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Trends in Agriculture and Agricultural Practices in Ganga Basin

Part II: Uttar Pradesh

GRB EMP : Ganga River Basin Environment Management Plan

by

Indian Institutes of Technology

IIT Bombay | IIT Delhi | IIT Guwahati | IIT Kanpur | IIT Kharagpur | IIT Madras | IIT Roorkee

Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin Management Plan (GRBMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin Management Plan (GRBMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin Management Plan (GRBMP). The overall Framework for documentation of GRBMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRBMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialogue in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. A list of persons who have contributed directly and names of those who have taken lead in preparing this report is given on the reverse side.

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1. Introduction

Agriculture is the major livelihood activity of majority of rural population in the Ganga Basin. It is, therefore, necessary to study the trends in agriculture and agricultural practices and suggest alternative livelihood options to augment income of rural workforce and reduce the stress on the river water resources. The Ganga river, being a perennial source of water, facilitates both surface and groundwater irrigation in the basin. Agriculture is the major consumer of water in the basin area. Against 71 percent of total global consumption of water in agriculture, the corresponding percentages for India and Uttar Pradesh are 89 and 93 respectively. Uttar Pradesh has a wide network of around 73,637 km canals, 27,600 State owned tube-wells, 17,768 deep tube-wells and 3.96 million shallow tube-wells owned by individual farmers. These systems irrigate around 13.08 million hectares area in which canals share 18 percent, state tube-wells 3 percent and private tube-wells share 70.2 percent. An overview of the trends in agriculture and agricultural practices in the entire Ganga Basin is presented elsewhere (Report No. 015_GBP_IIT_SEC_ANL_01_Ver 1_Dec 2011).The entire basin is divided into three stretches, namely, Upper Ganga Basin (Uttarakhand), Middle Ganga Basin (Uttar Pradesh) and Lower Ganga Basin (Bihar and West Bengal). This report deals with trends in agriculture and agricultural practices in Uttar Pradesh.

The report, among others, examines land-use pattern, occupational structure, size of land holdings, cropping pattern, crop-wise production and yield, area under different sources of irrigation, irrigation intensity, cropping intensity, use of chemical fertilizer and pesticides, status of groundwater utilization, trends in value of agricultural output, costs and returns from major crops and profitability in agriculture, etc. Based on the analysis of agricultural related indicators, some plausible measures have been suggested.

2. Trend in Land use Pattern

Figure 1 reveals that the area under forest cover has increased from 10.9 percent of total reported area in 1951 to 17.3 percent in 1995-96 and thereafter it declined to 6.3 percent in 2000-01. The main reason for this is the bifurcation of the State. The State now has about seven percent of area under forest. This is 23 percent less than the norms set for maintaining a sound ecological balance (GOI, 2007b). Net sown area (NSA) shows a rising trend throughout the period. The percentage of NSA to the total reported area has increased from 55.5 in 1950-51 to 58.1 in 1970-71and further to 68.9 in 2004-05 and thereafter declined to 67.9 in 2007-08. Recent decline in the percentage of NSA is a serious issue for the food security and sustainability of livelihood of farm workers. Since, the scope of bringing more area under cultivation is limited, future requirement of agricultural commodities may be met by intensive use of land, water and other resources which would have some implications for degradation of soil and water resources. Another important use of land is found in non-agricultural activities, such as industries, roads, urban and rural dwellings, commercial establishments, educational institutions, hospitals and government offices, etc. The growth of urbanization and industrialization has increased the demand of land for non-agricultural uses. The area under non-agricultural uses shows a steady increase from 6.3 percent in 1950-51 to 8.5 percent in 1995-96 and further to 11.4 percent in 2007-08. The speculative demand for urban land is also one of the reasons for the fast increase in land for non-agricultural purposes. Figure 1reveals that the cultivable wasteland has significantly declined over the period. Fallow land (both permanent and current) has recorded fluctuations across the years.

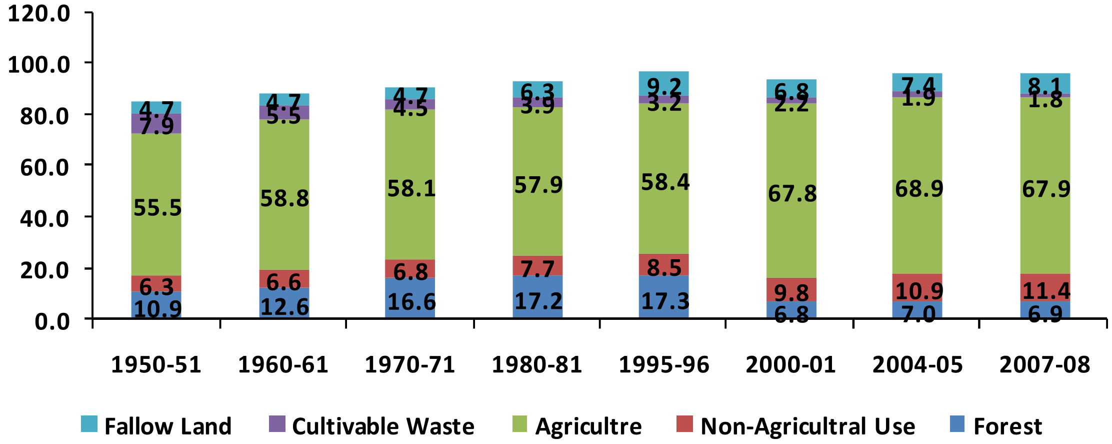

Figure 1: Trends in percentage distribution in land use for various purposes in Uttar Pradesh (in %)

2.1. Regional Trend in Area under Forest

An attempt has been made to examine regional trends in the key constituents of land-use. For this purpose, the State is divided into five NSS regions as shown in Figure 2. A regional pattern of forest cover in the State reveals that, on an average, southern region has the highest percentage of area under forest among all the regions in the entire duration of study. In this region, the area under forest ranges from 8.3 to 10.8. Since 1994-95, the forest area shows a declining trend in the southern region. Next to southern region is the Eastern Region which occupies the second place in terms of forest cover. However, no trend is visible in the percentage of area under forest cover in this region. The area increased from 7.2 percent in 1984-85 to 7.9 percent in 1994-95 and then declined in 2004-05. Central region has the lowest percentage of area under forest cover among all the regions. The percentages range from 2.0 and 2.5. In south upper Ganga plains region, the percentages of area under forest range from 5.2 to 5.6. Similarly, in north upper Ganga plains region, the area under forest cover varies from 4.3 percent to 5.4 percent. It can be concluded from the analysis that the area under forest varies across regions but does not evince any trend.

