DETERMINANTS OF STAGNATION IN PRODUCTIVITY OF IMPORTANT CROPS IN PUNJAB

Sanjay Kumar
Parminder Singh

Agro Economic Research Centre
PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA

2010

Table of contents

List of Tables

List of Figures

ACKNOWLEDGEMENTS

Punjab agriculture has registered spectacular progress and the food-grain production in the state increased from 3 million tonnes in 1961 to 25.6 million tonnes in 2009-10 which accounted for about 13 per cent of total food-grains production in the country with only 1.75 per cent of total geographical area in the country. But the transformation of Punjab agriculture has started showing signs of new set of problems since the nineties. The productivity of major crops like wheat and rice has stagnated leading to increase in cost of production resulting in reduced profitability making many small and marginal farmers unviable. The present study was undertaken in order to analyse the growth pattern of production and productivity of important crops across the districts and state and to trace the determinants for changes in productivity and stagnation of important crops in the state. The present study was conducted in the Punjab state of India and was based on the secondary data.

The Punjab state manifests the growth in agriculture sector achieved by India after the green revolution period. The productivity of wheat in Punjab rose from 1.1 t/ha during 1960-61 to 4.5 t/ha during 2007-08 and that of paddy from 1.6 t/ha to 6.0 t/ha over the same period. The total production of wheat rose from 1.74 million tons in 1960-61 to 15.7 million tons in 2007-08 and that of paddy from 0.34 million tons to 15.7 million tons during this period. Per cultivated hectare fertilizer consumption in Punjab is about 213 kg as compared to the national average of 90 kg. Almost 97 per cent of the cultivated area is under assured irrigation which is the major reason for higher productivity and input use in agriculture. The proportion of net sown area to total geographical area has reached to 83.14 per cent by triennium ending 2006-07. The proportion of gross capital formation in Punjab agriculture at current prices to the gross capital formation showed a decline from 21.7 per cent in 1980-81 to 9.8 per cent by the year 2005-06. The growth of capital formation in public sector was lesser as compared to the private sector since 1980s. The average total expenditure on agriculture, which was Rs 14.55 crore during 1981-85, declined to Rs 9.44 crore during 1996-00 and became Rs. 55.67 crore during the period 2001-05. The state is dominated by paddy wheat crop rotation. But the problem of stagnation of productivity was found to be more acute in wheat crop as compared to rice. The problem has further aggravated recently, as there was deceleration in growth in productivity of these crops in most of the districts of the state in recent years. Due to revival of cotton during period II, the area under rice was found to decrease and replaced by cotton in south western districts of the state (cotton belt). The stagnation in area under the pulses and oilseed crops has been the main impediment in their receding output in the state. For paddy and wheat, the TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of these crops in period II as compared to the earlier period. The TFP index for cotton showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of cotton in period II as compared to the earlier period, which is due to the adoption of Bt cotton variety in the state since 2002-03, which has increased the productivity and reduced the cost of cultivation due to lesser number of sprays required for the control of insect pest and diseases in the variety. The results of decomposition of TFP confirm that market infrastructure, June to August rainfall, the agricultural terms of trade and investment on Research and Development (R&D) are the most important instruments of growth in TFP. The predominance of paddy-wheat monoculture is posing a serious threat to soil health and disturbing underground water, along with creating marketing problems and disturbing ecological balances in the state. To overcome these constraints, the study highlighted the need for evolution of high yielding variety of crops, contract farming scheme for diversification of agriculture, creation of more non-farm opportunities, integrated use of balanced chemical fertilizers in conjunction with organic manures (compost and green manure), to promote Integrated Pest Management (IPM) technology, to increase the investment on R & D, infrastructure for agro-processing industry, seed, biotechnology and product quality development.

The authors are grateful to the Ministry of Agriculture, Government of India for funding this study. We are also thankful to the coordinating centre, Agricultural Development and Rural Transformation (ADRT) Centre, Institute for Social and Economic Change, Bangalore for very well coordination of the study and providing constructive comments to the report, which has helped immensely in improving the present report.

Authors

Chapter I

Introduction

1.1 Background

Punjab agriculture has registered spectacular progress since the country became independent in 1947. At the time of independence, the Punjab agriculture was reeling under the prevalence of fragmented and scattered unirrigated holdings under zamidari system, indebtedness of farmers from moneylenders, outmoded farming techniques, subsistence farming and fluctuation in crop output. It was only after independence that an era of planning began when the first five-year plan started in 1951. The main emphasis of the five-year plans in agriculture sector was to overcome these problems. During the plans, emphasis was laid down on the consolidation of holdings, land reforms, irrigation infrastructure, power, research and extension service, credit, marketing and transport network along with effective price policy and facilities for procurement and distribution of farm inputs. Consequently, the food-grain production in the state increased from 3 million tonnes in 1961 to 25.6 million tonnes in 2009-10 which accounted for about 13 per cent of total food-grains production in the country with only 1.75 per cent of total geographical area in the country. During the same period, the share of agriculture in Net State Domestic Product and share of work force engaged in this sector decreased from 54 percent and 56 percent to 41 percent and 39 percent, respectively. Punjab is also a major contributor of food grains to the central pool, although its share has declined for paddy from 45 per cent in 1980-81 to 34 per cent in 2006-07, while for wheat also the contribution has remained at the same level (75 per cent) during the same period. But still, Punjab is the largest contributor of wheat to the central pool while it ranks second after Andhra Pradesh for contribution of paddy.

Effective price policy coupled with relatively better technology available, has resulted into the emergence of paddy and wheat crops as the most secure and profitable ones in the state. The area under other cereals, gram and oilseeds has declined significantly since the emergence of the Green Revolution period. Successive failures of cotton and low returns from this crop, have pushed the farmers to grow paddy even on marginal lands, which is another cause of concern that can thwart the efforts of diversification. The productivity of paddy and wheat has recorded a significant growth of 4.33 and 3.30 per cent per annum for the period of 1965-66 to 1989-90, but it has shown the signs of stagnation since nineties. But still the yield rates of the major crops in the state are quite high as compared to the national average. This was made possible by the Punjab state taking a big leap forward in terms of irrigation facilities, use of chemical fertilizer, pesticide, high yielding varieties, mechanization etc. The irrigated area, which was merely 54 per cent to the gross cropped area in 1960-61 has reached to a level of about 96 percent by the year 2006-07. While the proportion of area irrigated by the canals has declined from 58 per cent to 24 per cent and that of tube well irrigation has increased from 41 per cent to 76 per cent during 1960 to 2007. As a result, the proportion of area under HYVs to gross cropped area has increased tremendously. The proportion has now reached to a level of more than 94 per cent for wheat, rice and maize crops. The adoption of HYVs in Punjab raised the consumption of chemical fertilizers tremendously in the state. The per hectare consumption of chemical fertilizers which was merely one kg in 1960-61 has achieved the levels of 225 kgs in 2008-09. Since the introduction of high yielding varieties, the consumption of chemical fertilizers has been increasing steadily from 5 thousand tonnes in 1960-61 to 1767 thousand tonnes in 2008-09. The rapid adoption of the green revolution technology in Punjab has led to the sharp increase in

farm mechanization. The number of tractors jumped from 22345 in 1970-71 to 4.41 lakhs in 2000-01. There were only 6 tractors per thousand hectares in 1970-71 which shot to 103 in 2007-08. The Punjab state is one of the leading states for number of tractors tillers in terms of density per 1000 hectare of net sown area. This excessive mechanization has led to the underutilization of farm machinery, which ultimately results in raising the cost of production.

1.2. Need for the Present Study

The transformation of Punjab agriculture has started showing signs of new set of problems since the nineties. The productivity of major crops like wheat and rice has stagnated leading to increase in cost of production resulting in reduced profitability making many small and marginal farmers unviable. It is important to note that the growth in recent past as well as during the last three decades has been attributed due to adoption of innovative technologies. Thereafter, the impacts of technology have slowed down mainly because of soil fatigue resulting in decline in fertilizers use efficiency. A strong tendency is developing among small and marginal farmers to lease out their land due to uneconomic holdings. This along with stunted growth of non-agriculture sector, over utilization of farm machinery, migratory agricultural labour from other states and use of the weedicides have further aggravated the problem of unemployment. The predominance of paddy-wheat monoculture is posing a great threat to soil health, resulting in depletion of underground water. It is also resulted in some marketing problems besides creating ecological imbalances in the state. The new world trade agreements under the WTO regime during nineties put further pressure on the state agriculture economy to face tough competition in the international markets.

It is well beyond the doubt that the productivity of crops varies across regions and sub-regions depending their agro-climatic conditions. In some regions, the yield level of crops are much below the potential due to lack of developmental initiatives of the state and incentives to the farmers. Moreover, at the macro level (both national and state) aggregated productivities of various crops do not provide enough picture of the extent of variations and factors determining these variations in them.

A historical meeting of the National Development Council was called by the Prime Minister specially to discuss the problems of agricultural sector. The NDC appointed sub-committees for finding solutions to the current problems in agricultural sector and a sub-Committee headed by Shri Naveen Patnaik, Chief Minister of Orissa state looked into the problems of stagnation in productivity. The sub-committee submitted its report and opined that the causes of stagnation in the agricultural sector are region specific and hence policy interventions have to be chalked out keeping in view the regional specifications (GoI, 2007).

Hence, the present study tries to examine the district-wise growth and the stagnation in the important agricultural crops. Further, it also seeks to find out the causes and remedial policies to deal with the stagnation.

1.3 Objectives of the study

1. To analyse the growth pattern of production and productivity of important crops across the districts and State;
2. To study the regional variations in productivity of important crops (specifically bringing out the districts with differentiated growth behaviour) and to map out the regions with acute stagnation;

3. To trace the determinants for changes in productivity and stagnation of important crops, and
4. To suggest district level interventions to overcome the problems of stagnation.

1.4 Organisation of the Study

This study is organized into six chapters. Chapter I is introduction. It gives a brief account of the agricultural development and subsequent changes in agricultural policy measures in Punjab and the emergence of problems of productivity stagnation in Punjab agriculture and enlist the objectives of the present study.

Agricultural development scenario of the state is discussed in chapter II, where development pattern of the land use, input use, cost structure, prices and capital formation of the state agriculture economy are analyzed. Chapter III relates to the review of the literature on the measurement of agricultural growth and stagnation and methodology adopted for the present study. The study of trends in agricultural production and productivity at the district level in the state forms the IV chapter. Chapter V highlights the determinants of stagnation of productivity of important crops in the state. Finally, the Chapter VI encompasses the conclusions drawn from the present study.

Chapter II
Recent Developments in Agriculture in the State

2.1. Introduction

The Punjab state manifests the growth in agriculture sector achieved by India after the green revolution period. With mere 1.53% of the geographical area of India, it contributes around 55-65% of wheat and 35-45% of rice to the national pool every year. The productivity of wheat rose from 1.1 t/ha during 1960-61 to 4.5 t/ha during 2007-08 and that of paddy from 1.6 t/ha to 6.0 t/ha over the same period. The total production of wheat rose from 1.74 million tons in 1960-61 to 15.7 million tons in 2007-08 and that of paddy from 0.34 million tons to 15.7 million tons during this period. Additionally, the state now produces 10% milk, 26% honey and 48% mushrooms of the country. Per cultivated hectare fertilizer consumption is about 213 kg as compared to the national average of 90 kg. Almost 97 per cent of the cultivated area is under assured irrigation which is the major reason for higher productivity and input use in agriculture.

This structural transformation was the result of new farm technology in the form of high yielding seeds, fertilizers and pesticides as well as irrigation infrastructure and agricultural credit. Rapid dissemination and adoption of new technologies, development of necessary infrastructure and setting up of institutional mechanisms for the supply of agricultural inputs and procurement of agricultural produce created an enabling environment in enhancing agricultural production. The income from such increased agricultural production resulted in better education, health care and social status of the people in rural areas.

However, the state agriculture is currently facing many difficulties which are hampering its potential for realizing higher growth in future. The growth rate in

agriculture, which was 6.63 per cent per annum in mid 1960s to mid 1970s and 4.74 per cent per annum during the next decade, decelerated to 3.87 per cent per annum in the third decade and was barely 1.3 percent after the mid 1990s. The farm household incomes could grow barely at 1.21% annually during the 1990s after growing tremendously at 8-9% per annum during the 1970s and 1980s. The agriculture sector is in crisis and the negative impacts of intensive agriculture have manifested in many forms. Besides slow down in agricultural growth, escalation in costs of production and falling profitability, reduction in employment elasticity of agriculture sector, increased incidence of landlessness and indebtedness among farmers and farmers' suicides are other major issues afflicting Punjab agriculture. Degradation of natural resources in the form of fall in the ground water table, increasing incidence of nutrient deficiency in the soils, including micronutrients and insect-pest attacks on the crops are also posing major threats to productivity, food grain production and sustainability of agriculture in the long run.

2.2. Rainfall

The district-wise annual rainfall was estimated for Punjab since 1960-61 and presented in Table 2.1. Various districts of Punjab can be divided into four categories based on the quantum of rainfall across the state. The Northern region of the state lies in the Shivalik foothills and experiences heavy rains, particularly during the monsoon. The districts of Gurdaspur, Hoshiarpur and Rupnagar can be categorized into the high rainfall regions as the average annual rainfall was observed to be higher than the state average over different years. Besides paddy and wheat maize is also one of the important crops in these districts. The districts like Amritsar, Kapurthala, Jalandhar, Patiala and Ludhiana can be categorized into the medium rainfall region of the state as the average annual rainfall in these districts was near the average rainfall of the state in most of the years

under study. This region comprises the Western, Eastern and Central regions of the state. The technological breakthrough during the green revolution has mostly impacted this region of the state and most of the region is irrigated through the electric tube-wells. Paddy and wheat are the predominant crops of the region. Sangrur and Faridkot districts of the state can be categorized into low rainfall region as in most of the years the average annual rainfall was found to be lesser than the state average. The region lies in the Southern part of the state. Besides paddy and wheat, cotton is also one of the important crops of the region. Canals also play an important role in irrigating the farm fields. Ferozepur and Bathinda can be categorized into the very low/scarce rainfall region of the state as lowest rainfall was observed in these districts of the state over the study period. The region lies in the Southern part of the state. Wheat in the rabi season and cotton and paddy in the kharif season are the important crops of region. Canals are the main source of irrigation in this region.

Table 2.1: Average Annual Rainfall in the State: 1960-61 to 2005-06

(mm)

Districts	1961-65	1966-70	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-06
High rainfall regions										
Gurdaspur	1127	989	825	1068	490	908	1065	940	875	955
Hoshiarpur	1047	850	765	830	389	1102	965	835	613	579
Rupnagar	NA	833	733	731	363	971	884	751	695	450
Medium rainfall regions										
Amritsar	635	605	472	707	418	689	475	567	938	426
Kapurthala	542	582	498	517	429	558	628	650	407	571
Jalandhar	699	679	484	673	464	883	682	945	543	615
Patiala	700	555	568	723	354	786	755	658	499	450
Ludhiana	707	593	571	657	187	642	659	537	417	381
Low rainfall regions										
Sangrur	548	488	438	455	392	493	347	407	206	422
Faridkot	NA	NA	271	453	188	387	418	569	264	490
Very low/Scare rainfall										
Firozpur	405	345	309	465	325	400	365	273	68	252
Bathinda	523	409	369	366	152	332	173	163	166	321
Punjab Average	693	630	522	633	331	721	610	591	401	492

Source: Various issues of Statistical Abstracts of Punjab

2.3. Irrigation Status

The excellent network of irrigation facilities is serving the Punjab agriculture. Irrigation coverage, which was about 76 per cent of net sown area in triennium ending 1972-73, has increased to the level of about 97 per cent in triennium ending 2006-07 (Table 2.2). Canals and tube wells are the main sources of irrigation in the state. Punjab has an irrigation distribution network of 1,45,000 kilometres of canals including branch canals and minor distributaries, and one lakh kilometres of field channels or water courses. The canal irrigation system irrigated 13,08,000 hectare land in triennium ending 1972-73 while only 11,41,000 hectare was irrigated in triennium ending 2006-07. While canal irrigation has been declining over the years, tube well irrigation, particularly in the central and northern region of Punjab has been on an increase. This is mainly due to availability of cheap credit and free supply of electricity in the state. But the extensive use of canal irrigation and reckless use of ground water through tube wells have caused water logging problems in some areas and lowering of the ground water table in other areas.

Table2.2: Proportion of Gross Irrigated Area and Net Irrigated Area from different Sources of Irrigation Triennium Ending Average (TE) 1972-73 to 2006-07

Particulars	1972-73	1982-83	1992-93	2000-01	2003-04	2004-05	2005-06	2006-07
Gross Irrigated Area(000,ha)	4396.8	5965.2	7102.9	7619.4	7632	7692.2	7679.7	7657.4
Percent GIA to GCA	76.1	86.8	94.4	96.3	96.9	97	97.6	97.4
Source of Irrigation: Percentage to Net Irrigated Area								
Govt. Canals	44.69	40.76	38.67	26.34	27.76	27.29	27.93	29.16
Private Canals	0.18	0.00	0.15	0.00	0.00	0.17	0.10	0.10
Tubewells & Wells	54.62	58.92	60.97	73.53	72.07	72.34	71.77	70.75
Other sources	0.51	0.32	0.20	0.12	0.17	0.20	0.20	0.00
Net Irrigated Area(000 ha)	2927.7 (100.0)	3446.7 (100.0)	3903.3 (100.0)	4017 (100.0)	4032.0 (100.0)	4035.0 (100.0)	4060.0 (100.0)	4078.0 (100.0)

Note: TE indicates Triennium Ending Average
Source: Various issues of Statistical Abstracts of Punjab

2.4. Land Use Pattern

Punjab is a tiny state with total geographical area of 50.33 lakh hectares (Table2.3). There has been continuous increase in the net sown area in the state since 1960-61 and the

proportion of net sown area to total geographical area, which was 75.83 per cent in triennium ending 1962-63 has reached to 83.14 per cent by triennium ending 2006-07. This was made possible by the adoption of short duration dwarf varieties of wheat and rice, along with the expansion in the irrigated area, fertilizer consumption and growth of farm mechanization in the state. There has been significant increase in area under forests in the state as proportion of area under forests to total geographical area increased from 0.68 per cent in triennium ending 1962-63 to 5.42 per cent by triennium ending 2006-07. There has been significant decrease in area under permanent barren and unculturable land and current fallow over the study period of 1960-60 to 2006-07. There has been marginal increase in net area sown from 3.81 million ha in triennium ending 1962-63 to 4.18 million ha by triennium ending 2006-07, though the gross cropped area increased from around 4.84 million ha to 7.87 million ha during the same period. This has resulted in an increase in the cropping intensity from around 127 per cent in triennium ending 1962-63 to about 189 per cent in triennium ending 2006-07. This increase was higher during the period of 1960-61 to 1980-81 as compared to the later period and it has not increased from the level of 186 per cent since the year 1995-96. Because of the absence of any scope to increase the cultivated area of the state horizontally, the vertical expansion of area has become increasingly limited due to already achieved higher levels of cropping intensity and some topographical and irrigational constraints in some pockets of the state. Therefore, sustainability in the growth of production per unit of land area has to come through raising the input use efficiency or upward shift in the use of technology.

Table 2.3: Changes in the Land Use Pattern

(Percent to total geographical area)

Type of Land use	TE 1962-63	TE 1972-73	TE 1982-83	TE 1992-93	TE 2000-01	TE 2006-07
Forests	0.68	2.35	4.38	4.77	5.89	5.42
Barren and un culturable land	Na	4.13	1.84	1.53	4.65	0.52
Land put to non-agricultural uses	Na	8.28	8.61	7.52	3.47	9.35
Culturable waste	Na	1.56	0.77	0.64	0.59	0.16
Permanent pastures & other grazing lands	Na	0.1	0.08	0.12	0.08	0.08
Land under Misc. tree crops and groves	Na	0.08	0.07	0.15	0.09	0.07
Current fallows	5.49	2.56	0.8	1.7	0.85	0.79
Other fallow lands	Na	Na	0.02	0.37	0.09	0.01
Net Area sown	75.83	80.93	83.60	83.26	84.29	83.14
Area sown more than once	20.50	33.92	53.09	66.23	76.64	73.56
Geographical Area (Lakh ha)	5038	5036	5036	5036	5036	5036

Note: TE indicates Triennium Ending Average
Source: Various issues of Statistical Abstracts of Punjab

2.5 Changing Structure of Landholdings

Since the introduction of the green revolution technology, the agrarian structure of Punjab has witnessed interesting changes. Till 1980-81, the number of marginal and small holdings declined sharply, while those in the higher-size categories showed a modest increase. These changes occurred primarily due to the reasons that with the onset of the green revolution technology, crop production activities became economically attractive, which created an active land-market for leasing and selling land. In the later period (1980-81 to 1990-91), when profitability in farming started falling and growth of employment opportunities in the non-farm sector became limited, the absolute number of holdings in the state increased, even with a significant decline in the total operated area. Consequently, the average holding size in the state fell sharply from 4.07 hectare in 1980-81 to 3.61 hectare in 1990-91 (Table 2.4). All except the small farmers registered a decline in average landholding size. The number of marginal farmers increased steeply from 1,97,323 in 1980-81 to 2,95,568 in 1990-91 (an increase of more than 50%), while their operating land base, during the same period, increased from a total of 1,26,000

hectare to around 1,64,000 hectare (i.e., an increase of about 30%). Small farms too increased but marginally, with more than a proportionate increase in their total operated area, primarily due to progressive subdivision of medium and large farms under the law of inheritance. These negative developments in Punjab agriculture appear to have been slightly arrested now. Data from the 2000-01 agriculture census indicated that the average holding size in the state had improved to nearly 4.03 hectare but there was marginal decrease to 3.95 hectare in the recent years (2005-06). In 2000-01, except marginal and small farms, all other categories of farms have considerably increased. As a result, the average operating land base for all categories of farms has declined, except for the marginal ones. The state of agrarian structure was due to the fact that marginal and small size farming, though the largest in numbers, were fast becoming unviable and were leasing out land to large farmers but the trend seems to be reversing marginally in 2005-06.

Table 2.4: Changing Structure of Land Holdings and Area Operated: 1970-71 to 2005-06

Holdings	Number of holdings					Area Operated (000 hectare)				
	1970-71	1980-81	1990-91	2000-01	2005-06 (P)	1970 -71	1980-81	1990-91	2000-01	2005-06 (P)
Marginal (Below 1.0 ha)	517568 (37.63)	197323 (19.21)	295568 (26.46)	122761 (12.31)	134000 (13.36)	NA	126 (3.02)	164 (4.07)	77 (1.91)	83 (2.09)
Small (1.00-1.99 ha)	260083 (18.91)	199368 (19.41)	203842 918.25)	173071 (17.35)	183000 (18.25)	NA	291 (6.98)	328 (8.13)	242 (6.02)	258 (6.51)
Semi-Medium (2.00-3.99 ha)	281103 (20.44)	287423 (27.98)	288888 (25.86)	328231 (32.91)	319000 (31.80)	NA	841 920.16)	841 (20.86)	876 (21.78)	855 (21.57)
Medium (4.00 -9.99 ha)	247755 (18.01)	269072 (26.20)	261481 (23.41)	300977 (30.18)	296000 (29.51)	NA	1672 (40.09)	1622 (40.23)	1731 (43.04)	1701 (42.91)
Large (10.00 & above)	68883 (5.01)	73941 (.20)	67172 (6.01)	72356 (7.25)	71000 (7.08)	NA	1241 929.75)	1077 (26.71)	1096 (27.25)	1067 (26.92)
All	1375392 (100.0)	1027127 (100.0)	1116951 (100.0)	997396 (100.0)	1003000 (100.00)	NA	4171 (100.0)	4032 (100.0)	4022 (100.0)	3964 (100.00)
Average						NA	4.07	3.61	4.03	3.95

Note: P denotes Provisional.
Source: Various issues of Statistical Abstracts of Punjab.

2.6. Changes in Cropping Pattern

Cereals, particularly rice and wheat dominate the cropping pattern scenario in the state. This has been made possible through the technological breakthrough in wheat and rice

crops along with higher use of fertilizers and HYV seeds and assured price policy for these crops in the state. Due to these policies, the country has become net exporter of food grains as compared to the position of net importer in the early 1960s. Punjab has also been significantly contributing rice and wheat to the national pool. Although, wheat was grown on about 30 per cent of gross cropped area in the state in triennium ending 1962-63 but Punjab was not a traditional rice grower as it occupied only about 5 per cent of GCA in the state. The dominance of rice in the cropping pattern, which has occupied about 33 per cent of the GCA in the state in triennium ending 2006-07, has serious implications on the indiscriminate and uncontrolled u se of ground water resources.A perusal of the Table 2.5 also revealed that the increase in area under paddy and wheat in the state was at the expense of area under oilseed, pulses, maize and bajra crops. The proportion of area under oilseed and pulses to the gross cropped area was about 23 per cent in triennium ending 1962-63 has come down to the level of about one per cent in the year triennium ending 2006-07. Area under gram, which used to be the most important pulse crop in the state during the sixties, has recorded a sharp decline from about 8,37,493 hectare in triennium ending 1962-63 to less than 10,000 hectare in triennium ending 2006-07. Yield of gram, which stagnated till 1990-91, has started improving, though it has not yet become attractive enough to arrest the decline in its area and production.This tremendous decrease in area under these crops may be attributed to the absence of technological improvements and ineffective price policy for these crops in the state. Cotton is also one of the important crops in the state but due to severe attack of insect-pest and variation in prices, the area and productivity of this crop has very wide fluctuations. Areas under crops such as sugarcane, potato, etc., have not remained stable (Table 2.5).

Table 2.5: Changes in the Cropping Pattern

(Percent to Gross Cropped Area)

Crop	TE 1962-63	TE 1972-73	TE 1982-83	TE 1992-93	TE 2000-01	TE 2006-07
Rice	4.8	7.6	19.3	27.3	31.8	33.5
Maize	4.9	9.6	5.0	2.5	2.0	1.9
Jowar	0.1	0.1	0.0	0.0	0.0	0.0
Bajra	2.7	2.8	0.8	0.1	0.1	0.1
Wheat	30.0	40.6	42.7	43.4	41.7	44.0
Barley	1.3	0.9	1.1	0.6	0.4	0.2
Other cereals	0.3	0.0	0.0	0.0	0.0	0.0
Total Cereals	44.1	61.6	67.9	73.9	76.0	79.7
Black gram	17.3	5.8	3.0	0.5	0.1	0.1
Other pulses	1.4	1.0	1.2	1.0	0.7	0.3
Total pulses	18.7	6.8	4.2	1.5	0.8	0.4
Total Food grains	62.8	68.4	72.1	75.4	76.8	80.1
Groundnut	1.5	2.9	1.2	0.2	0.1	0.1
Total Oil seeds	3.9	5.6	3.2	2.3	1.3	1.0
Cotton-A	4.6	4.0	7.9	8.4	4.9	6.5
Cotton-D	5.0	4.0	2.1	1.0	1.3	0.6
Sugarcane	2.6	1.9	1.4	1.4	1.4	1.1
Tobacco	NA	NA	NA	NA	NA	NA
Dry Chillies	0.0	0.3	0.1	0.0	0.0	0.0
Fruits	NA	NA	0.3	1.0	0.6	0.7
Vegetables	NA	NA	0.6	0.8	1.5	1.4
Gross Cropped Area (in ha)	4841000	5778000	6869000	7524000	8099000	7887000

Note: TE indicates Triennium Ending Average
Source: Various issues of Statistical Abstracts of Punjab

2.7. Area, Production and Productivity Growth

The temporal changes in the area, production and productivity of different crops in the Punjab state has been presented in Table 2.6 and the productivity level of important crops are shown in Fig. 1. To ascertain the temporal growth in area, production and productivity of different crops in the Punjab state, the analysis were done for the four periods viz. period I (1960-61 to 1966-67); period II (1967-68 to 1979-80); period III (1980-81 to 1989-90) and period IV (1990-91 to 2006-07).

