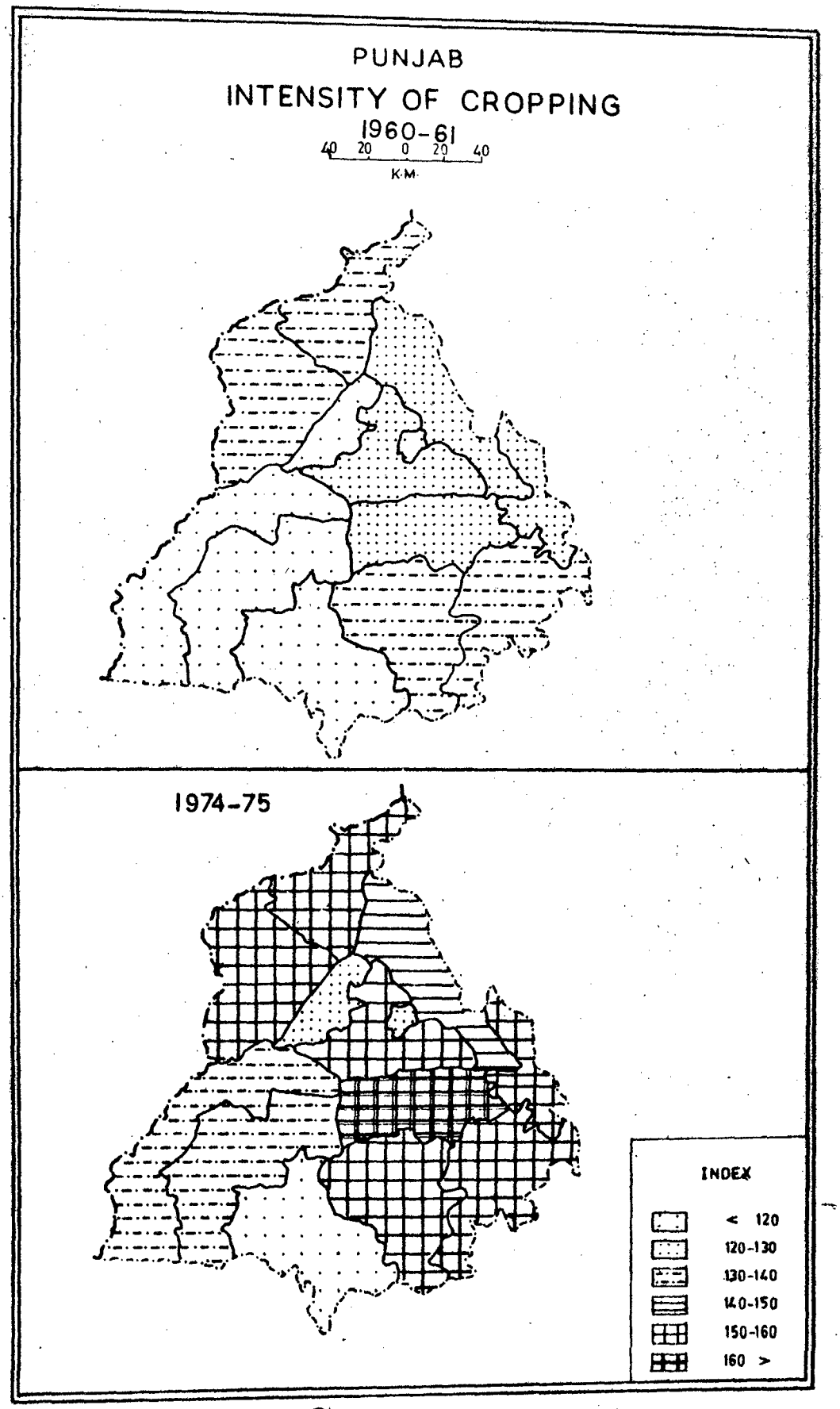
PUNJAB
INTENSITY OF CROPPING
1960-61
40 20 0 20 40
K.M.
1974-75
INDEX
< 120
120-130
130-140
140-150
150-160
160 >

Fig. 17

per cent when the state average was 140.83 per cent. But Ludhiana occupied this position during 1974-75 and Bhatinda was relegated to the lowest position (118.66%) during the year 1974-75.

Table 4.3 and the graphs (fig.) clearly depict the yearly variations in all the districts from 1960-61 to 1974-75. However, the general trend is towards increase in most of the districts. It has been noted that in most of the districts the fluctuations in intensity of cropping are more pronounced during the pre-green revolution period. Since 1965-66 the crop intensity has shown continuous increase in Ludhiana and Jullunder districts. In Kapurthala it has shown a continuous decline from 1964-65 to 1972-73 after 1972-73 it has registered some increase. In Hoshiarpur crop intensity has shown a continuous increase from 1961-62 to 1966-67, afterwards it has declined from 141.66 per cent in 1966-67 to 136.92 per cent in 1969-70, but since 1970 it has shown an increasing trend. Similarly in Ropar, the intensity has declined during 1964-65 and 1965-66 and since 1966-67 it has shown increasing trend. The intensity of cropping has shown a slight increase in Ferozepur district with minor yearly fluctuations. It is highly variable from one year to the other in the districts of Patiala, Amritsar, Gurdaspur, Sangrur and Bhatinda. In Bhatinda it was 117.71 per cent during 1960-61, while during 1974-75 it is recorded to be 118.66 per cent, showing no significant increase over these 15 years.

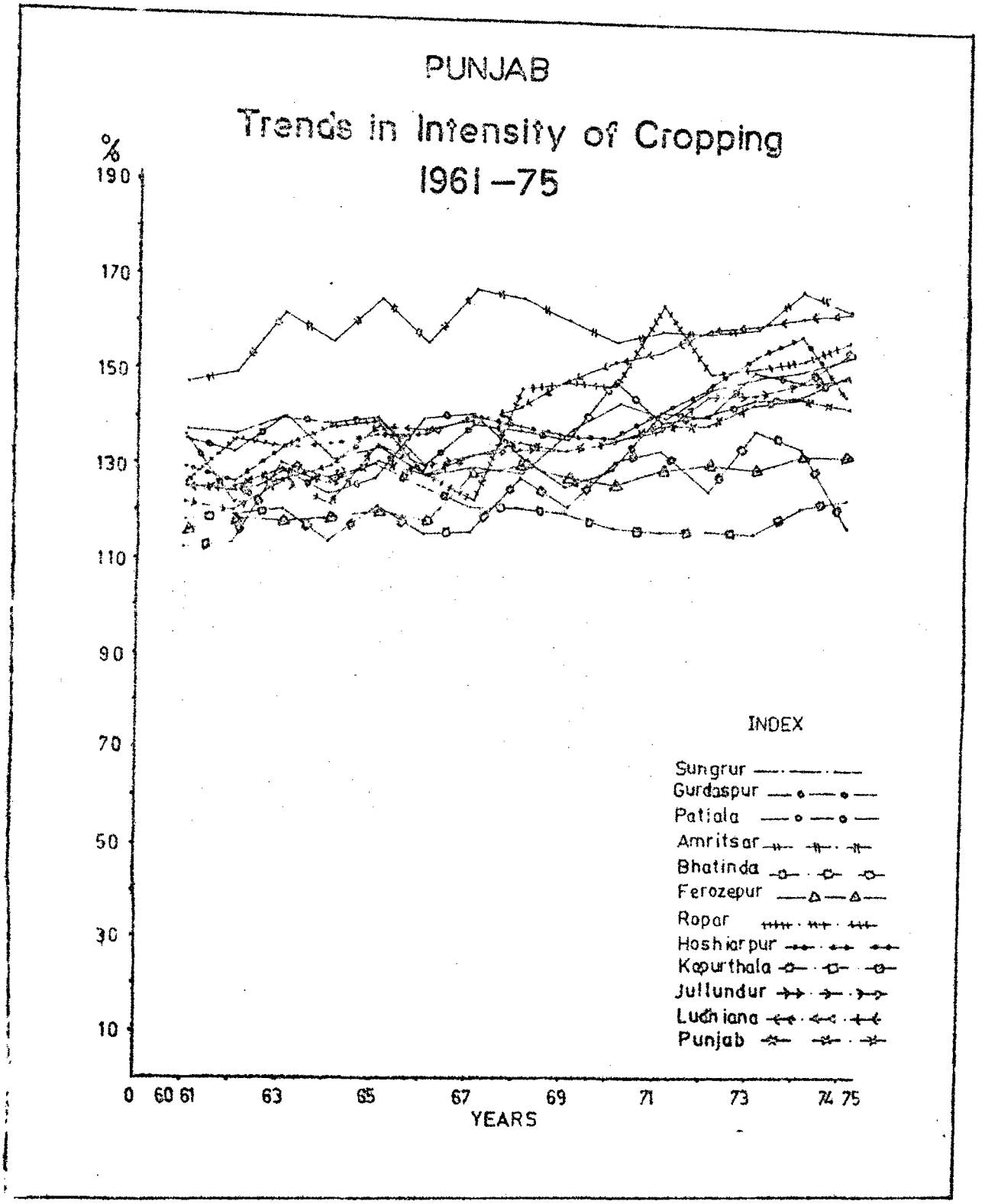
PUNJAB
Trends in Intensity of Cropping
1961–75
%
190
170
150
130
110
90
70
50
30
10
0
60 61
63
65
67
69
71
73
74 75
YEARS
INDEX
Sungrur
Gurdaspur
Patiala
Amritsar
Bhatinda
Ferozepur
Ropar
Hoshiarpur
Kapurthala
Jullundur
Ludhiana
Punjab

Fig. 18.

Amritsar which was the leading district in Punjab in respect of crop intensity during 1960-61, has also shown great fluctuations up to 1966-67. It has shown a slight increase after 1970, though it has all along been above the state average.

Patiala is another district which has shown well marked yearly variations, but in general, 1962, 1964 and 1969 were the pronounced years, but since 1969 the trend is towards increase. It is recorded to be 155.81 per cent during 1974-75, as compared to 136.37 per cent in 1960-61. Sangrur has also shown a declining trend up to 1968-69, but since then it has been continuously increasing with the only exception of 1970-71. Gurdaspur has shown an overall increase from 135-21 per cent during 1960-61 to 151.18 per cent during 1974-75. To depict the spatial pattern of intensity of cropping certain time points have been chosen and the districts have been grouped in various intensity categories. Year 1960-61 and 1965-66 have been chosen to represent the crop intensity during the pre-green revolution period and 1970-71 and 1974-75 are the periods of post-green revolution years.

...

Intensity of Cropping - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	To-tal
1960-61	135.21	137.34	113.39	122.18	129.59	126.36	125.85	116.12	117.71	137.24	136.31	125.94
1961-62	132.86	139.25	114.03	120.83	126.87	135.77	124.75	119.12	119.71	136.61	122.67	125.45
1962-63	140.37	152.28	131.81	126.86	133.48	133.94	127.33	118.68	121.26	139.86	128.83	129.71
1963-64	139.17	146.08	128.20	122.30	134.80	138.53	130.42	119.39	114.48	130.99	124.39	126.66
1964-65	140.52	155.42	131.40	134.68	137.11	139.82	139.53	121.24	122.16	134.38	127.73	131.57
1965-66	130.67	146.29	126.40	130.22	137.33	128.18	137.82	118.50	116.26	128.31	140.79	128.50
1966-67	139.35	158.13	122.13	133.08	141.66	123.01	140.65	129.60	117.00	130.04	141.61	133.09
1967-68	138.00	156.19	122.30	134.64	139.31	147.58	143.26	131.04	128.61	139.33	132.80	136.29
1968-69	136.36	151.59	121.09	133.92	137.60	148.71	149.20	128.59	122.69	138.49	126.43	134.17
1969-70	149.21	147.28	118.32	136.78	136.92	148.30	153.50	127.29	132.39	144.41	130.12	136.55
1970-71	149.69	150.00	117.42	138.73	142.21	165.83	155.69	130.92	134.78	141.42	142.37	140.09
1971-72	142.24	149.48	117.42	146.47	147.82	151.69	160.69	131.94	126.20	148.00	141.86	140.45
1972-73	145.73	150.25	116.79	146.71	155.11	152.45	160.99	131.31	139.17	150.22	151.43	145.15
1973-74	146.51	158.33	122.72	149.65	159.68	154.47	163.46	134.36	135.61	152.00	149.48	146.17
1974-75	151.18	155.05	124.81	150.68	146.45	158.53	164.39	133.78	118.66	155.75	155.81	144.24

Source: Computed from the data obtained from Statistical Abstracts of Punjab, 1974-75 Government of Punjab.

CHAPTER 5

CORRELATES OF PRODUCTIVITY

5.1.0 The Variables Considered

In the present chapter an attempt has been made to analyse the value productivity of some selected crops in Punjab and its correlates. In the first exercise contributions of various variables in explaining the variation in productivity have been analysed for certain selected years for the state and in the second exercise an attempt has been made to analyse the spatial and temporal variations in productivity and its determinants including various parametres of water. As the productivity is a function of a combination of factors, a number of variables have been chosen to explain the temporal and spatial variations in productivity. The dependent variable (productivity in value terms) has been explained by volume of canal water, volume of rain water, volume of groundwater, volume of total water (all sources), the fertilizer consumption per hectare of gross cropped area, area irrigated under the six selected crops as percentage to the gross cropped area under these crops, number of agricultural workers to per hectare of cultivated land and the

percentage to area under these six crops. This analysis is based on the time series data from 1961-62 to 1974-75 for individual districts. But the HYV as an explanatory variable has been included in the study from 1968-69 to 1974-75 and the number of workers from only 1962 to 1971 due to the non-availability of data.

5.1.1 The Value Productivity

In the present study the value productivity per hectare has been calculated for the six selected crops i.e. wheat, rice, maize, cotton, sugarcane and rape and mustard. To obtain the per hectare value productivity, the production of each crop in the district has been multiplied by the constant prices of respective crop for the year 1974-75, and thus the value of total output from six crops is added and divided by the area under these six crops. The value productivity for each district has been calculated for all the years from 1961-62 to 1974-75 and it is given in the table 5.1.

The productivity per hectare during 1961-62 was Rs.1765 which rose to Rs.2826 during 1974-75, the general trend has been towards the increase since 1962, except for two years when the productivity had shown slight decline. It has also shown an increasing trend in all the districts over time. The lowest productivity was recorded in Bhatinda during 1961-62 (Rs1474) and the highest in Patiala (Rs.2239). During 1974-75, the highest productivity was recorded in

Table 5.1

Value Productivity - 1961-62 to 1972-73

Year	Gurdaspur	Amritsar	Kapurthala	Jullundar	Hoshiarpur	Ropar	Ludhiana	Ferozepur	Bhatinda	Sangrur	Patiala	Punjab
1961-62	1649	1612	1593	1953	1656	-	2152	1673	1474	1756	2239	1765
1962-63	1792	1449	1920	1930	1549	-	2030	1463	1941	1531	1577	1605
1963-64	1979	1703	1840	2052	1552	-	2382	1620	1239	1724	1893	1795
1964-65	1363	2071	1933	2212	1624	-	2528	1709	1373	1734	1919	1965
1965-66	1515	1933	1739	2504	1273	1930	2534	1652	1635	1690	1752	1809
1966-67	1913	1939	2325	2104	1457	1624	2321	1755	1699	1619	1967	2002
1967-68	1932	2023	2149	2272	1630	1950	2392	2253	1993	2023	2291	2100
1968-69	2243	2525	2571	2643	1602	2016	2502	2462	1991	2350	2691	2469
1969-70	2397	2020	2510	2379	1942	2591	3203	2259	2436	2700	2641	2560
1970-71	2694	2751	2913	2787	1842	2549	3569	2524	2332	2461	2457	2592
1971-72	2652	3002	2549	2713	1921	2219	3291	2616	2597	2740	2656	2670
1972-73	2572	2613	2560	2897	2201	1907	3141	2603	2016	2610	2466	2527
1973-74	2532	2719	2371	2555	2021	2726	3076	2583	2129	2606	2767	2696
1974-75	2052	2004	2070	3259	2455	2762	3341	2549	2351	2650	2799	2525

Source: Computed from the data obtained from Government of Punjab (India), The Statistical Abstract of Punjab, 1962-1973.