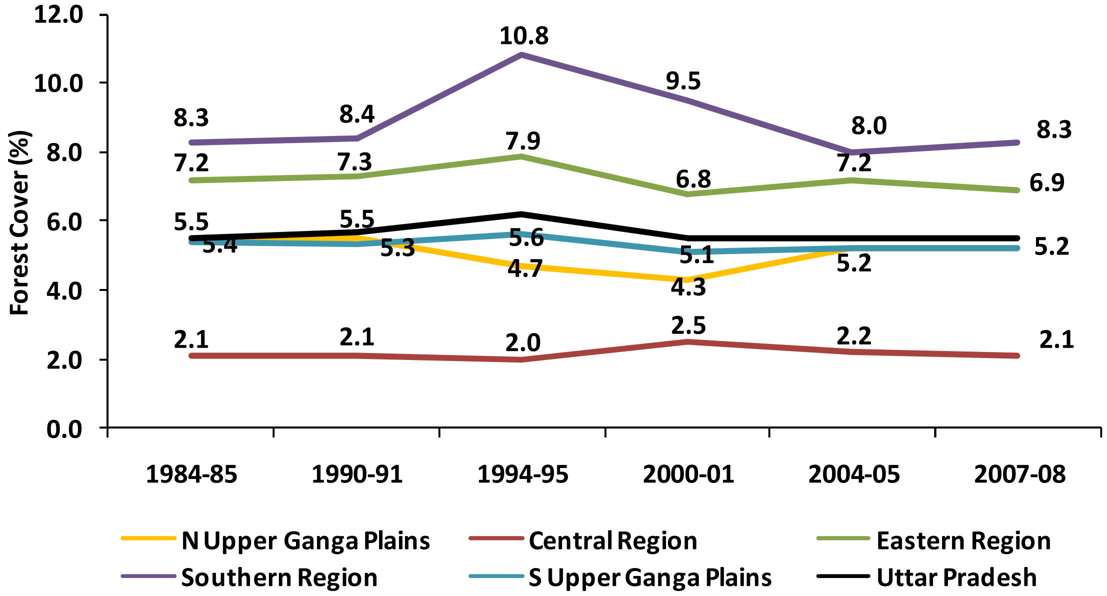

Figure 2: Region-wise trend in forest cover

In order to understand whether there exists any significant difference in the land use-pattern of the district along river Ganga and Ganga Canals and other districts of the State, all the districts of the state have been divided into two categories, namely districts along River Ganga and its canals (henceforth named as Ganga bank districts) and districts away from River Ganga and its canals (henceforth named as non-bank districts). Figure 3 shows the comparison in percentage of forest cover in the two categories of districts. It is significant to note that in the undivided state, the percentage share of forest cover in the total reported area was higher in non-bank districts than the Ganga bank districts. Contrary to this, in the divided State, the percentage of forest cover was higher in Ganga bank districts than non-bank districts. Thus, when hill regions are excluded, the River Ganga bank districts have more area under forest than the non-bank districts.

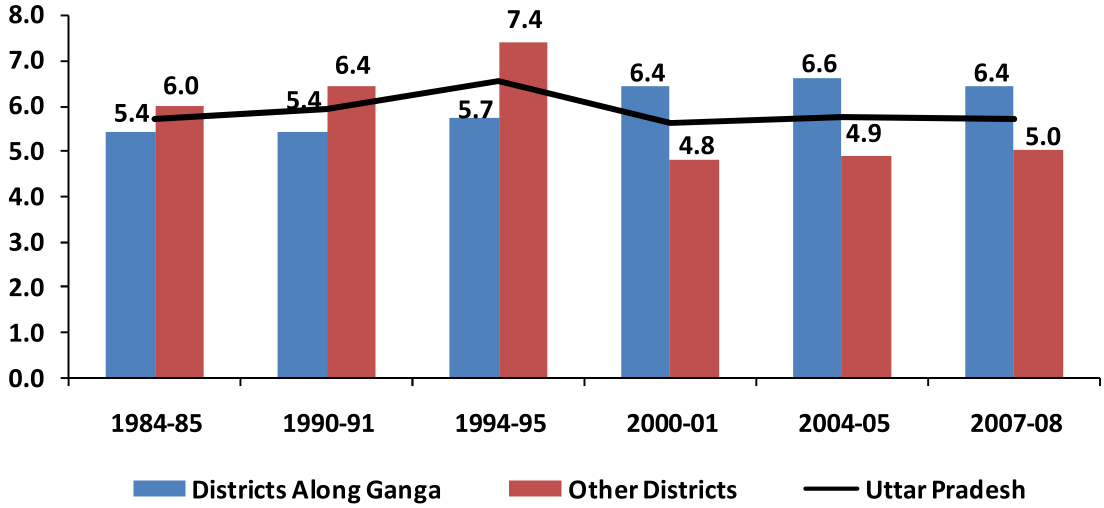

Figure3: Percentage of area under forest covers in Ganga bank districts and non-bank districts

On the basis of percentage of area under forest, all the districts can be classified into four categories: less than 1.0%, 1.0-5.0 %, 5.0 – 10.0% and 10% & above. Figure 4exhibits the trend in percentage distribution of districts by these categories. It is observed that the percentage share of number of districts with less than 1.0% forest cover has declined from 74.5 in 1984-85 to 17.1 in 2000-01 and thereafter increased to 32.9 percent in 2004-05 and then declined to 14.3 percent in 2007-08. A look at the forest related statistics for divided Uttar Pradesh highlights that, in recent years, the number of districts having forest cover in the categories of 5.0-10.0% and 10.0% & above have increased. This implies that there has been some improvement in the forest cover of the State in the recent years.

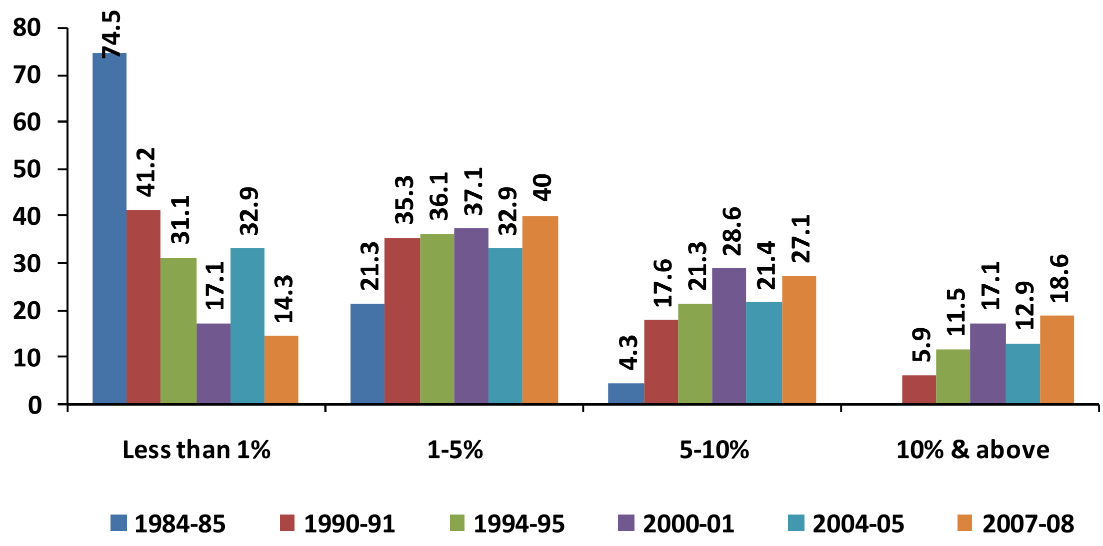

Figure 4: Proportion of districts by class of forest cover

2.2 Region-wise Trend in the Net Sown Area (NSA)

Figure 5 brings to the fore that the percentage of net sown area to the total geographical area is highest in the north upper Ganga plains, followed by the south upper Ganga plains. North upper Ganga plains, on an average, has about 76 percent of total area under cultivation. The percentage of NSA has slightly declined from 76.8 percent in 2000-01 to 75.9 percent in 2007-08. Similarly, the percentage of NSA in south upper Ganga plains declined from 73.6 percent in 2000-01 to 73.4 percent in 2007-08. Central region, on the other hand, registers a rising trend in the percentage of NSA. The percentage increased from 55.9 in 1984-85 to 67.4 in 2004-05 and then declined to 66.6 in 2007-08. A perusal of Figure 5 reveals that after 1990-91, percentage of NSA in almost all the regions increased slightly up to 2004-05 and then declined.