There was tremendous increase in area, production and yield under paddy for all the periods under study. Wheat also showed the same trend but the increase was at lesser pace than for the paddy. Increase in area and productivity of these crops are the main movers for this increase in production of these crops in the state. All other crops showed either decrease in area or the insignificant increase in area during this period. It clearly reveals that the paddy and wheat crop rotation became predominant at the cost of maize, other cereals, oilseed and pulses in the state. A cursory glance on the table revealed that the productivity of paddy was consistently improving over the years but the growth has slowed down in period III, particularly during nineties. The productivity of rice increased

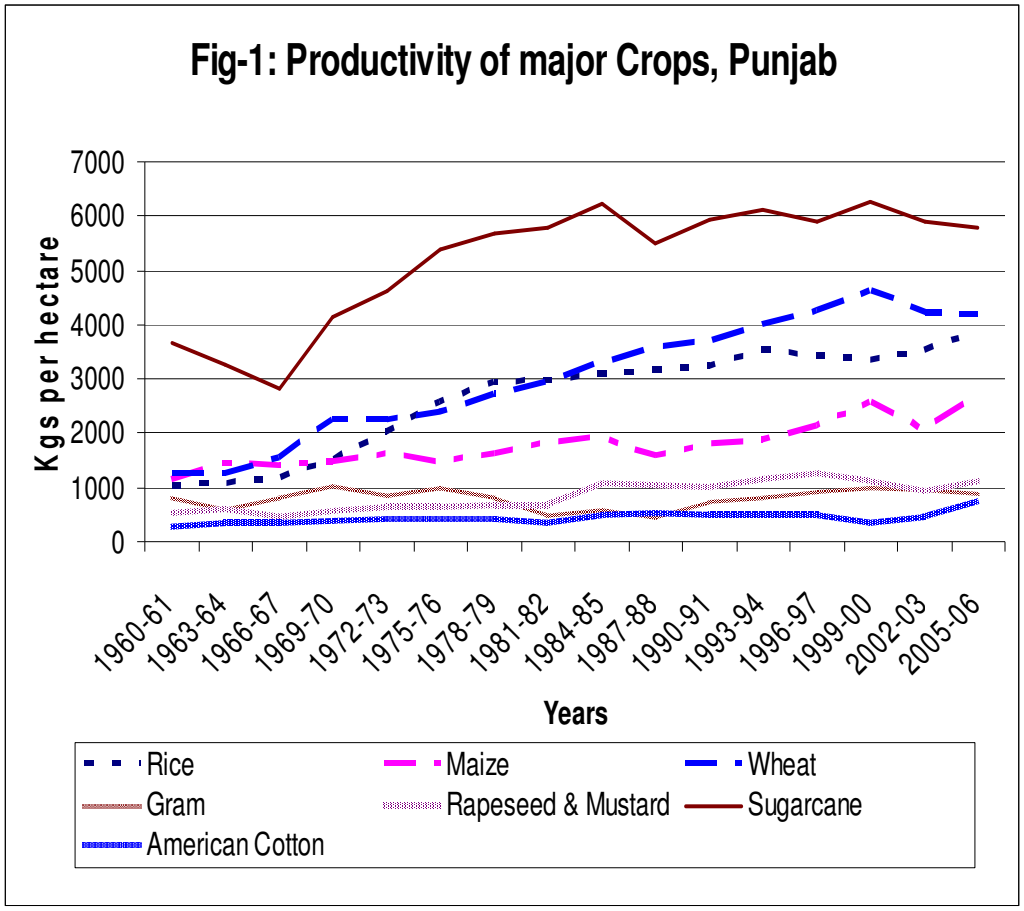


Table 2.6: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods

(Per cent per annum)

YEAR	1960-61 to 1966-67			1967-68 to 1979-80			1980-81 to 1989-90			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	4.86** (0.75)	7.18** (1.76)	2.20 (1.40)	11.17** (0.78)	18.90** (0.79)	6.95** (0.70)	5.34** (0.62)	6.70** (1.23)	1.30 (0.78)	1.86** (1.86)	2.95** (0.23)	1.07** (0.22)
Bajra	6.83 (3.93)	10.57 (6.66)	3.97 (4.67)	-8.54** (1.80)	-9.04** (1.94)	-0.55 (0.80)	-18.63** (2.31)	-21.34** (2.21)	-3.07* (1.24)	-3.45* (1.26)	-4.61** (1.48)	-0.98 (0.60)
Maize	23.60 (20.51)	10.14* (3.65)	5.11 (3.82)	-1.47 (0.82)	-1.38 (0.85)	-0.08 (0.83)	-5.64** (0.55)	-6.83** (1.49)	-1.27 (1.74)	-1.42** (0.19)	1.68* (0.65)	3.13** (0.57)
Wheat	2.20** (0.35)	5.44* (1.89)	3.17 (1.74)	2.95** (0.40)	5.42** (0.70)	2.40** (0.37)	1.25** (0.25)	4.29** (0.67)	3.0** (0.65)	0.45** (0.07)	1.31** (0.29)	0.29 (2.72)
Barley	4.54 (4.27)	8.59* (3.68)	3.76 (3.43)	-4.98 (3.35)	-1.26 (3.32)	3.87** (0.87)	-7.92** (1.71)	-2.99 (2.50)	5.55** (1.38)	-5.32** (0.52)	-4.0** (0.68)	1.38** (0.28)
Other cereals	-32.60* (11.95)	0.0 (9.90)	-	-1.89 (1.89)	-7.69** (1.29)	-	1.42 (6.82)	-3.67 (6.27)	-	0.68 (2.18)	5.63 (5.41)	-
Total Cereals	4.23** (1.23)	6.64** (1.53)	-	3.05** (0.20)	6.36** (0.53)	-	1.81** (0.26)	4.55** (0.57)	-	0.92** (0.10)	1.90** (0.23)	-
Gram	-5.64** (1.07)	-6.95 (3.58)	-1.39 (3.22)	-2.86* (1.19)	-3.27 (1.83)	0.12 (0.95)	14.15** (2.15)	-10.20* (3.83)	4.52 (2.84)	-13.61** (0.90)	-12.30** (0.94)	1.46** (0.48)
Other pulses	-4.96* (2.43)	-5.29* (2.30)	-	0.71 (1.18)	0.01 (1.46)	-	0.88 (1.64)	1.89 (3.32)	-	-7.28** (0.72)	-7.94** (0.72)	-
Total pulses	-5.58** (1.14)	-6.87* (3.43)	-	-2.51* (1.0)	-2.63 (1.68)		-8.21** (1.54)	-5.04* (2.50)	-	-8.71** (0.57)	-9.01** (0.62)	-
Total Food grains	0.89 (0.52)	4.24* (1.77)	-	2.46** (0.17)	5.96** (0.48)	-	1.58** (0.32)	4.46** (0.57)	-	0.81** (0.10)	1.88** (0.23)	-
Arhar	-	-	-	14.59** (3.23)	18.05** (3.64)	3.02* (1.03)	2.40 (4.93)	0.55 (5.83)	-1.81 (1.71)	-3.16** (0.49)	-3.79** (0.76)	-0.66 (0.69)
Moong	-11.34** (3.68)	-6.38 (4.62)	5.62** (1.85)	0.80 (2.82)	2.53 (2.89)	1.71 (1.01)	10.46** (2.66)	8.78* (3.90)	-1.52 (1.51)	-9.64** (1.10)	-10.10** (1.15)	-0.51 (0.88)
Rapeseed & mustard	-0.52 (2.70)	0.34 (1.27)	0.87 (3.02)	0.90 (2.58)	2.06 (3.08)	3.19* (1.25)	-0.04 (2.57)	5.51 (3.59)	5.49** (1.66)	-3.78** (0.83)	-3.37** (0.93)	0.41 (0.55)
Sunflower	-	-	-	-	-	-	-	-	-	-1.39 (4.75)	-1.16 (4.84)	0.07 (0.56)
Sesamum	7.85 (5.94)	9.61* (4.79)	1.64 (3.65)	0.73 (2.27)	0.70 (2.16)	-0.03 (0.74)	-1.85 (2.12)	-1.20 (1.73)	0.67 (1.59)	-4.01** (0.88)	-4.23** (1.01)	-0.22 (0.57)
Total Oilseeds	8.42** (1.85)	15.40** (2.11)	-	-3.30** (1.10)	-3.33* (1.18)	-	-4.53* (1.72)	-2.56 (2.38)	-	-5.76** (1.24)	-6.22** (1.63)	-
Sugarcane	3.91 (2.87)	2.50 (3.47)	-1.32 (1.99)	-3.41** (0.92)	0.77 (1.30)	4.31** (0.65)	2.07 (1.59)	2.71 (1.56)	0.64 (0.70)	0.15 (1.18)	-0.13 (1.21)	0.29 (0.25)
Dry chillies	-	-	-	-0.98 (2.72)	-1.18 (2.59)	-0.20 (0.79)	-14.48** (2.03)	-9.47** (2.22)	2.28 (0.93)	-3.73* (1.39)	-3.12* (1.44)	0.64** (0.20)
Potato	9.46** (2.51)	10.57* (3.87)	0.95	10.31** (1.29)	15.00** (1.90)	4.32** (0.84)	-2.37** (1.62)	-2.47 (1.65)	0.29 (2.59)	8.07** (1.24)	8.02** (1.33)	-0.19 (0.46)
Cotton A	-1.23 (2.01)	1.80 (2.51)	3.04** (0.90)	7.67** (0.77)	8.17** (0.76)	-0.12 (0.42)	2.44 (1.70)	11.28** (2.81)	8.61* (1.85)	-2.32* (0.86)	-0.85 (2.39)	1.51 (2.03)
Cotton D	0.38 (1.96)	0.01 (2.33)	-0.36 (0.51)	-0.94 (1.15)	-2.35 (1.53)	-1.96** (0.46)	-10.83** (1.85)	-5.72 (3.16)	5.71 (2.910	-2.10 (1.84)	1.18 (1.72)	3.32* (1.25)

**significant at I percent level
* Significant at 5 per cent level

Note: figures in the parentheses indicate Standard error

at the significant rate of 6.95 per cent per annum during period II, but then it plateau during the period III and did not show any significant growth. Recently, the productivity of paddy also showed the signs of stagnation but the decline in the wheat yield was more dramatic as compared to paddy. It shows that the genetic potential of wheat was exploited till 1980s and then got stabilized while in paddy crop, the process has been continuing but the rate of growth has slowed down. The monoculture of paddy and wheat has also caused resurgence of pest and diseases and weeds, which have adversely affected the crop yield. Cotton (American) showed significant increase in area during the period II and III and replaced the area under Cotton (Desi). But due to the persistent attack of insect pest on the Cotton (American) crop, its area and production was badly hit during nineties. The productivity of sugarcane and potato have also stagnated during the recent years. Recently, the productivity growth was notable for maize in the state, but the area was still decreasing at a significant rate.

2.8. Changes in Inputs Use

Agricultural Credit

The adoption of HYVs itself might not have occurred on a large scale, if the state had not taken the complementary steps of expanding the availability of rural credit through formal credit institutions, such as co-operative societies, co-operative banks, land mortgage banks, regional rural banks and commercial banks. Besides institutional credit, a substantial amount of credit flows to the farmers from non-formal channels, i.e. commission agents or arhtias. The use of agricultural loans for the unproductive purpose like marriage, social functions, medical treatment etc. has resulted in the present situation of indebtedness in the state (Grover et al.; 2003). Compared to other states, the spread of banks is fairly well developed in Punjab. There are 50 bank branches per thousand square km in Punjab as compared to 20 for the whole country, 21 for Maharashtra, 18 for Andhra Pradesh and 19 for Gujarat. Overall, on an

average, the total availability of agricultural credit has increased form Rs 945 million during 1971-75 to Rs 88838 million in 2001-05 (Table 2.7). Till mid 1960s primary agricultural cooperative societies were the only formal agency for the disbursal of rural credit. This availability of credit was augmented through Land Development Banks (LDB) and later through commercial and regional rural banks.

Fertilizer

Fertilizer, the most important component of new technology, has played a very important role in enhancing the agricultural production in the state. The availability of high fertilizer responsive varieties of seed along with assured source of irrigation increased the consumption of chemical fertilizers in the state. Total consumption of NPK in Punjab, which was merely 276 thousand nutrient tones during 1971-75, has continuously increased over time and reached to a level of 14.52 lakh nutrient tones by the period 2001-05 (Table 2.7). Now, Punjab has the highest consumption of chemical fertilizer per hectare in the country. It consumed about 184 kgs/ha of fertilizers in the period 2001-05 as compared to average of 47kgs/ha during 1971-75. While the productivity of crops increased during the first two decades, on account of increasing nutrient use efficiency, it began to decline thereafter on account of imbalances in the use of N, P and K, along with the deficiencies of micro nutrients. The use of nitrogenous fertilizers showed a significant growth of 2.52 per cent while phosphatic and potassic fertilizers showed a negative growth rate over the period of 1985-86 to 1999-2000 (Singh et al., 2002). This has further distorted the NPK ratio in favour of nitrogenous fertilizer, which is disturbing the soil structure of the Punjab farms.

Table 2.7: Major inputs use

Year	Gross Area under HYVs (000,ha)	Agriculture Credit (in lakhs)	Tractor (Number)	No. Pump set (Number)		Fertiliser consumption (NPK)	
				Electrical	Diesel	Per ha GCA (kg)	Total (000,nutrients tonnes)
1971-75	2232.60	9451.12	39469	120600	182600	47.03	275.80
1976-80	3375.60	23798.33	82400	234400	343400	75.04	484.40
1981-85	4450.60	76278.70	143100	384600	281200	130.09	901.20
1986-90	4995.20	124328.39	226600	548000	211600	153.18	1117.60
1991-95	5432.40	205677.15	293000	648200	190000	162.72	1233.00
1996-00	5691.60	394593.03	375951	732000	173000	168.74	1321.40
2001-05	6120.80	888386.07	450691	827000	242400	183.96	1452.80

Source: Various issues of Statistical Abstracts of Punjab and Directororate of Agriculture, Punjab

Agricultural Machinery

The rapid adoption of green revolution technology in Punjab has led to a sharp increase in farm mechanization. The Punjab agriculture is highly mechanized in nature. The density of tractors per thousand hectares is 64 in Punjab, which is highest in India. It has increased from the level of mere 5 tractors per thousand hectares of land during 1960-61. On an average, there is now one tractor for every eight hectare of net cultivated land, and in some districts the area operated by a tractor is even lower. There are numerous farmers in Punjab with little land, owning a tractor, while many large farmers have more than one tractor. The available stock of tractors in the state is not fully utilized. In addition, lack of facilities for the service and maintenance of farm equipment near the villages results in raising the cost of production. Excessive farm tractorization has caused damage to physico-chemical characteristics of soils, particularly where puddling is done for rice cultivation. With the loss of soil characteristics, biological activities are also impaired and in the long run, such soils are likely to become unproductive. Similarly, electric tube wells are increasing rapidly in Punjab and it has crossed the figure of 8.27 lakh by 2001-05 (Table 2.7). Diesel engines are also increasing in the state but at lesser pace than the electrical tube wells. It was due to the policy of supply of free electricity of the state

Govt. The number of diesel tube wells it has reached 2.42 lakh by 2001-05. The large-scale farm mechanization has led to increase in cropping intensity and commercialization of Punjab agriculture. But in turn, there has been decline in the use of agricultural labour and underutilization of farm machinery, which has led to increase in the cost of production of agriculture in the state.

Seed

As already discussed, the impact of Green Revolution was achieved due to the adoption of high yielding varieties (HYVs), particularly for paddy and wheat and presently almost all the area under rice, wheat and bajra has been covered by the high yielding variety seeds. Punjab was never known for rice cultivation. It was only after the adoption of short stature HYVs of rice IR8 in 1968 and Jaya in 1971, along with the expanded tube well irrigation facilities, the area under rice showed a tremendous increase. The area under HYVs of rice, wheat and bajra was about 57, 72 and 45 per cent respectively in triennium ending 1972-73 (Table 2.8). For maize, the area under HYVs increased tremendously from 7 per cent in triennium ending 1972-73 to about 95 per cent by triennium ending 2006-07. Overall, the area under HYVs increased from about 21 lakh hectares in the triennium ending 1972-73 to about 63 lakh hectares during triennium ending 2006-07. The introduction of HYVs of different crops resulted in big jump in the productivity of these crops in the state. It is this remarkable increase in productivity of rice and wheat in the state that came to be known as green revolution. But the saturation of yield of rice and wheat in the recent years calls for an urgent need for further genetical improvement in the present day varieties used in the state.

Table 2.8: Area under HYV Crops of the State

(Percentage Area to total area under the Crop)

Crop	TE 1962-63	TE 1972-73	TE 1982-83	TE 1992-93	TE 2000-01	TE 2006-07
Rice	NA	56.6	94.4	93.6	97.0	100.0
Maize	NA	6.8	36.4	89.4	91.3	94.5
Bajra	NA	44.9	60.6	96.7	68.8	100.0
Wheat	NA	72.4	98.8	100.0	100.0	100.0
Gross area under HYVs(in ha)	NA	2058000	4238000	5356000	6030000	6258000

Note: TE indicates Triennium Ending Average
Source: Various issues of Statistical Abstracts of Punjab

Table 2.9: Gross Area under Irrigation of Principal Crops of the State

(thousand hectares)

Crop	TE 1962-63	TE 1972-73	TE 1982-83	TE 1992-93	TE 2000-01	TE 2006-07
Rice	188.0 (80.0)	402.0 (92.0)	1235.0 (98.0)	2034.0 (99.0)	2558.0 (99.0)	2627.0 (100.0)
Maize	214.0 (90.0)	390.0 (70.0)	235.0 (68.0)	96.0 (52.0)	92.0 (57.0)	101.0 (67.0)
Jowar	4.0 (46.0)	2.0 (85.0)	2.0 (100.0)	3.0 (73.0)	0.3 (73.0)	1.0 (63.0)
Bajra	49.0 (39.0)	97.0 (60.0)	38.0 (67.0)	8.0 (80.0)	5.0 (92.0)	5.0 (83.0)
Wheat	838.0 (58.0)	2036.0 (87.0)	2677.0 (91.0)	3144.0 (96.0)	2291.0 (68.0)	3407.0 (98.0)
Barley	21.0 (36.0)	25.0 (46.0)	58.0 (75.0)	37.0 (85.0)	29.0 (95.0)	20.0 (99.0)
Other cereals	3.0 (26.0)	0.4 (33.0)	0.2 (20.0)	0.0	0.0	0.0
Total Cereals	1317.0 (62.0)	2952.4 (83.0)	4245.2 (91.0)	5322.2 (96.0)	4976.0 (81.0)	6161.0 (98.0)
Black gram	239.0 (29.0)	92.0 (27.0)	59.0 (28.0)	6.0 (14.0)	5.0 (51.0)	3.0 (72.0)
Other pulses	17.0 (26.0)	19.0 (33.0)	46.0 (56.0)	64.0 (87.0)	49.0 (90.0)	25.0 (91.0)
Total pulses	256.0 (28.0)	111.0 (28.0)	105.0 (36.0)	70.0 (62.0)	54.0 (84.0)	28.0 (88.0)
Total Food grains	1637.0 (52.0)	3136.4 (79.0)	4445.2 (91.0)	5486.2 (97.0)	5227.0 (84.0.0)	6370.0 (99.3)
Sugarcane	92.0 (73.0)	96.0 (86.0)	85.0 (92.0)	102.0 (95.0)	105.0 (95.0)	86.0 (96.0)
Cotton	443.0 (95.0)	449.0 (98.0)	676.0 (98.0)	708.0 (100.0)	502.0 (100.0)	556.0 (100.0)
Gross irrigated area	2724.0 (71.2)	4397.0 (76.1)	5965.0 (86.8)	7103.0 (94.4)	7619.0 (96.3)	7676.0 (97.3)

Note: TE indicates Triennium Ending Average: Figures in the parentheses indicate per cent to total area
Source: Various issues of Statistical Abstracts of Punjab

Irrigation

The excellent network of irrigation facilities is serving the Punjab agriculture. Irrigation coverage, which was about 76 per cent of net sown area in triennium ending 1972-73, has increased to the level of about 97 per cent in triennium ending 2006-07 (Table 2.9). Canals and tube wells are the main sources of irrigation in the state. Rice and wheat, being the major crops of

the state, have more than 98 per cent of the area under irrigation. More than 63 per cent of the area under other crops is also irrigated, being the least for jowar (63%) and maize (67%).

2.9. Changing Cost Structure of Principle Crops

This section is based on the data from the, "Comprehensive cost of cultivation of principal crops in Punjab" for the five periods viz. period I (1970-71 to 1979-80); period II (1980-81 to 1989-90); period III (1990-91 to 1999-00); period IV (2000-01 to 2005-06) and period V (1990-91 to 2005-06). Since paddy, wheat and cotton are the predominant crops in the state, this analysis was also restricted to the data for these crops and presented in Tables 2.10.1 to2.10.3. The inputs have been divided into traditional inputs (includes seed, manure, human labour and bullock and animal labour) and modern inputs (includes pesticides and chemicals, irrigation, fertilizer, tractor and machine labour etc.). The modern inputs were the contribution of Green Revolution and became popular after the Green Revolution period.

Table 2.10.1 indicated that in paddy cultivation the level of most of the major input use, except for human labour, has increased significantly in period IV (2000-01 to 2005-06) as compared to other periods. The total human labour use for paddy cultivation was significantly lower at Rs. 2928/ha in period III (1990-91 to 1999-00) as compared to Rs. 4581/ha in period IV (2000-01 to 2005-06). The bullock/animal labour was found to decline over the period of time in the wake of mechanization of various operations especially the preparation of fields and harvesting of paddy as well as increased dependence on chemicals for weed control. The expenditure on weedicides and insecticides increased overtime from Rs.29/ha in period I (1970-71 to 1979-80) to Rs.1305/ha in period IV (2000-01 to 2005-06). Over this time period, the amount spent on seeds (value of paddy nursery) increased from Rs. 112/ha to Rs. 585/ha. The fertilizer

use increased from Rs. 478 kg/ha period I (1970-71 to 1979-80) to Rs. 2221/ha during period IV (2000-01 to 2005-06). Similarly, the total machine labour in paddy crop increased from Rs. 162/ha to Rs. 3032/ha during the same period. The operational costs increased at a lower rate than the fixed costs and the cost C3.

Table 2.10.1: Trends in Cost Structure of Paddy Crop of the State: 1970-71 to 2005-06

(Rs./Ha)

Crop	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-00	2000-2001 to 2005-06	1990-91 to 2005-06
Operational costs	2230	4371.02	8502	14973	10928
Traditional Inputs					
Seed	112	139	309	585	412
Manure	28	106	127	129	128
Human Labour	873	1525	2928	4581	3548
Bullock/Animal Labour	136	154	55	53	54
Modern Inputs					
Pesticides/chemicals	29	158	608	1305	869
Irrigation	354	759	1324	2653	1822
Fertilisers	478	903	1482	2221	1759
Tractor/ Machine labour	162	511	1444	3032	2040
Misc. Expenses	-	-	1	17	7
Interest on working capital	58	116	224	12691	10152
Fixed Costs	927	2756	7099	12691	6449
Rental value of owned land	651	1787	5118	8668	6449
Rent paid for leased-in land	67	376	879	2425	1459
Land revenue, cesses & taxes	5	4	3	-	2
Depreciation on implements & buildings	28	96	161	173	165
Interest on fixed cost	176	493	938	1425	1121
Total cost (C2)	3157	7127	15601	27664	20124
Paid out cost A1	1940	3918	7546	13272	9694
Total Cost C3	3473	7840	17161	30430	22136

Source: Various issues of *CACP (Commission for Agricultural Costs and Prices) Reports*

Table 2.10.2 indicated that in wheat cultivation the use level of most of the major inputs has increased significantly in period IV (2000-01 to 2005-06) as compared to other periods. The total human labour use for wheat cultivation increased marginally from Rs. 2349/ha in period III (1990-91 to 1999-00) as compared to Rs. 2457/ha in period IV

(2000-01 to 2005-06) as the total machine labour increased in wheat crop, particularly during harvesting and its expenses increased from Rs. 1478/ha to Rs. 3479/ha during the same period. The bullock/animal labour was found to decline over the period of time in the wake of mechanization of various operations especially the preparation of fields. The expenditure on weedicides and insecticides increased overtime from almost negligible (Rs.3/ha) in period I (1970-71 to 1979-80) to Rs.1068/ha in period IV (2000-01 to 2005-06). Over this time period, the amount spent on seeds increased from Rs. 105/ha to Rs. 801/ha. The fertilizer use increased from Rs. 367/ha in period I (1970-71 to 1979-80) to

Table 2.10.2: Trends in Cost Structure of Wheat Crop of the State: 1970-71 to 2005-06

(Rs./Ha)

Crop	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-00	2000-2001 to 2005-06	1990-91 to 2005-06
Operational costs	1449	2995	7213	11461	8807
Traditional Inputs					
Seed	105	223	543	801	640
Manure	14	14	21	43	30
Human Labour	426	784	2349	2457	2390
Bullock/Animal Labour	189	125	57	88	69
Modern Inputs					
Pesticides/chemicals	3	91	347	1068	617
Irrigation	119	165	278	479	353
Fertilisers	367	866	1911	2683	2201
Tractor/ Machine labour	186	634	1478	3479	2228
Misc. Expenses	3	12	35	44	38
Interest on working capital	37	81	194	319	241
Fixed Costs	936	2220	7367	12174	9170
Rental value of owned land	632	1361	5081	7976	6167
Rent paid for leased-in land	97	338	999	2117	1418
Land revenue, cesses & taxes	6	4	3	0	2
Depreciation on implements & buildings	52	95	204	236	216
Interest on fixed cost	149	422	1080	1845	1367
Total cost (C2)	2385	5215	14580	23635	17977
Paid out cost A1	1336	2771	6632	10756	8178
Total Cost C3	2624	5737	16038	25999	19775

Source: Various issues of *CACP (Commission for Agricultural Costs and Prices) Reports*

Rs. 2683/ha during period IV (2000-01 to 2005-06). The operational costs increased at a lower rate than the fixed costs and the cost C_3.

Table 2.10.3 indicated that in cotton cultivation the use level of most of the major inputs has increased significantly in period IV (2000-01 to 2005-06) as compared to other periods. The total human labour use for cotton cultivation increased marginally from Rs. 4204/ha in period III (1990-91 to 1999-00) as compared to Rs. 4819/ha in period IV (2000-01 to 2005-06) as the total machine labour increased in cotton crop and its expenses increased from Rs. 1039/ha to Rs. 2803/ha during the same period. The

Table 2.10.3: Trends in Cost Structure of Cotton Crop of the State: 1970-71 to 2005-06

(Rs./Ha)

Particulars	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-00	2000-2001 to 2005-06	1990-91 to 2005-06
Operational costs	**1237**	**2840**	**9027**	**17344**	**12147**
Traditional Inputs					
Seed	29	91	311	1519	764
Manure	21	16	18	24	20
Human Labour	641	1395	4204	4819	4435
Bullock/Animal Labour	155	217	117	173	138
Modern Inputs					
Pesticides/chemicals	47	332	2203	5661	3500
Irrigation	75	164	372	653	415
Fertilisers	145	299	652	1207	860
Tractor/ Machine labour	97	261	1039	2803	1701
Misc. Expenses	-	-	-	5	2
Interest on working capital	27	65	211	480	312
Fixed Costs	**811**	**2121**	**6159**	**9350**	**7139**
Rental value of owned land	589	1479	4315	6436	5110
Rent paid for leased-in land	65	244	732	744	597
Land revenue, cesses & taxes	9	17	29	481	138
Depreciation on implements & buildings	37	79	195	258	202
Interest on fixed cost	111	302	888	1431	1092
Total cost (C2)	**2048**	**4961**	**15186**	**26694**	**19286**
Paid out cost A1	**976**	**2206**	**7159**	**16107**	**10515**
Total Cost C3	**2253**	**5457**	**16705**	**29363**	**21215**

Source: Various issues of *CACP (Commission for Agricultural Costs and Prices) Reports*

bullock/animal labour was found to decline over the period of time in the wake of mechanization of various operations especially the preparation of fields. The expenditure on weedicides and insecticides increased overtime from Rs. 47/ha) in period I (1970-71 to 1979-80) to Rs.5661/ha in period IV (2000-01 to 2005-06). Over this time period, the amount spent on seeds increased from Rs. 29/ha to Rs. 1519/ha. The increase was recorded highest during the current decade due to more use of Bt hybrid, which costs more. The fertilizer use increased from Rs. 145/ha period I (1970-71 to 1979-80) to Rs. 1207/ha during period IV (2000-01 to 2005-06).