Ludhiana (Rs.3341) and lowest by Bhatinda (Rs.2361). It is worth mentioning that the lowest productivity in 1974-75 has surpassed the highest in 1961-62.

Five categories of productivity have been identified for the year 1961-62 and 1974-75 separately. During 1961-62 the average value productivity per hectare for the state was Rs.1765. The districts, having productivity ranging from 1700 to 1900 have been grouped in medium productivity, from Rs.1000 to Rs.1700 as low productivity and below Rs.1500 very low productivity. The district, having productivity more than Rs.1900 to Rs.2100 have been designated as high productivity district and those having above Rs.2100 as very high productivity districts. Similar categories have been made for the year 1974-75, but as the average value productivity per hectare for the state rose from Rs.1765 to Rs.2826 during 1974-75 the productivity levels for all the categories were changed. The lowest productivity with Rs.2361 was recorded in Bhatinda which in fact is more than the highest productivity of Patiala (Rs.2239) during 1961-62. For 1974-75, the districts which have recorded productivity ranging from Rs.2700 to Rs.2900 are considered as medium productivity districts, from Rs.2500 to Rs.2700, low and below Rs.2500 as very low productivity districts. The districts which have recorded productivity above Rs.3100 have been designated as very high productivity districts and from Rs.2900 to Rs.3100 as high productivity districts. The table gives the category classes and the districts in each productivity category

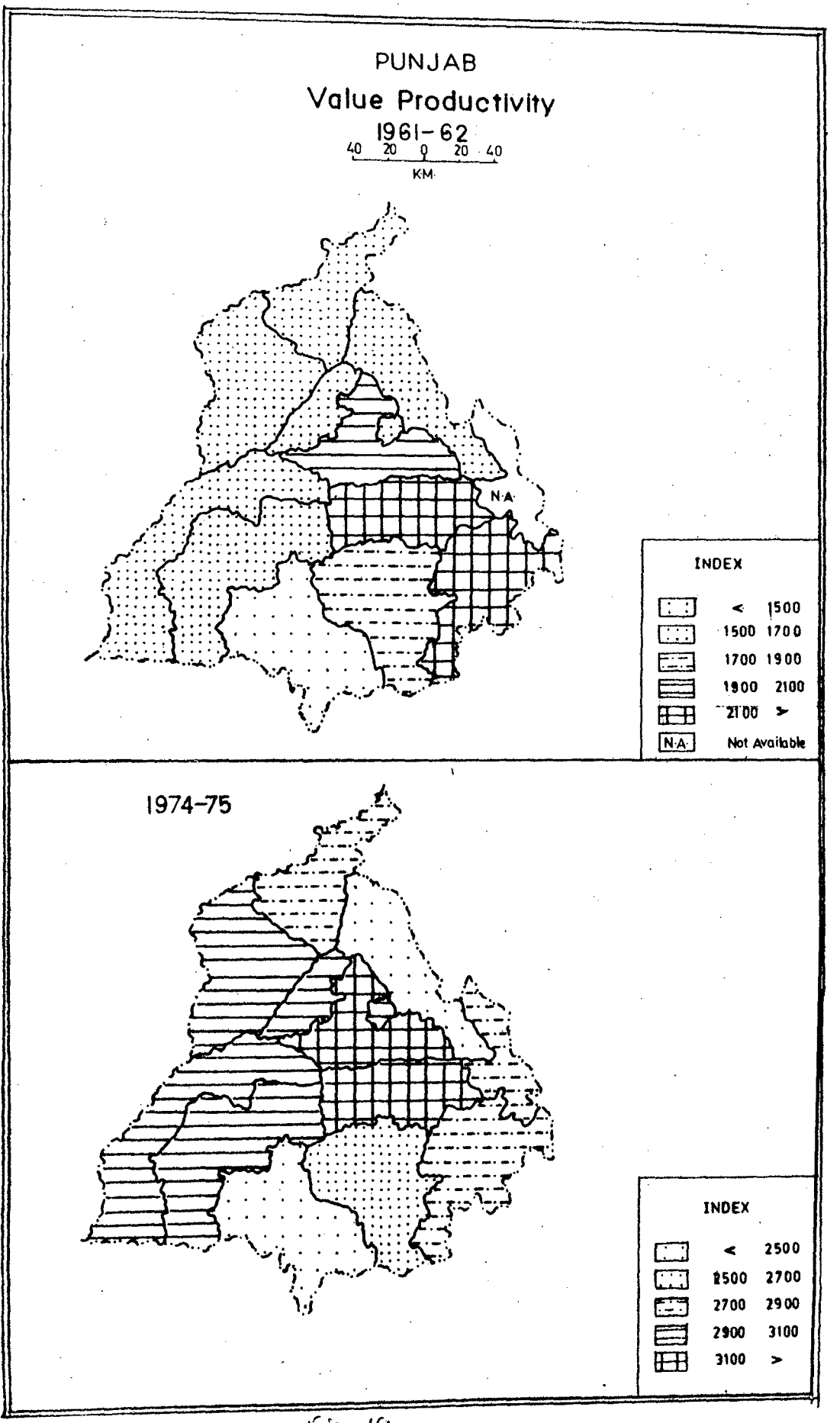
PUNJAB
Value Productivity
1961-62
40 20 0 20 40
KM
N.A
INDEX
< 1500
1500 1700
1700 1900
1900 2100
2100 >
N.A Not Available
1974-75
INDEX
< 2500
2500 2700
2700 2900
2900 3100
3100 >

Fig. 19.

during 1961-62 and 1974-75.

Table 5.2

Value Productivity Categories and Districts in Each Category 1961-62

Productivity in Rs.	Category	Name of the Districts
Below Rs.1500	Very low	Bhatinda
Rs.1500-1700	Low	Gurdaspur, Amritsar, Kapurthala, Hoshiarpur, Ferozepur
Rs.1700-1900	Medium	Sangrur
Rs.1900-2100	High	Jullunder
Above Rs.2100	Very High	Ludhiana, Patiala

Table 5.3

Value Productivity Categories and Districts in each Category 1974-75

Productivity in Rs.	Category	Name of the Districts
Below Rs.2500	Very low	Hoshiarpur, Bhatinda
Rs.2500-2700	Low	Sangrur
Rs.2700-2900	Medium	Gurdaspur, Ropar, Patiala
Rs.2900-3100	High	Amritsar, Kapurthala, Ferozepur
Above Rs.3100	Very high	Jullunder, Ludhiana

The tables clearly show the fact that the value productivity is very high in Ludhiana, as compared to other districts of Punjab in both the time periods. Bhatinda consistantly remains in the very low productivity category during both the periods. Amritsar, Kapurthala and Ferozepur fall in the high productivity category during 1974-75, while all these three districts were in low productivity group during 1961-62. Patiala which was in the very high productivity category during 1961-62 has relegated back in the medium productivity category during 1974-75 while Sangrur has shifted to the low productivity group.

The year-wise trend of productivity for each district is given in the table which clearly shows that productivity has generally an increasing trend in all the districts.

5.1.6 Consumption of Fertilizers

The chemical fertilizers is one of the important components of the package technology adopted in Punjab. The high yielding varieties, by their agronomic trait are fertilizers intensive. As the farm yard manure and green manuring cannot possibly meet the full requirements for replenishing the soils at higher levels of production envisaged under the new technology, the use of fertilizers is of great importance to exploit fully the potentialities of higher yields. To maintain the present tempo of production

even under continuous cropping, the adequate supply of plant nutrients in the form of manures and fertilizers is necessary. Punjab is the leading state in the consumption of fertilizers as it uses 74 kg per hectare of the cropped area as against 25 kg per hectare at the national average.

The fertilizers were introduced since 1960-61, but it was only 627 kg per hectare during 1960-61, but it has shown a steady increase in the consumption of fertilizers up to 1966-67 and it rose to 9.635 kg per hectare. It witnessed a very rapid increase after 1966-67. The fertilizer consumption has shown decline from 34.750 kg per hectare to 31.032 kg per hectare during 1969-70. But since 1969-70 it has risen up continuously. It decreased to 42.093 kg per hectare during 1974-75 as against 55.193 kg per hectare during 1973-74 due to very higher prices of fertilizers.

However, the consumption of fertiliser per hectare of the gross cropped area has shown an increase from 1960-61 to 1973-74 with only one exceptional year of 1969-70, but the rate of increase in the consumption of fertilizers is not the same for all the districts in the state. It is clear from the table that it was highest in Ludhiana during 1960-61 and lowest in Amritsar. The consumption of fertilizers in Ludhiana increased at a much faster rate as compared to the other districts in state even in the pre-green revolution as the district was one of the seven districts selected for IADP in the country during 1960-61. In Ludhiana it reached to

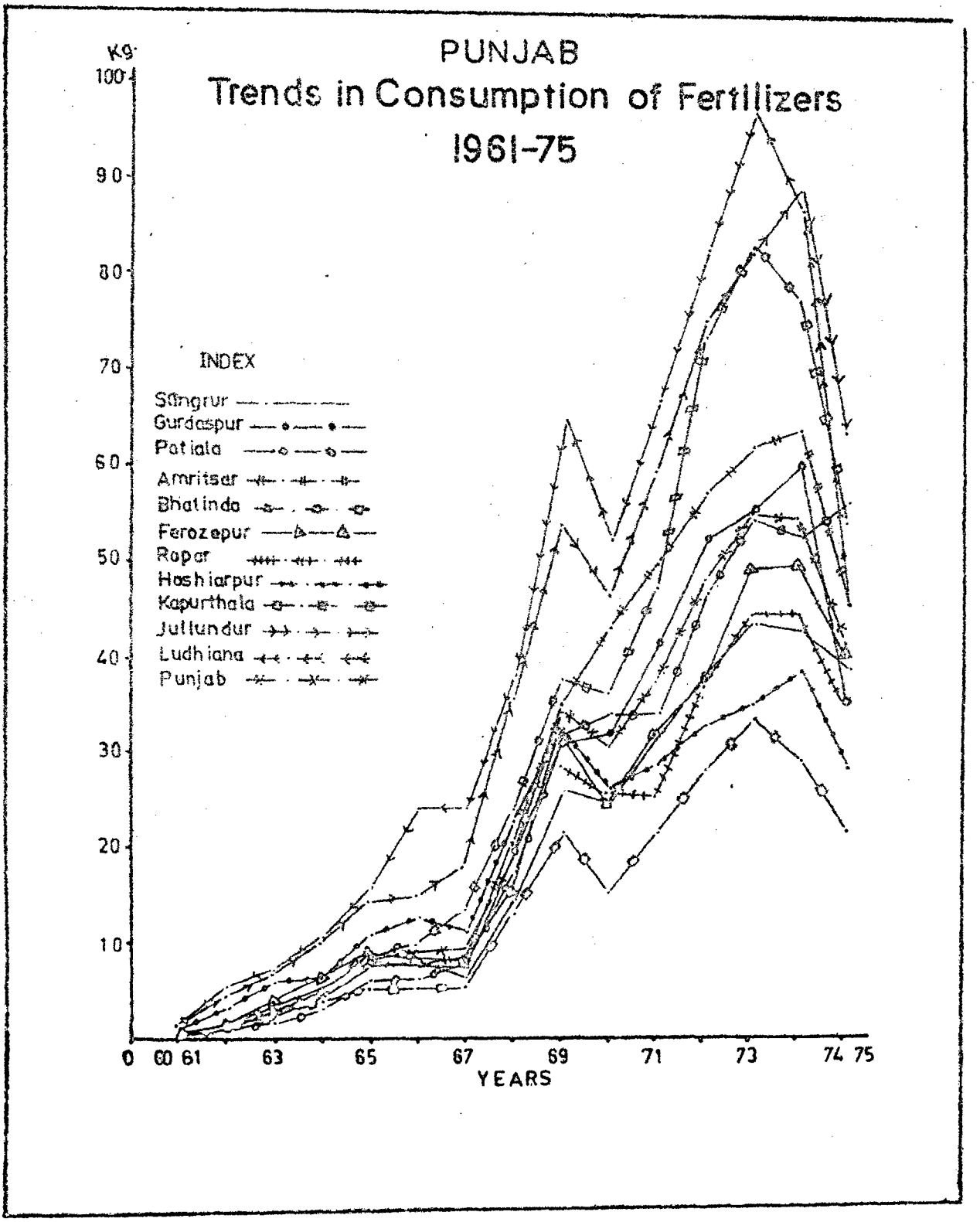
PUNJAB
Trends in Consumption of Fertilizers
1961-75
Kg
100
90
80
70
60
50
40
30
20
10
0
INDEX
Sangrur
Gurdaspur
Patiala
Amritsar
Bhatinda
Ferozepur
Ropar
Hoshiarpur
Kapurthala
Jullundur
Ludhiana
Punjab
60 61
63
65
67
69
71
73
74 75
YEARS

Fig. 20

Table 5.4

Consumption of Fertilizers* (District-wise) - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	.295	.203	.544	1.478	1.163	-	1.551	.402	.465	.640	.474	.62687
1961-62	1.199	.856	2.032	4.704	3.424	-	5.598	1.605	1.087	1.554	1.095	1.961
1962-63	2.713	2.230	3.272	6.746	6.267	-	7.377	3.946	2.316	2.581	1.697	3.510
1963-64	4.887	4.855	4.741	10.076	6.613	-	10.627	6.471	3.780	4.507	3.148	5.575
1964-65	8.077	7.417	8.869	14.407	11.054	-	15.768	9.222	5.090	7.772	5.941	8.588
1965-66	7.839	7.678	10.417	14.937	12.739	-	24.034	8.150	5.215	8.167	6.020	9.402
1966-67	7.457	8.413	13.810	18.168	11.220	-	24.126	7.943	5.394	6.637	7.824	9.635
1967-68	20.030	20.627	24.402	36.025	23.034	-	38.285	15.321	13.091	14.849	17.468	19.486
1968-69	31.419	35.303	38.181	54.234	32.656	28.769	64.912	32.042	21.736	26.406	31.807	34.750
1969-70	32.386	43.187	36.667	46.778	26.504	25.864	52.315	24.833	15.194	25.260	34.050	31.032
1970-71	41.720	50.138	47.718	60.095	29.027	25.697	67.008	31.898	21.723	32.120	34.148	38.144
1971-72	52.704	57.689	74.030	75.711	33.020	37.387	83.019	37.570	28.401	39.915	51.895	48.456
1972-73	55.923	62.541	83.716	82.755	35.470	44.976	97.446	49.409	33.637	44.086	54.770	55.581
1973-74	60.728	64.236	77.962	89.733	38.771	45.073	87.264	49.734	29.453	43.248	52.728	55.193
1974-75	35.486	46.057	54.747	64.028	28.502	35.289	45.760	40.619	21.911	39.388	56.610	42.093

* Kg./hectare

Source: Computed from the data obtained from (1) W.B. Donde and Dorris D. Brown, Effective Demand for Fertilizers in India (unpublished) (Fertilizer Association of India, New Delhi, May 10, 1970, Appendices; (2) The Fertilizer Association of India, Fertilizer Statistics (New Delhi, 1971-72, 1975-76, 1976-77).