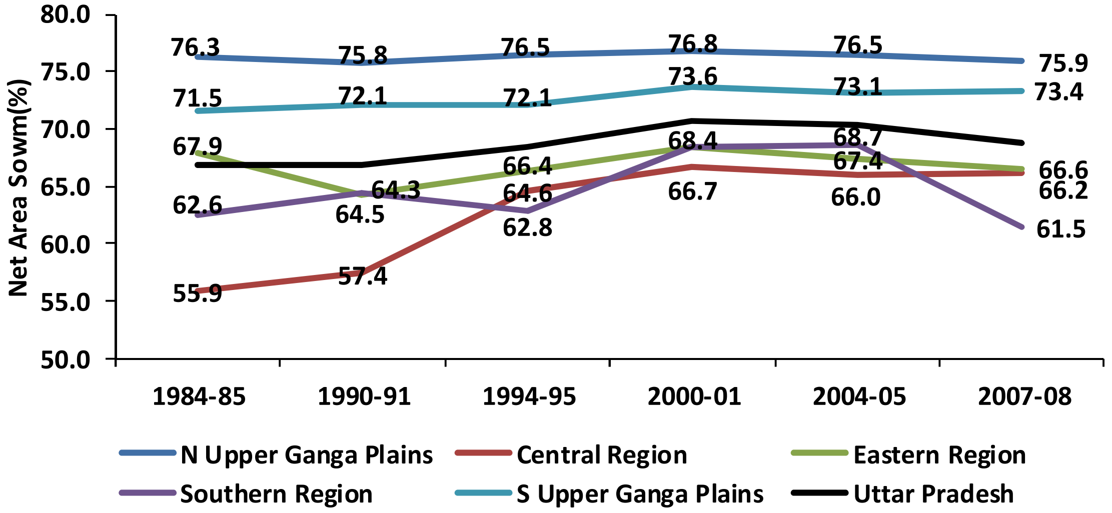

Figure5: Region-wise trends in net sown area (in %)

In this regard, it is interesting to compare the NSA of Ganga bank districts with that of non-bank districts. The results are displayed in Figure 6 which reveals that the percentage of NSA to total reported area has been higher in Ganga bank districts than that in non-bank districts of the State. In 1984-85, percentage of NSA in Ganga bank districts was 69.1 while the corresponding percentage for non-bank districts stood at 66.7. Similarly, in 2007-08, Ganga bank districts had reported 70.2 percent of total land under cultivation, while the corresponding percentage for non-bank districts was found to be slightly less at 68.1. Thus, Ganga bank districts have, on an average, 2.5 to 3.0 percent point more NSA than their counterparts.

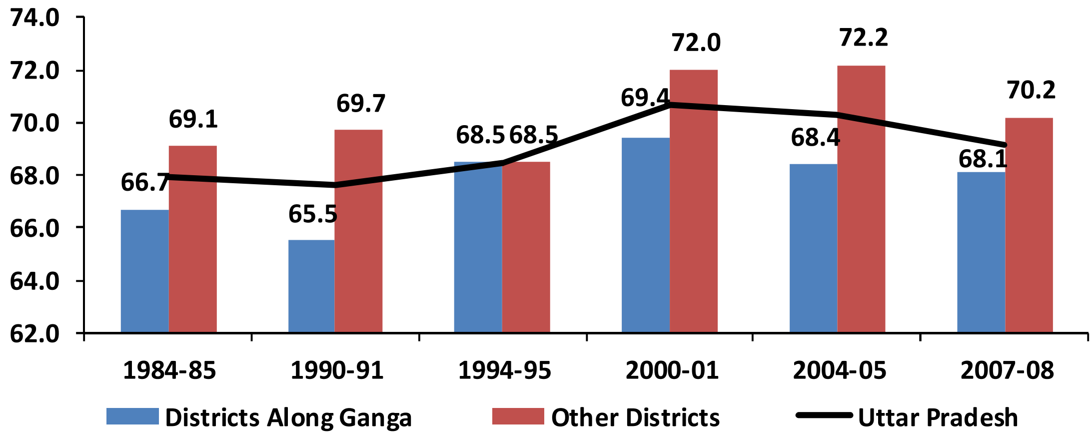

Figure6: Percentage of NSA in Ganga-bank and non-bank districts

Districts of the State have also been classified into five categories by the percentage of NSA, as shown in Figure 7 in order to look at the difference across categories in regard of the above. Figure7 reveals that a majority of districts in the State have NSA in the range of 60 to 80 percent, with highest proportion settling in the range of 60 to 70 percent. In about 13 percent of districts, NSA was found to be less than 60 and almost equal percentages of districts are having NSA at 80 percent and above. Thus, about three-fourth of total districts of the State have NSA in the range of 60-80 percent. Analysis of the year-wise data suggests that the distribution of districts by the category of NSA varies across years without any trend.

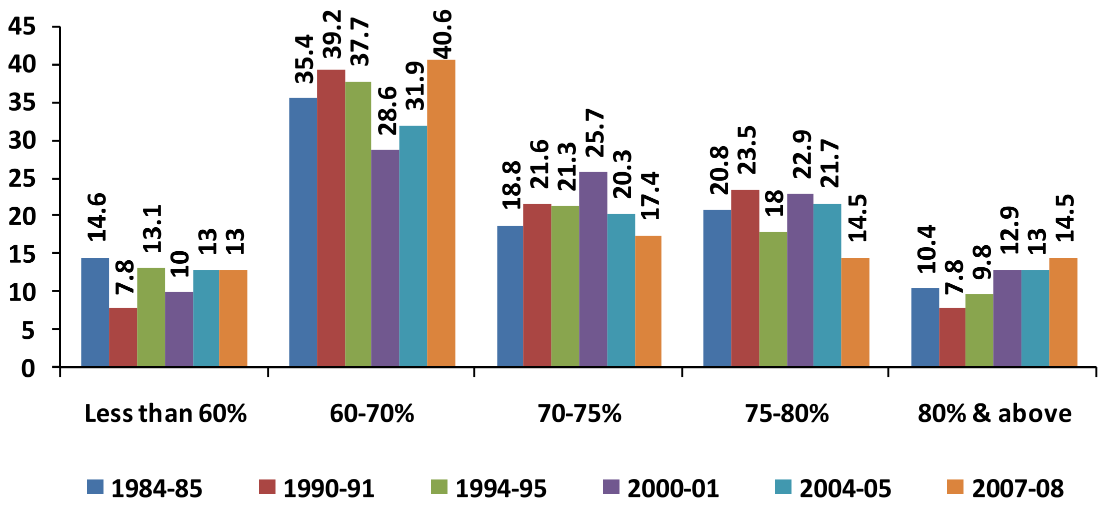

Figure7: Percentage distribution of districts by category of NSA

2.3 Region-wise Trends in Area under Non-Agriculture Use

Steady increase in the conversion of agricultural land into non-agricultural uses is a serious issue for livelihood security of workforce dependent on agriculture. At aggregate level, the area under non-agricultural uses has increased from 8.8 percent in 1990-91 to 12.5 percent in 2007-08, a net increase of about 33 percent. North upper Ganga plains have the highest percentage share of land in non-agricultural uses, followed by the eastern region (Figure 8). In north upper Ganga plains, the share of non-agricultural uses in the total reported area has increased from 11.1 percent in 1990-91 to 13.2 percent in 2007-08, while the corresponding percentage in eastern region increased from 10.4 to 13.1 during the same period. Southern region has the lowest percentage of land under non-agricultural uses among all the regions. It is followed by south upper Ganga plains. Overall, area under non-agricultural uses shows a rising trend in all the regions of the State.