2.10 Trends in Agricultural Prices

In this section, the Compound Annual Growth Rates (CAGRs) have been calculated to know the comparative growth of minimum support price (MSP), average wholesale prices (WSP) and farm harvest price (FHP) over the years for three important crops of the state viz., paddy, wheat and cotton for the five periods viz. period I (1960-61 to 1966-67); period II (1967-68 to 1979-80); period III (1980-81 to 1989-90) and period IV (1990-91 to 2006-07). As the announcement of MSP was started in 1970-71, that's too for the selected crops, therefore the CAGRs for MSP are missing for the period I. Table 2.11 shows that although procurement price, wholesale price and farm harvest price showed significantly consistent growth over the years but for paddy and maize crops, the growth of MSP in period III was higher than for the growth in WSP and FHP, whereas reverse was the situation in period IV. A cursory glance at Table 2.12 reveals that the growth rate of MSP, WSP and FHP were very close to each other in case of wheat and there was an evident improvement in growth rates for period IV as compared to period III for all the three types of prices. For cotton, in period IV, the growth was the highest for MSP while in period III, it was the highest for FHP. The price policy was effective for

paddy, wheat, cotton and sugarcane as the government has made the arrangements for procurement of these crops in the state. But for all other crops only the MSP was announced and no procurement is done by the Government agencies.

Table 2.11: Average Annual Compound Growth Rates of Wholesale Price Index (WPI), Farm Harvest Prices (FHP) and Minimum Support Prices (MSP) of Major Crops in different periods

	1960-61 to 1966-67			1967-68 to 1979-80			1980-81 to 1989-90			1990-91 to 2006-07		
YEAR	WPI	FHP	MSP	WPI	FHP	MSP#	WPI	FHP	MSP	WPI	FHP	MSP
Rice	5.80** (0.91)	5.0** (0.78)	-	6.32** (1.00)	4.78** (1.10)	6.85** (0.84)	7.58** (0.80)	7.66** (0.71)	5.47** (0.41)	5.90** (0.49)	6.23** (0.44)	6.66** (0.49)
Maize	13.79** (13.79)	12.49* (4.94)	-	7.75** (1.51)	7.32** (1.38)	5.53** (0.84)	6.29** (0.95)	7.58** (1.03)	4.01** (0.45)	4.19** (0.65)	5.06** (0.79)	6.95** (0.41)
Jowar	19.53** (3.94)	13.29** (2.68)	-	6.26** (1.61)	6.73** (1.90)	-	5.23** (0.72)	6.95** (1.68)	4.01** (0.45)	5.63** (0.69)	7.87** (0.73)	7.39** (0.35)
Bajra	12.20** (2.86)	10.73** (2.95)	-	5.24* (2.06)	6.14** (1.85)	-	5.98** (1.33)	6.25** (1.38)	4.01** (0.45)	3.62** (1.09)	5.96** (0.75)	7.39** (0.35)
Wheat	14.07** (2.11)	13.17** (2.22)	-	4.46** (0.62)	5.58** (1.12)	5.79** (0.95)	5.13** (0.58)	3.56** (0.34)	4.37** (0.43)	6.14** (0.46)	7.72** (0.45)	8.46** (0.44)
Barley	20.17** (3.84)	18.05** (3.33)	-	6.24** (1.79)	5.79** (1.78)	-	6.34** (0.81)	4.79** (1.05)	3.83** (0.42)	7.73* (3.21)	7.46** (0.77)	7.76** (0.48)
Gram	15.56** (2.41)	17.87** (3.08)	-	9.27** (1.65)	9.34** (1.97)	-	10.16** (1.98)	8.26** (1.70)	9.65** (2.34)	7.56** (0.75)	8.64** (0.78)	8.56** (0.30)
Rapeseed mustard	-	15.93** (2.02)	-	-	8.68** (1.63)	-	-	6.34** (1.73)	4.52** (0.88)	-	5.12** (0.62)	6.87** (0.26)
Cotton	7.28** (0.92)	6.33** (1.34)	-	6.85** (1.16)	6.88** (1.40)	-	6.70** (1.51)	7.70** (1.46)	6.33** (0.73)	4.18** (0.89)	4.41** (0.97)	6.82** (0.62)
Chillies	-	-	-	-	-	-	8.68** (2.78)	-	-	6.66** (1.03)	-	-
Sugarcane	-	-	-	-	-	-	-	-	6.37** (0.65)	-	-	9.69** (0.59)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error
#1970-71 to 1979-80

2.11. Capital Formation in Agriculture

The proportion of gross capital formation in Punjab agriculture at current prices to the gross capital formation showed a decline from 21.7 per cent in 1980-81 to around 11 percent till 2003-04 but then decreased up to 9.8 per cent by the year 2005-06 (Table 2.12). The growth of capital formation in public sector was lesser as compared to the private sector since 1980s. The capital formation in public sector at current prices increased from Rs 42 crores in 1980-81 to about Rs 198 crores in 2005-06, while the growth in private sector during the period was from Rs 108 crores to about 1797 crores.

Therefore, the private sector contributes more as compared to the public sector in the capital formation in Punjab agriculture.

Entirely different picture emerges when we look at the trends in expenditure on agricultre in the state during this period. It is the story of almost stagnant real expenditure on agriculture (at 1980-81 prices). Another dismal feature of the expenditure was, the exenditure on capital account was negative during some of the years under study. The total expenditure on agriculture, which was Rs 14.55 crore during 1981-85, declined to Rs 9.44 crore during 1996-00 and became Rs. 55.67 crore during the period 2001-05. In a similar way, the expenditure at 1980-81 prices declined from Rs 13.58 crore to Rs 1.93 crore and further increased to Rs. 9.69 crores. Such trends undermines the extension delivery system of the state department for dissemination of latest technologies. The decline in expenditure on agriculture sector therefore has severe implications for the growth of Punjab agriculture. A further look at the per hectare budgetary expenditure on agriculture in Punjab further establishes the stagnation trends during the period of study. The per hectare expenditure is given in Table 2.13. No doubt, the expenditure on agriculture on current prices more than quadrupled from 1981-85 to 2001-05, there was a decrease in such expenditure at the constant prices

The proportional allocation to agriculture in the budgetary allocations has also declined significantly over time. The share of expenditure on agriculture in total budgetary expenditure is given in Table 2.13. The share of agriculture in expenditure on budetary expenditure at current prices declined continuously from 11.86 per cent during 1981-85 to mere 0.69 per cent during 1996-00 and then jumped to 2.41 per cent during 2001-05. While at constant prices,it declined continuously from 13.91 per cent during to 2.75 per cent during 1996-00 and then jumped to 11.85 per cent during the latest period

under study. Hence, it appears that the agriculture sector has been totally neglected in the planned development efforts of the Government of Punjab despite the fact that around 31 percent of state GDP comes from agriculture.

Table 2.12: Trends in Capital Formation in Agriculture and its share in total GCF of the State

(Rs in crores)

Year	Public	Private	Total	% share of total GCF in agriculture to total CGF of the State
1980-81	42.0	108.0	150.0	21.74
1995-96	415.19	1031.26	1446.45	11.65
2000-01	303.29	1305.99	1609.28	11.91
2003-04	72.8	1566.33	1639.13	11.30
2004-05	142.73	1665.07	1807.8	9.22
2005-06(P)	197.82	1797.32	1995.17	9.86

P-provisional
Source: Various issues of Statistical Abstracts of Punjab

Table 2.13: Public Investments in Agriculture (Average)

Year	Capital Expenditure on Agricultural & allied heads Rs. Crore/year		Capital Expenditure per hectare of net sown area Rupees Per year		Share of Budget expenditure on agriculture	
	at Current prices	at 1980-81 prices	at Current prices	at 1980-81 prices	at Current prices	at 1980-81 prices
1978-80	-13.70	-18.14	-33.0	-43.0	Na	Na
1981-85	14.55	13.58	35.0	32.0	11.86	13.91
1986-90	-7.39	-3.0	-18.0	-7.0	Na	Na
1991-95	28.76	8.90	68.0	21.0	3.30	8.52
1996-00	9.44	1.93	22.0	5.0	0.69	2.75
2001-05	55.67	9.69	151.0	26.0	2.41	11.85

Source: Various issues of Statistical Abstracts of Punjab

Chapter III
Measurement of Growth and Stagnation in Crop Productivity

3.1 Introduction

Growth in total factor productivity (i e, technical change) in agriculture is both a necessary and sufficient condition for its development. It is a necessary condition because it enables agriculture to avoid a trap into Ricardo's law of diminishing returns to which the sector is more prone. And it is a sufficient condition because it increases production at reduced unit-costs/prices in real terms (Kahlon and Tyagi 1983; Sidhu and Byerlee 1992; Kumar and Mruthyunjaya 1992; Rao 1994; Kumar and Rosegrant 1994; Singh, Pal and Morris 1995; Acharya 1997). Past literature shows that technical change in agriculture is determined by non-price factors like government expenditure on Research and Development and infrastructure. But more recent literature also considers relative farm prices that would provide incentives for technical change. This has been reinforced by the present policy in the wake of reforms that reduce protection to trade and industry for advocating its prime role for technical change. Among the non-price factors it separately considers government investment in R and D, inputs, credit, rural literacy, and marketing and banking infrastructure density in addition to land reforms. But the earlier studies show that technical change is influenced by non-price factors like government investment in agricultural research, education, extension, and infrastructure like rural roads, regulated markets, etc (Rosegrant and Evenson 1994; Kumar and Rosegrant 1994). It must be stated that among the three agricultural strategy options of extensive farming, intensive agriculture, and technical change, it is technical change which is universally accepted as the best strategy (Desai 1997).

Total factor productivity (TFP) postulates increases in total output less increases in total (all) inputs (Abramovitz 1956; Dension 1962; Hayami, Ruttan and Southworth 1979). This implies an upward/downward shift in production/ cost function and hence it represents efficiency growth. Technical change so defined is studied in earlier literature that has three heroic assumptions. One, it assumed perfectly competitive product and factor markets. Two, it considered technical change to be Hicks- neutral, i e, relative payments to factors of production are unbiased. And three, technical change is disembodied (Evenson and Kislev 1975; Dholakia and Dholakia 1993). More recent literature, however, does not make any of these restrictive assumptions (Sidhu and Byerlee 1992; Kumar and Mruthyunjaya 1992; Kumar and Rosegrant 1994; Rosegrant and Evenson 1994; Desai 1994). Underlying the approach in this literature that follows Christenson (1975) and Diewert (1976), is a translog production function. This production function allows for non-constant as well as constant retums to scale, complementarity so unique to agricultural production process,' and operation of imperfect markets. Diewert (1976) derived Tornqvist-Theil index of TFP from the translog production function. This index is computed as the ratio of an index of aggregate output to an index of aggregate inputs. Earlier stated five studies which use this index-based method include two studies on wheat (Sidhu and Byerlee 1992; Kumar and Mruthyunjaya 1992), one on rice (Kumar and Rosegrant 1994), one on major crops-sector as a whole (Rosegrant and Evenson 1994), and one on agriculture and allied sectors excluding forestry (Desai 1994).

3.2 **Review of Literatures/Studies on Measurement of Growth & Fluctuations**

To analyse the spatial variations of agricultural productivity in Uttar Pradesh, Bhatia (1967) used a modified crop yield index first developed by Ganguli (1938). He

expressed the unit area yield of a crop in a district (minor civil division) as a percentage of the average unit area yield of that crop in the state. The yield ratio so obtained was then multiplied by the proportion of cropped area under the crop to get a weighted yield ratio. Finally, the sum of weighted yield ratios of the crops concerned was divided by the proportion of cropped area occupied by them.

This method has been used by several others to measure agricultural productivity differences between districts in some states of India (George and Nampoori 1966). It assumed equal value for all crops, which is often not the case. Such distortions may occur if the relative values of cropping patterns are not taken into account in calculating productivity. A more realistic agricultural productivity index must therefore be based on the value of crop output and not simply on yield per unit area and areal strength of crops. In another study Shafi (1971) applied Enyedi's index to measure food crop productivity in India. This index is very similar to the one used by Bhatia and therefore suffers from the same deficiencies. Enyedi's index produced a pattern for food crop productivity that appears erroneous. For example, some areas widely acclaimed for high productivity, such as Punjab, Haryana, Western Uttar Pradesh and Tamil Nadu, do not stand out. On the contrary, some acknowledged low productivity areas, such as the central western coast, Karnataka, southern districts of Uttar Pradesh, and northern districts of Madhya Pradesh, stand out deceptively as high productivity regions.

Singh (1974) used a ratio of caloric output per unit area under food crops available for human consumption and the average standard nutrition required by the population in the unit area, to measure carrying capacity, which he called farming efficiency. He then compared the carrying capacity of each areal unit with that of the nation to get a relative index value of agricultural efficiency. As this method excludes all non-food crops, it

does not appear satisfactory for measuring agricultural productivity. In some parts of India non-food crops, such as cotton, jute, oil seeds and tobacco, dominate the cropping pattern; therefore, their exclusion is certain to give a deceptive picture of the productivity pattern.

In his study of agricultural efficiency in Uttar Pradesh, Shafi (1960) employed Kendall's ranking coefficient, using unit area yields of selected crops to measure and map efficiency patterns in one state of India. A productivity measure based on unit area yields of crops alone can be misleading, as it does not take into account the areal strength of crops. Often a major crop of a region may occupy an insignificant area in some minor subdivisions of the region, e.g. sugarcane in southern districts of Uttar Pradesh, and may have an unimportant position in the cropping pattern. Thus it may make no significant contribution to agricultural productivity in the subdivision. However, if only unit area yields are used, this may give an exaggerated productivity rating to an unimportant crop in a statistical unit. Furthermore, a ranking coefficient based on crop yields alone may at best give only some idea of land productivity.

Using data for states, Nath (1969) examined the principal regional features of agricultural growth rates in India. He was mainly concerned with growth rates and not with the regional analysis of agricultural productivity. However, he did use productivity indexes developed by Anand (1964) and compared these with agricultural growth rates in Indian states. These indexes, if mapped, produce broad patterns of productivity by states, which when compared with more refined patterns for districts; display some dis similarities and a few broad agreements. The most surprising difference is the relative rank of Punjab, which is even lower than Assam,West Bengal and Orissa on the land productivity index used by Nath. The superiority of the Punjab region (present Punjab

and Haryana) in agricultural productivity is unquestionable. The differences outlined above could be due to aggregation of data and to using data for the period prior to the Green Revolution. Since the introduction of the high yielding variety (HYV) program, important changes in productivity levels have occurred in different parts of India. Nath's claim that a more refined analysis of agricultural productivity based on district data is not likely to be any different is not supported by this study (Nath 1969).

McClelland (1974) measured agricultural productivity in India by the output per unit area of only the leading individual crops in the districts. He then explained the variations in output per unit area of individual crops in terms of several independent variables by means of multiple regression models. Owing to the research design he used, his regression analysis occasionally suffered from an excessively small number of observations, which made the results less reliable. Moreover, McClelland's work, being of an economic nature, is again concerned with the identification of factors affecting productivity of individual crops and not with the regional variations of agricultural productivity.

The study made by Christensen (1975) to measure agricultural productivity recommended that among various methods like Index number procedure, Laspeyer's weighing method, Divisia- Tornquist Index etc, the Divisia- Tornquist Index was the most commonly used. It was mentioned that the main difference between Laspeyer's Index and Divisia- Tornqvist Index is that the Laspeyer's Index holds prices fixed at their base period levels while latter used the prices from both base period and comparison period. Laspeyer's Index can be interpreted as a discrete approximation to the Divisia Index.

Ester et al. (1977) measured agricultural productivity in terms of value of wheat and rice output in two regions of India. They then employed a three stage procedure to

explain regional variations in the productivity through several variables. As they based the measure of productivity on the output of a single crop in a region, they were obviously not concerned with agricultural productivity as such, but rather with the factors affecting variations in productivity of single crops. Their main aim was to reveal the regional effect on rice and wheat productivity, which they did by using an error component model. They did not discuss or even identify intraregional variations in productivity in two regions.

Patil and Jha (1978) studied changes in output, input and agricultural productivity growth in Maharashtra state in 1951-52 to 197172. During the sub-period 1951-52 to 1960-61, 18 out of 25 districts recorded positive output growth. Growth in inputs varied between 0.82 per cent and 2.89 per cent per annum in different districts and the average growth in inputs was nearly 1.84 per cent. Total factor productivity growth rates were between 0.85 to 5.92 per cent per annum. During the sub-period 1960-61 to 1971-72 the growth rate decreased. Only nine of 23 districts showed growth rates of over 2.5 per cent per annum. About 2.19 per cent of this increase was due to growth in modern inputs although output growth did not seem to be related to growth in both traditional and modern inputs. Only three districts recorded productivity gains, others showed decline in productivity. During sixties agricultural output stagnated in spite of rapid growth in modern inputs mainly because the technological assets acquired in the 1950's had depreciated greatly and this completely nullified the contribution of modern inputs.

Bramhananda (1982) estimated Total Factor Productivity (TFP) for agricultural sector i.e. crop production and livestock vis-a-vis other sector of India. The chain index of productivity in agriculture sector showed a productivity improvement by 1.5 per cent per annum during 1950-51 and 1960-61 and thereafter it declined at a rate of 0.8 per cent per

annum between 1960-61 and 1970-71 and of 0.3 per cent per annum between 1970-71 and 1980-81. The contribution of TFP moved down over the decades and for the entire period. Thus the contribution of TFP improvement to sectoral growth seems to have become less and less as we move from the first decade to the third decade. The most important commodity producing sector like agriculture had a negative contribution to TFP growth in the third decade. The productivity growth momentum was thus lost.

Ekanayake and Jayasuriya (1987) used frontier production function approach to measure the technical efficiency and applied both stochastic frontier production function and corrected ordinary least square (COLS). The study was conducted at two locations which were at the 'head' and 'tail' of major irrigation channels in Sri Lanka. The COLS estimated of C-D frontier production function analysis indicated that in the' head' the mean sample technical efficiency was 53 per cent and in the 'tail' it was 50 per cent. However, they felt that COLS estimate tended to over estimate the average level of inefficiency.

Sidhu and Byerlee (1991) studied technical change and wheat productivity in Post Green Revolution Punjab. The study was based on the data available in cost of cultivation scheme from the period 1971-72 to 1986-87. The survey data provided information on yields, human labour, machine costs, animal labour, fertilizer use, irrigation charges, pesticides use and land rental charges. A total factor productivity index was computed. The input index was constructed as an index of all input quantities valued by their prices in a base year. The output index was estimated simply as the yield in period t divided by the yield in the base period. The TFP was calculated as the ratio of the output index to input index. The technical change and wheat productivity in the 1970's and 1980's reveals that green revolution had consolidated through further intensification in the use of modern land saving inputs, especially fertilizer and herbicides. However the use of labour saving

technologies especially tractors had expanded even more rapidly in this period. Labour saving technologies had reversed the trend toward higher labour inputs in wheat production that was observed when new wheat technology was first introduced. The increase in Total Factor Productivity (TFP) was due to use of labour saving technology. The use of biochemical had only moderately increased total productivity.

Jain *et al* (1992) in their study, 'Factor Productivity in Punjab agriculture- A macro level approach' measured the efficiency of controllable and uncontrollable factors contributing to the productivity of land. The variables considered were fertilizer use, cropped area, extent of irritation, area under high yielding varieties (HYVs), education in terms of literates per hectare of net sown area and coefficient of variation of rain fall during the crop seasons. The time series data for the above variables were obtained for the period representing green revolution (1967-68 to 1979-80) and post green revolution period (1980-81 to 1990-91). The factor productivity in Punjab agriculture and the response of these variables over time was ascertained by using the Cobb-Douglas production function. The results of the study indicated a further scope to increase the area under HYV in kharif season as one percent increase in area under HYV resulted in an increase in productivity by 1.23 per cent. Fertilizer used during kharif season was 7.74 per cent higher over its optimum level at 122.56 kg per hectare. While in rabi season its use was found to be more than 13 per cent higher over the optimum level of 169 kg per hectare. It was concluded that the excess use of fertilizer could be reduced without adversely affecting the productivity.

Kumar and Rosegrant (1994) used the Divisia- Tornquist Index for computing total output, input and TFP for rice using farm level data from 1971-87. They have shown that for India, the TFP growth, excluding the western region was 1.03 per cent. Nearly

one-third of output growth in Indian rice was contributed by TFP. The TFP growth during post green revolution period has declined because the early productivity gains from green revolution were already exploited.

The absolute and relative contributions of growth in inputs and TFP from the various sectors were studied by Rosegrant and Evenson (1994) and Desai (1994). While the former shows that little over 50 per cent of growth in crop-output is contributed by technical change, the latter estimates that close to 38 per cent of growth in output of agricultural and allied sectors is accounted for by technical change. This lower estimate of relative contribution of technical change may be because this study is more comprehensive in its inputs coverage. Moreover, technical change has not been so important in allied sectors of dairying and fisheries which account for about 30 per cent of agricultural production. Both the studies, however, show that the contribution of technical change in post-green revolution (GR) is much higher. They further show deceleration in total factor productivity in later period of GR. Both the studies conclude that GR type of technical change is land, labour, and intermediate inputs with complementary capital augmenting. Indeed, employment elasticity in agriculture during post-GR was 1.37 per cent as against only 0.52 per cent prior to GR. The remaining study (Desai 1994) on agriculture and allied sectors, except forestry, was most comprehensive in its input coverage that includes 11 farm inputs that are both credit and self-financed, namely, land, labour, seeds, organic manure, fertilisers, pesticides, diesel, electricity, irrigation charges, private and public capital (that consists of land improvements, farm equipments and tools, public and private irrigation, agricultural machinery, farmhouses, livestock, and inventories).

Kalirajan *et. al.* (1996) they studied a decomposition of total factor productivity of Chinese agricultural growth before and after reforms. The objective of the study was to explain a method to decompose the source of TFP growth into technological progress and changes in technical efficiency with in the frame-work of the varying coefficients of frontier production functions. An application is demonstrated using the Chinese provincial-level agricultural data covering the period 1970-87. The results indicated that the TFP growth in the pre-reform period was negative in twenty' out of twenty-eight provinces and that it was positive in almost all provinces during the reforms period, while negative in sixteen out of twenty-eight provinces in the post reforms period 1984-87.

Desai and Namboodiri (1997) attempted to study determinants of TFP inn Indian agriculture. For this purpose they considered both price and non-price factors to understand the process of change in TFP for the period from 1966-67 to 1989-90. The results revealed that as much as 86 per cent of variation in TFP in post green revolution period was explained by the combined role of agricultural research and extension with location specific farmers own knowledge. It was found that technical change was most influenced by government expenditure on research and development and land reforms followed by liberal tenancy regulation, rural literacy, marketing and banking infrastructure and efficiently managed canal irrigation. While relative farm prices have deleterious ramifications to technical change process and as a result it had secondary and neutral but not passive role.

Singh and Hossain (2002) conducted a study 'on TFP analysis and its component. The data collected under the cost of cultivation scheme in Punjab for different years were used to split TFP growth in three components i.e. technical change, technological improvement and environmental degradation. The contribution of technology was estimated through

dummy variables. The coefficient indicates the growth rate of 1.27 and 2.38 per cent for rice and 2.97 and 1.81 per cent for wheat during period I (1982-83 to 1989-90) and period II (1990-91 to 1996-97) respectively. The contribution of technical efficiency of farm at different time period based on the frontier analysis was worked out. This indicated that technical efficiency improved by 1.66 per cent and 0.89 per cent for rice during period period I and II respectively. However, for wheat technical efficiency of farmers in period I showed slight decline, whereas, in period II showed improvement by 1.01 per cent.

Elumalai and Pandey (2004) measured the technological change in the livestock sector across districts, regions and the whole Haryana state (India) during the last three decades. Specifically it (i) works out the factor shares and value shares of output in the livestock sector under different periods across districts in Haryana and (ii) examines the residual productivity growth pattern in the livestock sector of Haryana at the disaggregated level during the last three decades. The Tornqvist aggregate output and input index were computed to arrive at a total factor productivity index using 1970/71-1998/99 data on livestock products (milk, eggs, wool and meat) and inputs (feeds, human labour, veterinary services, vaccines and other inputs like medicines, mineral mixture and composite dairy feed, etc.). The 12 districts of Haryana studied for the purpose include Ambala, Karnal, Kurukshetra, Sonepat, Rohtak, Jind, Hisar, Sirsa, Bhiwani, Mahendragarh, Gurgaon and Faridabad. Analysis of the data indicates the occurrence of technical change in the livestock sector across districts in Haryana. However, there is still scope for the exploitation of modern technologies across the districts in the state, which may be done by developing livestock technologies, revamping livestock production and marketing policy prescriptions by the state policy planners and disseminating such policies to the farmers.

Surya (2005) used a non-parametric approach to estimate productivity growth in wheat production in the major producing states of India from 1982-83 to 1999-2000. The states chosen for the study are: Punjab and Haryana (where green revolution has made a significant progress); Uttar Pradesh (which has made a moderate progress with the green revolution); and Rajasthan and Madhya Pradesh (which have been lagging behind). The productivity change in wheat production (measured by Malmquist indices) is decomposed into technical and efficiency change using Data Envelopment Analysis. It is concluded that although technological progress has contributed mainly to the total productivity growth of wheat production for the period under study, it has been uneven among major wheat-producing states. It is higher in the already developed states of Punjab (11.4%) and Haryana (4.6%) in comparison to the relatively less developed states of Uttar Pradesh (0.4%), Madhya Pradesh (-3.2%), and Rajasthan (1.7%).

Rao (2005) studied the variations in the indices of total factor productivity in the crop sector, foodgrain crops and non-foodgrain crops in Andhra Pradesh and the contribution of the total factor productivity in the state during 1980-81 to 1999-2000 has been evaluated. Tornqvist- Theil Index has been used to calculate the index of total factor productivity. The average annual index of total factor productivity during the post-reform period has been found five per cent. In the case of non-foodgtains, it has been found nine per cent less than that during the pre-reform period, while in case of food grains, it is less than 100 during both the periods. The contribution of total factor productivity to yield growth has been found to be a healthy 31 per cent in the pre-reform period. An absolute decline (-37 per cent) has been noted during the post-reform period in the crop sector of the state. The absolute decline in the contribution of technical change has been drastic in the case of non-foodgrain crops in the state during the post-reform period. This absolute

decline in total factor productivity seems to be one of the main reasons for the distress of fanners in the state which has been manifesting in the form of suicides since the late 1990s.

Singh and Aggarwal (2006) estimated the total factor productivity (TFP) growth and its components (technical efficiency change and technology change) in the sugar industry of Uttar Pradesh. The TFP growth is estimated applying SBM-DEA-based Malmquist Productivity Index (MPI) on the panel data of 36 sugar mills for the period 1996-97 to 2002-03. The study finds that the average TFP in the industry grew at a moderate rate of 1.6 per cent per annum during the entire period. The decomposition of TFP growth into technical efficiency change (catch-up effect) and technical change (frontier shift) reveals that the TFP growth is primarily contributed by technical change rather than by technical efficiency change. Sector-wise estimation of the TFP testifies that the private sector has the highest growth, followed by the cooperative sector. Regional pattern of the growth demonstrates that the sugar mills in the western region achieved relatively better TFP growth than their counterparts in other two regions. The study also finds that the mills with bigger plant size attained higher productivity growth than the smaller ones. Further, relatively higher TFP growth achieved during the later part of the study *period* provides some indication that the policy-induced factors, such as de-licensing and partial decontrol of sugar sector have made some *positive* impact on the TFP growth.