24.034 kg per hectare during 1966-67, and Patiala was the lowest consumer of fertilizers (6.020 kg per hectare) during this year.

The year 1969-70 has been noted for the decline in the consumption of fertilizers in most of the districts except with marginal increases in Patiala, Amritsar and Gurdaspur. During 1970-71 the consumption of fertilizers again went up and it reached to 67.0 kg per hectare, and 60.1 kg per hectare in Ludhiana and Jullunder respectively against the state average of 38.4 kg per hectare. Bhatinda had the lowest consumption with 21.72 kg per hectare which was far below the state average. Besides Bhatinda, the consumption of fertilizers was below the state average in Patiala, Sangrur, Ferozepur and Ropar during 1970-71. In Ludhiana the consumption of fertiliser touched all time high during 1972-73 with 97.45 kg per hectare, but it has declined during the two subsequent years i.e. 1973-74 and 1974-75 (45.760 kg per hectare). Ludhiana became the second largest consumer of fertilizer in state during 1974-75 after Patiala with consumption of 56.610 kg per hectare while Bhatinda remained the lowest consumer with only 21.911 kg per hectare. In 1974-75 an absolute decline in the consumption of fertilizer has taken place in all the districts of state except Patiala. The rate of decline was also very sharp. The reason behind this was a very high price of fertilizers and no corresponding increase in the prices of agricultural products.

Mechanization of Agriculture

Mechanization in agriculture means the use of power operated machines to do the various farm jobs which otherwise are performed with manual or animal labour. Mechanization of farm operations is another important aspect alongwith high yielding varieties of seeds, heavy does of fertilizers and use of pesticides and insecticides, of the new strategy for agricultural development. The double cropping or multiple cropping is not possible without the use of improved technology and farm practices even in the irrigated aren or in the areas with assured rainfall. The HYV seeds have the shorter period of growth, but they require more sophisticated farm equipments to obtain optimum yields and to allow multiple cropping.

In Punjab the use of machines for various farm operations has been increasing rapidly since 1966-67. During 1950-51, only 1,511 tractors were available in the state, the number of tractors rose to 4,997 during 1960-61, and to 10,636 during 1966. But it has increased four-fold from 1966 to 1972, when the number rose to 41,185 tractors.

The number of tractors was highest in Ferozepur during 1961, when there were 1,378 tractors in the district out of total tractors of 4,997 in Punjab, while there were only 95 tractors in Kapurthala in 1961. The availability

of tractors per 1000 hectares gross cropped area is also given in table 5.5 which reveals that it was highest (1.48) in Ferozepur during 1961, in Ludhiana during 1966 (3.878), in Jullunder during 1972 (11.338). The number and per hectare availability of tractors was found lowest in Ropar during 1972. The availability of tractors has been recorded to be 0.375 in Hoshiarpur and 0.713 per 1000 hectares of gross cropped area in 1961 and 1966 respectively.

5.1.7 The Number of Agricultural Workers Per Hectare of Cultivated Land

The number of agricultural workers per hectare of cultivated land is also included as an indicator to explain the variations in productivity. As it is revealed by the table 5.6 that the number of agricultural workers has increased since 1961-62, but the increase in number of agricultural workers per hectare of cropped area is only marginal. The number of agricultural workers in Punjab was recorded to be .45 during 1961-62 which rose to .57 during 1970-71. It was recorded to be highest in Ropar during 1961-62 as well as in 1974-75 (0.75 and 0.74 respectively). It was lowest in Bhatinda (0.38) during 1961-62 and in Ferozepur during 1970-71 (p.46).

5.1.3 to 5

The pattern of the variables viz. volume of canal water, volume of rain water, volume of ground water, volume

Table 5.5

Number and Availability of Tractors per thousand hectare of Gross Cropped Area

District	1961		1966		1972	
	No. of Tractors	Tractors per 1000 hectare	No. of Tractors	Tractors per 1000 hectare	No. of Tractors	Tractors per 1000 hectares
Gurdaspur	108	0.375	234	0.713	2137	5.822
Amritsar	237	0.532	560	1.135	3893	6.643
Kapurthala	95	0.748	174	1.101	1150	7.419
Jullunder	369	1.135	813	2.329	4717	11.338
Hoshiarpur	164	0.567	381	1.233	2061	5.510
Ropar	-	-	140	0.992	623	3.480
Ludhiana	458	1.237	1625	3.878	4764	9.322
Ferozepur	1378	1.483	3130	3.394	10353	9.352
Bhatinda	1153	1.621	1653	2.267	2754	3.383
Sangrur	474	0.793	974	1.705	4278	6.423
Patiala	561	1.115	952	2.074	4455	8.114
Total (Punjab)	4999	1.058	10636	2.180	41185	7.195

Source: Statistical Abstract of Punjab, 1961, 1966, 1973, Government of Punjab (India).

TABLE 3.6

Number of Agricultural Workers to per hectare of Culturable Area 1961-62 to 1970-71

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sing-rur	Patia-la	Punjab
1961-62	.56	.49	.48	.52	.59	.75	.43	.40	.38	.45	.39	.45
1962-63	.57	.50	.45	.54	.59	.75	.44	.41	.39	.46	.41	.47
1963-64	.58	.51	.46	.55	.60	.76	.46	.41	.40	.47	.42	.47
1964-65	.60	.51	.43	.55	.60	.75	.47	.42	.40	.48	.43	.48
1965-66	.61	.52	.44	.56	.62	.79	.47	.42	.41	.48	.43	.49
1966-67	.62	.53	.44	.56	.62	-	.48	.43	.42	.50	.44	.49
1967-68	.66	.56	.48	.60	.65	.74	.53	.49	.50	.56	.52	.55
1968-69	,67	.57	.48	.61	.67	.86	.56	.52	.53	.58	.55	.57
1969-70	.72	.68	.53	.66	.65	.71	.67	.45	.47	.55	.58	.57
1970-71	.67	.69	.54	.68	.65	.74	.64	.46	.47	.55	.56	.57

Source: Computed from the data obtained from Government of Punjab (India), The Statistical Abstract of Punjab, 1962-1972.

of total water, and area irrigated under the six crops as percentage to area under these crops has been discussed earlier in chpater 4.

5.1.8 High Yielding Varieties of Wheat, Rice and Maize

Introduction of the seeds of high yielding varieties of various crops is an important innovation in the agricultural sector for achieving a rise in agricultural production through a new strategy for agricultural development during the Fourth Five Year Plan. The programme was launched in the state of Punjab during the year 1966-67, in 90 development blocks when a high yielding variety of wheat "Lerma Rojo" was imported from Mexico in 1966-67. PV 18, Kalyan-Sona-227 are other varieties evolved during the same year; Sonalika 308 and triple dwarf varieties are latest recommended by the authorities on agriculture.[1] Except these varieties, Sonara 64, Sharbati Sonara, Chotti Lerma, Safed Lerma and some other varieties like L 306, C-273, C-591 are also recommended for cultivation in the state.

In 1967-68 the area under high yielding varieties of wheat accounted for 34.69 per cent of its total area. The response of farming community was quite encouraging in case

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1 Government of Punjab, Economics of Tractor Cultivation and Economic of Productivity and Cultivation Practices of H.Y.V. of Wheat, Maize and Rice in Punjab, 1971-72 (Chandigarh, 1975).

of adoption of HYV wheat because of higher yield expectation of these varieties. The area under HYV has shown a continuous increase since 1967-1968 and rose to 88.26 per cent during 1974-75 of its total area in the state. In the beginning the area under HYV wheat was highest in Ludhiana district where it accounted for 57.89 per cent of the total cropped area of the district while it was lowest in Gurdaspur where only 8.13 per cent of the total cropped area under HYV wheat. The area under HYV has increased almost in all the districts at a very fast rate since 1966-67. It shot up in the districts of Amritsar, Jullunder, Ludhiana, Sangrur, Bhatinda, Patiala and Kapurthala also. Its area in Gurdaspur, Hoshiarpur, Ropar and Ferozepur was also above 60 per cent. The HYV wheat has shown a rapidly increasing trend and has replaced the indigenous varieties to a larger extent in most of the districts.

Rice has been gaining importance in Punjab since 1961. It is grown entirely for marketing out. The rice varieties namely Jhona-10, Jhona-227, Jhona-349, Johna-351, Palman Safed-246[2] were recommended for the commercial cultivation in the state in the beginning. IR-8, Jaya, RR-106, Palman-579, RR-103, HM-95 and Basmati 370 have also been recommended for cultivation in Punjab. All these varieties are semi dwarf (100 cm tall) except Basmati 370 which is 150-160 cm tall and possesses superfine quality rice.[3] All

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2 K.S. Gill, "Punjab's Improved Kharif Varieties", The Tribune, 17 July 1979, pp. 6-10.

3 Ibid.

these varieties are stiff strawed resistant to lodging and highly responsive to doses of chemical fertilizers and other inputs.

Although the turning point in rice cultivation came in 1965-66, when a new variety of HYV rice was developed in Taiwan and introduced in Punjab. Even then the spread of area under HYV rice was slow as compared to that of wheat. Only 5.45 per cent of area of the total area under rice consisted of HYV during 1967-68 in Punjab and up to 1970-71 the increase in the area under HYV rice was very slow as it accounted for only 33.33 per cent of the total rice area in the state during 1970-71. It is clear from the table 5.7 that spread of area under HYV rice since 1969-70 remained either absent or below 500 hectare in the districts of Bhatinda, Ropar and Jullunder. The area under HYV rice was highest in Kapurthala district where it accounted for 57.14 per cent of its total area during 1970-71 against the state average of 33.33 per cent. Since 1970-71 the area under HYV rice has increased at a very rapid rate. During 1973-74 its area as proportion to total rice area became 100 per cent in Bhatinda, Jullunder and Kapurthala while it was 90 per cent in Ferozepur and Gurdaspur and 60 per cent in the remaining districts. The area under HYV rice has increased to 84.53 per cent during 1974-75, from 83.26 per cent in 1973-74, but during this year some districts have shown a decline but others have registered further increase.

Table 5.7

Percentage of HYV Area under Six Crops to Area under Six Crops

District	1967-68	1968-69	1969-70	1970-71	1971-72	1973	1973-74	1975
Gurdaspur	6.206	27.819	32.428	40.602	46.929	47.842	59.101	59.435
Amritsar	24.659	37.512	44.906	52.024	60.186	68.721	69.542	81.353
Kapurthala	32.128	39.399	53.356	59.574	75.389	79.722	77.566	77.298
Jullundor	31.645	47.654	56.850	59.262	60.948	69.218	66.845	65.812
Hoshiarpur	10.313	21.102	27.916	28.853	29.105	29.055	34.246	43.106
Ropar	7.597	18.078	23.900	20.202	23.643	31.693	34.146	38.554
Ludhiana	39.430	58.879	60.247	62.395	62.927	65.173	64.283	66.615
Ferozepur	19.649	31.374	37.482	44.894	51.120	48.406	54.033	59.382
Bhatinda	9.688	30.553	37.150	27.832	26.961	36.308	41.064	41.457
Sangrur	26.639	40.879	53.689	53.982	53.811	60.955	61.605	65.931
Patiala	16.520	37.780	46.798	46.517	61.229	57.797	62.574	65.939
Punjab	20.255	36.029	43.607	45.782	50.410	53.803	57.378	60.764

Source: Computed from the data, Government of Punjab, Statistical Abstract of Punjab, 1969-75.

The maize varieties viz. composites, Vijay and Ageti-76 and Hybrid Ganga 5 have been recommended for cultivation. In addition to these varieties there are many new superior varieties under evaluation like J 54 (Pratap) and Sangam.[4] It is expected that these will give higher yields by offering resistance to lodging and various crop diseases. Though, the maize holds an important place in the cropping pattern of state and accounts for about 10 per cent of total cropped area, it has not proved a profitable crop. The area under HYV maize accounted for about 10 per cent of total cropped area. The area under HYV maize accounted for 1.62 per cent in the state during 1967-68. The district-wise proportion of area under HYV maize ranged from 0 to 3 per cent with only one exception of Ludhiana where it was 5.26 per cent. The HYV maize has shown a slight increase in the beginning up to 1969-70, as it rose to 9.73 per cent during this year in the state, and also recorded an increase in all the districts. But since 1969-70 the trend in the spread of HYV maize area is, on a whole, towards the decrease with exception of a few districts. The table clearly shows that the area under HYV has been highly variable in all the districts over the time period — 1969-70 and 1973-74. On the whole the HYV seeds have not been able to achieve a thrust in the state because the quality of HYV grain does not compare to the desi variety for which the people have

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4 Ibid., p. 10.

preference due to taste and also because input cost is more for the HYV maize than the desi.

Except cereals the HYV varieties have also been introduced in other crops. But the cultivation of these could not be as popular as the wheat and rice. In desi cotton a variety G-27, was developed and released in 1969, followed by another variety known as ID 133 released in 1978. In American cotton a new variety of F-414 has been developed.[5]

Co.J. 64, an early maturing sugarcane has become the most popular variety in the state. Co.J.46 and Co.1148 (late maturing variety) are the other two popular varieties being recommended for cultivation in Punjab.[6]

The variety, Punjab G-Nut I developed in 1953 covered the entire area in the subsequent years. In recent years M-13 has been released in 1972.

As the data for area under the HYV varieties of cotton, sugarcane and groundnut is not available, the spread of area under the HYV crops could not be included in the above discussion.

5.2.0 Correlation Matrix

The correlation matrix for each district for a time period of 14 years is given in Appendix table which reveals

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5 Ibid.

6 Ibid.

the correlation amongst the variables and the correlation between the dependent (value productivity) and various independent variables. The following variables have been chosen to develop the explanatory system.

Y = value productivity of six crops (rice, maize, wheat sugarcane, cotton, rape/mustard) per hectare.

X_1 = Volume of canal water per hectare of GCA

X_2 = Volume of rain water per hectare of GCA

X_3 = Volume of ground water per hectare of GCA

X_4 = Volume of total water (all sources) per hectare

X_5 = Proportion of area irrigated under six crops to the Gross Cropped Area under these crops

X_6 = Fertilizer consumption per hectare of gross cropped area

X_7 = Number of agricultural workers per hectare of GCA

X_8 = Proportion of area under HYV (area under six crops to GCA of these crops).

The correlation matrix for the state of Punjab shows that productivity is highly correlated with HYV (X_8) r being 0.994 and fertilizer consumption (X_6), r being 0.913. The productivity is also positively correlated with volume of canal water (r = 0.79) and volume of ground water (r = 0.779). These high positive correlations between the HYV fertilizer and water parameters do indicate towards the complimentarity of inputs. HYV and fertilizer cannot form

the package of technology without water and the present matrix (Table) does bring out the importance of water. The productivity with volume of ground water shows a positive correlation of 0.736.

The correlation matrices for all the districts of Punjab over a time period of 14 years almost conform to the state pattern. The productivity has highest correlation with HYV in Ludhiana, Hoshiarpur, Ropar, Ferozepur, Sangrur, Gurdaspur, Kapurthala with coefficients of correlation of 0.859, 0.872, 0.751, 0.971, 0.898, 0.970 and 0.891 respectively. In Ludhiana, Hoshiarpur, Ropar, Sangrur and Gurdaspur the second variable which is highly correlated with productivity is the proportion of gross irrigated area of the six selected crops to their gross cropped area. The coefficients of correlation vary from 0.893 in Gurdaspur to 0.659 in Ropar. In Ferozepur and Kapurthala second variable is found to be consumption of fertilizer and the irrigation comes third in terms of the value of coefficients. In Jullunder the proportion of gross irrigated area has the highest correlation with productivity while in rest of the three districts i.e. Amritsar, Patiala and Bhatinda, the productivity is highly correlated with fertilizer consumption. In all these three districts, the second highest correlation is with HYV invariably followed by irrigation. This again reflects the complimentarity of these package inputs.