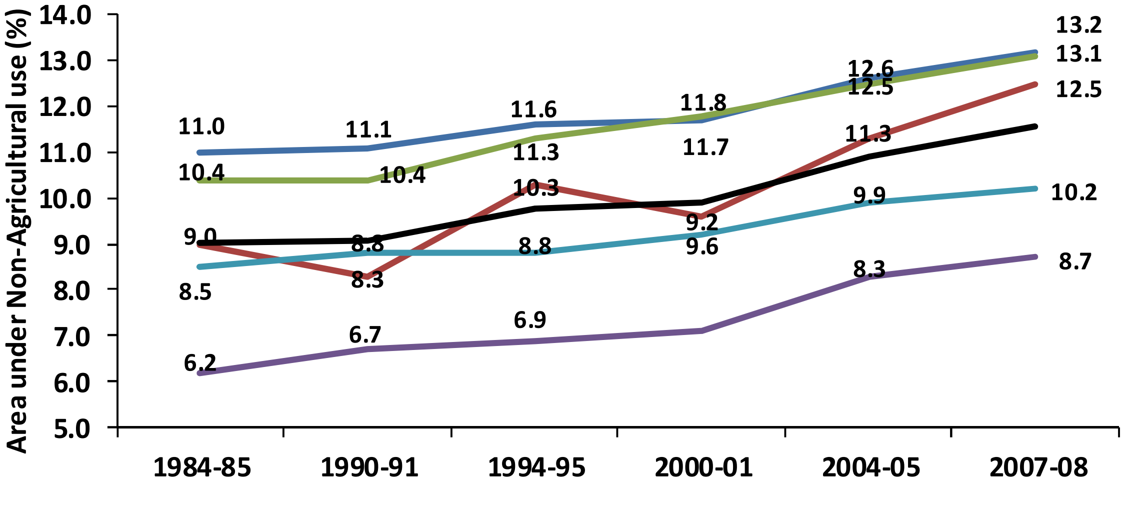

Figure8: Region-wise trends in area under non-agricultural uses

Although, area under non-agricultural uses has increased over the period, there is not much difference in the use of land for non-agricultural purposes between Ganga bank districts and non-bank districts, as is shown by Figure 9.

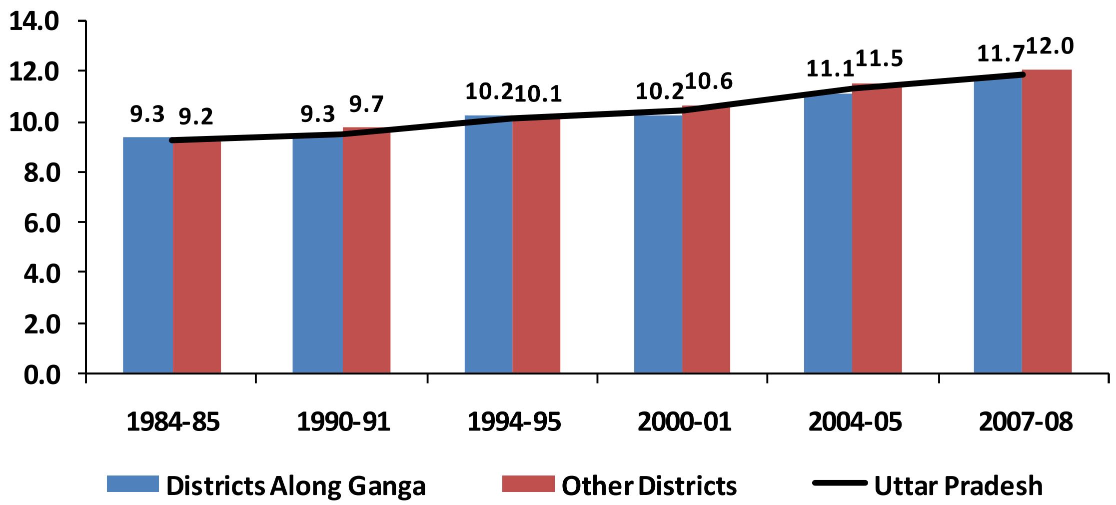

Figure9: Trends in area under non-agricultural use in Gangabank districts and non-bank districts

It is interesting to observe that since 1990-91, the number of districts having less than 8 percent of land under non-agricultural uses has significantly declined while at the same time, the number of districts having 13 percent and above land area under non-agricultural uses registered an increase. For instance, the percentage of districts having less than 8 percent area under non-agricultural uses has declined from 27.5 in 1990-91 to 5.7 percent by 2007-08, whereas the corresponding percentage for districts having 13 percent and above land under non-agricultural uses has increased from 4.3 in 1990-91 to 31.4 by 2007-08 (Figure 10). This implies that number of districts having non-agricultural land area 13 percent and above had grown faster than the number of districts under other categories.

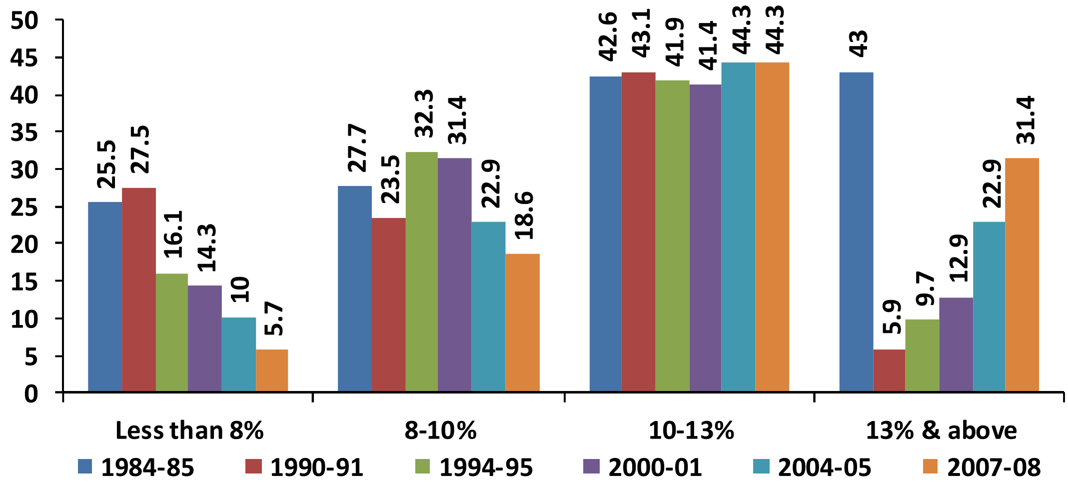

Figure 10: Trends in proportion of districts by class of area under non-agricultural use

3. Trends in Number of Operational Holdings

Increase in the ratio of marginal holdings to the total holdings points towards marginalization of the agricultural workforce. Figure 11presents the trends in the number of operational holdings which reveals that the percentage share of marginal holdings (below one ha) has increased significantly from 66.8 percent in 1970-71 to 76.91 percent in 2000-01. The percentage share of number of small size of holdings (1.0-2.0 hectares), on the other hand, declined from 17.2% in 1970-71 to 14.20% by 2000-01. The combined share of marginal and small holdings increased from 84.0 percent in 1970-71 to about 91.10 percent in 2000-01. The data suggests that except for marginal holdings, the percentage share of all other categories of holdings in the total number of holdings have significantly declined over the period. This poses a serious concern regarding the sustainability of the economic viability of land holdings which may take grim dimensions in near future.