Chandel (2007) estimated the Total Factor Productivity of six edible oilseed crops, namely, rapeseed and mustard (RSM), groundnut (GNUT), sunflower (SUN F), soybean (SOYA), sesamum (SESA) and safflower (SAFF) using Tornquist - Theil indices. The results analysed in terms of growth rate and trends in TFP showed erosion of

sustainability in majority of the oi Iseeds in the past twenty years (I980-81 to 1999-2000) except in rapeseed and mustard. The TFP of rapeseed and mustard grew at a significant rate while it was close to zero in case of groundnut, sunflower and soybean. The TFP declined substantially in sesamum and safflower. The rate of increase in output index was higher than the input index of rapeseed and mustard, groundnut and sunflower, while in sesamum and safflower, the output index reduced at a rate higher than the input index causing TFP to decline in these crops. The commensuration of increase in input index with output index in soybean reflected production inefficiencies causing TFP to be almost stable. Among states, Rajasthan registered the highest TFP growth rate for oilseeds production in the country followed by Uttar Pradesh. In the remaining states, overall TFP of oilseedswere observed to be stagnant except in Kamataka where it declined significantly. The overall growth rate of TFP for six edible oilseeds was found significantly negative (-1.21) manifesting overall unsustainable behaviour of total factor productivity of oilseeds in India. There is a need to reverse this trend. Technology being a major contributing factor for TFP growth, greater R&D emphasis on oilseed crops is needed. Other factors, which could make a dent on the present unsustainable behaviour of TFP, are the price parity of oil seeds with competing cereal crops, market support and irrigation, with oilseeds being a rainfed crop. A growth in TFP will maintain relative profitability of oilseeds to ensure undisrupted flow of growth in TFP will maintain relative profitability of oilseeds to ensure undisrupted flow of resources and investment in their cultivation.

Shanmugam and Soundararajan (2008) employed the varying or random coefficients stochastic frontier production function methodology to measure Technical Efficiency (TE) of raising agricultural outputs in 15 major States of India. Following

Kalirajan and Shand (1997), the decomposition of total output growth into input growth, technical advancement and technical efficiency improvement. Total Factor Productivity (TFP) growth can be defined as the output growth not explained by input growth. The TPF growth consists of two components: Technical efficiency change and technological advancement. Kalirajan and Bhide (2004) also point out that this decomposition of TFP into these components helps us to distinguish technical changes from technology adoption. High rate of technological progress can exist with low rate of change in technical efficiency, a case in which there is poor technology adoption and diffusion. High growth in technical efficiency can also coexist with low technological advancement.

3.3 Methodology for Measuring the Stagnation in Productivities across the Crops

The value of any scientific study depends on the methods and procedures adopted in investigating the problem. This helps the investigator to design and conduct the study on scientific lines. This chapter explains the methodology that was used for carrying out the study in hand. The procedure adopted is discussed under various heads such as:

Collection of Data

The present study was conducted in the Punjab state of India. The study was based on the secondary data and various sources were tapped to achieve the stipulated objectives of the study. The requisite data for the study relating to area, production, productivity of various crops, minimum support prices, harvest prices, wholesale prices, marketing infrastructure, market arrivals and major growth parameters have been collected from the various sources such as *Centre for Monitoring Indian Economy*, *Statistical Abstracts of Punjab, Agricultural Statistics at a Glance,* and Directorate of Agriculture, Punjab. The data relating to the estimates of cost of cultivation/production of

paddy, wheat and cotton have been collected various issues of *CACP (Commission for Agricultural Costs and Prices) Reports* and *'Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Punjab'* running in the Department of Economics, Punjab Agricultural University Ludhiana.

Five new districts emerged in the state during the period 1990-91 to 1995-96 and further 3 more districts emerged in 2005-06. To make the district-wise comparisons feasible, these districts were merged with the parent districts. As some of the districts were formed by extracting area from more than one parent district, the figures of these districts were merged into parent districts according to the ratio of net sown area extracted. The new districts were thus merged using the following coefficients:

Sr.No.	New district	Original district	Proportion of figures of new districts merged with original district
New districts formed during the period 1990-91 to 1995-96			
1	Nawan Shahar	Jalandhar,	0.56
		Hoshiarpur	0.44
2	Mukatsar	Faridkot	1.00
3	Moga	Faridkot	1.00
4	Mansa	Bathinda	1.00
5	Fatehgarh Sahib	Patiala	0.77
		Ludhiana	0.29
		Sangrur	0.03
New districts formed during 2005-06			
6.	Tarantaran	Amritsar	1.00
7.	SAS Nagar	Roopnagar	0.58
		Patiala	0.42
8.	Barnala	Sangrur	1.00

Analytical Framework:

The compound annual growth rates were calculated by fitting the exponential function to different aspects of prices, infrastructure and agricultural growth parameters of Punjab State.

$Y=ab^x$

Log Y= log a + x log b

Compound annual growth rate= (Antilog b-1)X 100

Where: Y= Absolute value

x= Time (years)

Total Factor Productivity (TFP)

In order to measure the Total Factor Productivity (TFP) in paddy, wheat and cotton, the farm level data relating to input costs (Rs/ha) like Human Labour, Machine Labour, Bullock Labour, Fertilizers and Manures, Insecticides, Irrigation charges etc., and returns of these crops (main product only) for the period of 1981-82 to 2003-04 were collected from the Reports of Commission for Agricultural Costs and Prices (CACP) published by Ministry of Agriculture, New Delhi and 'Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Punjab' running in the Department of Economics, Punjab Agricultural University Ludhiana.

Total output, total inputs and TFP indices were calculated by using Tornqvist-Theil Index as follow:

$$\Delta TFP = ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = \ln\left(\frac{QI_t}{QI_{t-1}}\right) - \ln\left(\frac{XI_t}{XI_{t-1}}\right)$$

$$= \sum \frac{1}{2}\left(R_{it} + R_{it-1}\right) \ln\left(\frac{Q_{it}}{Q_{it-1}}\right) - \sum \frac{1}{2}\left(S_{jt} + S_{jt-1}\right) \ln\left(\frac{X_{jt}}{X_{jt-1}}\right)$$

Where

ΔTFP *is the growth in total factor productivity,*

QI_t *is the output index*

XI_t *is the input index*

Q_{it} *is the output i*

X_{jt} *is the input j*

R_{it} *are the revenue shares of output i*

S_{jt} *are the cost share of input j*

All are in period t and t-1.

Determinants of Total Factor Productivity

After calculation of TFP index, the factors affecting TFP at different stages of agricultural development in the state were determined by using regression analysis. In order to assess the determinants of TFP, the TFP index was estimated as a function of the independent variables like June to August rainfall; annual rainfall; agricultural terms of trade which is measured as the ratio of comnposite price indices of agricultural to non-agricultural commodities; investment on Research and Development (R&D) per hectare; literacy (the proportion of rural population who are literate) and the number of regulated markets per thousand hectare of cropped area. As most of the independent variables are sector specific (cropwise data for independent variables was not available) and therefore wighted TFP index for the state as a whole was constructed (by taking cropwise area share as weights) and then factors affecting TFP was analysed. Dependent variable is the log of TFP index. All variables were specified in logarithms, except the literacy, which was entered linearly.

Chapter IV

Trends and Patterns in Production and Productivity: District Level Analysis

4.1 Introduction

The trends of production and productivity at the state level depict only the broader picture and conceals the basic purpose of stagnation of the yield. The indepth analysis of the trends of production and productivity at the district level will help to dissect the causes of the stagnation of productivity at the regional level as the agroclimatic conditions vary across different regions/district of the state. This will help to evolve policy measures at the regions/district level, which is the basic purpose of carrying out the present study. To ascertain the district-wise temporal growth in area, production and productivity of different crops in the Punjab state, the analysis were done for the three periods viz. period I (1990-91 to 1999-00); period II (2000-01 to 2006-07) and overall period III (1990-91 to 2006-07).

4.2 District-wise Growth of Production and Productivity

Amritsar

The temporal changes in the area, production and productivity of different crops in the Amritsar district have been presented in Table 4.1.1. The district is dominated by paddy wheat crop rotation. There was significant increase in area, production and yield under paddy for the period I under study but the productivity showed negative growth during the period II. Wheat also showed the same trend but in period II the decrease in productivity was at higher pace than for the paddy. All other crops showed either decrease in area or the insignificant increase in area during this period. It clearly reveals that the paddy and wheat crop rotation became predominant at the cost of maize, other

cereals, oilseed and pulses in the district. Sugarcane, the other important crop in the district, has shown significant decrease in area during the recent years.

Table 4.1.1: District-wise Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Amritsar district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	1.22** (0.33)	2.34** (0.62)	1.11* (0.49)	1.86** (0.42)	1.77 (1.34)	-0.08 (1.04)	1.38** (0.13)	1.56** (0.31)	0.17 (0.26)
Maize	-8.70** (1.45)	-8.79** (1.25)	0.17 (1.31)	-9.90** (2.09)	-0.05 (5.0)	10.70* (4.15)	-8.51** (0.58)	-5.86** (1.05)	2.77* (1.01)
Wheat	0.31 (0.33)	2.16* (0.95)	2.23 (0.77)	0.52 (0.28)	-1.16 (0.86)	-1.67* (0.64)	0.52** (0.11)	1.22** (0.38)	0.83* (0.35)
Gram	-5.61 (10.23)	-2.78 (9.45)	2.64 (1.36)	31.35** (3.68)	30.25** (3.73)	1.16 (1.13)	-9.51* (3.64)	-8.1* (3.46)	1.39* (0.47)
Arhar	10.60 (8.03)	10.31 (8.03)	-0.27 (2.17)	-2.86 (2.47)	-4.76 (2.06)	-1.97 (2.57)	3.04 (2.17)	3.04 (2.48)	-0.004 (0.84)
Moong	10.19 (28.54)	9.61 (28.97)	-0.52 (1.44)	-13.64** (2.58)	-10.74** (3.40)	3.38 (2.39)	3.93 (8.18)	1.66 (8.12)	-2.18* (0.77)
Rapeseed & mustard	-11.55** (3.82)	-10.61* (3.71)	1.02 (1.05)	-4.65 (4.86)	-3.91 (4.56)	0.72 (1.15)	-15.05** (1.63)	-14.51** (1.61)	0.60 (0.37)
Sunflower	52.43* (22.45)	40.40 (21.44)	-3.96** (0.62)	25.41* (10.03)	36.50* (15.14)	6.64* (3.25)	-6.84 (7.72)	-11.01 (7.66)	-1.50 (0.86)
Sesamum	-3.77 (3.86)	-8.83 (4.46)	-5.24** (1.48)	-12.78* (4.72)	-12.25* (5.74)	0.62 (3.06)	-4.40* (1.60)	-5.29* (1.91)	-0.94 (0.88)
Sugarcane	8.49 (4.50)	9.42* (4.62)	0.85 (1.05)	-10.65** (2.24)	-12.51** (2.27)	-2.07 (1.10)	1.06 (1.82)	1.02 (1.97)	-0.01 (0.41)
Dry chillies	19.65 (13.43)	18.04 (11.81)	-1.34 (1.42)	-28.69** (5.46)	-27.33** (4.36)	1.92 (1.76)	-4.62 (4.73)	-4.79 (4.28)	-0.18 (0.56)
Potato	29.65** (6.56)	27.59** (5.22)	-1.58 (1.33)	-7.40 (4.83)	-3.69 (4.26)	4.00* (1.90)	10.22** (3.19)	11.04** (2.68)	0.76 (0.63)
Cotton A	3.94 (10.60)	-3.33 (12.01)	-8.79 (7.69)	20.11 (14.09)	28.51 (20.29)	6.95 (5.77)	-9.99* (4.32)	-4.98 (4.95)	4.93 (3.34)
Cotton D	21.62* (9.17)	20.0 (14.64)	15.45 (14.68)	-30.84 (15.93)	-14.91 (23.70)	22.89** (6.98)	-7.62 (5.52)	2.81 (6.60)	16.65** (4.58 0

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Bathinda

Bathinda district lies in the south western region of the state. The district is dominated by paddy, cotton and wheat crops. The area under rice was found to grow significantly by 15.17 per cent per annum in period I, as the area under cotton was replaced due to failure of cotton in this period. But due to lower productivity of rice in these replaced cotton fields, productivity decreased during this period by 0.1 per cent per annum. Due to revival of cotton during period II, the area under rice was found to decrease by 1.85 per cent per annum, while the growth in productivity during this period was 8.47 per cent per annum. Wheat showed a

significant growth of productivity by 8.47 per cent per annum in period I and 4.7 per cent per annum in the later period. Cotton was the other important kharif crop in the district after rice and is more popular in Mansa area of the erstwhile district (now it has become a separate district) and showed marvelous increase in area and productivity in period II mainly due to higher returns from the Bt cotton. Moong the important pulse crop of the district has shown significant growth in production and productivity in the recent years, while the area was still decreasing. Potato is becoming more popular in the district as it has shown significant increase of area and production by about 22 per cent per annum since 1990 (period III). All other crops showed either decrease in area or the insignificant increase in area during this period (Table 4.1.2).

Table 4.1.2: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Bathinda district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	15.17** (2.53)	14.04** (2.46)	-0.10 (0.94)	-1.85 (1.95)	1.30 (1.91)	8.47 (5.65)	7.57** (1.38)	8.48** (1.15)	2.21 (1.12)
Bajra	-10.31 (6.91)	-11.71 (8.42)	-2.60 (3.17)	-2.76 (5.38)	1.56 (6.11)	10.55 (6.37)	-0.12 (2.84)	0.14 (3.40)	1.38 (1.62)
Wheat	0.94 (0.73)	3.86** (1.16)	7.76* (3.43)	0.11 (0.13)	-0.22 (0.91)	4.70 (4.60)	1.05** (0.23)	2.19** (0.46)	2.58 (1.41)
Barley	-5.85* (2.0)	-2.49 (2.94)	3.56** (1.13)	-8.63** (2.35)	-7.74* (3.74)	6.39 (3.63)	-7.70** (0.75)	-6.43** (1.16)	2.80** (0.76)
Gram	-22.77** (3.08)	-21.86** (3.22)	1.19 (2.00)	-13.66** (3.52)	-6.73 (5.32)	12.42* (5.45)	-22.56** (1.26)	-21.60** (1.65)	2.33 (1.30)
Moong	-0.73 (2.85)	-3.47 (5.12)	-2.75 (3.02)	-5.15 (2.98)	10.28* (5.08)	16.27** (2.80)	-5.64** (1.13)	-6.02* (2.10)	-0.40 (1.60)
Rapeseed & mustard	-4.75 (2.62)	-5.56 (3.33)	-0.83 (3.60)	-3.01 (5.62)	-3.33 (3.74)	4.65 (8.50)	-4.43** (1.23)	-4.33** (1.20)	1.44 (1.82)
Sesamum	-	-	-	2.08 (16.60)	-3.44 (14.44)	-5.41 (4.58)	-	-	-
Sugarcane	-6.02 (4.47)	-7.71 (6.38)	-1.99 (2.23)	-21.24** (6.81)	-22.36** (7.19)	-1.43 (2.35)	-3.79 (2.55)	-3.81 (3.08)	-0.35 (0.82)
Dry chillies	6.53 (3.60)	13.55* (5.70)	6.59 (4.74)	-2.45 (7.40)	2.94 (5.92)	5.52 (5.16)	3.01 (1.79)	7.60** (2.07)	4.46* (1.66)
Potato	25.57* (10.45)	35.43* (12.10)	7.85 (5.14)	13.15** (2.46)	8.52* (3.18)	0.77 (4.36)	22.46** (3.17)	22.82** (3.77)	1.21 (1.81)
Cotton A	-2.12 (1.56)	-13.08** (3.50)	-11.18** (3.45)	4.97* (2.35)	19.82** (2.59)	19.88* (8.47)	-1.37 (0.78)	1.06 (2.53)	4.78 (2.89)
Cotton D	14.67** (2.37)	10.18* (4.17)	-3.92 (2.98)	-21.24** (0.92)	-14.09** (3.99)	14.56* (7.14)	-0.51 (2.48)	2.42 (2.15)	4.30* (1.92)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Ferozpur

Ferozpur district lies in the south western region of the state. The district is dominated by paddy, cotton and wheat crops. The area under rice was found to grow significantly by 2.5 per cent per annum in period I, as the area under cotton was replaced due to failure of cotton in this period. But due to lower productivity of rice in this replaced cotton fields, the growth in productivity during this period was 0.7 per cent per annum. Due to revival of cotton during period II, the area under rice was found to decrease by 0.33 per cent per annum, while the growth in productivity during this period was significant (2.13 per cent per annum). Wheat showed a grim picture in terms of growth of productivity in the recent years as the productivity was decelerating significantly by 1.38 per cent per annum in period II. Cotton was the other important kharif crop in the district after rice and is more

Table 4.1.3: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Ferozpur district.

	1990-91 TO 1999-00			2000-01 TO 2006.07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	2.50** (0.71)	3.21** (0.77)	0.70 (0.75)	-0.33 (0.51)	1.79* (0.81)	2.13** (0.65)	0.21 (0.36)	1.37** (0.35)	1.15** (0.27)
Bajra	-33.26** (5.07)	-33.50** (5.36)	-2.80 (1.75)	-	-	-	-	-	-
Wheat	-0.0. (0.48)	2.18** (0.47)	2.18** (0.48)	0.53 (0.28)	-0.87 (0.87)	-1.38* (0.62)	-0.37* (0.18)	0.07 (0.33)	0.44 (0.30)
Barley	-3.06 (2.02)	1.31 (3.02)	4.30* (1.51)	0.10 (4.48)	2.25 (5.23)	1.79 (0.96)	-0.79 (1.02)	1.34 (1.27)	2.08** (0.54)
Gram	-11.42* (5.29)	-10.24 (5.29)	1.08 (1.50)	-7.44** (1.04)	-6.65* (2.65)	1.12 (2.84)	-7.52** (1.72)	-7.13** (1.73)	0.47 (0.66)
Arhar	-4.11 (5.29)	-6.80 (5.17)	-2.80 (2.90)	10.87 (6.68)	10.87* (5.42)	0.0	0.73 (2.16)	0.53 (2.19)	-0.20 (1.09)
Moong	-25.78 (14.06)	-9.56** (2.73)	21.84 (23.22)	-15.98** (2.76)	-13.53** (4.35)	2.92 (3.93)	-15.72** (1.20)	-16.73** (1.39)	-1.20 (1.03)
Rapeseed & mustard	0.23 (4.80)	1.37 (6.10)	1.14 (2.75)	12.63 (18.97)	-6.55 (18.60)	-3.39 (3.24)	-5.84 (3.44)	-8.57* (3.72)	-0.47 (1.01)
Sesamum	-6.81 (3.84)	-4.60 (4.77)	2.37 (3.36)	-10.98** (1.82)	-13.94** (3.30)	-3.32 (4.73)	-2.71 (1.55)	-3.94* (1.81)	-1.26 (1.29)
Sugarcane	8.64 (5.20)	7.82 (5.25)	-0.70 (0.51)	-30.06** (6.94)	-28.67** (5.50)	2.85 (23.31)	-6.34 (3.26)	-7.42* (2.95)	-0.98 (0.65)
Dry chillies	-9.78* (4.80)	-10.22* (4.41)	-0.50 (1.15)	-33.99** (9.88)	-35.33** (10.34)	-2.03 (2.01)	-26.68** (4.98)	-28.80** (4.90)	-2.90** (0.57)
Potato	33.83** (5.75)	33.66** (4.71)	-0.26 (1.61)	10.0 (5.17)	6.12 (4.42)	-3.48** (1.14)	8.95* (2.74)	9.23** (3.06)	0.24 (0.61)
Cotton A	-2.24 (1.85)	-11.26** (2.99)	-9.23* (3.34)	4.82* (2.07)	16.41** (2.97)	11.05** (3.47)	-0.46 (0.79)	1.51 (2.21)	1.98 (1.99)
Cotton D	0.77 (7.15)	4.98 (7.54)	4.17 (3.07)	-12.01** (1.37)	-3.10 (5.52)	10.14 (5.91)	-4.23 (2.20)	2.58 (2.46)	7.10** (1.42)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

popular in Abohar and Fazilka pockets of the district and showed marvelous increase in area and productivity in period II mainly due to higher returns from the Bt cotton. All other crops showed either decrease in area or the insignificant increase in area during this period (Table 4.1.3).

Faridkot

Faridkot district lies in the south western region of the state. The district is dominated by paddy, cotton and wheat crops. The area under rice was found to grow significantly by 9.19 per cent per annum in period I, but the productivity deccerlated by 1.43 per cent per annum during this period. Due to revival of cotton during period II, the area under rice was found to decrease by 1.48 per cent per annum, while the growth in productivity during this period was significant (2.91 per cent per annum). Wheat showed a grim picture in terms of growth of productivity in the recent years as the productivity was decelerating significantly by 1.74 per cent per annum in period II. Cotton was the other important kharif crop in the district and showed marvelous increase in area and productivity in period II mainly due to higher returns from the Bt cotton. All other crops showed either decrease in area or the insignificant increase in area during this period (Table 4.1.4).

Gurdaspur

Gurdaspur district lies in the foothills of the Shivalik range in northern most region of the state. The district is dominated by paddy, maize and wheat crops. Some of the regions of the district, which have assured irrigation, are dominated by paddy wheat crop rotation; while maize is the major crop in the rainfed regions. The productivity of rice was found to grow significantly by 1.4 per cent since nineties. The growth in productivity was still higher in the period II, which shows that still there is potential to increase the productivity

Table 4.1.4: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Faridkot district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	9.19** (2.02)	7.51** (1.46)	-1.43 (0.79)	-1.48 (2.35)	1.39 (2.33)	2.91** (0.88)	6.57** (1.02)	7.20** (0.77)	0.63 (0.41)
Bajra	-21.86* (10.83)	-23.70* (9.67)	-0.19 (2.54)	-27.18** (8.77)	-22.20* (9.39)	6.84** (2.10)	-3.0 (5.79)	-3.72 (5.38)	0.0 (0.98)
Maize	-	-	-	-30.38** (4.73)	-29.74** (3.86)	0.87 (5.25)	-	-	-
Wheat	1.57 (1.46)	4.63** (1.14)	10.82* (5.03)	-1.08 (1.90)	-2.80 (1.92)	-1.74** (0.47)	1.70* (0.59)	2.55** (0.68)	1.0 (1.79)
Barley	-5.34 (2.84)	-3.39 (2.79)	1.53 (0.81)	-9.78** (2.67)	-9.11* (3.27)	0.72 (0.80)	-8.55** (1.02)	-7.83** (1.11)	0.38 (0.31)
Gram	-15.97** (3.14)	-13.16** (2.46)	3.26 (1.86)	-16.81** (3.06)	-19.71** (1.64)	-3.49 (3.08)	-13.47** (1.19)	-13.02** (0.97)	0.50 (0.88)
Arhar	7.83 (6.22)	5.44 (8.37)	-2.22 (3.68)	25.49 (20.37)	-1.62 (3.60)	-21.60 (11.78)	12.53** (3.84)	13.14** (3.29)	0.78 (3.55)
Moong	-8.59** (1.74)	-14.83** (2.62)	-6.84** (1.87)	-20.19** (3.21)	-9.77 (6.44)	13.06** (4.05)	-12.80** (1.08)	-12.48** (1.38)	0.37 (1.51)
Rapeseed & mustard	-2.36 (3.11)	-1.11 (3.82)	1.31 (1.70)	-12.59** (3.16)	-16.70* (6.98)	-4.70 (9.13)	-6.51** (1.25)	-5.32* (2.03)	1.29 (1.81)
Sunflower	42.73 (35.16)	42.01 (36.81)	-0.49 (2.99)	-	-	-	-	-	-
Sesamum	17.64 (12.11)	14.78 (12.32)	-2.43* (1.16)	-22.56** (6.22)	-25.56** (7.82)	-3.87 (3.85)	15.81* (5.39)	13.73* (5.69)	-1.79* (0.78)
Sugarcane	21.34** (6.96)	18.46* (6.60)	-2.61** (0.43)	-31.43** (8.13)	-34.60** (8.0)	-4.62* (2.24)	5.79 (4.80)	4.30 (4.92)	-1.49* (0.52)
Dry chillies	0.39 (1.70)	4.73 (4.95)	4.32 (5.05)	-21.65* (9.85)	-36.92** (11.09)	-19.49** (6.28)	-4.70 (2.57)	-6.22 (4.40)	-1.60 (2.54)
Potato	26.00 (20.35)	34.22** (8.83)	-0.04 (2.0)	-26.25 (21.04)	-27.82 (22.09)	-2.12 (2.82)	11.19 (8.54)	6.74 (7.32)	-1.31 (0.78)
Cotton A	-7.55 (4.39)	-19.52** (4.00)	-12.96* (5.21)	6.62 (4.57)	21.96** (5.43)	-2.88 (13.29)	-3.70* (1.76)	-2.07 (3.21)	-0.12 (3.43)
Cotton D	9.50** (2.29)	3.05 (3.44)	-5.88* (2.72)	-22.07** (2.18)	-12.90** (4.27)	11.75* (5.83)	-1.07 (2.27)	2.45 (1.89)	3.56 (1.83)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

of rice in the district as the productivity level is still lower than some of the districts of the central Punjab. Wheat showed a grim picture in terms of growth of productivity in the recent years as the productivity was decelerating at 2.06 per cent per annum in period II. As compared to rice, the productivity of wheat is not that much lower than the average productivity at the state level, therefore, it is the cause of concern as deceleration in productivity for period II in the district was more as compared to the state. Maize was the other important kharif crop in the district after rice and is more popular in rain fed pockets of the district and showed marvelous increase in productivity since nineties. All other crops showed either decrease in area or the insignificant increase in area during this

period. Sugarcane, the other important crop in the district, has shown decrease in area and production during the recent years (Table 4.1.5)

Hoshiarpur

Hoshiarpur district lies in the foothills of the Shivalik range in northern region of the state. The district is dominated by paddy, maize and wheat crops. Some of the regions of the district, which have assured irrigation, are dominated by paddy wheat crop rotation; while maize is the major crop in the rain fed regions. During the period III, there was significant increase in area, production and yield under paddy and wheat but growth has become stagnant during the period II. Maize was the other important kharif crop in the district and showed an increase in productivity since nineties. All other crops showed either decrease in area or the insignificant increase in area during this period. Sugarcane, the other important crop in the district, has shown increase in area during the recent years. Potato has shown significant increase in area and production during the period I under study but reverse picture was observed during period II (Table 4.1.6).

Table 4.1.5: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Gurdaspur district.

YEAR	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
Rice	1.15* (0.40)	2.31** (0.47)	1.15* (0.47)	0.64 (0.48)	0.81 (1.76)	1.37** (0.44)	0.70* (0.15)	1.85** (0.35)	1.4** (0.16)
Maize	-2.59* (1.05)	3.72 (2.57)	6.57** (1.76)	0.80 (1.33)	3.57* (4.18)	2.95 (3.07)	-1.58** (0.44)	2.44* (1.05)	4.18** (0.80)
Wheat	0.05 (0.53)	3.12* (1.10)	3.06** (0.62)	1.25* (0.54)	-0.84 (1.79)	-2.06 (1.56)	0.60** (0.20)	1.75** (0.52)	1.14* (0.47)
Gram	-8.33 (4.75)	-3.68 (6.34)	2.64 (1.36)	-9.81* (4.02)	-16.42* (8.10)	-9.57 (8.59)	-0.04 (2.25)	-1.68 (2.86)	-1.75 (1.83)
Rape seed & mustard	5.36 (4.42)	10.12 (6.41)	4.36* (1.74)	1.45 (1.49)	4.40 (2.29)	3.78 (2.04)	0.63 (1.41)	2.81 (2.03)	2.32** (0.68)
Sesamum	-9.17** (1.34)	-8.27** (13.5)	1.0 (1.81)	-14.29** (1.0)	-16.08** (1.86)	-2.08 (2.65)	-8.46** (0.67)	-9.97 (0.74)	-1.64* (0.77)
Sugarcane	-6.98 (11.59)	-16.19 (21.07)	1.06 (0.99)	2.12 (2.11)	0.50 (2.25)	-1.60* (0.71)	-2.32 (3.68)	-8.0 (6.98)	0.79* (0.37)
Potato	31.46* (10.66)	27.87* (10.34)	22.45 (37.95)	-1.81 (6.76)	-2.91 (8.67)	-1.12 (2.37)	3.69 (4.12)	4.22 (3.98)	12.38 (10.38)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Table 4.1.6: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Hoshiarpur district.