When we examine the coefficients of correlation of productivity with the various parametres of water availability,

the pattern is very interesting. In Punjab as a whole the productivity is positively correlated with water availability particularly ground water (r = +0.736). In Hoshiarpur, Ferozepur, Sangrur, Patiala and Bhatinda the ground water is highly correlated with productivity, coefficients of correlation being 0.608, 0.262, 0.841, 0.75 and 0.449 respectively. In other districts the irrigation itself speaks of the high correlation where it is available from various sources. The complimentary nature of these inputs comes out clearly in the step-wise regression, exercise which provides a measure of the role of these inputs in agricultural development.

5.2.1 Step-wise Regression Analysis for Temporal Variations in Individual Districts

A multiple regression analysis is attempted to see the best possible explanatory variables in explaining the variations in value productivity of the selected crops in Punjab from 1961-62 to 1974-75. In this exercise the regression equations for various steps have been obtained. The analysis shows the contribution of an added variable in explaining the variability in dependent variable with the help of the difference in the values of $\bar{R}^2$. It helps to see as to whether the new variable is worth including in the model or not.[7] (By seeing the changes in the values of $\bar{R}^2$).

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7 Aslam Mahmood, Statistical Methods in Geographical Studies (New Delhi: Rajesh Publications, 1977), p. 151.

For the step-wise regression analysis the same eight explanatory variables have been taken as in the case of correlation matrices. The step-wise regression analysis has been attempted for all the districts taking the fifteen i.e. 1961-62 to 1974-75 as observations.

The table 5.8.A-L giving the results of the step-wise regression analysis for individual districts provide the contribution of the selected variables in explaining the variation in productivity over time. It has been attempted in the following paragraphs to highlight the results in order to get an idea of the spatial pattern of the behaviour of variables.

The step-wise regression analysis for the state as a whole shows that the maximum variations in agricultural productivity in respect of six crops is explained by HYV area (X_8) to the extent of 91 per cent. The regression coefficient is highly significant at 1 per cent level of significance. As the other variables like fertilizer consumption, total water value and labour and irrigated area are added in the subsequent step the value of $\bar{R}^2$ has decreased and it has also reduced the level of significance for HYV (X_8) which became significant at 2 per cent level in second and third steps and at 5 per cent level in the 4th and 5th steps. This probably happens due to the colinearity within the variables.

The value of F ratio shows that the analysis is significant up to the last step.

Table 5.8.A

Results of Step-wise Regression Analysis
Punjab State

Step	Variables	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_8	16.105*	0.9101	-	0.9101	120.206*
II	X_8	17.692**	0.9101	0.0000	0.9025	55.339*
	X_6	-2.111				

* Significant at 1% level

** Significant at 2% level.

Table 5.8.B

Results of Step-wise Regression Analysis

Gurdaspur

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	19.028*	.0409	-	.9409	188.404*
II	X_8	21.185*	.9506	.0097	.9467	106.486*
	X_7	265.801				
III	X_8	21.389*	0.9545	.0039	.9183	68.440*
	X_7	289.459				
	X_4	-0.014				

* Significant at 1% level

** Significant at 2% level

Table 5.8.C

Results of Step-wise Regression Analysis

Amritsar

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_6	20.441*	0.8408	-	.8408	63.298*
	X_6	17.565*	0.8630	0.0222	0.8519	34.652*
II	X_5	15.006				
	X_6	6.859				
III	X_5	15.798	0.8817	0.0187	0.8593	24.854*
	X_8	8.124				
IV	X_6	5.650				
	X_5	14.790	0.9025	0.0208	0.8742	20.919
	X_8	11.452				
	X_7	398.593				
V	X_6	6.331				
	X_5	15.384	0.9025	—	0.8611	14.967*
	X_8	10.868				
	X_7	396.085				
	X_4	-0.007				

* Significant at 1% level.

Table 5.8.D

Results of Step-wise Regression Analysis
Kapurthala

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	12.930*	0.7921	-	0.7921	45.679*
II	X_8	14.926*	0.8100	0.0179	0.7938	23.423*
	X_7	428.444				
III	X_8	16.051*				
	X_7	609.260	0.8190	0.0090	0.7849	14.999*
	X_5	-0.246				

* Significant at 1% level.

Table 5.8.E

Results of Step-wise Regression Analysis

Jullunder

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_5	43.970*	0.9120	-	0.9120	125.586*
II	X_5	31.539*	0.9273	0.0153	0.9216	69.909*
	X_8	3.835				
III	X_5	31.011*				
	X_8	3.093	0.9350	0.0077	0.9235	48.526
	X_7	-166.722				
IV	X_5	36.818*				
	X_8	9.381***	0.9584	0.0234	0.9467	52.157*
	X_7	-387.098***				
	X_6	-9.531***				
V	X_5	38.359*				
	X_8	9.516***	0.9604	0.0020	0.9409	38.029*
	X_7	-379.693***				
	X_6	-10.232				
	X_4	- 0.016				

* Significant at 1% level
** Significant at 2% level
*** Significant at 5% level

Table 5.8.F

Results of Step-wise Regression Analysis

Hoshiarpur

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	16.715*	0.7603	-	0.7603	38.081*
	X_8	13.335*	0.8208	0.0605	0.8064	25.235*
II	X_5	0.812				
	X_8	13.534*				
III	X_5	0.856	0.8556	0.0348	0.8299	19.877*
	X_4	-0.032				
	X_8	1.295*				
IV	X_5	0.772	0.8742	0.0186	0.8353	15.585*
	X_4	-0.026				
	X_7	-199.187				
	X_8	18.029				
	X_5	0.434				
	X_4	-0.025	0.8836	0.0094	0.8335	12.227*
	X_7	-222.426				
	X_6	- 9.152				

* Significant at 1% level.

Table 5.8.G

Results of Step-wise Regression Analysis

Ropar

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	21.194**	0.5041	-	0.5041	10.357*
II	X_8	39.050*	0.7396	0.2355	0.7072	9.921*
	X_6	-28.035				
III	X_8	32.872***	0.7638	0.0242	0.6972	6.471***
	X_6	-32.079				
	X_5					

* Significant at 1% level
** Significant at 2% level
***Significant at 5% level

Table 5.8.H

Results of Step-wise Regression Analysis

Ludhiana

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_5	48.961*	0.7814	-	0.7814	42.904*
	X_5	53.455*				
II	X_7	340.605	0.8082	0.0278	0.7921	23.159*
	X_5	61.840*				
III	X_7	332.152	0.8244	0.0162	0.7921	15.606*
	X_4	0.021				
	X_5	67.513*				
IV	X_7	350.943	0.8262	0.0018	0.7744	10.712*
	X_4	0.023				
	X_6	- 1.656				

* Significant at 1% level.

Table 5.9. I

Results of Step-wise Regression Analysis

Ferozepur

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	19.408*	0.9428	-	0.9428	197.976*
II	X_8	17.301*				
	X_5	8.455	0.9467	0.0039	0.9428	97.909*
	X_8	17.761*				
III	X_5	8.582	0.9467	0.0	0.9370	19.877*
	X_7	81.870				

* Significant at 1% level.

Table 5.8. J

Results of Step-wise Regression Analysis

Bhatinda

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_6	24.780*	0.4774	-	0.4774	10.993*
II	X_6	27.798*				
	X_5	-15.938	0.5745	0.0971	0.5387	7.437**
	X_6	21.737**				
III	X_5	-21.535	0.6130	0.0385	0.5416	5.275*
	X_7	-575.224				
	X_6	11.549				
IV	X_5	-24.807	0.6625	0.0495	0.5610	4.420***
	X_7	-884.032				
	X_4	-0.047				
	X_6	-3.090				
V	X_5	-28.572	0.7140	0.0515	0.5868	3.999***
	X_7	-926.502				
	X_4	-0.061				
	X_8	9.746				

* Significant at 1% level
** Significant at 2% level
*** Significant at 5% level

Table 5.8. K

Results of Step-wise Regression Analysis

Sangrur

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_8	14.645*	0.8064	-	0.8064	49.873*
II	X_8	11.003*				
	X_6	9.627***	0.8704	0.0640	0.8593	36.805*
	X_8	9.697*				
III	X_6	17.668*	0.9196	0.0492	0.9044	38.252*
	X_7	615.025***				
	X_8	10.573*				
IV	X_6	21.857**	0.9254	0.0058	0.9025	27.840*
	X_7	790.288***				
	X_5	- 4.643				

* Significant at 1% level

** Significant at 2% level

***Significant at 5% level

Table 5.8 L

Results of Step-wise Regression Analysis

Patiala

Step	Variables	Regression Coefficients	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_6	16.541*	0.7569	-	8.7569	37.366*
	X_6	19.607*				
II	X_7	512.752	0.8190	0.0621	0.8028	24.827*
	X_6	21.749*				
III	X_7	791.085***	0.8574	0.0384	0.8317	20.182*
	X_4	0.040				
	X_6	10.978				
IV	X_7	99.146*	0.9044	0.0470	0.8760	21.410*
	X_4	0.053***				
	X_8	10.097				
	X_6	9.434				
V	X_7	977.669**	0.9063	0.0019	0.8630	15.318*
	X_4	0.055***				
	X_8	10.192				
	X_5	2.520				

* Significant at 1% level
** Significant at 2% level
*** Significant at 5% level.

The overwhelming importance of HYV (X_8) in explaining the variation in productivity shows that it subsumes the effects of other complimentary variables e.g. water and fertiliser because HYV cannot go alone.

More or less the same pattern in the analysis emerges in the districts also. Since the data pertains to fifteen years span, the HYV helped with water and fertilizer has the greatest contribution in explaining the variations in the productivity. In Ferozepur, Gurdaspur, Hoshiarpur, Kapurthala, Sangrur and Ropar the HYV explains 94.3, 94.1, 76.0, 79.2, 80.6 and 50.4 per cent variations in productivity. But in Jullunder and Ludhiana 91 and 78 per cent variations respectively is explained by irrigation. In the rest of the districts of Amritsar, Bhatinda and Patiala fertilizer explains 84.1, 47.1 and 75.7 per cent variation respectively. It seems that HYV and fertilizer with water explain the variations at the first level. In the individual districts different supporting and complimentary inputs combine to increase the extent of explanation for the variation in productivity. These entered into various steps are workers per hectare of cultivated area and the volume of water available, which explain the variations marginally. It brings out clearly the fact that the basic inputs are complimentary to each other; so one tends to subsume the effect of the other where fertilizers entered first. It decreased the significance of HYV (X_8) and water because water is a prerequisite for

applying fertilizers so it subsumes the effect of water. As the percentage of irrigated area under these crops was already high and water was available in sufficient quantities before the introduction of package inputs, the maximum proportion of the variation of value productivity of these crops has been explained by the HYV and fertilizers instead of water. As the HYV and fertilizer cannot go alone without sufficient water availability it can be concluded that the effect of water is subsumed in these package inputs.

5.3.0 Correlation Matrix for the years 1961-62 to 1966-67

The period from 1962 to 1967 is the pre-green revolution period. The correlation matrices for each year with districts as observations have been obtained to see the association of various explanatory variables with the productivity. During this period only seven explanatory variables have been considered due to the absence of the area under HYV. The correlation matrices (Appendices A-H) clearly reveal the coefficient of correlation between productivity and independent variables as well as the correlations between the variables with each other.

During 1961-62 all the variables chosen in the analysis show positive correlation with productivity except the number of workers per hectare of cultivated area (X_7). The high positive correlation exists between productivity and value of total water (X_4) ($r = 0.690$) and volume of ground water (X_3) ($r = 0.691$).

During 1966-67 the highest positive correlation is found between productivity and value of ground water (X_4) ($r = 0.612$), followed by volume of ground water (X_3) ($r = 0.515$).

Within the independent variables the fertilizer consumption shows positive correlation with water parametres i.e. volume of ground water and total water in both the years. This fact obviously leads to the conclusion that fertilizer is potent only in presence of water and always goes with it.

Correlation Matrices from 1968-69 to 1969-70

The HYV seeds were introduced during 1967-68 in a big way and is added as the independent variable after 1967-68. The tables 5.9.A-H show that high positive correlation is found between productivity and HYV (X_8) and productivity (X_6) and fertilizer consumption (X_2) the volume of rainfall shows negative correlation with productivity in both the years. Other water parametres are positively correlated with productivity.

This reflects the fact that the agriculture in Punjab had been able to free itself from the shackles of the environmental factor to a large extent at the available level of technology and the other sources of water have been made available.

The matrices obtained for 1972-73 and 1973-74 show positive correlation between productivity and all

Table 5.9.A

Results of Step-wise Regression Analysis 1961-62

Step	Variables	Regression Coefficient	R^2	Increase in R^2	$\bar{R}^2$	F
I	X_4	0.035***	.4475	-	.4475	6.497*
II	X_4	0.049**	.5818	.1423	.5387	5.036***
	X_5	-5.473				
III	X_4	0.048				
	X_5	-5.796	.5943	.0065	.4687	2.892
	X_7	-177.929				

* Significant at 1% level

** Significant at 2% level

*** Significant at 5% level

Table 5.9. B

Results of Step-wise Regression Analysis - 1999-67

Punjab State

Step	Variables	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_4	0.127***	0.3745	-	0.3745	5.389***
II	X_4	0.109	0.4422	0.0677	0.3806	3.173
	X_5	4.471				
III	X_4	0.095				
	X_5	7.775	0.5372	0.0950	0.4225	2.712
	X_6	24.856				
IV	X_4	0.094				
	X_5	2.936	0.5913	0.0541	0.4173	2.177
	X_6	37.696				
	X_7	1682.135				

* Significant at 1% level
** Significant at 2% level
***Significant at 5% level

Table 5.9. C

Results of Step-wise Regression Analysis (1968-69)

Punjab State

Step	Variables	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_8	28.386*	0.5975	-	0.5975	13.336*
II	X_8	19.473	0.6938	0.0963	0.6593	9.068*
	X_4	0.092				
	X_8	-15.128				
III	X_4	0.190*	0.8779	0.1841	0.8482	16.835*
	X_6	29.609**				
	X_8	-11.715				
IV	X_4	0.191**				
	X_6	27.508***	0.8817	0.0038	0.8317	11.195*
	X_7	363.901		-		

* Significant at 1% level

** Significant at 2% level

*** Significant at 5% level

Table 5.9.E

Results of Step-wise Regression Analysis (1971-72)

Punjab State

Steps	Variables	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_5	15.080*	0.6352	-	0.6352	15.660*
II	X_5	11.725***	0.7005	0.0653	0.6674	9.375*
	X_6	6.272				
III	X_5	19.068***				
	X_6	12.597	0.7586	0.0581	0.6988	7.364*
	X_8	-14.953				
IV	X_5	23.280*				
	X_6	24.330**	0.8723	0.1137	0.8190	10.326*
	X_8	-38.331***				
	X_4	0.078				

* Significant at 1% level

** Significant at 2% level

*** Significant at 5% level

Table 5.9. F

Results of Step-wise Regression Analysis (1972-73)

Punjab State

Step	Variable	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_8	19.418*	0.7157	-	0.7157	22.647*
II	X_8	26.745*	0.8100	0.0943	0.7903	17.117*
	X_4	-0.076				
III	X_8	29.182*				
	X_4	-0.078	0.8190	0.0090	0.7744	10.548*
	X_5	-02.615				

* Significant at 1% level

** Significant at 2% level

*** Significant at 5% level

Table 5.9. 0

Results of the Step-wise Regression Analysis (1973-74)

Punjab State

Step	Variable	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_6	11.171**	0.5055	-	0.5055	9.198***
II	X_6	9.877***	0.5505	0.0450	0.5012	4.907***
	X_4	0.033				

* Significant & 1% level

** Significant at 2% level

*** Significant at 5% level

Table 5.9. G H

Results of Step-wise Regression Analysis (1974-75)

Punjab State

Step	Variables	Regression Coefficients	R^2	Difference in R^2	$\bar{R}^2$	F
I	X_6	11.798***	0.4542	-	0.4542	7.503***
II	X_6	8.646	0.5821	0.1279	0.5358	5.580***
	X_8	8.425				
III	X_6	8.582				
	X_8	10.246	0.6256	0.0435	0.5314	3.898
	X_4	-0.032				

* Significant at 1% level
** Significant at 2% level
***Significant at 5% level

other variables except volume of rain water. The inter-variable correlations for 1972-73 reveal that HYV (X_7) is highly correlated with volume of total water (X_4) ($r = 0.794$) while for 1973-74 it is positively correlated with volume of ground water (X_3) ($r = 0.839$). The same pattern of correlation exists between consumption of fertilizer and parametres of water which again show the complimentary nature of each other.