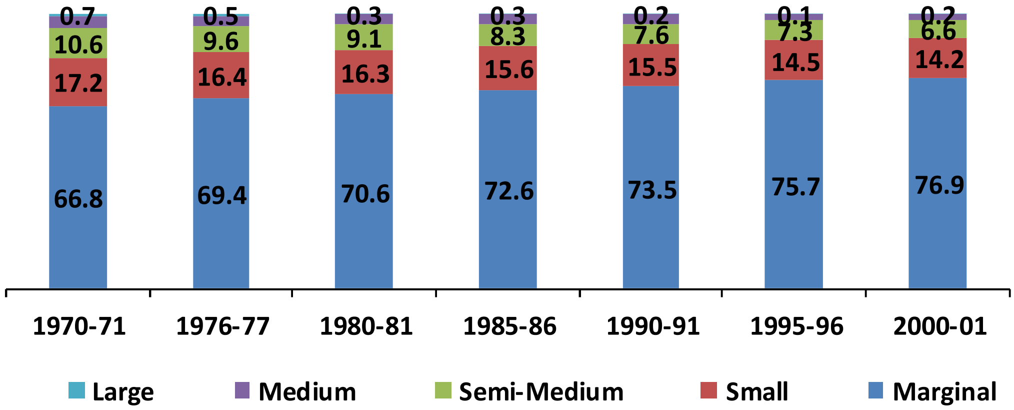

Figure11: Trends in percentage share of number of operational holdings by size class

4. Trends in Gross Irrigated Area by Sources of Irrigation

Trends in percentage of gross irrigated area (GIA) to gross cropped area (GCA) are presented in Figure 12. There is significant increase in the GIA in Uttar Pradesh over the period. The percentage of GIA to GCA increased from 26 in 1950-51 to 36 in 1970-71 and further to 58 percent in 1990-91. After 1995-96, the percentage of GIA to GCA has shown a rising trend throughout the study period. The GIA increased from 70 percent in 2000-01 to 76 percent in 2007-08. The State has higher percentage of GIA than the national average which stands at 40%. Groundwater is an important source of irrigation in the State. Its share in the total GIA has increased tremendously during the last six decades. The percentage of GIA to GCA increased from 26 in 1950-51 to 36 in 1970-71 and further to 58 percent in 1990-91. After 1995-96, the percentage of GIA to GCA shows a rising trend. The GIA increased from 70 percent in 2000-01 to 76 percent in 2007-08. About 80 percent of total GIA in the State was irrigated by tube-wells/wells in 2007-08 (Figure 12). However, surface irrigation plays a crucial role in the agricultural development of the State. It facilitated the growth of tube-wells in its command area as cost of drawing groundwater in the canal command is relatively lower and productivity of water is much higher than that is from the tube-wells installed in non-canal command area. Conjunctive irrigation system being followed by the farmers in the canal command provides relatively higher agricultural output per unit of land as the farmers get assured irrigation under this system.

Canal irrigation is developed, managed and controlled by the State and its access is limited by the topographic constraints, whereas groundwater is a decentralized and democratic resource, largely developed and managed by the farmers. It is preferred on various grounds such as equity, efficiency, productivity and private investment. However, due to the government policies related to agricultural credit, subsidy, inputs, and energy; and lack of effective regulation of groundwater irrigation, the sustainability of this precious resource in the basin area has become one of the major issues of concern.

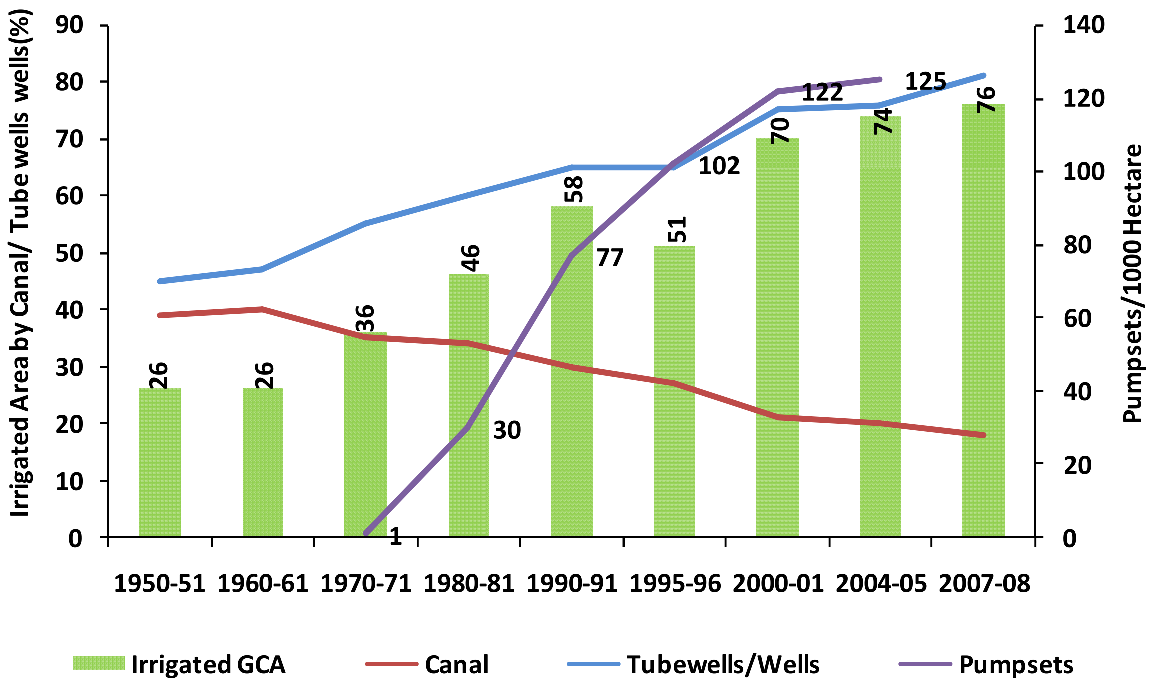

Figure 12: **Trends in gross irrigated area by sources of irrigation and number of pump sets in operation in Uttar Pradesh**

Tube-well technology was introduced in the State during the green revolution period. In the post-green revolution period, number of pump-sets per 1000 hectares of NSA has increased drastically. The number increased from 30.2/1000 ha in 1980-81 to 125/1000 ha in 2004-05, a more than four-fold increase.

4.1 Trends in Irrigation Intensity in Uttar Pradesh

Irrigation intensity is the ratio of gross irrigated area to net irrigated area. It is expressed in percentage. Figure 13 shows that there is steady increase in the irrigation intensity during the period 1950-51 to 1990-91 and thereafter it does not evince any increase. The irrigation intensity increased from 107.6 percent in 1950-51 to 148.3 percent in 1995-96 and after that it marginally declined to 146.3 percent in 2007-08. Analysis of data on irrigation intensity reveals that during the last decade, there has not been any increase in the irrigation intensity.