YEAR	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
Rice	4.55** (1.33)	5.18** (1.17)	0.60* (0.26)	0.10 (0.74)	0.64 (1.14)	0.74 (0.67)	2.35** (0.51)	2.81** (0.51)	0.45** (0.14)
Bajra	-14.42 (14.97)	-19.02 (15.42)	-4.93 (3.57)	-	-	-	-	-	-
Maize	-0.58 (0.71)	-0.06 (4.42)	0.52 (4.44)	0.63 (0.41)	3.08 (3.40)	2.43 (2.98)	0.45 (0.24)	4.14* (1.59)	4.19* (1.55)
Wheat	0.91 (0.46)	4.0** (0.81)	3.06** (0.53)	0.56 (0.47)	0.68 (0.72)	0.12 (0.63)	0.98** (0.16)	2.65** (0.34)	1.66** (0.28)
Gram	-16.70** (3.49)	-13.98** (2.90)	2.52 (3.81)	-37.82** (11.88)	-0.54 (6.27)	2.07 (4.05)	-18.87** (3.41)	-9.20** (1.58)	0.16 (1.34)
Arhar	-17.48** (5.56)	-21.71** (4.84)	-5.13* (2.14)	-6.72 (5.00)	-6.92 (8.07)	-0.21 (7.02)	-8.65** (2.31)	-7.96** (1.88)	0.74 (2.62)
Moong	-	-	-	-24.98* (9.90)	-27.15** (8.55)	-2.89 (6.11)	-	-	-
Rapeseed & mustard	29.86 (16.63)	10.27 (6.11)	-1.06 (1.59)	5.57 (2.92)	8.99 (6.30)	3.23 (4.47)	11.04* (4.77)	5.78* (2.13)	0.22 (0.92)
Sunflower	-	-	-	21.37* (9.95)	23.52* (11.48)	1.78 (2.05)	-	-	-
Sesamum	-7.28** (2.41)	-4.05 (4.30)	3.49 (3.66)	-31.29* (14.33)	-33.75* (14.84)	-3.59 (3.65)	-10.34* (4.06)	-8.55 (4.63)	1.99 (1.34)
Sugarcane	7.69* (3.81)	9.85* (4.49)	2.00 (2.07)	0.36 (2.61)	-1.08 (2.29)	-1.43 (1.27)	5.54** (1.40)	5.18** (1.53)	-0.49 (0.63)
Potato	12.02* (4.61)	24.85** (7.23)	0.42 (1.05)	-4.56 (2.91)	-8.11* (3.18)	-3.72** (1.12)	3.86* (1.78)	6.29* (3.02)	-1.13* (0.45)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Kapurthala

The temporal changes in the area, production and productivity of different crops in the Kapurthala district have been presented in Table 4.1.7. The district is dominated by paddy wheat crop rotation. There was significant increase in area, production and yield under paddy for the period II under study but the productivity showed the insignificant growth during the period I. Wheat showed a grim picture in terms of growth of productivity in the recent years as the productivity was decelerating at 1.45 per cent per annum in period II. Sugarcane, the other important crop in the district, has shown significant decrease in area during the recent years. Potato has shown significant increase in area during all the periods under study but the productivity was decelerating at 2.83 per cent per annum in period II. All other crops showed either decrease in area or the insignificant increase in area during this period. It clearly reveals that the paddy and wheat crop rotation became predominant at the cost of maize, other cereals, oilseed and pulses in the district.

Table 4.1.7: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Kapurthala district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	0.14 (0.34)	5.57 (10.73)	1.95 (1.05)	1.01** (0.32)	3.22** (0.91)	2.17* (0.88)	0.66** (0.13)	6.01 (3.21)	2.31** (0.35)
Maize	-4.23** (2.18)	0.90 (2.53)	5.52* (1.94)	-4.03 (2.49)	-2.61 (3.62)	2.60 (2.71)	-3.88** (0.56)	-0.34 (1.0)	3.57** (0.78)
Wheat	-0.008 (0.57)	0.99 (1.51)	1.86 (1.14)	-0.29 (0.34)	-1.76 (1.16)	-1.45 (1.14)	-0.06 (0.21)	0.81 (0.53)	0.87 (0.45)
Moong	53.25* (18.02)	47.97* (18.92)	-3.44 (2.96)	-26.02** (5.0)	-37.41** (6.54)	-15.40** (4.41)	-6.35 (6.74)	-9.66 (6.96)	-3.53* (1.60)
Rapeseed & mustard	11.81 (10.29)	17.18 (10.76)	4.82 (3.36)	-2.25 (2.89)	-1.29 (4.29)	1.29 (4.030	-0.38 (3.11)_	1.00 (3.41)	1.49 (1.26)
Sunflower	10.03 (6.64)	9.29 (7.31)	-0.79 (1.01)	14.54 (10.91)	17.03 (11.60)	2.89 (2.00)	-5.27 (3.35)	-4.58 (3.47)	1.06* (0.52)
Sesamum	-9.09 (6.02)	-11.55 (8.24)	-2.72 (3.22)	-15.91 (8.68)	-18.92 (14.09)	-3.58 (7.23)	-12.81** (2.36)	-12.63** (3.59)	0.21 (1.70)
Sugarcane	9.64 (7.78)	7.98 (7.28)	-2.10* (0.70)	-6.48* (2.99)	-7.91** (2.55)	-1.94 (1.20)	2.72 (2.48)	2.24 (2.34)	-0.70 (0.37)
Dry chillies	8.39 (6.80)	-4.91 (7.98)	3.80 (3.28)	-21.06** (4.47)	-18.44** (5.56)	3.31 (3.88)	-18.22** (2.82)	-20.54** (2.84)	-2.83 (1.490
Potato	27.93* (10.64)	30.14* (11.86)	1.72 (1.59)	10.51** (3.12)	7.39 (4.13)	-2.83 (2.66)	16.27** (3.25)	17.46** (3.65)	1.02 (0.74)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Jalandhar

The temporal changes in the area, production and productivity of different crops in the Jalandhar district have been presented in Table 4.1.8. The district is dominated by paddy wheat crop rotation. Both rice and wheat presented almost the similar picture in terms of growth in area, production and yield for the period II under study. The productivity of rice and wheat plateau during the recent years. Sugarcane, the other important crop in the district, has shown significant decrease in area during the recent years. Potato has shown increase in area during all the periods under study but the productivity was decelerating in all the periods under study. All other crops showed either decrease in area or the insignificant increase in area during this period. It clearly reveals that the paddy and wheat crop rotation became predominant at the cost of maize, other cereals, oilseed and pulses in the district.

Table 4.1.8: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Jalandhar district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	-0.38 (0.91)	-0.25 (1.34)	0.14 (0.68)	2.22** (0.55)	2.62* (1.05)	0.42 (0.84)	0.86* (0.34)	1.41* (0.49)	0.53* (0.25)
Maize	-2.65 (1.43)	0.49 (1.59)	3.13* (1.20)	-3.09** (0.35)	-1.33 (2.81)	1.74 (2.57)	-1.92** (0.45)	1.11 (0.72)	3.15** (0.58)
Wheat	-1.86 (0.96)	0.22 (1.67)	2.14 (1.10)	0.20 (0.33)	-1.07 (0.82)	-1.30 (0.70)	-0.33 (0.35)	0.55 (0.54)	0.88* (0.41)
Arhar	3.32 (5.56)	-3.05 (4.86)	-6.04* (2.68)	6.63 (3.34)	8.51 (4.31)	1.96 (1.87)	6.78** (1.85)	7.32** (2.22)	0.33 (1.22)
Moong	12.04* (5.65)	4.38 (8.13)	-6.90 (9.0)	3.47 (10.19)	8.72 (8.69)	5.08 (5.64)	-0.90 (2.75)	-2.57 (2.92)	-1.69 (3.07)
Rapeseed & mustard	1.53 (5.30)	1.25 (4.44)	-0.33 (2.55)	-7.65** (1.84)	-7.85** (2.61)	-0.38 (2.29)	-4.90* (1.70)	-4.46* (1.51)	0.45 (0.87)
Sunflower	-0.76 (10.13)	-4.72 (10.49)	-4.05** (1.31)	22.16** (4.97)	26.74** (5.88)	-1.61 (2.69)	-8.61* (3.86)	-9.64* (4.23)	-1.03 (0.77)
Sesamum	21.27* (10.16)	27.55* (13.53)	5.62 (3.53)	-13.25* (5.59)	-8.59 (5.93)	6.25 (3.68)	-1.43 (3.75)	-1.05 (4.54)	0.36 (1.42)
Sugarcane	7.20 (12.18)	-1.18 (3.32)	-0.72 (2.41)	-7.36** (2.33)	-8.82** (2.48)	-1.81 (1.81)	1.01 (3.57)	-3.68** (1.17)	-1.43 (0.78)
Dry chillies	-2.32 (7.04)	-2.01 (8.82)	0.32 (2.16)	-4.25 (2.40)	-5.33 (2.99)	-1.12 (0.65)	-3.60 (2.11)	-3.44 (2.64)	0.17 (0.66)
Potato	4.76 (8.62)	9.49 (5.15)	-0.11 (0.89)	7.04* (2.43)	1.71 (4.14)	-4.41 (2.61)	6.82* (2.66)	5.13* (1.74)	-1.08 (0.60)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Ludhiana

The temporal changes in the area, production and productivity of different crops in the Ludhiana district have been presented in Table 4.1.9. The district is dominated by paddy wheat crop rotation. The productivity of rice was decelerating by 0.59 per cent per annum in period I, but improved significantly by 2.36 per cent per annum in period II. Wheat showed a grimmer picture in terms of growth of productivity in the recent years as the productivity was significantly decelerating by 1.63 per cent per annum in period II. The district is also significantly contributing towards the oilseed and pulses production in the state but area and production of these crops either decreased or the insignificant increased during this period. Sugarcane has also shown significant decrease in area during the recent years. Potato has shown significant increase in area and production during all the periods under study but the productivity was observed to be decelerating.

Table 4.1.9: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Ludhiana district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	1.25* (0.48)	0.66 (0.96)	-0.59 (0.82)	0.31 (0.54)	2.68* (1.23)	2.36** (0.78)	0.63** (0.19)	2.40** (0.42)	1.76** (0.41)
Maize	-8.95** (2.21)	-2.23 (2.45)	7.40** (1.24)	-15.13** (2.55)	-15.00** (3.41)	0.21 (2.65)	-6.51** (1.18)	-1.52 (1.55)	5.39** (0.76)
Wheat	0.18 (0.25)	1.54 (9.76)	-13.09 (12.03)	-0.68 (0.40)	-2.31* (1.01)	-1.63* (0.80)	0.12 (0.11)	2.76 (2.98)	-2.22 (4.33)
Barley	1.46 (1.41)	4.16* (1.69)	2.62* (1.10)	-6.81* (2.67)	-8.58* (3.21)	-2.06 (1.75)	-2.12* (0.83)	-1.85 (1.14)	0.53 (0.54)
Gram	3.53 (3.02)	3.53 (11.06)	3.81* (1.54)	-8.10 (6.44)	-8.10 (6.44)	-1.04 (1.03)	1.11 (1.70)	-1.10 (3.44)	0.99 (0.60)
Arhar	-7.34** (3.66)	-14.21** (3.66)	-7.41* (3.45)	-5.79* (2.18)	-3.82 (2.13)	2.09 (1.15)	-7.22** (0.71)	-8.64** (1.43)	-1.54 (1.35)
Moong	-4.73 (2.57)	-6.10 (3.58)	-1.44 (1.79)	-9.23* (3.42)	1.0 (8.42)	11.26 (7.13)	-10.05** (1.140	-10.81** (1.98)	-0.85 (1.52)
Rapeseed & mustard	3.11 (6.43)	0.44 (6.44)	-2.45 (1.60)	-9.85 (5.67)	-11.91 (14.62)	-0.37 (15.29)	-2.97 (2.25)	0.44 (3.60)	3.97 (2.94)
Sunflower	17.19 (8.60)	19.80 (10.47)	2.23 (2.20)	19.87* (7.28)	23.44* (8.47)	5.99* (2.28)	-6.23 (4.11)	-5.94 (4.32)	1.30 (0.88)
Sugarcane	3.52 (5.86)	5.32 (5.66)	1.74 (1.31)	-23.66** (3.78)	-23.45** (4.13)	0.15 (3.16)	-5.30* (2.56)	-5.11 (2.60)	0.003 (0.70)
Potato	29.18** (5.520	26.80** (5.43)	-1.82 (1.45)	5.51** (1.65)	3.42 (2.21)	-1.98 (1.67)	12.97** (2.41)	12.95** (2.28)	0.01 (0.60)
Cotton A	-10.20 (0.13)	-16.02 (13.89)	-3.14 (4.69)	-2.82** (0.50)	56.24** (14.55)	71.95* (31.50)	-4.25 (5.68)	-5.58 (7.17)	1.50 (2.55)
Cotton D	-1.78 (11.18)	0.80 (9.0)	10.54* (3.89)	10.01 (12.16)	-45.28** (7.92)	-47.96** (7.37)	-17.52** (4.62)	-18.56** (4.50)	0.16 (1.65)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Patiala

Patiala district lies in the western region of the state. The district is dominated by paddy and wheat crops. The productivity of rice decelerated by 0.46 per cent per annum in period I and improved significantly by 2.68 per cent per annum in period II. The reverse pattern of growth in productivity was observed for wheat. Potato, the other important crop in the district, has shown significant increase in area by 17.59 per cent per annum in during the period I, but it decreased during the period II. All other crops showed either decrease in area or the insignificant increase in area during this period (Table 4.1.10).

Ropar

Ropar district lies in the foothills of the Shivalik range in northern region of the state. The district is dominated by paddy, maize and wheat crops. Some of the regions of the district, which have assured irrigation, are dominated by paddy wheat crop rotation; while

maize is the major crop in the rain fed regions. The productivity of rice decelerated by 1.09 per cent per annum in period I and improved significantly by 1.09 per cent per annum in period II (Table 4.1.11). The reverse pattern of growth was observed for wheat. Maize was the other important kharif crop in the district and showed an increase in productivity since nineties. Sugarcane, the other important crop in the district, has shown decrease in area during since nineties. All other crops showed either decrease in area or the insignificant increase in area during this period.

Table 4.1.10: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Patiala district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006.07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	1.18** (0.30)	0.71 (0.75)	-0.46 (0.61)	-2.42 (1.43)	0.20 (1.72)	2.68** (0.58)	0.14 (0.35)	1.59** (0.41)	1.45** (0.32)
Bajra	1.19 (6.98)	1.61 (6.31)	0.41 (0.92)	-	-	-	-	-	-
Maize	-4.05 (2.23)	2.12 (2.64)	6.63* (2.36)	-2.17 (1.56)	-3.62 (6.24)	-1.49 (4.97)	-5.17** (0.76)	-2.74 (1.44)	2.64* (1.25)
Wheat	-0.32 (0.27)	1.47 (0.82)	1.80* (0.66)	-2.22 (1.37)	-3.43* (1.21)	-1.24 (1.06)	-0.38 (0.30)	0.34 (0.46)	0.73* (0.33)
Barley	4.29 (4.26)	4.39 (5.52)	0.27 (1.73)	-17.96** (3.78)	-19.45** (2.95)	-1.82 (2.38)	-2.55 (2.05)	-1.74 (2.34)	0.90 (0.71)
Gram	-32.69** (8.01)	-28.77** (8.68)	4.02* (1.79)	-11.38 (6.32)	-11.38 (6.32)	0.52 (0.30)	-15.03** (4.01)	-13.18** (3.94)	2.32** (0.58)
Arhar	-14.69** (2.90)	-19.66** (3.22)	-5.82* (2.38)	-17.57** (4.61)	-16.58** (4.56)	1.20 (1.15)	-14.15** (1.23)	-15.14** (1.42)	-1.15 (0.97)
Moong	-7.86 (10.15)	-9.01 (18.13)	-1.25 (11.51)	-3.41 (3.54)	10.24 (7.45)	14.13* (6.10)	-6.66* (3.12)	-8.90 (5.67)	-2.40 (3.72)
Rapeseed & mustard	-2.79 (8.68)	-1.69 (8.87)	1.32 (1.30)	-11.16* (5.53)	-10.43 (9.62)	0.82 (7.30)	-6.16* (2.74)	-7.26* (3.10)	-1.10 (1.33)
Sunflower	21.91 (15.45)	21.35 (16.21)	-0.49 (0.83)	0.72 (9.21)	6.72 (11.28)	5.95* (2.22)	-8.30 (5.07)	-7.20 (5.30)	1.17 (0.60)
Sugarcane	3.80 (6.14)	2.58 (5.85)	-1.19 (3.22)	-16.38** (4.41)	17.60** (3.97)	-1.47 (1.81)	-3.73 (2.32)	-3.65 (2.26)	0.08 (1.04)
Dry chillies	3.05 (4.43)	2.54 (5.60)	-0.50 (1.79)	-3.07 (3.93)	-7.83** (2.16)	-4.91 (2.96)	2.38 (1.55)	2.82 (1.95)	0.43 (0.90)
Potato	17.59** (3.04)	14.53** (3.54)	-2.60 (1.81)	-3.82 (3.27)	-6.87* (3.33)	-3.17 (1.70)	5.74** (1.83)	4.71* (1.84)	-0.10 (0.69)
Cotton A	-19.19 (13.19)	-10.81 (14.46)	10.33** (3.17)	-	-	-	-	-	-
Cotton D	5.78 (14.88)	4.20 (16.61)	-1.73 (3.14)	6.34 (5.10)	16.79 (9.34)	9.78* (4.04)	2.11 (4.39)	11.30* (5.57)	8.70** (1.84)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Table 4.1.11: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Ropar district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	3.94** (0.52)	2.76** (0.82)	-1.09 (0.75)	2.22 (1.19)	3.42* (1.54)	1.21* (0.55)	2.99** (0.29)	3.91** (0.37)	0.41 (0.31)
Bajra	-	-	-	7.37 (14.04)	15.60 (19.32)	7.61 (4.25)	-	-	-
Maize	-1.73 (1.05)	3.61 (2.01)	5.36** (1.45)	-0.85 (1.66)	1.73 (3.48)	2.67 (3.08)	0.97* (0.43)	3.22** (0.86)	4.22** (0.71)
Wheat	0.49* (0.21)	2.87** (0.53)	2.37** (0.37)	0.03 (0.27)	-0.02 (0.94)	-0.06 (0.90)	0.43** (0.08)	1.20** (0.31)	0.78* (0.27)
Barley	- 13.76** (4.48)	-10.37* (5.11)	4.07* (1.57)	58.95** (19.16)	59.00** (19.12)	0.03 (0.09)	-8.62 (4.69)	-7.16 (4.71)	1.64* (0.55)
Gram	-17.25* (7.09)	-18.83* (7.67)	-1.39 (1.71)	3.13 (5.86)	4.34 (8.39)	-0.21 (7.40)	-16.86** (2.69)	-17.89** (3.01)	-1.06 (1.36)
Arhar	-8.32 (9.20)	-9.57* (4.33)	-1.37 (8.29)	-16.41** (1.78)	-11.11* (4.01)	6.33 (4.25)	-12.98** (2.68)	-16.12** (1.65)	-3.61 (2.64)
Rapeseed & mustard	-4.49 (10.66)	0.50 (11.31)	4.33 (2.50)	-2.02 (7.37)	2.00 (8.47)	4.03 (5.25)	-3.18 (3.45)	-2.34 (3.60)	0.02 (1.30)
Sunflower	-	-	-	45.33 (37.94)	80.97 (58.80)	1.31 (6.13)	-	-	-
Sesamum	-4.73* (1.87)	-2.28 (4.85)	2.57 (3.83)	-12.08* (4.50)	-3.34 (4.93)	9.94** (2.12)	-4.82** (1.17)	-3.90* (1.47)	0.97 (1.75)
Sugarcane	-1.79 (1.52)	-3.60* (1.34)	- 1.90** (0.63)	-14.91** (3.46)	- 13.43** (3.38)	1.71 (0.96)	-6.33** (1.16)	-6.96** (0.97)	-0.67 (0.34)
Dry chillies	-	-	-	-2.45 (5.18)	-13.65 (7.43)	-11.49** (3.37)	-	-	-
Potato	3.69 (4.91)	0.80 (7.11)	-14.76 (8.12)	-27.15 (15.37)	-31.45 (15.93)	-5.97* (2.45)	-5.69 (3.98)	-7.12 (4.55)	-1.17 (3.42)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

Sangrur

Sangrur district lies in the south western region of the state. The district is dominated by paddy, cotton and wheat crops. The productivity of rice in the district was found to grow significantly by 3.42 per cent per annum in period II but wheat showed a grim picture in terms of growth of productivity in the recent years as the productivity was decelerating significantly by 2.03 per cent per annum in period II. Cotton was the other important kharif crop in the district after rice and is more popular in certain pockets of the district and showed increase in area and productivity in period II mainly due to higher returns from the Bt cotton. All other crops showed either decrease in area or the insignificant increase in area during this period (Table 4.1.12).

Table 4.1.12: Average Annual Compound Growth Rates of Area (A), Production (P) and Yield (Y) of Major Crops in different periods of Sangrur district.

	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
YEAR	A	P	Y	A	P	Y	A	P	Y
Rice	2.36** (0.56)	2.18* (0.84)	-0.18 (0.63)	0.58 (0.34)	4.02** (0.93)	3.42** (0.68)	1.44** (0.22)	3.07** (0.32)	1.61** (0.34)
Bajra	-3.42 (2.97)	-6.97 (3.65)	-2.11 (2.08)	0.23 (1.86)	1.28 (3.15)	1.88 (1.54)	-1.61 (0.99)	-3.85* (1.34)	-1.23 (0.72)
Maize	-21.68 (12.10)	-20.37 (12.33)	1.23 (0.67)	-7.50 (6.32)	-7.65 (6.33)	-1.73 (3.61)	-0.82 (5.60)	2.28 (5.94)	2.61** (0.80)
Wheat	0.24 (0.23)	1.31** (0.43)	1.28* (0.49)	0.11 (0.08)	-1.92** (0.54)	-2.03** (0.59)	0.15* (0.07)	0.41 (0.26)	0.26 (0.28)
Barley	-1.50 (2.35)	0.55 (11.43)	2.10* (0.73)	-6.18* (2.31)	-7.85** (1.96)	-1.40 (1.06)	-3.25** (0.85)	0.05 (3.46)	0.91* (0.36)
Gram	-18.94* (7.47)	-11.06 (7.61)	9.21** (1.26)	-12.56** (3.94)	-16.13** (4.83)	-3.97 (3.05)	-10.28** (2.81)	-7.44* (2.69)	3.04* (1.11)
Arhar	-1.36 (1.50)	-2.86 (5.27)	-1.52 (4.05)	-3.87* (1.47)	-4.06 (3.33)	-0.20 (2.16)	-0.97 (0.57)	1.29 (1.89)	2.28 (1.42)
Moong	6.09 (5.71)	4.10 (6.71)	-1.88 (1.95)	-10.81** (1.82)	-0.86 (3.42)	11.15** (3.41)	-6.07* (2.10)	-6.00* (2.30)	0.07 (1.16)
Rapeseed & mustard	0.86 (3.19)	-1.38 (3.55)	-2.14 (1.16)	-8.28** (1.46)	-6.96 (6.70)	-0.86 (5.68)	-2.31* (1.12)	-2.44 (1.64)	-0.58 (1.06)
Sunflower	-14.79 (16.95)	-27.05* (12.37)	-2.10 (1.81)	3.99 (4.53)	11.29 (7.96)	-35.11* (15.68)	-19.81** (5.13)	-23.97** (4.57)	-11.49* (4.38)
Sugarcane	4.69 (5.95)	5.86 (6.08)	1.05 (0.88)	-13.05 (6.85)	-12.08 (7.17)	1.00 (0.86)	-6.13* (2.43)	-5.26* (2.49)	0.98** (0.30)
Dry chillies	12.44* (5.33)	14.91* (5.68)	2.19** (0.41)	-8.17 (4.19)	3.54 (11.70)	12.76 (7.67)	4.64* (2.16)	5.13 (2.81)	0.47 (1.54)
Potato	40.88** (6.84)	39.20** (7.77)	-1.18 (1.31)	2.93 (310)	2.84 (4.61)	-5.39 (3.11)	20.10** (3.22)	19.66** (3.34)	-0.11 (0.84)
Cotton A	-19.86** (5.66)	-22.36** (6.00)	-3.08 (2.30)	16.08 (8.32)	63.31* (23.03)	-23.55 (19.85)	-8.82* (3.10)	-0.71 (5.73)	-4.27 (4.65)
Cotton D	0.20 (9.73)	-0.48 (9.04)	-0.66 (2.70)	-14.32** (1.65)	-8.91** (2.59)	6.30 (3.95)	-1.80 (3.05)	0.57 (2.88)	2.41* (1.15)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses indicate Standard error

4.3 District-wise Performance of different crops

To trace out the causes of stagnation of agricultural productivity in Punjab, it would be pertinent to study performance of different crops in various districts of the state. The stagnation in area, production and productivity has been classified into 3 categories; viz. high stagnation (with negative and significant CAGR), medium stagnation (with negative but non significant CAGR) and low stagnation (positive but non significant CAGR). The analysis were done for the three periods viz. period I (1990-91 to 1999-00); period II (2000-01 to 2006-07) and overall period III (1990-91 to 2006-07) and presented below

Cereals

The state is dominated by paddy wheat crop rotation. But the problem of stagnation of productivity was found to be more acute in wheat crop as compared to rice. The problem has further aggravated in period II, as the productivity of wheat highly stagnated in 5 districts of the state and remaining districts have come into the category of medium stagnation. The major constraints in production of wheat include decreased soil organic carbon status, nutrient mining, soils of north western plains being deficient in Zn, S, Cu, B, Mo, Fe and Mn, imbalanced fertilization, crop residue burning leading to nutrient and organic C loss, receding water table (nearly 50-100 cm/year), and weed problem arising due to herbicide resistance. In case of rice in period II, the productivity in 3 districts of the state have come into the category of medium stagnation and into low stagnation in 8 districts of the state. The constraints in production of rice are shortage of water due to early summer transplanting, unsustainable intensive rice-wheat production systems, soil salinity/alkalinity and deficiency of micro elements, decreasing organic carbon content in soils, imbalanced fertilizer use and bacterial leaf blight. Amongst maize growing districts in period II, the productivity in 9 districts of the state have come into the category of medium stagnation and into low stagnation in one district. With the advancement of irrigation, much of the area has shifted to rice, which is a high water-consuming crop. This has considerably lowered the water table in the state, hence, it is suggested that there should be shift to maize since it requires only 3-4 light irrigations and also a good crop for diversification. The constraints in production, however, are inadequate availability of seed of high-yielding and longer duration single cross hybrid. For bajra and barley, medium stagnation in productivity was found in 3 and 7 districts respectively.