5.3.1 Step-wise Regression Analysis for Inter-District Variations in Productivity

In order to ascertain the contribution of various inputs in the variations in productivity over time period a number of regression analyses have been attempted. The main purpose of the exercise was to know the contribution made by water availability.

The exercise attempted for 1961-62 reveals interesting results. The step-wise regression analysis shows that about 44.8 per cent of the variation in productivity is explained by the availability of water. The availability of water coupled with proportion of irrigation could explain 58.9 per cent of the variations. This reveals the fact that in the pre-green revolution water availability has been the main contributor to the inter district variations in productivity.

The analysis for 1966-67 reveals more interesting features. It may be recalled that after the mid-term appraisal of the Third Five Year Plan, a strategy for

increasing the food production was recommended through the development of minor irrigation and use of fertilizer. During 1966-67 water still remains important factor in explaining the inter-district variations in productivity and the regression analysis shows the volume of total water explained 37.5 per cent of the variations. Alongwith the proportion of irrigated area it is able to explain 44.1 per cent of variations. The entrance of fertilizer into the analysis contributed increased the R2 and all the three variables explained 53.7 per cent of the variations. The regression coefficient is significant at 5 per cent level of significance but in the second step it is significant only at 10 per cent level.

After the introduction of high yielding varieties of seeds, it alone explained 59.8 per cent inter-district variations in the productivity and the regression coefficient is highly significant at 1 per cent level of significance. This is the year when the package technology of seed, water and fertilizer took root. In the second step the entrance of water improves the R^2 but it remains insignificant. The volume of ground water (X_4) has been able to increase the value of R^2 to 69.4 and the entry of fertilizer in the analysis further improves the R^2 value to 84.8 per cent. The fertiliser also enhanced the significance of water from insignificance in the previous step to a level of significance of 1 per cent, while fertilizer (X_6) is also significant at

1 per cent level of significance. Here one can see the interplay of all the three inputs together which are responsible for explaining the maximum variations.

The HYV still remained the most important variable responsible for inter district variations in productivity during 1972-73. The analysis for this year shows that HYV is able to explain 71.6 per cent of the variations. The water still remains a supporting variable and with its entry in the second step both explained 81.0 per cent of the variations. The regression coefficient for HYV is significant at 1 per cent level of significance in both the steps.

In 1974-75, with no significant breakthrough in HYV and it firmly stabilised in the agricultural system, fertilizer use became most important variable to explain the further inter-district variations in the productivity. Consumption of fertilizer explained 45.4 per cent of the variations during 1974-75 and in collaboration with HYV it is able to explain 58.2 per cent of variations. Irrigated area alongwith total water availability has tended to increase the effectiveness of HYV and fertilizer consumption.

The above analysis leads to conclude that at a lower level of technology water remains the most important determinant of productivity as is shown by the exercise for 1961-62. When the level of irrigation is increased

and it touches a maxima, the other inputs become important which bring a breakthrough in technology and water becoming constant HYV and fertilizer assume importance in explaining the inter-district variations in productivity.

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CHAPTER 6

SUMMARY AND CONCLUSIONS

In the present work an attempt has been made to see the spatial and temporal pattern of cropping, the behaviour of area and yield of some selected crops (wheat, rice, maize, rape/mustard, cotton, sugarcane) and their value productivity. The main objective of the study has been to analyse the relationship between the water availability and the productivity, measure to know the agricultural development. The water availability has been worked out with the help of its various parametres viz. surface flow, ground water, and rainfall. It was also aimed at to study the trend of various other complimentary inputs like H.Y.V. seeds and fertilizers and their contribution in the variation of value productivity. It also proposed to ascertain the juncture at which Punjab agriculture was able to neutralise the dependence on rainfall. The availability of water has been of crucial importance for the introduction of high yielding varieties of seeds and fertilizers. In this chapter an attempt has been made to highlight the finding of the study. The state of Punjab has seen rapid agricultural development in the recent years.

81 per cent of total geographical area in the state is under cultivation at present. The yield of wheat, rice and maize has increased substantially, especially after 1967-68, as a result of the introduction of high yielding varieties of seeds, in these crops. With the result the area and yield both have shown rapid increase under the wheat and rice after mid-sixties and state has emerged as the richest agricultural state in India. The state is producing a variety of crops, but wheat, rice, maize and cotton, sugarcane and groundnut are most important of them.

The area under cereals, i.e. wheat, rice and maize has increased rapidly since 1960-61 and very sharply during 1967-68 and 1970-71. This period witnessed a decline in the proportions of non-foodgrains. But after 1971-72 the trend has changed again as the area under non-foodgrains has shown a slow increasing trend. The area under non-foodgrains is comparatively high in southern dry districts of Bhatinda, Ferozepur and Sangrur than in the central plains and northern districts.

Wheat is the important rabi crop which ranks first in state in terms of area. The area under wheat in the state has shown an increasing trend since 1960-61, but the rate of increase was slow between 1960-61 and 1966-67, but it increased very rapidly afterwards from 1967-68 to 1971-72. The proportion of area under maize to the total cropped area in the state is about 10 per cent. The area under maize

has shown great fluctuations since 1960-61, and it has shown marginal increase during the period from 1960-61 to 1970-71.

The cultivation of rice has become important since 1966-67 and the area under rice has increased substantially in all the districts. Rice ranks second in Amritsar, Kapurthala, Gurdaspur and Patiala districts. The rice area has risen to 8.07 per cent during 1974-75 which was only 4.85 per cent during 1960-61 in the state.

The percentage of area under cotton to the gross cropped area in the state has shown a decreasing trend from 1964-65 to 1970-71, but afterwards it has slightly increased. Cotton is very important crop in the southern districts of Bhatinda, Ferozepur and Sangrur where it ranks second after wheat and occupies 24.47, 18.84, 11.19 per cent area respectively during 1974-75.

The area under sugarcane has increased slightly in the state, from 1960-61 to 1974-75. It has not shown great fluctuations over the time period. Rape and mustard also decreased in area between 1960-61 to 1970-71, and showed an increasing trend afterwards. The area under groundnut has shown increasing trend from 1960-61 to 1968-69, but after 1968-69 it has been losing its importance.

Punjab leads the other states in India in terms of yields of wheat, rice and cotton. The yield of wheat has shown an increasing trend since 1960-61, attained its highest yield level during 1971-72 and afterwards it has witnessed

slight decrease from 1971-72 to 1974-75. The yield of wheat was highest in Ludhiana (3001 kg) during 1974-75 and lowest in Ropar (1803 kg per hectare).

The rice yield in Punjab was 1035 kg per hectare during 1960-61 which rose to 2287 kg per hectare during 1973-74. The yield of rice in the state has been rising continuously since 1966-67. Kapurthala has been ahead of the districts with respect to rice yield from 1966-67 to 1971-72, but Ludhiana has become the leading (2979 kg) district after 1973-74.

The yield of maize is lower in Punjab as compared to the other states in the country (1467 kg per hectare during 1975-76 as against 3036 kg per hectare in Karnataka). The yield of maize has shown larger fluctuations during 1960-61 to 1967-68, but afterwards it registered increasing trend.

The cotton yield, has also shown an increasing trend after 1967-68. The yield of sugarcane in the state is lower than the other states in the country. The average cotton yield in the state was 362.3 kg per hectare during 1975-76 as against only 139 kg per hectare of the national average. The yield of American cotton has shown continuous increase since 1960-61, but yield of <u>desi</u> cotton has shown a slight decline during 1960-61 to 1968-69.

The state has witnessed a continuously increasing trend in the intensity of cropping with the minor declines in one or two exceptional years. The intensity of cropping

was only 125.94 per cent during 1960-61 which rose to 146.71 per cent during 1973-74. The highest cropping intensity was recorded in Ludhiana (164.39 per cent) and the lowest in Bhatinda (118.66 per cent) during 1974-75.

The consumption of fertilizers per hectare of gross cropped area in the state has increased at a very fast rate. The consumption of fertlizer rose from 0.63 kg per hectare during 1960-61 to 55.193 kg per hectare during 1973-74. Punjab is the leading state in respect of fertilizer consumption. The per hectare consumption of fertilizer is highest in Ludhiana as it was 97.45 kg per hectare during 1972-73. The increase in fertilizer consumption was very slow from 1961-1967, but when the H.Y.V. seeds were introduced in 1967-68 the fertilizer consumption also increased substantially in all the districts.

The H.Y.V. seeds were introduced in the state during 1966-67, the area under H.Y.V. wheat, and rice has increased at a very fast rate since then. 84.26 per cent of the area under rice and 88.26 per cent of area under wheat was under H.Y.V. in the state in 1974-75.

The number of tractors in the state has also increased very rapidly. It has risen to 41185 during 1972 from 4997 only during 1961-62. The number of tractors available per thousand hectares of gross cropped area was highest in Jullunder during 1972 (11.338) and lowest in Bhatinda 3.383 only.

The state has an excellent irrigation system. The first canal of Punjab is 120 years old (Upper Bari Doab canal).

The canal and the wells are the main sources for irrigation. The canals are the important source of irrigation in Bhatinda, Ferozepur, Sangrur and Amritsar as above 80 per cent of the net irrigated area in these districts is irrigated by the canals. The 45.48 per cent of the net irrigated area in the state has been irrigated by canals and 54.16 per cent by wells/tubewells during 1974-75. The volume of water available per hectare of gross cropped area from the canals was 514 m. cubic metres during 1974-75, while from ground water it was 197 m.c.m. during 1960-61 and 349 m.c.m during 1974-75. The variations in availability of water has been reduced after the development of minor irrigation works. The analysis shows that the ground water has been gaining importance in the state after the mid-sixties as further extension of surface irrigation is not possible because it has already been exploited to a reasonable extent.

From the results of regression analysis it can be seen that water parametres became neutral in furnishing explanation to the variation in productivity in Punjab after the attainment of a certain level of water technology. The variance in productivity is explained by other technological inputs, e.g. fertilizers consumption and high yielding varieties of seeds etc. at the given level of technology seeds etc. The regression analysis for the year 1961-62 shows that volume of water explained 44.8 per cent variance in the value productivity. The value of water in collaboration

with fertilizer was still important in explaining the productivity variations only during 1966-67 which supports our hypothesis that after a certain level of water technology the volume of water becomes neutral and the variations in productivity can be explained only by the variations in other inputs. Because it is a well known fact that HYV and fertilizer cannot go alone without the sufficient quantities of water, the emergence of HYV and fertilizer as more potent explanatory variable in explaining the variations in productivity is assumed that these have subsumed the effect of water also. But immediately after the introduction of HYV seeds it alone was able to explain the 59.8 per cent of variations and with volume of water and fertilizers entering in the third step the value of R^2 rose to 87.8 per cent. During 1974-75 when the HYV seeds got firmly established the variations in productivity was explained by fertilizers consumption up to 45.42 per cent. Similar analysis for all the districts over the time period shows that the variations in productivity has been explained either by the HYV or by the fertilizer consumption in the later years. It means that water still remains the key complimentary input in increasing the productivity of crops either directly or indirectly.

The hypothesis that the spread of area under HYV and fertilizer consumption is a function of the parametres

of water available through irrigation.[1] The correlation matrices show s that the rainfall in most of the districts of Punjab has lost significance over time. The correlations between HYV fertilizer and irrigation in almost all the districts is highly correlated.

A few important points emerge from the above discussion which can be highlighted by way of conclusions:

(i) The volume of rainfall water has been neutralised in explaining the variations in productivity.

(ii) After a certain level when water is available to all the crops, the variation in productivity is explained by other complimentary technological inputs viz. HYV and fertilizer.

(iii) All the technological inputs e.g. irrigation, HYV and fertilizers are complimentary to each other.

(iv) After a level attained by HYV seeds and in absence of any new breakthrough in research for new varieties fertilizer explains the variations in productivity to a larger extent.

(v) The importance of water at this level can be found out by working out its timely application number of

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1 Refer to the Correlation Metrices 1962, 1967 and 1972.

irrigation, depth of irrigation water in the beds and sources of irrigation only at micro-level taking farms as units of study. This is possible only through generating data at the farm level by conducting surveys at a higher level of research.

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APPENDIX

Utilization of Punjab Canals*

Year	U.B.D.C.	Sirhind canal	Western Jamuna canal	Shah-nahar	Bein-canal	Makhu-group C	Sirhind-feeder	Bhanau-canal	B.M.-line	Bist Doab-canal	Total utili-zation
1961-62	1052334	2156343	333437	101748	N.A.	66482	432553	-	852983	159930	5253415
1962-63	1167747	1981695	351694	132570	-	63425	724469	-	478878	183222	5758733
1963-64	1326052	2370280	455833	119589	-	85053	854529	-	606945	252818	6070099
1964-65	1022132	2186170	304333	120360	-	77052	1001459	-	611505	242907	5569451
1965-66	1201967	2164985	331972	144860	-	68060	643256	-	838633	226867	5620593
1966-67	1163441	2231333	290854	112780	1266	73467	812984	8753	676368	240410	5638656
1967-68	1154421	2416108	453120	115456	1276	91406	867591	14044	643346	230982	5988100
1968-69	1305784	2317484	430573	137564	709	91445	747815	24097	737756	295145	6118371
1969-70	1432519	2394656	474420	153929	635	87662	807925	17226	686793	286818	6363431
1970-71	1516093	2133786	335370	132451	-	82654	1082695	695311	679302	210571	6998303
1971-72	1335923	2308312	333703	147369	-	87507	1066669	682105	734958	198609	5910535
1972-73	1713462	2218170	370433	163341	-	101662	719249	746592	590767	204138	6183543
1973-74	1663490	2600453	420747	157349	-	90030	871581	NA	760764	232056	6794769
1974-75	1350611	1343924	578970	162108	-	114621	1098979	NA	628140	198243	6078596

* in cusecs day.

Source :- Irrigation Department, Government of Punjab (India), utilization of different canals in Punjab During the Rabi and Kharif (unpublished) 1962-75.