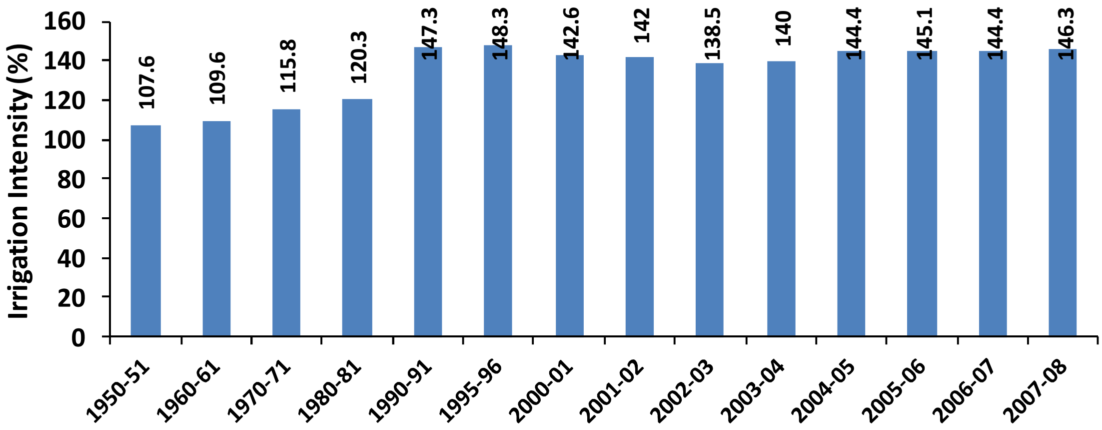

Figure 13: Trends in Irrigation Intensity

4.2 Trends in Percentage Share of Major Crops in the total GIA in Uttar Pradesh

Trends in percentage share of major crops in the total GIA is shown in Figure 14. Wheat crop has the largest share in the total GIA. It is followed by rice and sugarcane. Share of wheat in the total GIA increased significantly from 31 percent in 1950-51 to 63 percent in 1995-95 and thereafter it declined to 48 percent in 2007-08. Share of rice increased from 8 percent in 1950-51 to 26 percent in 1995-95 and then declined to 24 percent in 2007-08. These two cereal crops (wheat and rice) together constituted 72 percent of the total GIA of the State. Share of sugarcane in the total GIA does not evince any trend. Its share declined from 13 percent in 1950-51 to 10 percent in 1980-81 and then increased to 13 percent in 1995-96. After that it ranged from 10 to 11 percent during the subsequent years. In 2007-08, wheat, rice and sugarcane jointly shared 83 percent of GIA of the State. These are the crops which also consume far more quantity of water than the other crops such as pulses and oilseeds.

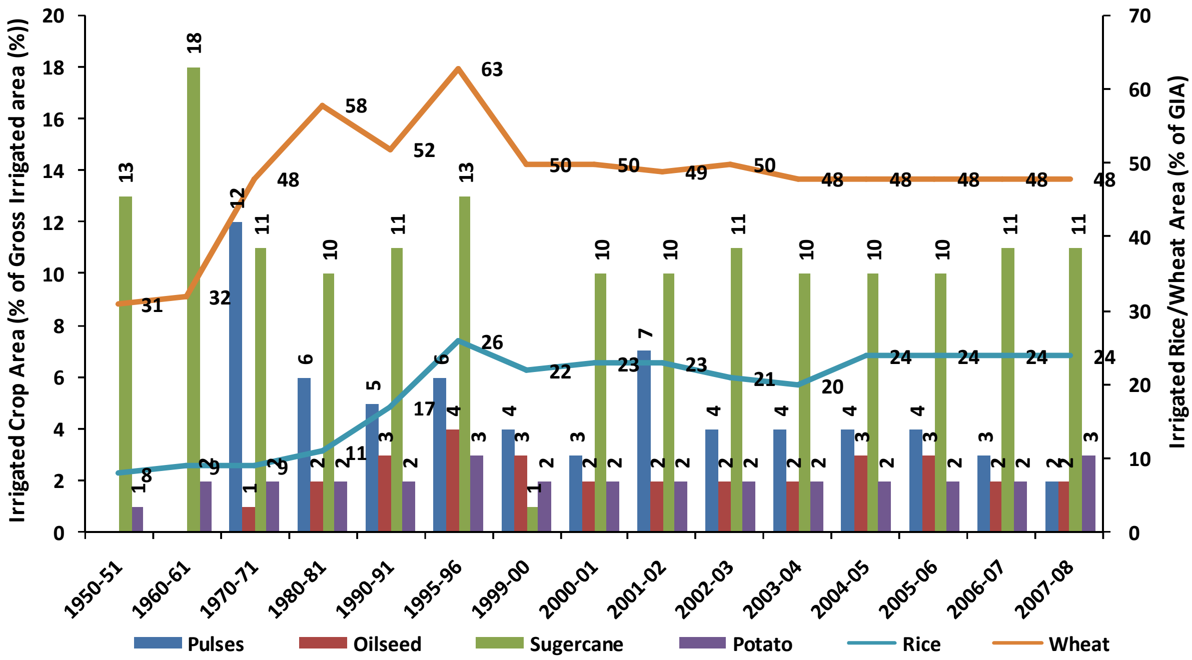

Figure 14: Percentage share of major crops in the total GIA in Uttar Pradesh

Figure 14 reveals that pulses shared only 2.1 percent of total GIA in 2007-08. Their share shows a declining trend during the entire study period. On the contrary, share of oilseeds in the total GIA increased from 0.5 percent in 1950-51 to 2.1 percent in 1980-81 and further to 4.4 percent in 1995-95. After that it declined to 2.3 in 2000-01 and then increased to 2.7 in 2005-06. In 2007-08, oilseeds shared only 2.4 percent of total GIA. Share of potato in the total GIA shows a rising trend. Its share increased from 1.5 percent in 1950-51 to 2.3 in 1980-81 and further to 2.7 percent in 2007-08.

The above analysis reveals that wheat, rice and sugarcane which consume very high quantity of water as compared to other crops, do occupy the maximum GIA in the middle Gang basin. Huge quantity of water could be saved by diversification of cropping pattern from these crops to less water consuming crops. Further, technological improvement and change in the irrigation practices could also help to reduce the water consumption in these water-intensive crops.

4.3 Region-wise Trends in Gross Irrigated Area

Regional pattern of GIA shows that north upper Ganga plains have the largest percent of GIA to GCA among all the regions. In this region, the percentage of GIA increased from 84.67 in 1959-60 to 95.0 in 2004-05. Next to it is south upper Ganga plains where about 84 percent of GCA was under irrigation in 2004-05. Central region also had percentage of GIA higher than the State average, whereas the eastern and southern regions had the percentage of GIA much lesser than the State average. In 2004-05, 35.7 percent of GCA in the southern region was under irrigation. Figure 15 reveals that except for the southern region which shows fluctuations in the percentage of GIA across years, in all other regions, percentage of

GIA shows a rising trend over the period. For example, the GCA under irrigation in eastern region increased from 50.3 percent in 1959-60 to 70 percent in 2004-05.

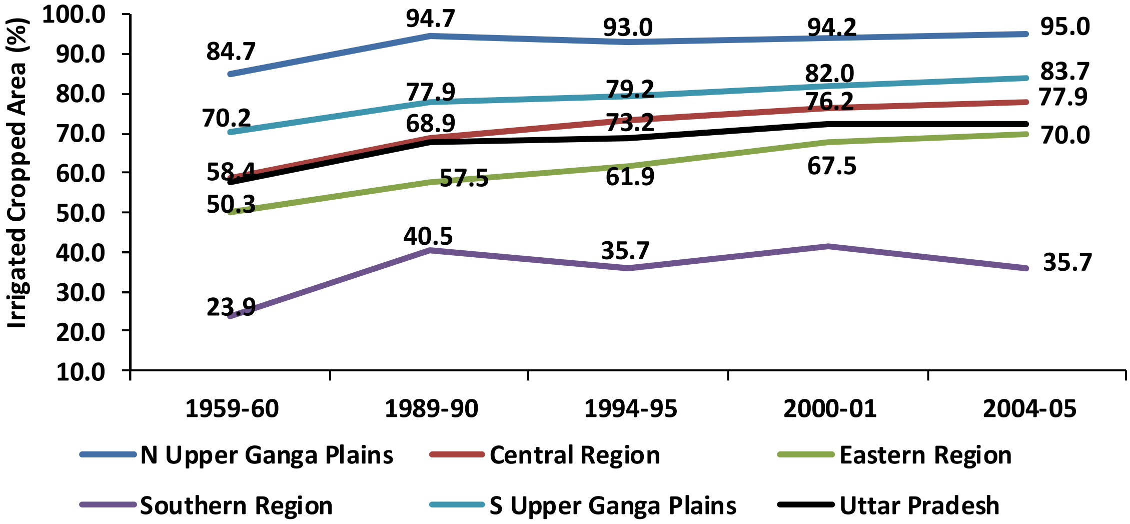

Figure 15: Region-wise trends in percentage of GIA

Comparison of the extent of irrigation facilities in the Ganga bank districts and non-bank districts of the State is presented in Figure 16. It is observed that the percentage of GIA to GCA is much higher in Ganga bank districts than non-bank districts. This percentage of GIA to GCA increased from 64.6 in 1989-90 to 78.90 in 2007-08 in the Ganga bank districts and from 50.1 to 68.9 in non-bank districts. A perusal of the Figure 16 reveals that between 1989-90 and 2007-08, GIA in the Ganga bank districts increased by 14.3 percent point while in non-bank districts it increased by 18.6 percent point. This implies that although the percent of GIA in the Ganga bank districts was higher than that in non-bank districts, the gap between the two has narrowed down over the period.