Table 4.2.1: Stagnation of Paddy crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category*	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	**P**	**Y**	**A**	**P**	**Y**	**A**	**P**	**Y**
High	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Medium	Kapurthala Jalandhar	Kapurthala Jalandhar Ludhiana Patiala	Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Hoshiarpur Faridkot Bathinda Patiala	Jalandhar Hoshiarpur Bathinda	Firozpur Patiala	Kapurthala	Amritsar Rupnagar Faridkot Bathinda
Low	Gurdaspur Amritsar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur	Gurdaspur Amritsar Hoshiarpur	Amritsar Kapurthala Jalandhar	Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Sangrur	Gurdaspur Kapurthala Rupnagar Ludhiana Firozpur Faridkot Sangrur Patiala	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Faridkot Bathinda Sangrur	Gurdaspur Amritsar Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Ludhiana Firozpur Sangrur Patiala

Table 4.2.2: Stagnation of maize crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	**P**	**Y**	**A**	**P**	**Y**	**A**	**P**	**Y**
High	Gurdaspur Amritsar Kapurthala Ludhiana	Amritsar	Nil	Amritsar Jalandhar Faridkot	Ludhiana Faridkot	Nil	Gurdaspur Amritsar Kapurthala Jalandhar Ludhiana Patiala	Amritsar	Nil
Medium	Jalandhar Hoshiarpur Rupnagar Sangrur Patiala	Gurdaspur Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Sangrur Patiala	Amritsar Sangrur	Gurdaspur Kapurthala Hoshiarpur Rupnagar Sangrur	Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Sangrur Patiala	Gurdaspur Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Faridkot Sangrur Patiala	Hoshiarpur Sangrur	Kapurthala Jalandhar Ludhiana Sangrur Patiala	Nil
Low	Nil	Nil	Gurdaspur Kapurthala Jalandhar Rupnagar Ludhiana Patiala	Nil	Gurdaspur	Amritsar	Rupnagar	Gurdaspur Hoshiarpur Rupnagar	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Sangrur Patiala

Table 4.2.3: Stagnation of wheat crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Nil	Nil	Nil	Nil	Ludhiana Sangrur Patiala	Amritsar Ludhiana Firozpur Faridkot Sangrur	Amritsar Firozpur	Nil	Nil
Medium	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Kapurthala Jalandhar Ludhiana Patiala	Kapurthala Jalandhar Ludhiana	Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda	Gurdaspur Kapurthala Jalandhar Hoshiarpur Rupnagar Bathinda Patiala	Kapurthala Jalandhar Ludhiana Patiala	Kapurthala Jalandhar Ludhiana Firozpur Sangrur Patiala	Kapurthala Ludhiana Firozpur Faridkot Bathinda Sangrur
Low	Rupnagar	Gurdaspur Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur	Gurdaspur Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur	Nil	Nil	Gurdaspur Amritsar Hoshiarpur Rupnagar Faridkot Bathinda Sangrur	Gurdaspur Amritsar Hoshiarpur Rupnagar Ludhiana Faridkot Bathinda	Gurdaspur Amritsar Jalandhar Hoshiarpur Rupnagar Patiala

Table 4.2.4: Stagnation of bajra crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Firozpur Faridkot	Firozpur Faridkot	Nil	Faridkot	Faridkot	Nil	Nil	Sangrur	
Medium	Hoshiarpur Bathinda Sangrur Patiala	Hoshiarpur Bathinda Sangrur Patiala	Hoshiarpur Firozpur Faridkot Bathinda Sangrur Patiala	Rupnagar Bathinda Sangrur	Rupnagar Bathinda Sangrur	Rupnagar Bathinda Sangrur	Faridkot Bathinda Sangrur	Faridkot Bathinda	Faridkot Bathinda Sangrur
Low	Nil	Nil	Nil	Nil	Nil	Faridkot	Nil	Nil	Nil

Table 4.2.5: Stagnation of barley crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Rupnagar Bathinda	Rupnagar	Nil	Ludhiana Faridkot Bathinda Sangrur Patiala	Ludhiana Faridkot Bathinda Sangrur Patiala	Nil	Ludhiana Faridkot Bathinda Sangrur	Faridkot Bathinda	Nil
Medium	Ludhiana Firozpur Faridkot Sangrur Patiala	Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Faridkot Patiala	Firozpur	Firozpur	Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Rupnagar Firozpur Patiala	Rupnagar Ludhiana Firozpur Sangrur Patiala	Ludhiana Faridkot Patiala
Low	Nil	Ludhiana	Rupnagar Ludhiana Firozpur Bathinda Sangrur	Rupnagar	Rupnagar	Nil	Nil	Nil	Rupnagar Firozpur t Bathinda Sangrur

Table 4.2.6: Stagnation of gram crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur Patiala	Hoshiarpur Rupnagar Faridkot Bathinda Patiala	Nil	Gurdaspur Hoshiarpur Firozpur Faridkot Bathinda Sangrur	Gurdaspur Firozpur Faridkot Sangrur	Nil	Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur Patiala	Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda Sangrur Patiala	Nil
Medium	Gurdaspur Amritsar Ludhiana	Gurdaspur Amritsar Ludhiana Firozpur Sangrur	Gurdaspur Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Bathinda	Rupnagar Ludhiana Patiala	Hoshiarpur Rupnagar Ludhiana Bathinda Patiala	Gurdaspur Amritsar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Sangrur Patiala	Gurdaspur Ludhiana	Gurdaspur Ludhiana	Gurdaspur Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda
Low	Nil	Nil	Ludhiana Sangrur Patiala	Amritsar	Amritsar	Bathinda	Nil	Nil	Amritsar Sangrur Patiala

Table 4.2.7: Stagnation of Arhar crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Hoshiarpur Ludhiana Patiala	Hoshiarpur Rupnagar Ludhiana Patiala	Jalandhar Hoshiarpur Ludhiana Patiala	Rupnagar Ludhiana Sangrur Patiala	Rupnagar Patiala	Nil	Hoshiarpur Rupnagar Ludhiana Patiala	Hoshiarpur Rupnagar Ludhiana Patiala	Nil
Medium	Amritsar Jalandhar Rupnagar Firozpur Faridkot Sangrur	Amritsar Jalandhar Firozpur Faridkot Sangrur	Amritsar Rupnagar Firozpur Faridkot Sangrur	Amritsar Jalandhar Hoshiarpur Firozpur Faridkot	Amritsar Jalandhar Hoshiarpur Ludhiana Faridkot Sangrur	Amritsar Jalandhar Hoshiarpur Rupnagar Ludhiana Faridkot Sangrur Patiala	Amritsar Firozpur Sangrur	Amritsar Firozpur Sangrur	Amritsar Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Sangrur Patiala
Low	Nil	Nil	Nil	Nil	Firozpur	Nil	Jalandhar Faridkot	Jalandhar Faridkot	

Table 4.2.8: Stagnation of Moong crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category*	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Faridkot	Firozpur Faridkot	Faridkot	Amritsar Kapurthala Hoshiarpur Ludhiana Firozpur Faridkot Sangrur	Amritsar Kapurthala Hoshiarpur Firozpur	Kapurthala	Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Ludhiana Firozpur Faridkot Bathinda Sangrur	Amritsar Kapurthala
Medium	Amritsar Ludhiana Firozpur Bathinda Sangrur Patiala	Amritsar Jalandhar Ludhiana Bathinda Sangrur Patiala	Amritsar Kapurthala Jalandhar Ludhiana Firozpur Bathinda Sangrur Patiala	Jalandhar Bathinda Patiala	Jalandhar Ludhiana Faridkot Sangrur Patiala	Amritsar Jalandhar Hoshiarpur Ludhiana Firozpur	Amritsar Kapurthala Jalandhar	Amritsar Kapurthala Jalandhar Patiala	Jalandhar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala
Low	Kapurthala Jalandhar	Kapurthala	Nil	Nil	Bathinda	Faridkot Bathinda Sangrur Patiala	Nil	Nil	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala

Table 4.2.9: Stagnation of sunflower crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Nil	Sangrur	Amritsar Jalandhar	Nil	Nil	Sangrur	Jalandhar Sangrur	Jalandhar Sangrur	Sangrur
Medium	Kapurthala Jalandhar Ludhiana Faridkot Sangrur Patiala	Amritsar Kapurthala Jalandhar Ludhiana Faridkot Patiala	Kapurthala Ludhiana Faridkot Sangrur Patiala	Kapurthala Rupnagar Sangrur Patiala	Kapurthala Rupnagar Sangrur Patiala	Kapurthala Jalandhar Hoshiarpur Rupnagar	Amritsar Kapurthala Ludhiana Patiala	Amritsar Kapurthala Ludhiana Patiala	Amritsar Jalandhar Ludhiana Patiala
Low	Amritsar	Nil	Nil	Amritsar Jalandhar Hoshiarpur Ludhiana	Amritsar Jalandhar Hoshiarpur Ludhiana	Amritsar Ludhiana Patiala	Nil	Nil	Kapurthala

Table 4.2.10: Stagnation of sesamumcrop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Gurdaspur Hoshiarpur Rupnagar	Gurdaspur	Amritsar Faridkot	Gurdaspur Amritsar Jalandhar Hoshiarpur Rupnagar Firozpur Faridkot	Gurdaspur Amritsar Hoshiarpur Firozpur Faridkot	Nil	Gurdaspur Amritsar Kapurthala Hoshiarpur Rupnagar	Amritsar Kapurthala Rupnagar Firozpur	Gurdaspur Faridkot
Medium	Amritsar Kapurthala Firozpur Faridkot	Amritsar Kapurthala Hoshiarpur Rupnagar Firozpur Faridkot	Gurdaspur Kapurthala Jalandhar Hoshiarpur Rupnagar Firozpur	Kapurthala Bathinda	Kapurthala Jalandhar Rupnagar Bathinda	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Firozpur Faridkot Bathinda	Jalandhar Firozpur	Gurdaspur Jalandhar Hoshiarpur	Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Firozpur
Low	Jalandhar	Jalandhar	Nil	Nil	Nil	Rupnagar	Faridkot	Faridkot	Nil

Table 4.2.11: Stagnation of American cotton crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Sangrur	Firozpur Faridkot Bathinda Sangrur	Firozpur Faridkot Bathinda	Ludhiana	Nil	Nil	Amritsar Faridkot Sangrur	Nil	Nil
Medium	Amritsar Ludhiana Firozpur Faridkot Bathinda Patiala	Amritsar Ludhiana Patiala	Amritsar Ludhiana Sangrur	Amritsar Faridkot Sangrur	Amritsar	Amritsar Faridkot Sangrur	Ludhiana Firozpur Bathinda	Amritsar Ludhiana Firozpur Faridkot Bathinda Sangrur	Amritsar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala
Low	Nil	Nil	Patiala	Firozpur Bathinda	Ludhiana Firozpur Faridkot Bathinda Sangrur	Ludhiana Firozpur Bathinda	Nil	Nil	Nil

Table 4.2.12: Stagnation of Desi cotton crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Nil	Nil	Faridkot	Firozpur Faridkot Bathinda Sangrur	Ludhiana Faridkot Bathinda Sangrur	Ludhiana	Ludhiana	Ludhiana	Nil
Medium	Ludhiana Firozpur Sangrur Patiala	Amritsar Ludhiana Firozpur Faridkot Sangrur Patiala	Amritsar Firozpur Bathinda Sangrur Patiala	Amritsar Ludhiana Patiala	Amritsar Firozpur Patiala	Firozpur Sangrur	Amritsar Firozpur Faridkot Bathinda Sangrur Patiala	Amritsar Firozpur Faridkot Bathinda Sangrur	Ludhiana Faridkot
Low	Amritsar Faridkot Bathinda	Bathinda	Ludhiana	Nil	Nil	Amritsar Faridkot Bathinda Patiala	Nil	Patiala	Amritsar Firozpur Bathinda Sangrur Patiala

Table 4.2.13: Stagnation of Sugarcane crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Nil	Amritsar Rupnagar	Kapurthala Rupnagar Faridkot Patiala	Amritsar Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Faridkot Bathinda Patiala	Amritsar Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Faridkot Bathinda	Gurdaspur Faridkot	Rupnagar Ludhiana Sangrur	Jalandhar Rupnagar Firozpur Faridkot Sangrur	Faridkot
Medium	Gurdaspur Amritsar Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Bathinda Sangrur Patiala	Gurdaspur Kapurthala Jalandhar Ludhiana Firozpur Bathinda Sangrur Patiala	Gurdaspur Amritsar Jalandhar Hoshiarpur Ludhiana Firozpur Bathinda Sangrur Patiala	Gurdaspur Hoshiarpur Sangrur	Gurdaspur Hoshiarpur Sangrur	Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Bathinda Sangrur Patiala	Gurdaspur Amritsar Kapurthala Jalandhar Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Kapurthala Ludhiana Faridkot Bathinda Patiala	Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Patiala
Low	Hoshiarpur Faridkot	Hoshiarpur Faridkot	Nil	Nil	Patiala	Nil	Hoshiarpur	Hoshiarpur	Gurdaspur Sangrur

Table 4.2.14: Stagnation of Potato crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	**P**	**Y**	**A**	**P**	**Y**	**A**	**P**	**Y**
High	Nil	Nil	Nil	Nil	Hoshiarpur Patiala	Hoshiarpur Rupnagar Firozpur	Nil	Nil	Hoshiarpur
Medium	Jalandhar Rupnagar Faridkot	Jalandhar Rupnagar	Gurdaspur Amritsar Kapurthala Jalandhar Hoshiarpur Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Gurdaspur Amritsar Hoshiarpur Rupnagar Firozpur Faridkot Sangrur Patiala	Gurdaspur Amritsar Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Faridkot Sangrur	Gurdaspur Kapurthala Jalandhar Ludhiana Bathinda Sangrur Patiala	Gurdaspur Rupnagar Faridkot	Gurdaspur Rupnagar Faridkot	Gurdaspur Amritsar Kapurthala Jalandhar Rupnagar Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala
Low	Gurdaspur Amritsar Kapurthala Hoshiarpur Ludhiana Firozpur Bathinda Sangrur Patiala	Gurdaspur Amritsar Kapurthala Hoshiarpur Ludhiana Firozpur Faridkot Bathinda Sangrur Patiala	Nil	Kapurthala Jalandhar Ludhiana Bathinda	Bathinda	Amritsar	Amritsar Kapurthala Jalandhar Hoshiarpur Ludhiana Firozpur Bathinda Sangrur Patiala	Amritsar Kapurthala Jalandhar Hoshiarpur Ludhiana Firozpur Bathinda Sangrur Patiala	Nil

Table 4.2.15: Stagnation of chillies crop regarding Area (A), Production (P) and Yield (Y) across the regions in the state

Category	1990-91 TO 1999-00			2000-01 TO 2006-07			1990-91 to 2006-07		
	A	P	Y	A	P	Y	A	P	Y
High	Firozpur	Firozpur	Nil	Amritsar Kapurthala Firozpur Faridkot	Amritsar Kapurthala Firozpur Faridkot Patiala	Rupnagar Faridkot	Kapurthala Firozpur	Kapurthala Firozpur	Firozpur
Medium	Amritsar Kapurthala Jalandhar Faridkot Bathinda Patiala	Amritsar Kapurthala Jalandhar Faridkot Patiala	Amritsar Kapurthala Jalandhar Firozpur Faridkot Bathinda Patiala	Jalandhar Rupnagar Bathinda Sangrur Patiala	Jalandhar Rupnagar Bathinda Sangrur	Amritsar Kapurthala Jalandhar Firozpur Bathinda Sangrur Patiala	Amritsar Jalandhar Faridkot Bathinda Patiala	Amritsar Jalandhar Faridkot Sangrur Patiala	Amritsar Kapurthala Jalandhar Faridkot Sangrur Patiala
Low	Sangrur	Bathinda Sangrur	Sangrur	Nil	Nil	Nil	Sangrur	Bathinda	Bathinda

Oilseed and Pulses

Gram, moong and arhar crops are the important pulse crops grown in Punjab, while sunflower, cotton, rapeseed and mustard and sesamum are the important oilseed crops of the state. But stagnation in area under these crops has been the main impediment in their receding output in the state. There has been many fold decrease in area under these crops over the period of time in the state. The major constraints to productivity of pulses are crop damage by insect, pest and deseases and allocation of marginal land for these crops. Cotton is the major oilseed crop of the state in South Western districts of the state and recently there has been significant increase in area, production and productivity of the crop due to adoption of Bt cotton by the growers. Major constraints in production of oilseed are imbalanced use of fertilizers and less use of sulphur containing fertilizers, and biotic stress. Major constraints for production of cotton include delayed sowing for want of canal water, non-availability of adequate amount of quality seeds, sub-optimal plant population, inadequate nutrient supply and indiscriminate and excessive use of pesticides.

4.3 Rate and Growth of Inputs Used

Irrigation

The Central and Southern Punjab has about 95 per cent of the NSA under irrigation when compared with less than 70 per cent of the NSA in Northern Punjab since 1990-91. It is interesting to note that more than 80 per cent of the irrigated area in Northern and Central Punjab is irrigated using groundwater. The Northern region of the state lies in the Shivalik foothills and includes the districts of Gurdaspur, Hoshiarpur and Rupnagar. There was significant increase in the net as well as gross irrigated area in these districts of the state as there has been continuous increase in the irrigated area in these districts since 1990-91. As all other districts of the state have more than 90 per cent of the NSA under

irrigation, therefore there has not been significant increase in the irrigated area in these districts. The technological breakthrough during the green revolution has mostly impacted this region of the state and mostly the region is irrigated through the electric tube-wells. In the southern part of the state, comprising of Ferozepur and Bathinda, canals are the main source of irrigation in the region.

Tractorisation

There has been significant increase in number of tractors since 1990-91 in all the districts of the state. The highest increase in annual compound growth rate in number of tractors since 1990-91 was found in Bathinda (6.05%), followed by Hoshiarpur (4.90%), Faridkot (4.58%) and Patiala (4.33%). Gurdaspur and Amritsar districts showed the least annual compound growth rate in number of tractors since 1990-91, which was 1.50 and 1.65 per cent, respectively (Table 4.3).

Electricity consumption for agricultural purposes

Similarly, electric tube wells are increasing rapidly in Punjab and it has crossed the figure of 8.27 lakh by 2001-05. There has been significant increase in electricity consumption for agricultural purposes since 1990-91 in all the districts of the state with the highest increase in annual compound growth rate in number in Bathinda (8.73%), followed by Faridkot (5.36%) and Patiala (3.90%). The high increase in Bathinda and Faridkot may be attributed to diversion of area from cotton to paddy in these districts as the profitability of cotton had fallen tremendously during this period. Ferozpur and Gurdaspur districts showed the negative annual compound growth rate in electricity consumption for agricultural purposes number of tractors since 1990-91, which was 3.06 and 1.65 per cent, respectively (Table 4.3).

Fertilizer

Fertilizer, the most important component of new technology, has played a very important role in enhancing the agricultural production in the state. The availability of high fertilizer responsive varieties of seed along with assured source of irrigation increased the consumption of chemical fertilizers in the state. There has been significant increase in fertiliser use since 1990-91 in all the districts of the state except in Gurdaspur district. The highest increase in annual compound growth rate in chemical fertiliser use was found in Hoshiarpur district, which may be due to the fact that Hoshiarpur is one of the leading district in terms of production of fruits and vegetables in the state, which require higher fertilisers.

4.4 Conclusions

The state is dominated by paddy wheat crop rotation. But the problem of stagnation of productivity was found to be more acute in wheat crop as compared to rice. The problem has further aggravated in period II (2000-01 to 2006-07), as the productivity of wheat highly stagnated in 5 districts of the state and remaining districts have come into the category of medium stagnation. In case of rice in period II (2000-01 to 2006-07), the productivity in 3 districts of the state have come into the category of medium stagnation and into low stagnation in 8 districts of the state. Amongst maize growing districts in period II, the productivity in 9 districts of the state have come into the category of medium stagnation and into low stagnation in one district. Due to revival of cotton during period II, the area under rice was found to decrease and replaced by cotton in south

Table 4.3:District-wise Average Growth Rates of Inputs Use and their CVs*1990-91 to 2006-07

Name of District	Irrigation		No. Tractor	Electricity Consumption for agricultural Purpose	Fertiliser consumption (NPK)	
	Net	Gross			Per ha GCA	Total
Gurdaspur	1.00 (13.60)	0.60* (6.23)	1.50** (7.32)	-1.65* (15.14)	-0.03 (10.42)	0.45 (10.09)
Amritsar	-1.03 (12.20)	1.86 (25.25)	1.65** (8.30)	0.53 (13.23)	3.21** (30.46)	2.33** (16.82)
Kapurthala	0.67 (13.12)	0.44* (3.87)	3.12** (14.82)	-0.11 (13.65)	1.18 (16.52)	1.60* (16.87)
Jalandhar	-0.50** (3.34)	-0.10 (2.55)	2.92** (13.88)	-0.54 (12.96)	2.16** (12.43)	2.17** (12.59)
Hoshiarpur	1.63* (13.92)	2.88** (14.15)	4.90** (22.87)	0.93 (14.97)	3.84** (24.44)	4.84** (27.67)
Rupnagar	3.84** (34.14)	2.37** (12.59)	3.05** (14.46)	1.97* (17.33)	2.96 (26.96)	3.64* (27.95)
Ludhiana	-0.08 (13.26)	0.38** (2.97)	2.82** (13.50)	-0.07 (14.26)	0.87* (8.78)	1.15* (9.36)
Firozpur	-0.56 (9.64)	-0.38* (3.32)	1.74** (8.73)	-3.06** (19.17)	0.96 (13.66)	0.46 (12.96)
Faridkot	1.35 (19.16)	1.56** (8.13)	4.58** (21.04)	5.36** (27.75)	2.03** (12.55)	3.50** (18.63)
Bathinda	0.42** (3.14)	-0.44 (13.70)	6.05 (35.57)	8.73** (40.99)	1.92 (22.01)	2.69* (22.95)
Sangrur	-0.37 (13.59)	0.02 (3.31)	2.70** (12.89)	1.23 (31.25)	2.37** (15.90)	2.21** (15.10)
Patiala	0.72 (19.59)	2.19 (18.62)	4.33** (20.46)	3.90** (24.20)	1.79** (13.13)	2.20** (15.95)

** Significant at 1% level, * significant at 5 % level
Note: figures in the parentheses are coefficient of variation

western districts of the state (cotton belt). For bajra and barley, medium stagnation in productivity was found in 3 and 7 districts respectively. Gram, moong and arhar crops are the important pulse crops grown in Punjab, while sunflower, cotton, rapeseed and mustard and sesamum are the important oilseed crops of the state. But stagnation in area under these crops has been the main impediment in their receding output in the state. There has been many fold decrease in area under these crops over the period of time in the state. The major constraints to productivity of pulses are crop damage by insect, pest and deseases and allocation of marginal land for these crops. Major constraints in production of oilseed are imbalanced use of fertilizers and less use of sulphur containing fertilizers, and biotic stress. Major constraints for production of cotton include delayed sowing for want of canal water, non-availability of adequate amount of quality seeds,

sub-optimal plant population, inadequate nutrient supply and indiscriminate and excessive use of pesticides.

The Central and Southern Punjab has about 95 per cent of the NSA under irrigation when compared with less than 70 per cent of the NSA in Northern Punjab since 1990-91. It is interesting to note that more than 80 per cent of the irrigated area in Northern and Central Punjab is irrigated using groundwater. The Northern region of the state lies in the Shivalik foothills and includes the districts of Gurdaspur, Hoshiarpur and Rupnagar. As all other districts of the state have more than 90 per cent of the NSA under irrigation, therefore there has not been significant increase in the irrigated area in these districts. The technological breakthrough during the green revolution has mostly impacted this region of the state and mostly the region is irrigated through the electric tube-wells. In the southern part of the state, comprising of Ferozepur and Bathinda, canals are the main source of irrigation in the region.

There has been significant increase in number of tractors since 1990-91 in all the districts of the state. The highest increase in annual compound growth rate in number of tractors since 1990-91 was found in Bathinda (6.05%), followed by Hoshiarpur (4.90%), Faridkot (4.58%) and Patiala (4.33%). Gurdaspur and Amritsar districts showed the least annual compound growth rate in number of tractors since 1990-91, which was 1.50 and 1.65 per cent, respectively. Similarly, electric tube wells are increasing rapidly in Punjab and it has crossed the figure of 8.27 lakh by 2001-05. There has been significant increase in electricity consumption for agricultural purposes since 1990-91 in all the districts of the state with the highest increase in annual compound growth rate in number in Bathinda (8.73%), followed by Faridkot (5.36%) and Patiala (3.90%). Ferozpur and Gurdaspur districts showed the negative annual compound growth rate in electricity consumption for

agricultural purposes number of tractors since 1990-91, which was 3.06 and 1.65 per cent, respectively. There has been significant increase in fertiliser use since 1990-91 in all the districts of the state except in Gurdaspur district. The highest increase in annual compound growth rate in chemical fertiliser use was found in Hoshiarpur district, which may be due to the fact that Hoshiarpur is one of the leading district in terms of production of fruits and vegetables in the state, which require higher fertilisers.

Chapter V

Determinants of Productivity Stagnation of Major Agricultural Crops

5.1 Introduction

The term Total Factor Productivity (TFP) is an attempt to measure the amount of increase in the total output, which is not accounted for by increase in total inputs. There is a large residual, measured by total factor productivity, which is the contribution of improvement of technology/knowledge, infrastructural developments. human capital improvement and policy interventions. The total factor productivity index is computed as the ratio of aggregate output index to the aggregate input index. The Total Factor Productivity (TFP) in Paddy, wheat and cotton was measured for these crops in the Punjab state, the analysis were done for the two periods viz. period I (1981-82 to 1989-90) and period II (1990-91 to 2004-05).

5.2 Determinants of Stagnation in Productivity of major Crops

The results of total factor productivity of Paddy, wheat and cotton for Punjab are presented in Tables 5.2.1 and 5.2.2 and Fig. 2 and 3. The results for period I (1981-82 to 1989-90) revealed that the total input index of paddy first increased to 1.11 till 1983-84; then decreased to 1.02 in 1984-85 and remained almost stable for the next two years and decreased constantly during afterwards till it reached 0.93 by the year 1989-90. As far as the total output index of paddy are concerned, there has been constant increase and the value touched the highest level of 1.59 in 1989-90. The TFP index was found to be less than one during the periods 1982-83 and 1983-84 and rest of the periods, it was more than one, which indicate the higher returns of paddy cultivation. The results for period II (1990-91 to 2004-05) revealed that the total input index of paddy in Punjab has been more than one in the year 1992-93 only, otherwise it was less than one for the other years.

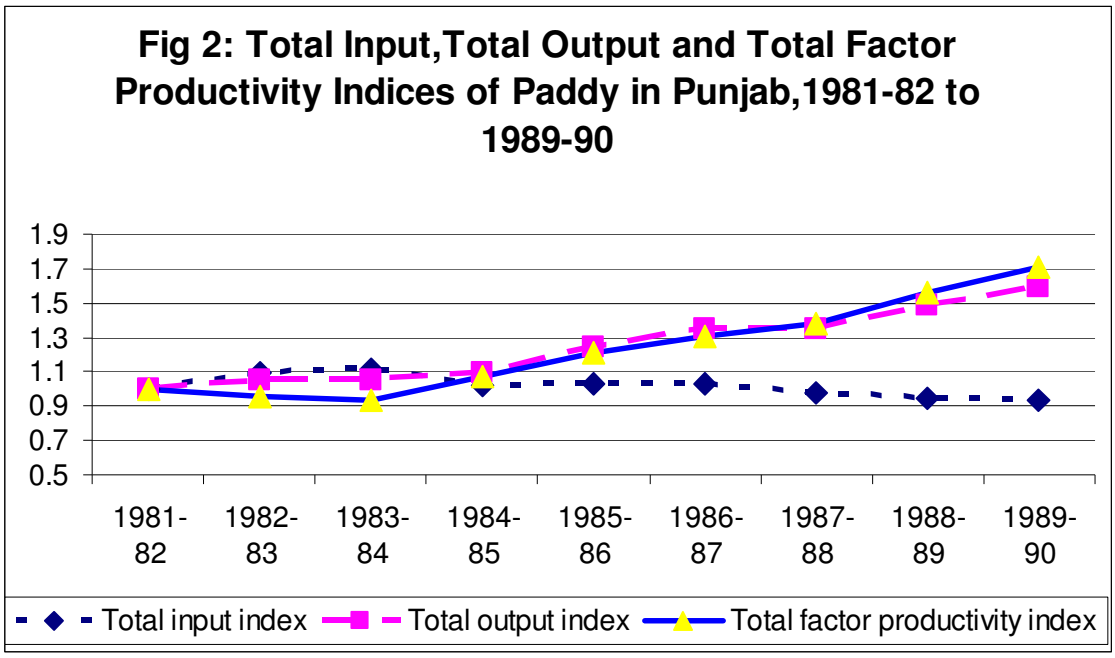
However, this index varied between 1.00 to 0.88 during this period. As far as the total output index of paddy for the period under study is concerned, there has been constant increase and the value touched the highest level of 3.29 in 2003-04. The TFP index for paddy has been increasing almost constantly and the value touched the highest level of 3.58 in 2003-04, which shows that the returns from paddy are increasing continuously. The TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of paddy in period II as compared to the earlier period.