APPENDIX

Area* irrigated by canals in Punjab

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-epur	Bhati-nda	Sang-rur	Patia-la	Punjab
1960-61	337	1982	8	25	122	4	240	4431	2811	1349	357	11663
1961-62	318	2074	22	109	122	1	250	4461	2910	1410	340	12017
1962-63	332	1865	22	106	122	1	250	4876	2987	1398	336	12294
1963-64	422	1895	26	93	128	5	250	4809	3072	1412	340	12456
1964-65	455	1911	28	97	126	7	260	4217	3233	1424	349	12098
1965-66	456	1976	28	113	124	7	269	4465	3665	1420	324	12883
1966-67	497	2040	43	142	128	7	332	4271	3427	1425	343	12660
1967-68	332	2043	57	233	134	11	288	4703	3267	1423	392	12883
1968-69	332	2061	53	235	96	14	290	4698	3237	1442	409	12897
1969-70	395	2093	54	242	110	20	309	2173	2607	1418	503	13011
1970-71	395	2105	54	143	116	21	330	2173	3079	1322	508	12859
1971-72	501	2126	54	163	117	21	325	2173	3340	1172	528	13333
1972-73	501	2126	54	179	117	22	274	1984	2369	1255	528	12752
1973-74	574	2133	40	179	118	24	275	1963	2594	1312	528	12844
1974-75	654	2131	26	185	115	25	250	2326	3705	1183	583	14478

* Area in 00, hectares,

Source :-Government of Punjab (India)
Irrigation, floods and water logging, statistics of Punjab, 1933, 1971-72, 1974-75.

APPENDIX

Area* irrigated by wells/tube wells

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-epur	Bhathi-nda	Sang-rur	Patia-la	Punjab
1960-61	666	936	571	1504	257	178	1170	603	54	880	1166	7985
1961-62	580	820	553	1654	251	199	1060	719	33	893	1094	7659
1962-63	607	1049	693	1660	255	200	1090	737	56	935	1118	8400
1963-64	615	1199	719	1687	263	232	1050	635	64	932	1026	8421
1964-65	657	1066	760	1693	225	240	1270	804	73	907	1040	8735
1965-66	634	1092	802	1701	379	244	1231	525 757	175	904	1043	8932
1966-67	687	1051	792	1680	292	272	1374	687	297	750	1060	8942
1967-68	659	1093	805	1716	274	283	1627	527	438	1325	1119	9886
1968-69	743	1257	892	1881	897	309	1732	1147	1198	2041	1919	13516
1969-70	809	1426	980	1961	398	324	2038	2158	1016	2221	1964	15295
1970-71	884	1454	939	2120	421	368	2250	2224	1013	2224	1934	15911
1971-72	793	1505	983	2128	437	384	2337	2145	2145	711	2048	2029
1972-73	852	1545	1012	2159	530	405	2433	2241	711	2439	2124	16518
1973-74	875	1570	1009	2172	625	457	2468	2304	862	2328	2138	16801
1974-75	903	1590	1039	2294	701	453	2527	2501	899	2580	2252	17239

* Area in 00 hectares

Source:- Government of Punjab,(India)
Irrigation floods and water logging statistics of Punjab
1969, 1971-72, 1974-75.

APPENDIX

Districtwise average annual rainfall in Punjab 1961-1975.

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullu-ndar	Hoshi-arpur	Ropar	Ludhiana	Ferozpur	Bhantinda	Sangrir	Patiala
1961	144	89	72	65	92	110	67	43	58	45	73
1962	95	72	86	90	103	95	114	59	72	70	74
1963	71	33	78	61	63	85	61	30	39	19	87
1964	84	63	30	80	67	113	66	34	56	88	55
1965	69	33	66	55	58	61	86	32	26	88	89
1966	102	83	75	90	92	73	70	50	44	50	56
1967	118	65	28	68	90	69	69	41	17	28	69
1968	103	54	24	61	81	84	49	28	39	53	43
1969	77	41	25	44	66	58	34	30	25	39	71
1970	93	59	55	77	100	98	76	23	50	52	66
1971	155	85	52	65	81	137	63	26	35	48	69
1972	137	123	59	63	99	63	69	68	42	63	88
1973	106	77	69	88	87	84	69	54	43	56	73
1974	60	38	34	37	51	56	37	21	24	28	42
1975	95	54	62	65	79	81	63	76	60	49	60

* Rainfall in centimetres

Source:-1. Government of Punjab. (India) Irrigation floods and water logging statistics of Punjab 1969

2. Government of Punjab. (India) Statistical abstract of Punjab 1966-1975.

APPENDIX

Net area* irrigated in Punjab

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-nder	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-epur	Bhati-nda	Sang-rur	Patia-la	Punjab
1960-61	1076	2938	598	1555	387	192	1410	5034	2885	229	1571	19855
1961-62	961	2710	607	1786	381	207	1310	5180	2946	2303	1474	19835
1962-63	1000	2930	754	1791	385	207	1340	2613	3049	233	1494	20890
1963-64	1103	3115	782	1806	399	243	1730	3444	3136	2344	1409	21539
1964-65	1177	2998	826	1813	850	253	1580	5021	3306	2371	1420	21215
1965-66	1281	3083	867	1815	517	259	1599	522	3840	2628	1408	22522
1966-67	1332	1308	867	1824	422	289	1849	5155	3724	2742	1442	22754
1967-68	1039	3126	856	1959	412	294	1965	5230	3705	2751	1551	22888
1968-69	1113	3348	945	2118	504	323	2022	5845	4465	3483	2349	26516
1969-70	2155	3530	1034	2205	518	350	2347	7413	3623	3639	2497	28411
1970-71	1337	3533	1043	2270	547	395	2580	4779	3318	3546	2491	28080
1971-72	1350	3639	1043	2292	564	140	2623	3427	4060	3483	2585	29545
1972-73	1406	3961	1066	2339	726	431	2707	7321	3340	3594	2680	29401
1973-74	1406	3709	1052	2352	753	488	2743	7386	3456	3640	2686	29761
1974-75	1603	3729	1065	2420	826	486	2777	7619	4281	3768	2959	28 31829

* Area in 00, Hectares

APPENDIX

Irrigated area under six crops as % to
Gross cropped area under crops

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-dar	Hoshi-apur	Ropar	Ludhi-ana	Feroz-epur	Bhati-nda	Sang-rur	Patia-la	Punjab
1962	42.77	81.00	68.00	70.32	11.65	-	74.06	70.87	81.39	59.66	59.68	63.48
1963	42.66	69.45	69.08	71.35	12.48	-	79.19	74.42	84.21	59.47	57.47	63.16
1964	48.93	92.48	76.38	75.41	11.33	-	79.00	83.95	79.90	61.60	59.65	67.99
1965	52.27	87.66	74.83	73.02	12.30	-	80.27	77.70	81.84	63.28	61.00	70.34
1966	51.25	91.01	82,53	83.39	24.91	29.04	83.89	81.07	85.32	85.47	72.56	64.87
1967	54.53	90.58	77.64	82.10	25.59	29.54	86.67	81.27	89.70	88.44	76.42	76.52
1968	49.61	89.79	69.86	82.43	18.92	25.83	88.17	82,30	84.64	87.38	71.47	74.72
1969	57.04	92.90	90 99.24	88.12	36.82	30.35	94.04	87.64	85.02	98.99	84.63	82.19
1970	59.68	93.05	91.56	91.31	42.37	34.03	96.05	87.45	12.13	95.07	85.07	81.15
1971	59.99	96.28	91.06	92.04	39.96	43.04	94.95	88.69	73.43	96.10	81.87	81.89
1972	61.24	95.16	97.83	91.58	46.99	46.84	96.23	90.30	74.26	97.49	87.27	83.80
1973	63.59	95.70	93.32	93.87	46.76	50.70	98.11	91.85	95.12	97.89	88.60	87.21
1974	63.72	93.91	68.96	94.70	40.99	49.91	97.76	91.93	95.94	97.91	88.91	86.79
1975	65.81	96.44	92.83	96.15	45.26	52.77	98.78	74.40	97.71	96.52	91.43	88.88

Source :- Computed from the data available from Government of Punjab (India). Irrigation, floods and water logging statistics of Punjab, 1969, 1971-72, 1974-75.

Area of Wheat - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	37.15	31.46	37.00	34.76	38.75	-	30.54	31.96	20.11	34.17	32.20	30.44
1961-62	38.86	31.27	40.00	36.05	37.15	-	30.68	30.65	20.94	34.84	33.55	30.50
1962-63	40.80	29.45	35.86	40.00	41.25	-	28.01	32.76	22.25	36.64	33.26	32.50
1963-64	33.11	32.14	34.00	38.05	40.84	-	33.99	33.09	21.87	37.99	30.93	31.59
1964-65	34.79	30.22	35.22	35.61	40.44	-	35.95	32.08	23.42	40.23	29.64	31.68
1965-66	40.64	32.61	33.86	38.65	34.20	24.32	36.20	31.32	22.64	32.22	29.56	31.72
1966-67	36.36	30.77	35.25	37.51	31.39	23.67	38.01	31.05	22.34	31.81	30.06	31.08
1967-68	35.65	32.65	35.84	40.05	34.66	26.22	38.25	32.19	26.72	34.45	31.07	32.89
1968-69	36.81	37.54	39.35	43.79	37.88	30.45	45.61	39.63	33.63	41.69	39.75	39.01
1969-70	46.06	39.65	43.87	44.38	38.18	31.42	47.71	37.38	33.05	42.34	40.80	39.84
1970-71	38.84	41.29	43.22	45.68	37.75	30.65	48.37	39.24	32.60	43.14	46.28	40.49
1971-72	38.41	40.61	43.22	46.63	40.64	34.07	48.33	37.94	34.02	44.59	44.08	40.81
1972-73	40.42	42.10	43.79	45.75	39.34	32.09	48.65	38.90	30.55	43.09	43.27	40.53
1973-74	38.88	39.10	45.06	46.31	36.38	33.15	45.64	36.82	27.56	40.93	43.10	38.72
1974-75	37.50	40.06	43.97	45.45	37.90	31.79	37.90	42.93	25.66	30.14	37.64	36.58

*Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area of Maize - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	6.25	7.42	9.45	12.92	24.56	[illegible]	10.54	2.69	1.41	6.87	8.55	7.07
1961-62	6.71	6.99	9.23	13.17	25.69	-	10.58	2.62	1.05	6.36	7.84	6.83
1962-63	6.68	9.94	8.96	12.94	25.08	-	10.99	2.81	1.18	7.17	7.19	7.30
1963-64	8.27	6.94	9.33	13.52	25.81	-	12.40	2.53	1.23	7.08	8.06	7.33
1964-65	9.40	7.46	8.18	18.35	26.11	-	11.90	3.17	1.02	5.55	7.09	7.59
1965-66	8.66	7.26	9.24	15.30	18.57	19.15	13.03	3.29	1.23	6.65	7.88	7.88
1966-67	9.28	9.79	9.31	15.78	19.10	19.29	13.52	3.56	1.99	7.57	8.93	8.59
1967-68	9.56	9.04	9.43	16.44	20.24	18.57	14.54	3.97	2.05	7.81	8.36	8.75
1968-69	8.40	8.59	9.67	16.62	20.49	17.81	14.93	5.13	2.71	9.42	7.45	9.26
1969-70	8.78	8.42	11.61	18.79	20.60	17.71	16.8 0	5.12	2.71	9.73	8.80	9.71
1970-71	9.92	5.97	10.96	18.78	22.19	22.61	17.07	4.50	2.18	10.39	7.80	9.60
1971-72	9.81	7.85	9.67	18.02	20.58	20.11	18.00	3.97	2.45	9.91	7.47	9.57
1972-73	9.57	6.11	10.45	18.63	20.56	20.43	18.07	3.31	2.83	10.99	7.58	9.47
1973-74	9.52	6.52	9.86	18.43	22.02	19.47	18.94	2.73	2.31	10.08	7.93	9.39
1974-75	8.33	6.68	9.03	17.27	20.43	19.48	17.70	2.16	1.98	8.98	8.13	8.87

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area* of Rice - 1960-61 to 1974-75

Year	Gurdas-pur	Amritsar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	16.66	11.46	11.81	2.66	11.07	-	0.44	3.80	-	1.78	6.22	4.85
1961-62	16.25	9.67	12.30	2.50	11.45	-	0.53	3.25	-	2.01	7.19	4.75
1962-63	16.38	12.19	11.72	2.65	10.23	-	0.26	3.86	-	1.30	6.16	4.96
1963-64	17.22	12.89	10.66	2.51	10.13	-	0.49	4.06	-	1.55	6.75	5.46
1964-65	18.80	13.01	10.69	2.19	9.87	-	0.71	4.26	0.13	2.52	8.56	5.62
1965-66	15.75	13.80	11.35	2.60	8.80	3.90	1.19	4.95	0.07	2.80	10.06	6.00
1966-67	18.81	12.24	11.75	2.29	7.77	3.41	0.76	3.98	0.09	1.15	9.34	5.52
1967-68	21.15	12.91	13.20	2.38	8.28	3.23	0.89	3.70	0.12	1.11	10.55	5.75
1968-69	22.89	13.46	15.48	3.16	9.00	3.48	0.64	5.53	0.13	1.76	10.76	6.52
1969-70	21.06	14.03	15.48	3.13	9.09	2.85	0.83	5.39	0.11	1.70	11.60	6.43
1970-71	22.04	15.18	18.06	3.55	8.93	2.51	1.02	5.88	0.23	1.73	11.07	6.86
1971-72	22.34	16.38	18.70	5.71	9.89	2.79	1.56	6.77	0.36	2.25	13.84	7.86
1972-73	21.80	15.79	18.30	6.84	10.15	4.30	2.30	5.94	0.14	2.38	15.17	8.02
1973-74	22.48	19.71	17.90	6.22	9.15	4.21	2.08	6.93	0.14	2.63	14.82	8.61
1974-75	24.21	17.10	18.07	8.18	9.14	3.58	3.57	8.83	0.33	3.77	16.91	8.07

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area* of Cotton - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	1.91	7.09	2.23	3.76	1.40	-	7.00	17.08	15.32	12.96	6.10	9.69
1961-62	1.71	8.99	2.49	3.80	1.68	-	7.92	17.20	15.14	14.50	6.43	10.28
1962-63	1.60	8.77	2.29	3.77	1.58	-	7.95	16.62	13.82	14.63	5.95	9.79
1963-64	1.65	7.53	2.00	4.71	1.96	-	9.42	19.18	15.95	15.37	6.31	10.81
1964-65	1.88	8.38	1.88	3.83	1.27	-	7.86	16.83	15.05	13.13	6.05	9.87
1965-66	1.37	6.53	1.71	3.06	1.03	1.63	7.35	17.98	17.42	9.46	5.49	9.52
1966-67	1.15	4.65	1.31	2.74	0.99	1.68	6.25	15.38	14.30	9.10	5.83	8.22
1967-68	1.16	6.01	1.45	2.41	1.04	1.53	4.56	14.80	13.92	6.65	4.66	7.69
1968-69	0.98	5.14	2.00	1.66	0.86	1.09	3.38	15.28	15.35	6.08	4.51	7.43
1969-70	0.98	5.07	1.03	2.01	0.84	0.97	4.04	14.99	14.26	6.44	4.30	7.54
1970-71	0.99	2.78	0.90	1.85	0.69	2.35	4.37	14.39	13.76	6.88	4.05	6.99
1971-72	1.01	3.07	0.84	1.78	0.75	1.12	4.66	16.60	18.75	8.75	3.86	8.298
1972-73	0.90	3.51	0.78	1.67	0.61	1.18	4.63	17.08	18.48	9.85	3.50	8.45
1973-74	0.85	3.57	0.92	1.91	0.89	1.10	4.75	18.20	18.91	9.91	3.67	8.83
1974-75	0.75	3.43	0.84	1.66	0.64	0.82	4.93	18.84	24.47	11.19	3.25	9.23