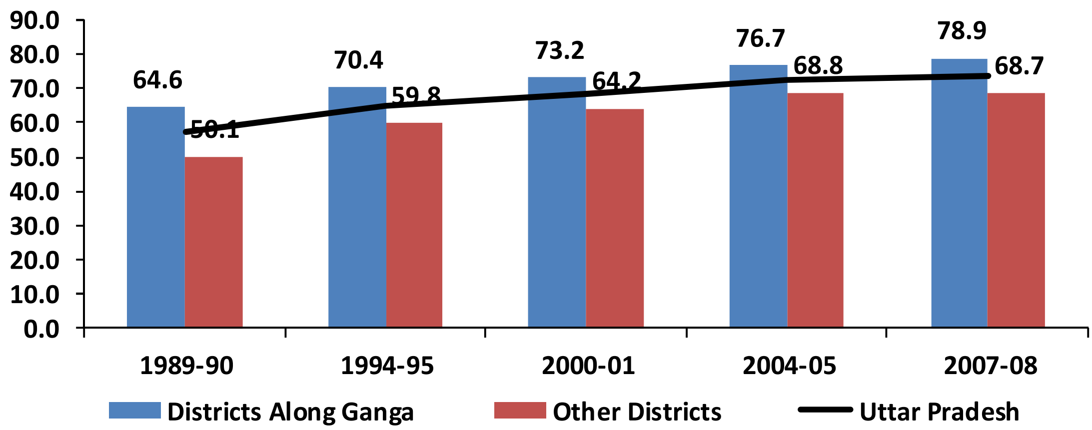

Figure 16: Comparison of percentage of GIA in Ganga bank districts with non-bank districts

Figure 17presents the percentage distribution of districts according to the category of GIA. In 2007-08, about 19 percent of total districts were having below 50 percent GIA and 23 percent were having GIA90 percent and above. It is observed that number of districts having GIA 75 percent and above has increased over the years. For example, the percentage of districts with GIA 90 percent and above increased from 8.0 in 1989-90 to 22.90 in 2007-08.

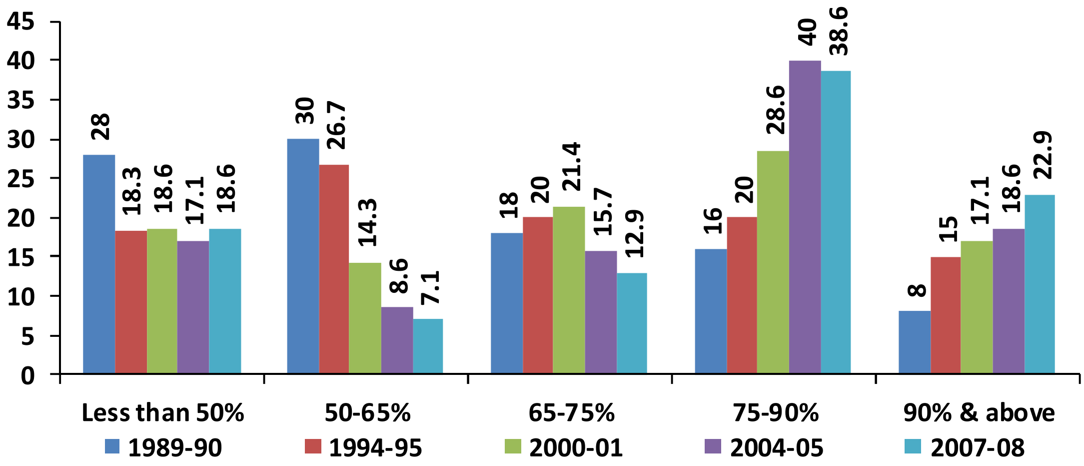

Figure 17: Proportion of districts by class of irrigated area in UP

4.4 Regional Pattern of Canal Irrigation

The share of canal irrigation in the total GIA has declined considerably in all the regions during the last five decades (refer Figure 18). For instance, canal irrigation constituted 48.6 percent of total GIA in north upper Ganga plains in 1959-60 which has decreased to 22.1 in 1989-90 and further to 10.2 percent in 2007-08. Thus more than 90 percent of GCA in this region is irrigated by the groundwater sources, mainly the tube-wells. In south upper Ganga plains, the share of canal in the GIA also registered a drastic decline from 45 percent in 1959-60 to 25 percent in 1989-90 and further to 17.3 percent in 2007-08. Similarly, the share of canal irrigation in the total irrigated area has shown a declining trend in other regions as well.

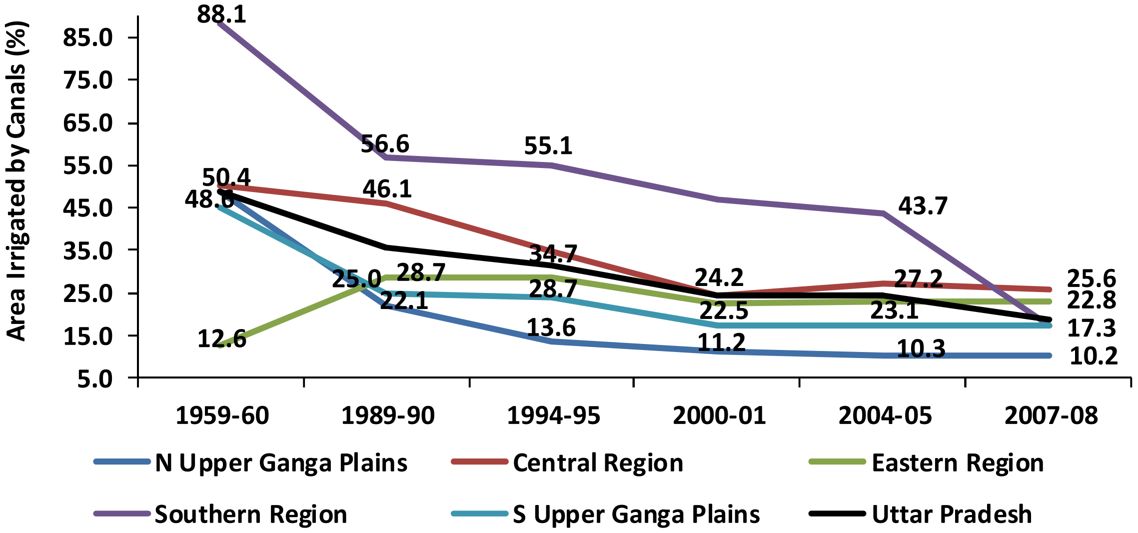

Figure 18: Region-wise trends in GIA by canals

Canal irrigation comprised 47.6 percent of total GIA in Ganga bank districts whereas in non-bank districts, it shared 37 percent of the total GIA in 1959-60. Over the years, share of canal irrigation in the total GIA has sharply declined in both the categories of districts. However, rate of decline is observed to be higher in the bank districts than in non-bank districts. For instance, in the Ganga bank districts, there was 32.5 percent decline in the share of canal between 1959-60 and 2007-08, while the corresponding decrease in the non-bank districts was found to be only 14.6 percent (Figure 19). This implies that the growth rate of tube-well irrigation has been higher in Ganga bank districts than that in non-bank districts.