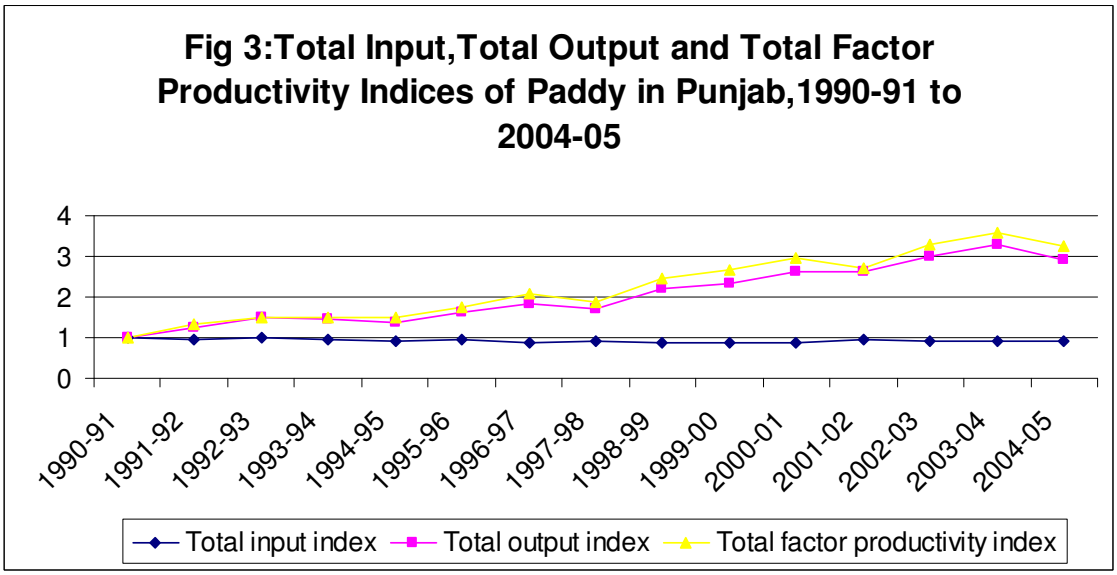
Table 5.2.1: Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Paddy in Punjab, 1981-82 to 1989-90.

Period	Total input index	Total output index	Total factor productivity index
1981-82	1.00	1.00	1.00
1982-83	1.09	1.05	0.96
1983-84	1.11	1.05	0.94
1984-85	1.02	1.09	1.07
1985-86	1.03	1.24	1.21
1986-87	1.03	1.35	1.31
1987-88	0.98	1.35	1.38
1988-89	0.95	1.49	1.56
1989-90	0.93	1.59	1.71
Average annual growth rates (%)	-0.77	6.55	7.89

Table 5.2.2 : Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Paddy in Punjab, 1990-91 to 2004-05.

Period	Total input index	Total output index	Total factor productivity index
1990-91	1.00	1.00	1.00
1991-92	0.95	1.27	1.35
1992-93	1.01	1.49	1.48
1993-94	0.97	1.47	1.51
1994-95	0.91	1.38	1.52
1995-96	0.95	1.64	1.73
1996-97	0.89	1.85	2.08
1997-98	0.90	1.70	1.89
1998-99	0.89	2.19	2.47
1999-00	0.88	2.34	2.67
2000-01	0.89	2.62	2.96
2001-02	0.97	2.61	2.70
2002-03	0.91	3.01	3.31
2003-04	0.92	3.29	3.58
2004-05	0.90	2.90	3.23
Average annual growth rates (%)	-0.66	12.67	14.87





The results of total factor productivity of wheat are presented in Tables 5.2.3 and 5.2.4 and Fig. 4 and 5. The results for period I (1981-82 to 1989-90) revealed that the total input index was revolving around one and was marginally more than one for most of the year except for the year 1988-89. The total output index and TFP index were showing

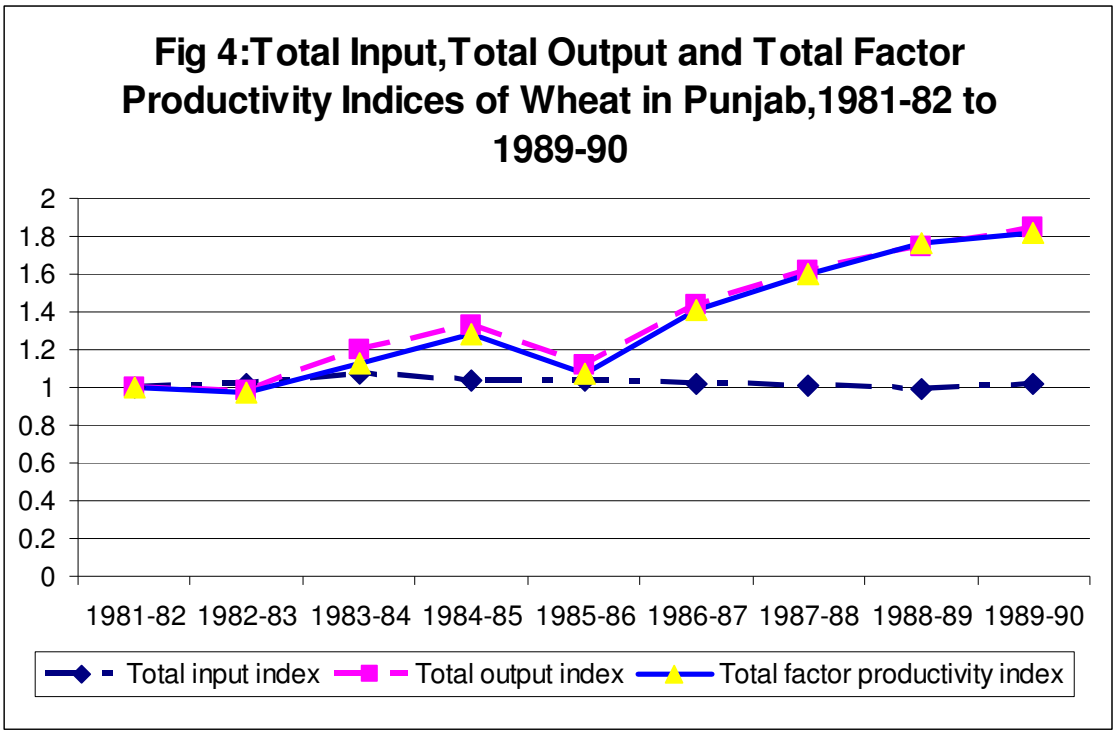
almost the same pattern of continuous increase over the period showing that the output and productivity were continuously increasing during the period. The results for period II (1990-91 to 2004-05) revealed that the total input index of wheat has been more than one in the years 1991-92 and 1992-93, otherwise it was less than or equal to one for the other years. As in period I, the total output index and TFP index were showing almost the same pattern of continuous increase over the period II showing that the output and productivity were continuously increasing during the period. Like paddy, the TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of these crops in period II as compared to the earlier period.

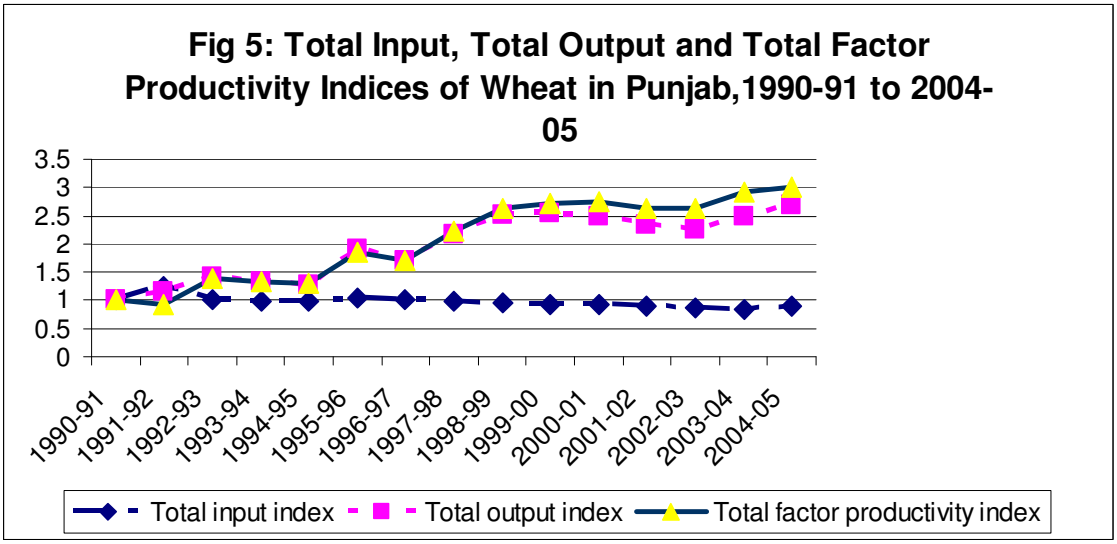
Table 5.2.3: Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Wheat in Punjab, 1981-82-1989-90.

Period	Total input index	Total output index	Total factor productivity index
1981-82	1.00	1.00	1.00
1982-83	1.02	0.98	0.97
1983-84	1.07	1.20	1.13
1984-85	1.04	1.33	1.28
1985-86	1.04	1.12	1.07
1986-87	1.02	1.44	1.41
1987-88	1.01	1.62	1.60
1988-89	0.99	1.75	1.76
1989-90	1.02	1.85	1.82
Average annual growth rates (%)	0.22	9.44	9.11

Table 5.2.4: Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Wheat in Punjab, 1990-91 to 2004-05.

Period	Total input index	Total output index	Total factor productivity index
1990-91	1.00	1.00	1.00
1991-92	1.24	1.16	0.94
1992-93	1.01	1.42	1.40
1993-94	0.99	1.32	1.34
1994-95	0.99	1.27	1.29
1995-96	1.03	1.90	1.85
1996-97	1.00	1.72	1.72
1997-98	0.97	2.16	2.24
1998-99	0.96	2.51	2.62
1999-00	0.94	2.55	2.72
2000-01	0.92	2.50	2.74
2001-02	0.89	2.35	2.62
2002-03	0.86	2.25	2.62
2003-04	0.85	2.49	2.92
2004-05	0.90	2.70	3.00
Average annual growth rates (%)	-0.67	11.33	13.33





The results of total factor productivity of cotton of in period I (1981-82 to 1989-90) revealed that the total input index of cotton has been increasing constantly during the period 1981-82 to 186-87 and then declined to 1.03 in the year 1987-88 and again increased to 1.11 in the year 1989-90 (Table 5.2.5 and Fig. 6). However, this index varied

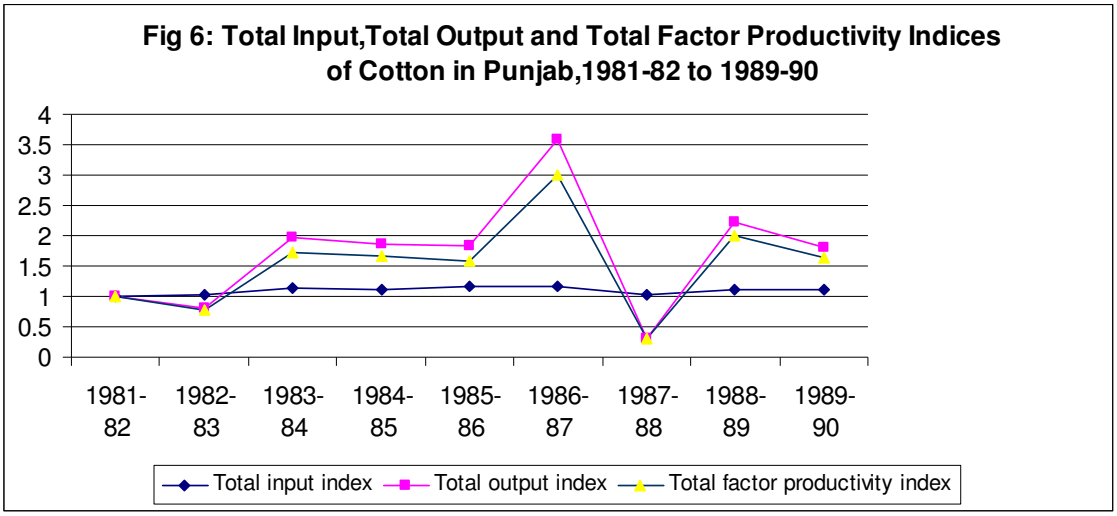
between 1.00 to 1.16 during this period. As far as the total output index and TFP index of cotton are concerned, many ups and down were seen. The TFP index of Punjab state was the highest during the period 1986-87 (3.01) and the lowest during the period 1987-88 (0.30). The cotton crop was damaged during the year 1987 due to the severe attack of pest and diseases. During the period II (1990-91 to 2004-05), total input index has been decreasing constantly during the period and reached the lowest ebb during the year 2004-05 (0.77). The total output index and TFP index of cotton showed a great variation over the period of time. The cotton crop was damaged during the period 1996-97 to 2001-02 due to the severe attack of pest and diseases. The TFP index was found become more than one since the year 1999-2000. The TFP of cotton was declining since mid 90's due to over-mechanisation, stagnant yield and high input costs (Table 5.2.6 and Fig. 7). The TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of cotton in period II as compared to the earlier period, which is due to the adoption of Bt cotton variety in the state since 2002-03, which has increased the productivity and reduced the cost of cultivation due to lesser number of sprays required for the control of insect pest and diseases in the variety.

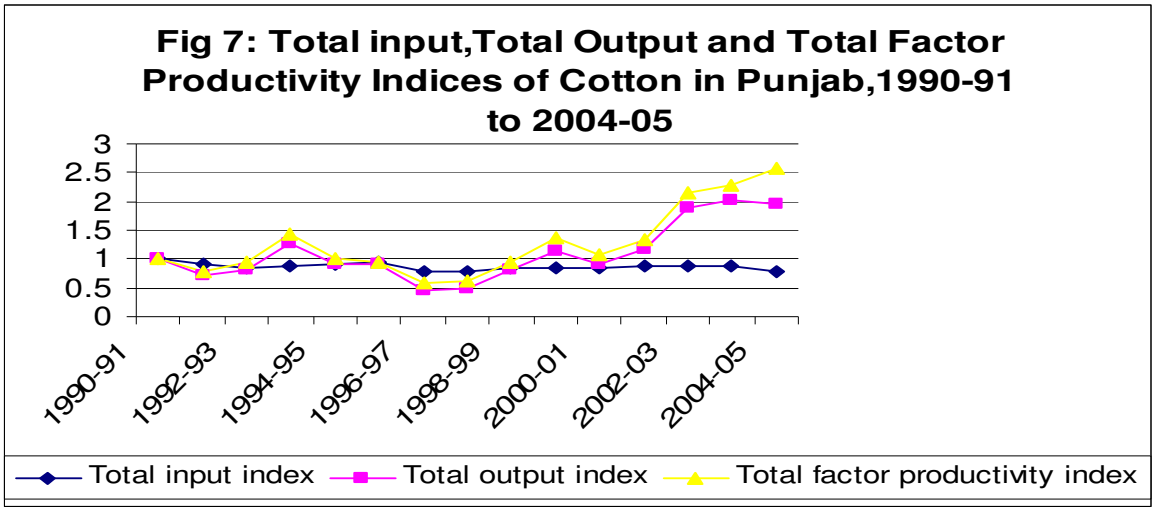
Table 5.2.5: Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Cotton in Punjab, 1981-82 to 1989-90.

Period	Total input index	Total output index	Total factor productivity index
1981-82	1.00	1.00	1.00
1982-83	1.04	0.81	0.78
1983-84	1.15	1.96	1.71
1984-85	1.12	1.87	1.67
1985-86	1.16	1.83	1.58
1986-87	1.18	3.57	3.01
1987-88	1.03	0.31	0.30
1988-89	1.10	2.22	2.01
1989-90	1.11	1.81	1.63
Average annual growth rates (%)	1.22	9.00	7.00

Table 5.2.6: Total Input, Total Output and Total Factor Productivity Indices and their Average annual growth rates of Cotton in Punjab, 1990-91 to 2004-05.

Period	Total input index	Total output index	Total factor productivity index
1990-91	1.00	1.00	1.00
1991-92	0.90	0.72	0.79
1992-93	0.85	0.82	0.96
1993-94	0.87	1.27	1.45
1994-95	0.91	0.92	1.02
1995-96	0.95	0.90	0.94
1996-97	0.78	0.46	0.59
1997-98	0.79	0.49	0.63
1998-99	0.85	0.82	0.96
1999-00	0.84	1.15	1.36
2000-01	0.84	0.90	1.07
2001-02	0.87	1.17	1.35
2002-03	0.89	1.90	2.14
2003-04	0.88	2.02	2.29
2004-05	0.77	1.97	2.57
Average annual growth rates (%)	-1.53	6.47	10.47





5.3 Determinants of Total Factor Productivity

Total factor productivity (TFP) postulates increases in total output less increases in total (all) inputs. Changes in output other than that generated by changes in inputs can be induced by research, extension, human capital, infrastructure, price policy and climatic factors. As an input into public investment decisions, it is useful to understand the relative importance of productivity enhancing factors in determining productivity growth. In order to assess the determinants of TFP, the TFP index was estimated as a function of the independent variables like June to August rainfall; annual rainfall; agricultural terms of trade; investment on Research and Development (R&D) per hectare; literacy (the proportion of rural population who are literate) and the number of regulated markets per thousand hectare of cropped area. As most of the independent variables are sector specific (cropwise data for independent variables was not available) and therefore wighted TFP index for the state as a whole was constructed (by taking cropwise area share as weights) and then factors affecting TFP was analysed. Dependent variable is the log of TFP index. All variables were specified in logarithms, except the literacy, which was entered linearly.

The estimated parameters of TFP equation for Punjab are presented in Table 5.3. The development of rural infrastructuke in India (such as roads, communications, institutional support and provision of storage and warehousing) are closely associated with the establishment of regulated markets, so the latter variable is used as a proxy for the level of infrastructure development. The results show that the number of regulated markets had a significant and positive effect on TFP. Annual rainfall has a significant negative impact on productivity which may be due to variations large variations in the rainfall during these years. The state experiences about 75 per cent of the total rainfall during the monsoon season in June to August months and has a positive impact on the growth of TFP. Agricultural terms of trade is a potentially important instrument to influence the efficiency and investments in agriculture, which showed a positive impact on TFP. The investment on Research and Development (R&D) has a positive impact on TFP. Rural literacy as the measure of human capital in farming has the negative sign but is **Table**

5.3: Determinants of Total Factor Productivity Growth in Punjab

Variable	Parametre estimates	Standard error
Intercept (constant)	6.771	1.979
June- August Rainfall	.0883	0.060
Annual Rainfall	-0.216*	0.099
Agricultural Terms of Trade	0.140	0.138
Expenditure on R & D per ha	0.0960	0.067
Literacy- the proportion of rural literate population	-0.0007	0.001
Number of Regulated Markets per thousand ha of Gross Cropped Area	3.898**	1.192
R2	0.87	
Degrees of freedom	13	

Note: ** Significant at 1% level, * significant at 5 % level.

insignificant. The results of decomposition of TFP confirm that market infrastructure, June to August rainfall, the agricultural terms of trade and investment on Research and Development (R&D) are the most important instruments of growth in TFP.

5.4 Conclusion

The results of total factor productivity of Paddy revealed that the total input index of paddy first increased to 1.11 till 1983-84; then decreased to 1.02 in 1984-85 and remained almost stable for the next two years and decreased constantly during afterwards till it reached 0.93 by the year 1989-90. As far as the total output index of paddy are concerned, there has been constant increase and the value touched the highest level of 1.59 in 1989-90. The TFP index was found to be less than one during the periods 1982-83 and 1983-84 and rest of the periods, it was more than one, which indicate the higher returns of paddy cultivation. The results for period II (1990-91 to 2004-05) revealed that the total input index of paddy in Punjab has been more than one in the year 1992-93 only, otherwise it was less than one for the other years. However, this index varied between 1.00 to 0.88 during this period. As far as the total output index of paddy for the period under study is concerned, there has been constant increase and the value touched the highest level of 3.29 in 2003-04. The TFP index paddy has been increasing almost constantly and the value touched the highest level of 3.58 in 2003-04, which shows that the returns from paddy are increasing continuously.

The results of total factor productivity of wheat for period I (1981-82 to 1989-90) revealed that the total input index was revolving around one and was marginally more than one for most of the year except for the year 1988-89. The total output index and TFP index were showing almost the same pattern of continuous increase over the period showing that the output and productivity were continuously increasing during the period.

The results for period II (1990-91 to 2004-05) revealed that the total input index of wheat has been more than one in the years 1991-92 and 1992-93, otherwise it was less than or equal to one for the other years. As in period I, the total output index and TFP index were showing almost the same pattern of continuous increase over the period II showing that the output and productivity were continuously increasing during the period. For paddy and wheat, the TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of these crops in period II as compared to the earlier period.

The results of total factor productivity of cotton in period I (1981-82 to 1989-90) revealed that the total input index of cotton has been increasing constantly during the period 1981-82 to 186-87 and then declined to 1.03 in the year 1987-88 and again increased to 1.11 in the year 1989-90. However, this index varied between 1.00 to 1.16 during this period. As far as the total output index and TFP index of cotton are concerned, many ups and down were seen. The TFP index of Punjab state was the highest during the period 1986-87 (3.01) and the lowest during the period 1987-88 (0.30). The cotton crop was damaged during the year 1987 due to the severe attack of pest and diseases. During the period II (1990-91 to 2004-05), total input index has been decreasing constantly during the period and reached the lowest ebb during the year 2004-05 (0.77). The total output index and TFP index of cotton showed a great variation over the period of time. The cotton crop was damaged during the period 1996-97 to 2001-02 due to the severe attack of pest and diseases. The TFP index was found become more than one since the year 1999-2000. The TFP of cotton was declining since mid 90's due to over-mechanisation, stagnant yield and high input costs. The TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to

period I (1981-82 to 1989-90), which shows the higher profitability of cotton in period II as compared to the earlier period, which is due to the adoption of Bt cotton variety in the state since 2002-03, which has increased the productivity and reduced the cost of cultivation due to lesser number of sprays required for the control of insect pest and diseases in the variety.

The results of decomposition of TFP confirm that market infrastructure, June to August rainfall, the agricultural terms of trade and investment on Research and Development (R&D) are the most important instruments of growth in TFP.

Chapter VI

Conclusion and Policy Implications

Introduction

Punjab agriculture has registered spectacular progress and the food-grain production in the state increased from 3 million tonnes in 1961 to 25.6 million tonnes in 2009-10 which accounted for about 13 per cent of total food-grains production in the country with only 1.75 per cent of total geographical area in the country. The transformation of Punjab agriculture has started showing signs of new set of problems since the nineties. The productivity of major crops like wheat and rice has stagnated leading to increase in cost of production resulting in reduced profitability making many small and marginal farmers unviable. This along with stunted growth of non-agriculture sector, over utilization of farm machinery, migratory agricultural labour from other states and use of the weedicides have further aggravated the problem of unemployment. The predominance of paddy-wheat monoculture is posing a great threat to soil health, resulting in depletion of underground water. It is also resulted in some marketing problems besides creating ecological imbalances in the state. The new world trade agreements under the WTO regime during nineties put further pressure on the state agriculture economy to face tough competition in the international markets.

The broad objectives of the study are:

a. To analyse the growth pattern of production and productivity of important crops across the districts and State;

b. To study the regional variations in productivity of important crops (specifically bringing out the districts with differentiated growth behaviour) and to map out the regions with acute stagnation;

c. To trace the determinants for changes in productivity and stagnation of important crops, and

d. To suggest district level interventions to overcome the problems of stagnation.

Methodology

The present study was conducted in the Punjab state of India. The study was based on the secondary data and various sources were tapped to achieve the stipulated objectives of the study. The requisite data for the study relating to area, production, productivity of various crops minimum support prices, harvest prices, wholesale prices, marketing infrastructure, market arrivals and major growth parameters have been collected from the various sources such as *Centre for Monitoring Indian Economy*, *Statistical Abstracts of Punjab, Agricultural Statistics at a Glance,* and Directorate of Agriculture, Punjab. The data relating to the estimates of cost of cultivation/production of paddy, wheat and cotton have been collected various issues of *CACP (Commission for Agricultural Costs and Prices) Reports* and *'Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Punjab'* running in the Department of Economics, Punjab Agricultural University Ludhiana. Five new districts emerged in the state during the period 1990-91 to 1995-96 and further 3 more districts emerged in 2005-06. To make the district-wise comparisons feasible, these districts were merged with the parent districts. As some of the districts were formed by extracting area from more than one parent district, the figures of these districts were merged into parent districts according to the ratio of net sown area extracted. The compound growth rates were calculated by fitting the exponential function

to different aspects of prices, infrastructure and agricultural growth parameters of Punjab State. In order to measure the Total Factor Productivity (TFP) for important crops in the state, the farm level data relating to input costs (Rs/ha) like Human Labour, Machine Labour, Bullock Labour, Fertilizers and Manures, Insecticides, Irrigation charges etc., and returns of these crops for the period of 1981-82 to 2003-04 were used.

Recent Developments in Agriculture in the State

The Punjab state manifests the growth in agriculture sector achieved by India after the green revolution period. With mere 1.53% of the geographical area of India, it contributes around 55-65% of wheat and 35-45% of rice to the national pool every year. The productivity of wheat rose from 1.1 t/ha during 1960-61 to 4.5 t/ha during 2007-08 and that of paddy from 1.6 t/ha to 6.0 t/ha over the same period. The total production of wheat rose from 1.74 million tons in 1960-61 to 15.7 million tons in 2007-08 and that of paddy from 0.34 million tons to 15.7 million tons during this period. Per cultivated hectare fertilizer consumption is about 213 kg as compared to the national average of 90 kg. Almost 97 per cent of the cultivated area is under assured irrigation which is the major reason for higher productivity and input use in agriculture. More than 75 per cent of annual rainfall is received during the South-west (SW) monsoon season (June-September). There has been continuous increase in the net sown area in the state since 1960-61 and the proportion of net sown area to total geographical area, which was 75.83 per cent in triennium ending 1962-63 has reached to 83.14 per cent by triennium ending 2006-07.

Data from the 2000-01 agriculture census indicated that the average holding size in the state had improved to nearly 4.03 hectare but there was marginal decrease to 3.95 hectare in the recent years (2005-06). Cereals, particularly rice and wheat dominate the cropping

pattern scenario in the state as about 70 per cent of gross cropped area in the state in is occupied by these two crops in the state. There was tremendous increase in area, production and yield under paddy for all the periods under study. Wheat also showed the same trend but the increase was at lesser pace than for the paddy. Increase in area and productivity of these crops are the main movers for this increase in production of these crops in the state. All other crops showed either decrease in area or the insignificant increase in area during this period. It clearly reveals that the paddy and wheat crop rotation became predominant at the cost of maize, other cereals, oilseed and pulses in the state.

The total availability of agricultural credit has increased form Rs 945 million during 1971-75 to Rs 88838 million in 2001-05. Total consumption of NPK in Punjab, which was merely 276 thousand nutrient tones during 1971-75, has continuously increased over time and reached to a level of 14.52 lakh nutrient tones by the period 2001-05. Now, Punjab has the highest consumption of chemical fertilizer per hectare in the country. It consumed about 184 kgs/ha of fertilizers in the period 2001-05 as compared to average of 47kgs/ha during 1971-75. The Punjab agriculture is highly mechanized in nature. The density of tractors per thousand hectares is 64 in Punjab, which is highest in India. It has increased form the level of mere 5 tractors per thousand hectares of land during 1960-61. On an average, there is now one tractor for every eight hectare of net cultivated land, and in some districts the area operated by a tractor is even lower. Similarly, electric tube wells are increasing rapidly in Punjab and it has crossed the figure of 8.27 lakh by 2001-05. The number of diesel tube wells it has reached 2.42 lakh by 2001-05. The area under HYVs increased from about 22 lakh hectares in the period 1971-75 to about 61 lakh hectares during 2001-01. The level of most of the major input use has increased significantly in

period IV (2000-01 to 2005-06) as compared to other periods for paddy, wheat and cotton crops, except for human labour in case of paddyand period IV (1990-91 to 2006-07). Although procurement price, wholesale price and farm harvest price showed significantly consistent growth over the years but for paddy and maize crops, the growth of MSP in period III (1980-81 to 1989-90) was higher than for the growth in WSP and FHP, whereas reverse was the situation in period IV (1990-91 to 2006-07). The proportion of gross capital formation in Punjab agriculture at current prices to the gross capital formation showed a decline from 21.7 per cent in 1980-81 to around 11 percent till 2003-04 but then decreased up to 9.8 per cent by the year 2005-06. The growth of capital formation in public sector was lesser as compared to the private sector since 1980s. The capital formation in public sector at current prices increased from Rs 42 crores in 1980-81 to about Rs 198 crores in 2005-06, while the growth in private sector during the period was from Rs 108 crores to about 1797 crores. The total expenditure on agriculture, which was Rs 14.55 crore during 1981-85, declined to Rs 9.44 crore during 1996-00 and became Rs. 55.67 crore during the period 2001-05. In a similar way, the expenditure at 1980-81 prices declined from Rs 13.58 crore to Rs 1.93 crore and further increased to Rs. 9.69 crores. This indicates the shrinkage of human resources engaged in agriculture as well as fall in investments in capial equipments required for future growth. Such trends even undermines the extension delivery system of the state department for dissemination of latest technologies.