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area* of Sugarcane - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	5.90	3.14	5.51	6.15	6.22	-	2.70	0.86	0.42	3.18	3.38	2.816
1961-62	4.95	3.08	4.61	5.95	6.25	-	2.64	0.84	0.39	3.35	3.48	2.68
1962-63	5.01	0.93	3.45	5.29	5.94	-	2.35	0.62	0.45	2.94	3.08	1.89
1963-64	4.63	2.38	2.66	5.34	4.90	-	3.22	0.71	0.55	2.94	2.61	2.35
1964-65	4.7	2.61	2.51	4.66	3.5	-	3.09	0.89	0.64	3.37	3.34	2.41
1965-66	6.70	3.45	3.16	6.30	3.56	7.80	3.82	1.63	1.09	2.97	5.01	3.42
1966-67	6.37	2.98	3.12	5.92	3.90	7.03	3.19	1.20	1.24	2.55	3.70	2.90
1967-68	6.01	2.76	2.51	5.04	3.37	6.56	2.46	0.99	0.85	1.91	2.79	2.52
1968-69	6.95	2.63	2.58	5.27	3.41	6.32	2.78	0.30	2.20	2.07	3.31	2.97
1969-70	6.46	2.63	2.58	4.96	3.33	5.71	2.07	1.42	1.18	2.16	3.00	2.65
1970-71	5.78	1.88	1.93	4.31	2.59	6.54	1.83	1.01	1.03	1.89	2.36	2.25
1971-72	5.72	1.70	1.93	3.12	1.60	4.47	1.37	0.72	0.86	1.50	1.82	1.80
1972-73	5.58	1.52	1.96	3.06	2.03	4.30	1.35	0.53	0.70	1.63	1.72	1.72
1973-74	5.29	1.43	1.85	3.22	2.72	5.26	1.52	0.52	0.58	1.90	1.90	1.88
1974-75	5.47	1.79	1.20	4.32	2.69	6.15	2.07	0.46	0.66	2.03	1.82	2.05

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area* of Groundnut - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	-	-	2.36	2.15	A		7.30	A	A	1.68	3.18	1.33
1961-62	-	-	3.07	2.19	A		7.67	A	A	1.89	3.48	1.39
1962-63	-	-	1.73	2.80	A		8.61	A	0.04	2.36	3.47	1.54
1963-64	A	A	6.66	2.83	A		11.91	A	A	3.28	3.92	2.13
1964-65	0.0	-	7.55	3.83	0.32	-	12.62	-	-	3.36	4.80	2.4
1965-66	-	A	8.35	4.70	0.03	4.04	12.84	0.04	0.04	3.68	5.29	2.77
1966-67	-	A	9.50	6.42	0.12	5.94	16.31	0.11	0.06	2.34	6.12	2.88
1967-68	A	0.02	9.56	7.74	1.23	7.54	16.71	0.42	0.41	6.87	6.81	4.08
1968-69	A	0.03	10.00	7.41	1.43	7.87	17.19	0.36	0.43	6.21	6.91	4.19
1969-70	0.05	0.02	8.64	6.21	1.42	7.14	13.77	0.17	0.25	4.93	5.88	3.38
1970-71	-	A	8.90	6.06	0.69	6.83	12.62	0.09	0.14	4.28	5.19	3.06
1971-72	A	A	9.07	5.45	0.72	6.31	12.35	0.14	0.16	4.34	4.99	3.03
1972-73	-	A	8.82	4.57	0.58	5.10	11.17	0.11	0.15	4.31	4.48	2.83
1973-74	0.02	A	7.53	4.01	0.52	5.26	10.11	0.21	0.17	4.15	4.65	2.56
1974-75	A	A	7.23	3.54	0.43	5.43	10.30	0.14	0.40	5.11	4.97	2.78

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Area* of Rape/Mustard - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	0.84	2.91	A	0.12	0.41	-	0.33	3.00	5.07	3.12	3.13	2.47
1961-62	0.71	2.74	A	0.25	0.56	-	0.32	2.16	6.87	2.84	2.38	2.49
1962-63	0.99	2.12	A	0.24	0.49	-	0.30	2.06	3.93	3.56	2.29	2.02
1963-64	0.66	2.77	A	0.31	0.32	-	0.24	2.13	4.54	2.76	2.17	2.02
1964-65	0.94	2.98	A	0.55	0.64	-	0.47	2.18	3.73	2.86	1.46	1.95
1965-66	1.19	2.59	0.12	0.34	0.45	1.06	0.33	2.20	3.89	1.22	1.37	1.72
1966-67	1.47	3.49	0.18	0.69	0.83	1.03	0.51	2.83	5.00	1.67	1.84	2.30
1967-68	1.10	3.87	0.31	0.71	0.79	1.36	0.56	4.06	7.49	1.34	1.69	2.92
1968-69	1.16	2.96	0.32	0.34	0.43	1.26	0.23	1.41	2.28	0.70	1.32	1.32
1969-70	1.32	4.42	0.51	0.65	0.72	1.25	0.49	1.80	0.69	0.65	1.16	1.67
1970-71	1.13	5.37	0.70	0.76	0.75	1.00	0.30	2.11	2.74	1.00	0.61	1.81
1971-72	1.09	5.51	0.06	1.18	0.93	1.23	0.39	2.90	4.21	1.35	0.12	2.096
1972-73	1.19	5.31	0.13	1.04	0.94	1.45	0.52	3.86	7.66	1.76	0.93	2.90
1973-74	1.29	5.23	0.55	1.10	1.09	1.51	0.72	3.95	7.41	1.93	1.03	2.96
1974-75	1.27	6.04	0.90	1.16	1.53	2.00	0.58	4.01	6.22	2.23	2.15	3.04

* Area as proportion to Gross Cropped Area of the respective Districts.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Wheat - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	885	1038	987	1336	831	-	1484	1241	1361	1364	1533	1237
1961-62	884	1156	820	1269	1002	-	1538	1202	1416	1382	1281	1230
1962-63	1007	1305	832	1290	856	-	1750	925	1410	1174	1187	1161
1963-64	956	1157	1145	1401	745	-	1968	1168	1312	1234	1401	1256
1964-65	1176	1674	1437	1569	959	-	2233	1299	1772	1376	1497	1510
1965-66	971	1458	1373	1208	623	845	1875	1134	1259	1278	1193	1238
1966-67	1352	1632	1955	1558	945	1208	2474	1352	1443	1270	1538	1514
1967-68	1315	1570	1597	1741	1269	1676	3136	1998	1939	1628	1839	1863
1968-69	1953	2342	2302	2311	1521	1789	2674	1874	2278	2144	2492	2177
1969-70	1955	2680	2065	2346	1283	1925	3040	1938	2278	2214	2330	2245
1970-71	2089	2326	2527	2492	1468	1948	3279	2045	2121	2143	2009	2238
1971-72	2077	2749	1916	2296	1435	1949	3310	2321	2513	2603	2067	2406
1972-73	2015	2198	2127	2504	1885	1538	2922	2292	1817	2400	1939	2233
1973-74	1868	2051	1920	2349	1687	1864	2929	2212	1940	2475	2195	2216
1974-75	2188	2276	2140	2507	2070	1803	3001	2566	2141	2403	2204	2395

*Yield in kg/hectare.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Maize - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	1061	1435	1344	1352	963	-	1427	1392	764	771	893	1135
1961-62	1072	1390	1255	1390	1160	-	2089	1410	1063	1318	1318	1381
1962-63	430	453	433	1171	1398	-	1140	438	597	697	725	851
1963-64	1075	1394	1299	1545	1630	-	1659	1156	827	1565	1218	1384
1964-65	1067	1262	1158	1512	1689	-	1452	1220	721	814	738	1274
1965-66	1040	1258	1145	2465	1379	1555	2463	1250	1444	1535	1528	1670
1966-67	880	811	1133	1411	1485	1200	2052	1179	1333	1612	1564	1379
1967-68	1280	1440	1800	1602	1558	1030	2492	1880	1235	1482	1404	1627
1968-69	1000	1292	1533	1464	1080	1032	2138	1563	1333	1508	1352	1440
1969-70	1018	1425	1333	1409	1342	1236	2121	1408	1374	1249	1542	1464
1970-71	1116	1805	1721	1541	1345	1299	2044	1331	1263	1698	1477	1555
1971-72	1030	1602	1535	1833	1244	1106	1858	1298	1942	1793	1582	1561
1972-73	1153	1655	1560	1678	1447	1086	2132	1206	1647	1866	1409	1612
1973-74	1330	1254	1557	1343	1348	1456	1759	665	1265	1079	1373	1348
1974-75	1970	1821	2019	1712	1533	1472	2001	1328	1681	1636	1686	1723

* Yield in kg/hectare.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Rice - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	1604	1660	1691	1552	1371	-	1530	1571	1505	1447	1422	1035
1961-62	1431	1488	1673	1580	1530	-	1883	1720	1009	1732	1550	1035
1962-63	1559	1259	1823	2153	1216	-	1142	2310	1557	2283	1646	1076
1963-64	1930	1544	1732	1375	1456	-	1507	1513	1670	1670	1670	1097
1964-65	1144	1394	1551	1340	1127	-	1235	1114	1111	1103	1105	1223
1965-66	682	1339	1085	835	810	545	800	1159	-	761	956	1000
1966-67	1088	1338	1389	1375	1020	600	1000	1370	1000	970	1009	1189
1967-68	1296	1425	1524	1500	1220	1000	1333	1215	1000	1645	1250	1322
1968-69	1383	1550	1590	1385	1145	915	1333	1237	1000	1000	1365	1364
1969-70	1399	1660	1725	1640	1380	1170	1505	1497	1000	1525	1321	1490
1970-71	1647	1953	1965	1850	1595	1335	1800	1820	1380	1365	1685	1765
1971-72	1687	2105	2276	2093	1930	1655	2125	2089	2000	2200	2252	2045
1972-73	1631	1897	2600	2235	1875	1585	1342	2642	1750	1967	1846	2007
1973-74	1821	2241	2311	2772	1684	2158	3123	2976	2466	2466	2192	2287
1974-75	1566	1885	2621	2339	1894	1514	2979	2539	2071	1815	1952	2071

* Yield in kg/hectare.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Cotton American - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	187	158	241	243	188	-	235	306	245	245	245	270
1961-62	180	201	273	330	179	-	297	321	322	321	234	298
1962-63	175	180	267	288	205	-	294	306	319	301	232	290
1963-64	159	200	276	244	182	-	311	364	332	305	287	327
1964-65	164	214	270	305	169	-	339	345	340	282	332	322
1965-66	159	199	266	316	164	160	312	333	316	233	310	311
1966-67	173	216	279	316	166	169	363	366	332	250	314	335
1967-68	186	232	280	298	178	154	329	416	365	267	327	371
1968-69	-	280	-	270	-	-	338	381	399	300	300	369
1969-70	-	265	-	360	-	-	397	399	402	324	348	381
1970-71	228	333	281	300	180	197	333	416	416	332	314	399
1971-72	191	299	283	299	173	205	293	433	416	299	281	407
1972-73	180	332	360	288	207	180	349	416	416	334	331	407
1973-74	229	366	300	331	207	247	383	439	433	366	382	430
1974-75	-	374	-	-	-	-	360	431	400	360	360	418

* Yield in kg/hectare.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Cotton Desi - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sangrur	Patia-la	Punjab
1960-61	178	198	244	241	143	-	238	392	187	239	225	267
1961-62	165	184	238	277	158	-	410	302	300	300	220	287
1962-63	169	182	224	252	171	-	300	282	275	351	265	280
1963-64	166	184	252	242	159	-	306	294	295	263	260	272
1964-65	166	214	211	299	161	-	318	272	289	273	274	274
1965-66	147	216	180	229	121	146	308	263	312	229	259	264
1966-67	168	231	197	231	121	117	311	294	313	247	259	277
1967-68	174	231	228	231	108	124	311	326	325	263	284	291
1968-69	180	262	270	231	120	180	338	360	363	264	257	316
1969-70	180	255	360	231	120	180	311	380	339	313	225	321
1970-71	187	298	265	232	126	161	296	395	378	314	240	378
1971-72	189	266	266	232	126	159	249	397	373	281	240	326
1972-73	192	281	245	215	135	171	299	351	360	299	277	322
1973-74	189	281	249	230	139	184	295	325	345	299	277	303
1974-75	180	260	360	257	180	180	325	339	295	300	305	301

* Yield in kg/hectare.

Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield* of Sugarcane - 1960-61 to 1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Luthia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	3838	3674	3042	4054	2639	-	3916	3648	3596	4128	3703	3679
1961-62	2869	2715	2649	3609	2399	-	3526	3173	2711	3219	2934	3016
1962-63	3487	3504	3138	3571	2455	-	3537	3670	2869	3303	2180	3072
1963-64	3025	3319	2965	3671	2243	-	3591	2987	3235	3525	3317	3209
1964-65	3373	4808	3221	4286	2421	-	4315	4188	3474	3921	2898	3639
1965-66	2955	3795	2800	4533	2464	3454	3938	3880	2885	3535	2590	3455
1966-67	2714	2191	3000	3195	1590	2035	4000	3769	3333	2805	2311	2779
1967-68	2600	4270	3000	3516	1636	2666	4091	3727	3875	5160	4140	3507
1968-69	2727	3740	2750	3500	1818	2731	3692	3462	3294	4214	3750	3289
1969-70	4105	4473	4164	3870	3696	4077	3640	4070	4400	4379	4634	4171
1970-71	4196	4275	3667	3948	3333	4610	4000	3550	3555	5500	4610	4117
1971-72	3810	4100	3643	4077	1845	3750	4143	3750	3875	4685	4400	3912
1972-73	4437	4778	4333	4846	2750	3300	5444	4375	4600	5727	5400	4602
1973-74	5909	5909	5833	5833	2666	5690	5750	4245	4200	5690	5342	5289
1974-75	4024	3876	4152	6624	3862	5804	5688	3861	6245	5347	4589	4997

* Yield in Kg/Hectare
Source: Government of Punjab (India), Statistical Abstract of Punjab, for the years 1961-1975.

Yield of Groundnut : 1960-61--1974-75

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshiar-pur	Ropar	Ludhia-na	Feroze-pur	Bhatin-da	Sang-rur	Patia-la	Punjab
1960-61	-	-	894	950	877	-	931	1156	914	920	930	925
1961-62	-	-	922	740	922	-	934	983	952	929	925	887
1962-63	-	-	832	739	736	-	926	959	767	934	925	901
1963-64	-	837	830	738	736	-	847	784	763	933	925	880
1964-65	-	1250	1136	1238	1238	-	1513	1175	829	1000	991	1261
1965-66	-	1000	1090	1202	1205	1052	1491	1565	829	955	957	1222
1966-67	-	1238	1001	903	801	1102	1214	1278	946	957	968	1065
1967-68	500	1001	1001	1006	901	803	1225	1214	1086	1036	1025	1079
1968-69	640	836	905	912	804	728	986	1172	1042	948	877	932
1969-70	-	-	1300	1250	1000	755	736	1480	1000	1031	940	946
1970-71	-	714	1002	913	801	827	984	925	880	987	1040	970
1971-72	-	-	1400	1172	950	905	888	1000	1000	1035	1255	1056
1972-73	-	-	1080	955	1000	600	829	1000	1670	869	1385	958
1973-74	-	-	1222	882	969	718	1007	969	969	766	1154	970
1974-75	-	-	774	828	861	875	816	861	876	881	966	861

* Kg/per hectare

Source: Government of Punjab (India), Statistical Abstract of Punjab for the years 1961-1975.

APPENDIX

Percentage of area under H.Y.V. wheat to the total area under wheat

Year	Gurdas-pur	Amrit-sa r	Kapur-thala	Jullun-der	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-epur	Bhathi-nda	Sang-rur	Patia-la	Punjab
1967-68	8.13	48.02	43.12	49.67	16.81	14.58	57.89	35.01	18.55	40.28	28.85	34.69
1968-69	51.18	65.88	60.65	72.28	35.24	33.98	79.81	52.03	50.77	59.77	55.73	57.87
1969-70	43.78	75.22	69.11	88.23	45.23	43.63	86.08	62.69	60.00	77.73	72.55	68.56
1970-71	64.53	76.44	73.11	90.00	47.33	40.98	89.65	70.96	44.87	78.45	62.74	69.11
1971-72	59.57	78.55	85.07	89.69	41.44	40.98	91.90	79.04	47.65	78.78	74.38	72.55
1972-73	55.92	92.33	95.52	100.0	49.51	57.37	91.30	71.56	70.83	93.10	75.69	78.62
1973-74	63.26	91.90	95.89	96.51	48.98	57.14	94.60	82.16	83,77	98.57	81.60	84.26
1974-75	68.75	95.52	89.05	94.50	60.28	66.12	98.73	74.64	90.32	94.02	89.86	88.26

Sources- Computed from the data, Government of Punjab (India) statistical abstract of Punjab 1969-1975

APPENDIX

Percentage of area under H.Y.V. Rice to the total area under Rice

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-opur	Bhanti-nda	Sang-rur	Patia-la	Punjab
1967-68	5.48	4.23	9.52	-	7.40	-	-	7.31	-	14.28	3.77	5.45
1968-69	7.69	5.78	8.33	-	10.34	-	33.33	9.09	-	9-09	7.69	7.53
1969-70	21.33	21.25	50.00	-	20.00	25.00	25.00	15.25	-	27.27	13.79	20.33
1970-71	29.75	35.95	57.14	35.71	22.58	-	80.00	32.81	-	36.36	29.50	33.33
1971-72	60.97	70.83	100000	66.67	54.83	25.00	62.50	76.00	33.33	73.33	73.68	69.11
1972-73	69.61	74.19	100.00	96.55	60.00	25.00	91.66	97.46	100.0	93.75	62.50	76.05
1973.74	95.29	70.96	100.0	100.0	67.56	62.50	100.0	94.68	100.0	100.0	68.60	83.26
1974-75	02.79	94.28	93.33	83.33	85.29	71.44	73.68	93.91	50.00	69.23	70.58	84.53

Source :- Computed from the data,
Government of Punjab (India). Statistical abstract of Punjab 1969-75.

APPENDIX

Percentage of area under H.Y.V. Maize to the total area under Maize

Year	Gurdas-pur	Amrit-sar	Kapur-thala	Jullun-der	Hoshi-arpur	Ropar	Ludhi-ana	Feroz-opur	Bhanti-nda	Sang-rur	Patia-la	Punjab
1967-68	1.62	1.69	3.50	3.31	1.76	2.08	5.26	0.56	-	0.46	1.28	1.62
1968-69	10.34	8.16	20.00	12.69	4.54	3.22	21.43	5.88	4.76	1.69	13.88	9.59
1969-70	6.25	6.25	16.66	15.27	5.88	3.22	12.34	11.11	8.69	4.76	15.90	9.73
1970-71	5.55	11.42	17.64	10.81	5.19	2.22	14.28	8.16	-	6.66	16.28	8.99
1971-72	2.77	17.39	6.66	6.33	1.29	2.77	1.08	-	5.00	-	36.53	7.29
1972-73	2.77	8.33	-	6.06	1.23	2.63	14.89	2.27	5.00	1.35	4.54	5.16
1973-74	2.77	2.43	18,75	3.75	3.37	2.70	11.00	5.40	6.25	-	-	4.53
1974-75	3.12	12.19	13.33	9.21	2.63	5.26	13.82	53.57	33.33	86.45	4.08	14.91

Source :- Computed from the data,
Government of Punjab (India),
Statistical abstract of Punjab 1969-75.

Appendix

Correlation Matrix

Punjab

	X	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_9
X	1.000								
X_1	-0.701	1.000							
X_2	-0.510	.553	1.000						
X_3	0.736	-.644	- .841	1.000					
X_4	- .457	.658	.958	- .720	1.000				
X_5	.148	-.321	-.375	.399	-.353	1.000			
X_6	.913	-.739	-.560	.728	-.345	0.669	1.000		
X_7	-.607	.303	.168	-.289	.155	-0.643	-.701	1.000	
X_8	0.954	.790	-.524	.775	-0.494	0.568	.965	-0.640	1.000

Appendix

Correlation Matrix

Gurdaspur

	y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
x	1.000								
X_1	0.169	1.000							
X_2	-0.042	-0.026	1.000						
X_3	0.008	-0.086	-0.899	1.000					
X_4	-0.021	0.125	0.973	-0.817	1.000				
X_5	0.893	-0.060	0.050	-0.065	0.029	1.000			
X_6	0.797	-0.016	0.057	-0.074	0.042	0.714	1.000		
X_7	-0.634	0.086	0.128	-0.189	0.112	-0.603	-0.505	1.000	
X_8	0.970	0.071	-0.006	0.016	0.012	0.905	0.797	-0.727	1.000

Appendix

Correlation Matrix

Amritsar

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000								
x_1	-0.180	1.000							
x_2	0.252	0.418	1.000						
x_3	-0.094	-0.812	-0.836	1.000					
x_4	0.133	0.655	0.844	-0.684	1.000				
x_5	0.757	-0.016	0.369	-0.362	0.304	1.000			
x_6	0.917	-0.014	0.296	-0.060	0.187	0.711	1.000		
x_7	-0.479	0.204	-0.300	0.081	-0.021	-0.385	0.608	1.000	
x_8	0.914	-0.096	0.186	0.002	0.070	0.660	0.957	-0.666	1.000

Appendix

Correlation Matrix

Kapurthala

	X	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	0.309	1.000							
X_2	-0.422	0.122	1.000						
X_3	0.154	-0.029	-0.362	1.000					
X_4	-0.424	0.171	0.845	-0.290	1.000				
X_5	0.152	-0.039	-0.023	0.078	-0.015	1.000			
X_6	0.855	0.425	-0.273	0.142	-0.347	0.055	1.000		
X_7	-0.544	-0.396	0.013	-0.184	0.123	0.233	-0.791	1.000	
X_8	0.891	0.305	-0.276	0.138	-0.394	0.179	0.962	-0.716	1.000

Appendix

Correlation Matrix

Jullunder

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000								
x_1	-0.649	1.000							
x_2	-0.635	0.341	1.000						
x_3	-0.014	0.128	-0.705	1.000					
x_4	-0.872	0.668	0.872	-0.289	1.000				
x_5	0.955	-0.554	-0.660	-0.024	-0.886	1.000			
x_6	0.890	-0.675	-0.718	0.110	-0.913	0.909	1.000		
x_7	-0.628	0.755	0.404	0.056	0.653	-0.554	-0.705	1.000	
x_8	0.922	-0.656	-0.665	0.052	0.876	0.914	0.959	-0.588	1.000

Appendix

Correlation Matrix

Hoshiarpur

	X	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	0.088	1.000							
X_2	-0.212	0.381	1.000						
X_3	0.608	0.297	-0.527	1.000					
X_4	-0.078	0.572	0.964	-0.293	1.000				
X_5	0.708	0.241	-0.020	0.509	0.118	1.000			
X_6	0.683	0.429	-0.112	0.656	0.070	0.275	1.000		
X_7	-0.755	0.027	0.207	-0.574	0.098	-0.498	-0.615	1.000	
X_8	0.872	0.419	-0.080	0.663	0.105	0.582	0.898	-0.688	1.000

Appendix

Correlation Matrix

Ropar

	y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
y	1.000								
X_1	-0.641	1.000							
X_2	-0.170	0.068	1.000						
X_3	-0.472	0.306	-0.288	1.000					
X_4	-0.076	0.249	0.900	-0.534	1.000				
X_5	0.659	-0.683	-0.355	-0.087	-0.396	1.000			
X_6	0.396	-0.656	0.631	0.027	-0.698	0.828	1.000		
X_7	-0.465	0.513	0.542	-0.140	0.575	-0.901	-0.861	1.000	
X_8	0.751	-0.783	-0.355	-0.145	-0.426	0.879	0.834	-0.784	1.000

Appendix

Correlation Matrix

Ludhiana

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000								
x_1	-0.852	1.000							
x_2	-0.752	0.749	1.000						
x_3	0.142	0.003	-0.039	1.000					
x_4	-0.590	0.690	0.903	0.245	1.000				
x_5	0.884	-0.952	-0.840	0.164	-0.742	1.000			
x_6	0.748	-0.826	-0.728	0.237	0.590	0.885	1.000		
x_7	-0.250	0.480	0.274	-0.219	0.239	-0.447	-0.524	1.000	
x_8	0.859	-0.873	-0.740	0.364	-0.594	0.941	0.907	-0.412	1.000

Appendix

Correlation Matrix

Ferozepur

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	-0.632	1.000							
X_2	-0.036	-0.098	1.000						
X_3	0.662	-0.397	-0.355	1.000					
X_4	-0.132	0.295	0.839	-0.155	1.000				
X_5	0.866	-0.516	-0.116	0.640	-0.194	1.000			
X_6	0.938	-0.775	-0.124	0.686	-0.301	0.871	1.000		
X_7	-0.659	0.778	-0.363	-0.338	-0.088	-0.611	-0.742	1.000	
X_8	0.971	-0.659	-0.075	0.776	-0.133	0.859	0.954	-0.696	1.000

Appendix

Correlation Matrix

Bhatinda

	X_y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_y	1.000								
X_1	-0.753	1.000							
X_2	-0.421	0.418	1.000						
X_3	0.449	-0.540	-0.676	1.000					
X_4	-0.517	0.585	0.901	-0.664	1.000				
X_5	-0.120	0.221	-0.194	0.022	-0.178	1.000			
X_6	0.691	-0.710	-0.540	0.735	-0.620	0.261	1.000		
X_7	-0.473	0.237	0.118	-0.093	0.201	-0.526	-0.665	1.000	
X_8	0.617	-0.516	-0.343	0.640	-0.394	0.358	0.824	-0.626	1.000

Appendix

Correlation Matrix

Sangrur

	X	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	-0.453	1.000							
X_2	-0.294	0.239	1.000						
X_3	0.841	-0.299	-0.574	1.000					
X_4	0.014	0.340	0.747	-0.084	1.000				
X_5	0.797	-0.007	-0.452	0.861	0.062	1.000			
X_6	0.784	-0.222	-0.322	0.687	0.040	0.720	1.000		
X_7	-0.305	0.164	0.113	-0.072	0.047	-0.173	-0.703	1.000	
X_8	0.898	-0.412	-0.371	0.783	-0.075	0.741	0.662	-0.327	1.000

Appendix

Correlation Matrix

Patiala

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y	1.000								
X_1	0.481	1.000							
X_2	-0.635	-0.162	1.000						
X_3	0.750	0.041	-0.885	1.000					
X_4	-0.065	0.516	0.683	-0.571	1.000				
X_5	0.838	0.296	-0.706	0.707	-0.296	1.000			
X_6	0.870	0.416	-0.595	0.623	-0.104	0.922	1.000		
X_7	-0.265	-0.392	-0.037	0.070	-0.411	-0.321	-0.544	1.000	
X_8	0.846	0.304	-0.348	0.635	-0.138	0.851	0.940	-0.578	1.000

Appendix

Correlation Matrix - 1961-62

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000								
x_1	0.220	1.000							
x_2	0.369	-0.235	1.000						
x_3	0.691	-0.123	0.644	1.000					
x_4	0.669	0.395	0.736	0.727	1.000				
x_5	0.059	0.524	0.215	0.314	0.555	1.000			
x_6	0.477	-0.416	0.694	0.684	0.467	-0.093	1.000		
x_7	-0.250	-0.660	-0.141	-0.124	-0.586	-0.691	0.225	1.000	

Appendix

Correlation Matrix - 1966-67

	X_y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_y	1.000								
X_1	-0.128	1.000							
X_2	-0.039	-0.414	1.000						
X_3	0.575	-0.429	-0.396	1.000					
X_4	0.612	0.015	0.341	0.353	1.000				
X_5	0.439	0.617	-0.612	0.300	0.312	1.000			
X_6	0.137	-0.580	0.192	0.318	0.022	-0.496	1.000		
X_7	-0.330	-0.499	0.578	-0.277	-0.185	-0.808	0.693	1.000	
X_8									

Appendix

Correlation Matrix - 1968-69

	$x\,y$	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
$x\,y$	1.000								
X_1	0.136	1.000							
X_2	-0.237	-0.411	1.000						
X_3	0.485	0.163	-0.134	1.000					
X_4	0.721	0.263	-0.306	0.515	1.000				
X_5	0.585	0.508	-0.694	0.544	0.815	1.000			
X_6	0.699	-0.133	-0.286	0.482	0.182	0.290	1.000		
X_7	-0.344	-0.410	0.637	-0.138	-0.604	-0.843	-0.139	1.000	
X_8	0.773	0.151	-0.551	0.719	0.615	0.788	0.784	-0.556	1.000

Appendix

Correlation Matrix - 1970-71

	X_y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_y	1.000								
X_1	-0.031	1.000							
X_2	0.012	-0.271	1.000						
X_3	0.403	-0.216	-0.655	1.000					
X_4	0.409	0.478	0.418	-0.090	1.000				
X_5	0.546	0.383	-0.671	0.754	0.272	1.000			
X_6	0.825	-0.034	-0.075	0.385	0.264	0.508	1.000		
X_7	0.231	-0.237	0.747	-0.435	0.321	-0.407	0.363	1.000	
X_8	0.636	0.030	0.007	0.218	0.279	0.251	0.837	0.312	1.000

Appendix

Correlation Matrix - 1971-72

	xy	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1.000								
x_1	0.330	1.000							
x_2	-0.088	0.243	1.000						
x_3	0.300	-0.370	-0.597	1.000					
x_4	0.438	0.726	0.575	0.003	1.000				
x_5	0.797	0.372	-0.272	0.581	0.544	1.000			
x_6	0.664	-0.251	-0.098	0.633	0.207	0.568	1.000		
x_7	0.688	0.142	0.017	0.658	0.637	0.848	0.801	1.000	
x_8									

Appendix

Correlation Matrix - 1972-73

	y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
y	1.000								
X_1	0.129	1.000							
X_2	-0.043	-0.338	1.000						
X_3	0.593	0.189	-0.177	1.000					
X_4	0.395	0.810	0.022	0.526	1.000				
X_5	0.575	0.539	-0.667	0.575	0.484	1.000			
X_6	0.632	0.072	-0.211	0.677	0.305	0.551	1.000		
X_7	0.846	0.408	-0.070	0.797	0.719	0.731	0.700	1.000	
X_8									

Appendix

Correlation Matrix - 1973-74

	X_1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	0.048	1.000							
X_2	-0.026	0.298	1.000						
X_3	0.327	-0.201	-0.019	1.000					
X_4	0.455	0.491	0.247	0.637	1.000				
X_5	0.355	0.665	0.009	0.405	0.659	1.000			
X_6	0.711	-0.287	0.141	0.670	0.360	0.260	1.000		
X_7	0.577	0.118	0.328	0.839	0.774	0.545	0.744	1.000	
X_8									

Appendix

Correlation Matrix (1974-75)

	X	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X	1.000								
X_1	0.118	1.000							
X_2	0.482	-0.029	1.000						
X_3	0.528	-0.286	-0.641	1.000					
X_4	0.037	0.737	0.074	0.200	1.000				
X_5	0.404	-0.193	0.103	-0.290	-0.401	1.000			
X_6	0.574	-0.047	-0.170	0.344	0.157	-0.197	1.000		
X_7	0.523	0.164	-0.724	0.763	0.378	-0.333	0.450	1.000	
X_8									

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