Trends and Patterns in Production and Productivity: District Level Analysis

The state is dominated by paddy wheat crop rotation. But the problem of stagnation of productivity was found to be more acute in wheat crop as compared to rice. The problem has further aggravated in period II (2000-01 to 2006-07), as the productivity of wheat

highly stagnated in 5 districts of the state and remaining districts have come into the category of medium stagnation. In case of rice in period II (2000-01 to 2006-07), the productivity in 3 districts of the state have come into the category of medium stagnation and into low stagnation in 8 districts of the state. Amongst maize growing districts in period II, the productivity in 9 districts of the state have come into the category of medium stagnation and into low stagnation in one district. Due to revival of cotton during period II, the area under rice was found to decrease and replaced by cotton in south western districts of the state (cotton belt). For bajra and barley, medium stagnation in productivity was found in 3 and 7 districts respectively. Gram, moong and arhar crops are the important pulse crops grown in Punjab, while sunflower, cotton, rapeseed and mustard and sesamum are the important oilseed crops of the state. But stagnation in area under these crops has been the main impediment in their receding output in the state. There has been many fold decrease in area under these crops over the period of time in the state. The major constraints to productivity of pulses are crop damage by insect, pest and deseases and allocation of marginal land for these crops. Major constraints in production of oilseed are imbalanced use of fertilizers and less use of sulphur containing fertilizers, and biotic stress. Major constraints for production of cotton include delayed sowing for want of canal water, non-availability of adequate amount of quality seeds, sub-optimal plant population, inadequate nutrient supply and indiscriminate and excessive use of pesticides.

The Central and Southern Punjab has about 95 per cent of the NSA under irrigation when compared with less than 70 per cent of the NSA in Northern Punjab since 1990-91. It is interesting to note that more than 80 per cent of the irrigated area in Northern and Central Punjab is irrigated using groundwater. The Northern region of the state lies in the

Shivalik foothills and includes the districts of Gurdaspur, Hoshiarpur and Rupnagar. As all other districts of the state have more than 90 per cent of the NSA under irrigation, therefore there has not been significant increase in the irrigated area in these districts. The technological breakthrough during the green revolution has mostly impacted this region of the state and mostly the region is irrigated through the electric tube-wells. In the southern part of the state, comprising of Ferozepur and Bathinda, canals are the main source of irrigation in the region.

There has been significant increase in number of tractors since 1990-91 in all the districts of the state. The highest increase in annual compound growth rate in number of tractors since 1990-91 was found in Bathinda (6.05%), followed by Hoshiarpur (4.90%), Faridkot (4.58%) and Patiala (4.33%). Gurdaspur and Amritsar districts showed the least annual compound growth rate in number of tractors since 1990-91, which was 1.50 and 1.65 per cent, respectively. Similarly, electric tube wells are increasing rapidly in Punjab and it has crossed the figure of 8.27 lakh by 2001-05. There has been significant increase in electricity consumption for agricultural purposes since 1990-91 in all the districts of the state with the highest increase in annual compound growth rate in number in Bathinda (8.73%), followed by Faridkot (5.36%) and Patiala (3.90%). Ferozpur and Gurdaspur districts showed the negative annual compound growth rate in electricity consumption for agricultural purposes number of tractors since 1990-91, which was 3.06 and 1.65 per cent, respectively. There has been significant increase in fertiliser use since 1990-91 in all the districts of the state except in Gurdaspur district. The highest increase in annual compound growth rate in chemical fertiliser use was found in Hoshiarpur district, which may be due to the fact that Hoshiarpur is one of the leading district in terms of production of fruits and vegetables in the state, which require higher fertilisers.

Determinants of Productivity Stagnation of Major Agricultural Crops

The results of total factor productivity of Paddy revealed that the total input index of paddy first increased to 1.11 till 1983-84; then decreased to 1.02 in 1984-85 and remained almost stable for the next two years and decreased constantly during afterwards till it reached 0.93 by the year 1989-90. As far as the total output index of paddy are concerned, there has been constant increase and the value touched the highest level of 1.59 in 1989-90. The TFP index was found to be less than one during the periods 1982-83 and 1983-84 and rest of the periods, it was more than one, which indicate the higher returns of paddy cultivation. The results for period II (1990-91 to 2004-05) revealed that the total input index of paddy in Punjab has been more than one in the year 1992-93 only, otherwise it was less than one for the other years. However, this index varied between 1.00 to 0.88 during this period. As far as the total output index of paddy for the period under study is concerned, there has been constant increase and the value touched the highest level of 3.29 in 2003-04. The TFP index paddy has been increasing almost constantly and the value touched the highest level of 3.58 in 2003-04, which shows that the returns from paddy are increasing continuously.

The results of total factor productivity of wheat for period I (1981-82 to 1989-90) revealed that the total input index was revolving around one and was marginally more than one for most of the year except for the year 1988-89. The total output index and TFP index were showing almost the same pattern of continuous increase over the period showing that the output and productivity were continuously increasing during the period. The results for period II (1990-91 to 2004-05) revealed that the total input index of wheat has been more than one in the years 1991-92 and 1992-93, otherwise it was less than or equal to one for the other years. As in period I, the total output index and TFP index were

showing almost the same pattern of continuous increase over the period II showing that the output and productivity were continuously increasing during the period. For paddy and wheat, the TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of these crops in period II as compared to the earlier period.

The results of total factor productivity of cotton of in period I (1981-82 to 1989-90) revealed that the total input index has been increasing constantly during the period 1981-82 to 186-87 and then declined to 1.03 in the year 1987-88 and again increased to 1.11 in the year 1989-90. However, this index varied between 1.00 to 1.16 during this period. As far as the total output index and TFP index of cotton are concerned, many ups and down were seen. The TFP index of Punjab state was the highest during the period 1986-87 (3.01) and the lowest during the period 1987-88 (0.30). The cotton crop was damaged during the year 1987 due to the severe attack of pest and diseases. During the period II (1990-91 to 2004-05), total input index has been decreasing constantly during the period and reached the lowest ebb during the year 2004-05 (0.77). The total output index and TFP index of cotton showed a great variation over the period of time. The cotton crop was damaged during the period 1996-97 to 2001-02 due to the severe attack of pest and diseases. The TFP index was found become more than one since the year 1999-2000. The TFP of cotton was declining since mid 90's due to over-mechanisation, stagnant yield and high input costs. The TFP index showed higher increase in average annual growth rate for period II (1990-91 to 2004-05) as compared to period I (1981-82 to 1989-90), which shows the higher profitability of cotton in period II as compared to the earlier period, which is due to the adoption of Bt cotton variety in the state since 2002-03, which has increased the productivity and reduced the cost of cultivation due to lesser number of

sprays required for the control of insect pest and diseases in the variety. The results of decomposition of TFP confirm that market infrastructure, June to August rainfall, the agricultural terms of trade and investment on Research and Development (R&D) are the most important instruments of growth in TFP.

Policy implications

Central Punjab is the major paddy producing areas though paddy is an important crop in Southern and Northern Punjab also. Maize is concentrated in northern and central Punjab, sharing roughly two third and one third of the maize area in the state. In Northern Punjab, maize and paddy are grown during *kharif* and wheat during rabi season. The region is well suited for growing fruit crops like citrus, peach, pear, and litchi. In Southern Punjab, paddy and cotton are the main *kharif* crops and wheat, gram and mustard are the *rabi* crops. In Central Punjab, paddy-wheat rotation is the dominant cropping system sharing more than one third of the area. Pulses, oilseeds and cotton are also grown during *kharif*. Sugarcane is a small component of the cropping system in this region. Predominance of paddy–wheat rotation has serious repercussions in the form of soil health due to toxicity, alkalinity/salinity, micronutrient deficiencies and depletion of groundwater due to excessive mining of water and therefore the productivity of these crops has almost become stagnant. Since legumes are a major source of nitrogen enrichment in the soils through natural means, their reduced cultivation has led to deterioration in soil quality. Further, this has reduced crop diversity which has also its own impact on the ecosystem. Considering these hazardous effects of mono-culture, paddy-wheat rotation needs diversification towards more sustainable cropping system. In order to avoid salinity and alkalinity problems and to sustain production, at least 10 per cent area under paddy

should be diverted to other crops like oilseeds, cotton, maize, pulses and fruits and vegetables which demand less water.

Under intensive agriculture, the alluvial soils are showing multi-nutrient deficiencies and low organic carbon levels. The declining soil health is causing reduction in factor productivity and stagnation in crop productivity. The central part of the state (3.16 million ha) under rice-wheat system is facing problem of falling water table due to overdraw of groundwater. The south-western part (1.41 million ha) is underlained with poor quality groundwater on one hand and, is threatened on the other hand by waterlogging and secondary salinity with the introduction of canal irrigation and cultivation of rice in place of cotton.

The rice-wheat cropping system is loosing its sustainability considering the slowing growth in production and productivity and its adverse impact on vital resources such as water and land. The productivity of both rice and wheat seems to be plateauing. This is despite the monsoon remaining favourable in the last decade. The productivity of other crops such as sugarcane, cotton, oilseeds and pulses has either stagnated or increased marginally.

The rice-wheat cropping system has strained the water and land resources. The over-exploitation of groundwater resulted in a sharp decline in the ground water table and rendered a sizable area less productive because of salination. Salts have accumulated in the upper layer of the soil surface and could render vast stretches useless for cultivation. Besides, about 70 blocks in the State are in the dark category, where water exploitation seems much more than what nature can replenish. The excess utilisation of water, especially in rice, has created water-logged conditions in the canal command areas

(Southern Punjab) and a sizable area is getting saline for want of adequate drainage. Free electricity and highly subsidised water have compounded problems. Research findings also indicate that irrigation practices are outmoded and need to be replaced. The flooding of fields can no longer be the right technology. Research has also established that proper field preparation, timely planting and irrigation techniques can lead to higher water-use efficiency. The easy and cheap availability of water have even changed the cropping season. The sowing/planting of the kharif crop starts a week or two before the monsoon's arrival. However, in Punjab's case, the monsoon arrives at the end of June and rice transplanting begins in May. It is estimated that at least 10 per cent of the rice is planted in April-May. Not only this, the economy of rice cultivation tempts farmers to farm two crops of rice followed by wheat. This practice raises the demand for water and energy. And, if groundwater is utilised, the standing water is conducive to the growth of the pathogen inoculums, which affects the crops at later stages.

The high profitability of rice-wheat crop production has led to the higher, if not excessive, input use. More reliance on chemical fertilisers and their imbalanced use has affected soil health. The micronutrient deficiency in soil has increased. A large area has become deficient in zinc, copper, iron and manganese. Besides, the gap in nutrient application and what is depleted by the crop has also increased. Integrated use of balanced chemical fertilizers in conjunction with organic manures (compost and green manure), rotation of cereals with legumes and use of bio-fertilizers and vermiculture have to be undertaken to maintain the health of the soil. To enhance fertilizer-use efficiency under different cropping systems, continuous technological inputs are needed to make them cost-effective. The use of farm compost and recycling of crop residues seems to have become a practice of the past. The crop residue management has become a major problem

in the State and many farmers are burning paddy and wheat straw which were earlier fed to the cattle and finally found its way into the fields as manure. Thus, the already low organic carbon content in the soil has decreased further. As per a recent report of the Indian Council of Agriculture Research, in most areas of Punjab, the soil is deficient in organic carbon, which has come down from 0.5 per cent in the 1960s to 0.2 per cent. Organic-carbon improves the biological activity in the soil, helps retain soil moisture longer and reduces the leaching of plant nutrients. The importance of green manuring to enrich the soil with organic-carbon is well established, but this practice does not seem to have been adopted by the farmers. It could, however, be successfully adopted with little adjustment and timely planting of rice in mid-June instead of May. Besides, the crop residue management practice has to be improved for which research would be required.

The spectrum of use of pesticides has been changing over the years in response to emerging pests- and weed-problems due to intensive cultivation. Excessive and indiscriminate use of pesticides and weedicides has led to several new problems, such as development of pest resistance, pest resurgence and outbreaks, and adverse effects on such non-target organisms as predators, pollinators and honey bees. Development of resistance in the American boll worm, because of abuse and misuse of pesticides in cotton, accounts for the inability to control cotton pests in cotton belt of the state. Similarly, abuse and misuse of pesticides is rampant on fruit and vegetable crops, which pose great health hazards to consumers. The strategy for effective management of pests- and weed-problem lies in the use of integrated pest management technology (IPM), wherein agronomic practices, intercropping and forecasting of pests and diseases are essential components, besides use of pesticides. Unfortunately, IPM technology for important crops has not reached the farmers, due to lack of effective extension efforts. On

the other hand, the pesticides available in the market, particularly at the village level, are usually unbranded, often adulterated or date-expired, and the advice on how to use pesticides is given by relatively ignorant pesticide sellers or commission agents. This inadequacy in the use of pesticides is not only wasteful but also dangerous, as it contributes heavily to the pollution of air, water and soil, in addition to health hazards.

Farm mechanization, no doubt, has been beneficial for the intensive use of land and has helped considerably in overcoming the risk of unfavourable effects of weather on maturing crops. The shift from animal to mechanical power has also indirectly affected soil health. In turn, there has been a decline in the use of agricultural labour, which has created serious social and economic problems, as alternative avenues for employment of displaced labour are few. The level of efficiency of farm implements, in terms of time and energy-consumption, needs to be improved through extensive research. Besides, there is also need to develop more innovative and inexpensive instruments, which could be used as timesaving devices and also for additional operations of cleaning, grading, packing, etc. For efficient water management the technologies like laser levelling of fields, optimal paddy transplantation date, diversification of agriculture to less water-requiring crops, bed or furrow planting, renovation of village ponds, roof-top rainwater harvesting and scheduling of irrigation for paddy by use of tensiometer, etc. need to be more popularised.

Increase in indebtedness, though officially attributed to the increasing cost of inputs, is high really because of unproductive spending habits of farmers; the relative ease with which credit is made available encourages farmers to spend it often on social ceremonies and excessively on domestic consumption. The arhtia-farmer relationship is traditionally very old and bitter, because of the excessive interest they charge. On the other hand, no institutional credit can match the services the arhtias provide --speedy supply of credit on

demand and on short notice. Sometime the artias manipulate the repayment, by giving more loans at a still higher interest rate, until the farmer is forced to sell a part or whole of his land, to meet the debt obligations. Nevertheless, with the increasing opening up of the rural economy, a system of direct linkages should be encouraged through face to face contact of the producers with the investors or marketing and processing agencies. The role of the corporate sector in such a venture needs full policy and governmental support in order to minimize the role of commission agents and arhtias.

At the national level, public sector investment has played a crucial role in the development of infrastructure such as irrigation, electricity, agricultural research, roads, markets and communications. Recently, the decline in public investment in Punjab was mainly due to the diversion of resources in the form of subsidies for fertilisers, rural electricity, irrigation, credit and other agricultural inputs rather than on creation of assets. Whether private sector investment can substitute for public sector investment is very doubtful, more so in agricultural infrastructure. Therefore, the declining trend in public sector agricultural investment needs to be reversed by augmenting agricultural credit and increasing allocation for agriculture. Since the Centre and States are facing a resource crunch, public investment can be increased only if the present level of subsidy on agricultural inputs such as power, water and fertilisers is readjusted.

Due to poor financial resources most of the States extension workers have no facility to undertake field visits and educate farmers with the latest developments in agriculture. With far-reaching changes in communication technology and breakthroughs in space technology, remote sensing, satellite broadcasting and the media spread revolution, extension workers will have to be totally re-oriented and re-trained to adapt themselves to these developments and emerging opportunities. Extension services have to be responsive

to the changing agricultural scene resulting from economic liberalisation. This is truer in Punjab where technological changes are faster. Research and extension would need to be focussed on environmentally sustainable diversification and intensification of agriculture, location-specific technologies tailored to suit local needs and greater efficiency in the use of inputs. To accelerate growth in agriculture, the transfer of technology has to be made more effective and the present extension needs to be reoriented to provide farmers the proper technology. They also need to be assisted through institutional credit for the adoption of the proper technology and investment for on-farm infrastructure.

REFERENCES

Acharya, S S (1997), "Agricultural Price Policy and Development: Some Facts and Emerging Issues", *Indian Journal of Agricultural Economics*, 52 (1):1-47.

Ahluwalia, M. S (1996), "New Economic Policy and Agriculture: Some Reflections", *Indian Journal of Agricultural Economics*, 51 (3): 412-26.

Anand, J.G. 1964, "Measurements of Actually Realised Agricultural Productivities per Acre and per Worker in Different Crop Regions of India", *Agricultural Sitution in India*, 19:401-11.

Armagan, G and Ozden, A (2007), "Determinants of Total Factor Productivity with Cobb-Douglas Production Function in Agriculture: the Case of Aydin-Turkey", *Journal of Applied Sciences,* 7(4): 499-502

Chandel B S (2007), "How sustainable is the Total Factor Productivity of Oilseeds in India?" *Indian Journal of Agricultural Economics*, 62 (2): 244-258.

Christensen L R (1975), "Concepts and Measurement of Agriculture Productivity" *American Journal of Agricultural Economics, 57:910-15.*

Dension, Edward F (1962), *The Sources of Growth in the United States and the Alternatives before Us,* Committee for Economic Development, New York.

Desai M B and Namboodiri N V (1997), "Determinants of Total Factor Productivity in Indian agriculture," *Economic and Political Weekly,* 52: A 165-A I71.

Desai, Bhupat M (1997), "Agricultural Paradigm: A Synthesis", in Bhupat M Desai (ed), *Agricultural Development Paradigm for the Ninth Plan under New Economic Environment*, Oxford and IBH Publishing, New Delhi.

Dholakia, Bakul H and Ravindra H Dholakia (1993), "Growth of Total Factor Productivity in Indian Agriculture", *Indian Economic Review*, 28 (1): 25-40.

Diewert, W E (1976), "Exact and Superlative Index Numbers", *Journal of Econometrics*, 4(2): 115-45.

Ekanayake S A, Band Jayasuriya S K (1987), "Measurement of Firm Specific Technical Efficiency-a Comparison of Methods, *Journal of Agricultural Economics, 38(1):155-22.*

Elumalai, K and Pandey, U K (2004), "Technological Change in Livestock Sector of Haryana, *Indian Journal of Agricultural Economics*, 59(2): 249-258.

Evenson, Robert E and Yoav Kislev (1975), *Agricultural Research and Productivity*, Yale University Press, New Haven and London.

Gangulli, N.N. 1938, *Trends of Agriculture and Population in the Ganges Valley*, Methuen and Co., London.

George, M.V. and T.N. Nampoori (1966), "Inter-District Variations in Agricultural Productivity in Kerala", *Agricultual Situation in India*, 21: 633-36.

Grover D. K.; Sanjay Kumar and Kamal Vatta (2003), *Market Imperfection and Farmers' Distress in Punjab*, Agro Economic Research Centre, PAU, Ludhiana.

Hayami, Yujiro, Vernon W Ruttan and Hermon M Southworth (Eds.) (1979), *Agricultural Growth in Japan, Taiwan, Korea, and the Philippines*, The University Press of Hawaii, Honolulu.

Jain K K, BR Garg and N K Arora (1992) Factor Productivity in Punjab Agriculture- a Macro Approach, *Indian Journal of Agricultural Economics, 47(3):55-7*5.

Kahlon, A S and D S Tyagi (1983), *Agricultural Price Policy in India*, Allied Publishers, New Delhi.

Kalirajan K P and M B Z S Obwona (1996), "A decomposition of Total Factor Productivity Growth: The case of Chinese Agricultural Growth Before and After Reforms, *American Journal of Agricultural Economics,* 78:331-38.

Kalirajan, K.P. and R.T. Shand (1994), *Economics in Disequilibrium: An Approach from the Frontier*, Macmillan India Ltd., New Delhi.

Kalirajan, K.P. and R.T. Shand (1997), "Sources of Output Growth in Indian Agriculture", *Indian Journal of Agricultural Economics*, 52: 693-706.

Kalirajan, K.P. and S. Bhide (2004), "The Post-Reform Performance of the Manufacturing Sector in India", *Asian Economic Papers*, 3(2): 126-165.

Kumar P and M W Rosegrant (1994), "Productivity and Sources of Growth for Rice in India, *Economic and Political Weekly*, 19:AI83-AI88.

Kumar, P and Mruthynjaya (1992), "'Measurement and Analysis of Total Factor Productivity Growth in Wheat", *Indian Journal of Agricultural Economics*, 47 (3): 451-58.

Nath, V. (1969), "The Growth of Indian Agriculture: A Regional Analysis", *Geographcial Review*, 59: 348-72.

Patil R G and Dayanatha Jha (1978), "Output Growth and Technological Changes in Maharashtra Agriculture: a District wise Analysis, *Indian Journal of Agricultural Economics,* 33 (3): 31-39.

Rao N C (2005), "Total Factor Productivity in Andhra Pradesh", *Agricultural Economics Research Review*, 18 (1): 1-19.

Rao, C H Hanumantha (1994), *Agricultural Growth, Rural Poverty and Environmental Degradation in India*, Oxford University Press, Bombay.

Rosegrant, Mark W and Robert Evenson (1994), "Total Factor Productivity and Sources of Long-Term Growth in Indian Agriculture", paper prepared for IFPR1/IARI workshop on Agricultural Growth in India, May 1-6, New Delhi.

Shafi, M. (1971), Measurement of crop productivity in India. ed. M. Shafi and Mehdi Raza, 99. 97-113, Aligarh:Aligarh Muslim University.

Shanmugam, K.R. and V. Soundararajan (2008), "Sources of Output Growth in Indian Agriculture during the Post-Reform Period", Paper presented at the 44th Indian Econometric Society Conference, Hyderabad, January.

Sidhu D S and D Byerlee (1991), "Technical Change and Wheat Productivity in Post Green Revolution in Punjab", *Economic and Political Weekly,* 26(52): AI59-AI65.

Singh J and F M Hossain (2002), "Total Factor Productivity Analysis and its Components in High-Potential Rice-Wheat System: a case Study of the Indian Punjab", Proceedings of international workshop on Medium and Long Term Prospects of Rice Supply and Demand in the 21st century, 3-5 Dec 2001, IRRI, Los Banos, Philippines: 409-17.

Singh, K.; D.K. Grover; Kamal Vatta and Sanjay Kumar (2001), *Land Size and Productivity Relationship in Punjab*, Agro Economic Research Centre, PAU, Ludhiana.

Singh, K.; Kamal Vatta and Sanjay Kumar (2002), *Impact of Minimum Support Prices on Agricultural Economy in Punjab*, Agro Economic Research Centre, PAU, Ludhiana.

Singh S P and S Agarwal (2006), "Total Factor Productivity Growth, Technical Progress and Efficiency Change in Sugar Industry of Uttar Pradesh", *The Indian Economic Journal*, 54 (2): 59-82.

Singh, J. (1974), *An Agricultural Atlas of India*, Vishal Publication, Kurukshetra.

Singh, R P, Suresh Pal, and Michael Morris (1995), *Maize Research, Development, and Seed Production in India: Contributions of the Public and Private Sectors*, CIMMYT Economics Working Paper 95-03, Mexico, CIMMYT.

Surya, Bhushan (2005), "Total Factor Productivity Growth of Wheat in India: a Malmquist Approach, *Indian Journal of Agricultural Economics*, 60(1): 32-48

Annexure I

Comments on the report "Determinants of Stagnation in Productivity of Important Crops in Punjab" received from Agricultural Development and Rural Transformation (ADRT) Centre, Institute for Social and Economic Change, Bangalore

1. Title of the draft report examined: Determinants of Stagnation in Productivity of Important Crops in Punjab
2. Date of receipt of the Draft report: 10 January 2010
3. Date of dispatch of the comments: 04 June 2010
4. Comments on the Objectives of the study: The study addresses all the objectives
5. Comments on the methodology

(i) The study has adopted a common methodology proposed for all the coordinating centres

(ii) Please see page 47 on Total Factor Productivity. Number of inputs and outputs used for constructing respective indices should be clearly mentioned. Provide details on data adjustments particularly price and quantity of items and their sources.

6. Comments on analysis, organization, presentation etc.

General Comments

Report is analytically good and presents the results in a lucid manner. The study results will be highly useful for policy planning if it can be partially revised in a careful way. At several places, data were interpreted very casually without adequate references. For instance, see page 18, "The studies has pointed out……"; page 29, "This indicates the shrinkage of human resources……". Typographical errors should be corrected: See Page 20, "increased form.."; "Tomquist-Theil index (Page 32, 35, 42, 44). I strongly suggest that the report should be copy edited before submitting its final version.

Specific Comments

(i) Please see Table 2.2, Page 9, numbers are not aligned properly.

(ii) Table 2.3, Page 11, items under type of land use are not visible, it needs to be formatted

(iii) In Table 2.3, unit of Gross Cropped Area is not mentioned. If it is per cent then it should not exceed 100.

(iv) Page 11, under sub-heading 2.5, it discusses the second phase, first phase and its period are not mentioned.

(v) Table 2.4, Page 12 shall be updated with 2005-06 Agricultural Census data.

(vi) Refer Table 2.6, Page 17. Since data on area and production area available, yield can be estimated by dividing production by area and then calculate its growth rate.

(vii) There are missing references. See Page 18, 19 and 76 for AERC, 2003 and AERC, 2002

(viii) Mention unit of data presented in Table 2.9, 2.10.1, 2.10.2 and 2.10.3

(ix) See page 31, expand R and D when it is used for the first time in the text.

(x) Chapter IV may be modified. It would be better to discuss growth in area, production and yield by crops across districts than by individual districts. Analysis of growth rates by crops across districts will provide meaningful results and better understanding of performance of different crops for suitable policy interventions. Please take districts instead of crops in the first column of Tables 4.1.1 to 4.1.12.

(xi) Please see page 63, sub-heading 4.3, criteria for categorization of districts is not clear. Further, instead of writing ACGR, adopt conventional way of mentioning of Compound Annual Growth Rate (CAGR).

(xii) See Page 81, in addition to presentation of index numbers, please calculate their average annual growth rates for different periods and interpret them. Growth in output, input and TFP index will provide extent of technical change in Punjab agriculture. It can be presented across crops and for State as whole. To construct weighted TFP index for the State, use area share of crops as weights.

(xiii) Find out determinants of TFP (weighted) by regressing against appropriate explanatory variables.

Refer: (a) Rosegrant, Mark W and Robert E Evenson (1992). "Agricultural Productivity and Sources of Growth in South Asia", *American Journal of Agricultural Economics*, 74:757-61, August.

(b) Desai, Bhupat M. and N.V. Namboodri (1997). "Determinants of Total Factor Productivity in Indian Agriculture", *Economic and Political Weekly,* 32(52):A165-A171, December 27-January 2.

(c) Kumar, Praduman and Mark W. Rosegrant (1994). "Productivity and Sources of Growth in Rice in India", *Economic and Political Weekly*, 29(53): A183-A188, December 31.

(xiv) References are not provided properly. Any standard method of writing references should be followed. Typographical errors in references should be corrected.

7. Overall view on acceptability of report

The report can be accepted after incorporating the above comments.

Appendix II: Action Taken Report on the Comments of Draft Report entitled *Determinants of Stagnation in Productivity of Important Crops in Punjab*

All the comments were taken into consideration while finalizing the report. These comments have been incorporated, wherever necessary, in the relevant chapters.

Authors