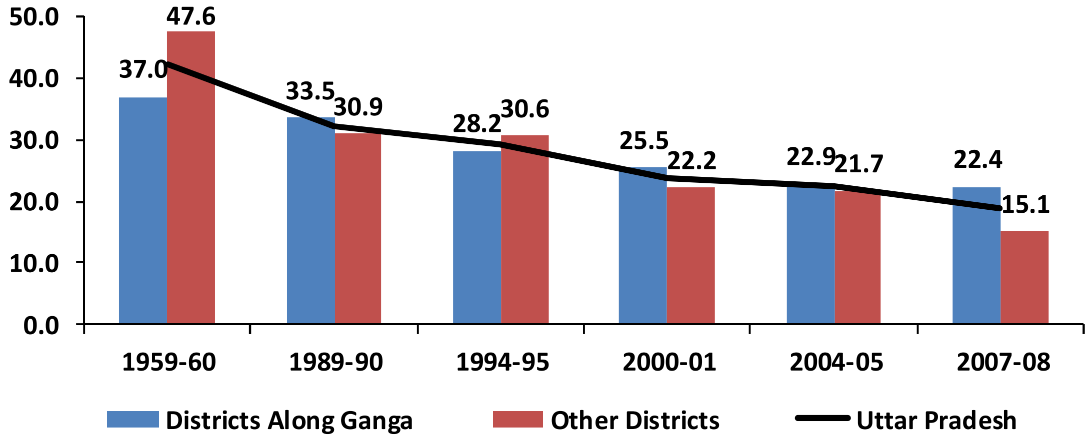

Figure 19: Trends in the share of canal irrigation in total GIA in Ganga bank districts and non-bank districts

Trends in percentage distribution of districts by class of canal irrigated area have also been estimated and the same are shown in Figure 20. It is evident that the number of districts having share of canal irrigation 35 percent and above has sharply declined during the last five decades. The percentage of districts declined from 55.8 in 1959-60 to 17.1 in 2007-08, a more than three-fold reduction. On the other hand, the percentage of districts with canal irrigation less than 10 percent has increased from 25.6 to 30 between the same years. The trends presented in Figure 20also reveal that number of districts having share of canal irrigationin the range of 10-20 percent of GIA has increased between the same years.

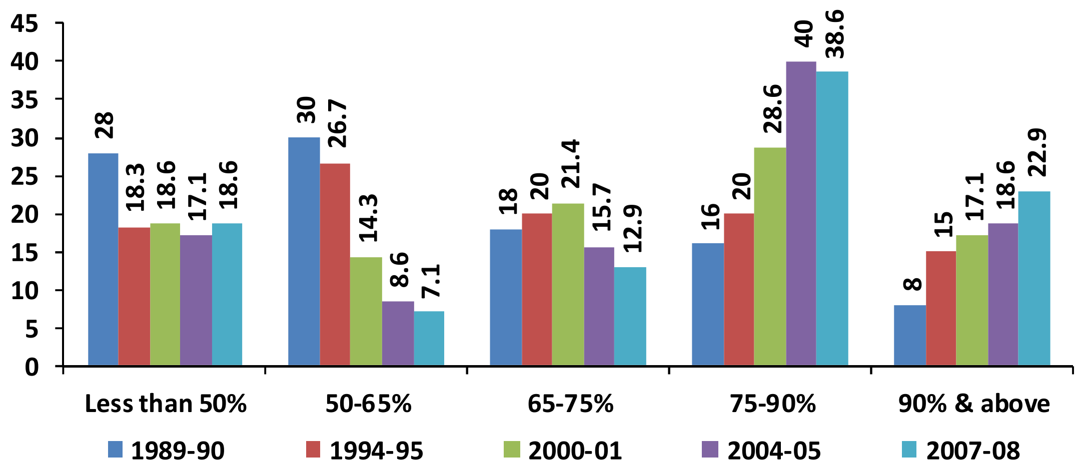

Figure 20: Trends in the percentage distribution of districts by class of canal water irrigation

4.5 Status of Groundwater Irrigation

Figure 21 indicates that the share of groundwater irrigation has extensively increased in all the regions during the period 1959 to 2008. Its share in the total GIA augmented from 45.5 percent in 1959-60 to 89.50 percent in 2007-08 in the north upper Ganga plains and from 45.9 percent to 83.0 percent in south upper Ganga plains. These two regions constitute the western part of Uttar Pradesh and are agriculturally most advanced regions of the State. In other regions also, the share of groundwater (tube-wells/wells) in the total GIA has increased over the years (refer Figure 21). Southern region comprises seven districts of Bundelkhand where irrigation facilities are highly inadequate. Since cost of installing tube-wells in this region is very high, it is not affordable to all categories of farmers. Deep tube-wells installed by the State government are the main sources of groundwater in the Bundelkhand region. Farmers also use open wells and lift irrigation to irrigate their farms. The problem of water is quite alarming in this region which needs to be tackled through the creation of a network of ponds and lakes to store the rainwater and investment in soil and water conservation related activities.

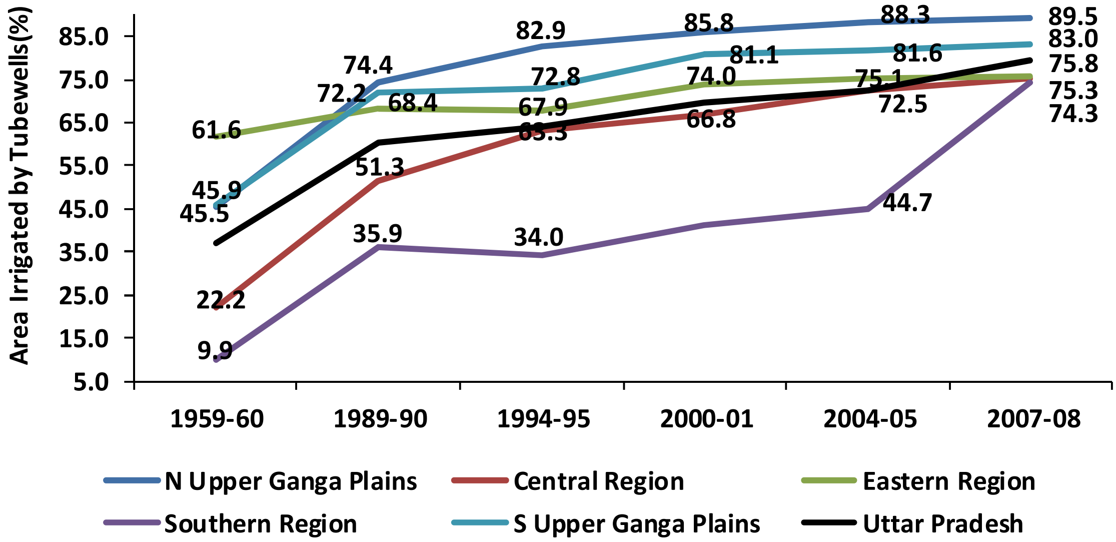

Figure 21: Region-wise share of area irrigated by tube wells/wells in total GIA

Tube-wells are the main source of irrigation in both bank and non-bank districts. Figure 22presents a comparison between these two categories of districts in terms of percentage share of tube-well irrigation in the total GIA. Figure 22 also indicates that there is not much difference in the bank and non-bank districts in regard of percentage share of tube-well irrigation in the total GIA. However, the growth of tube-well irrigation is observed to be slightly higher in non-bank districts than in the bank districts in the recent years.

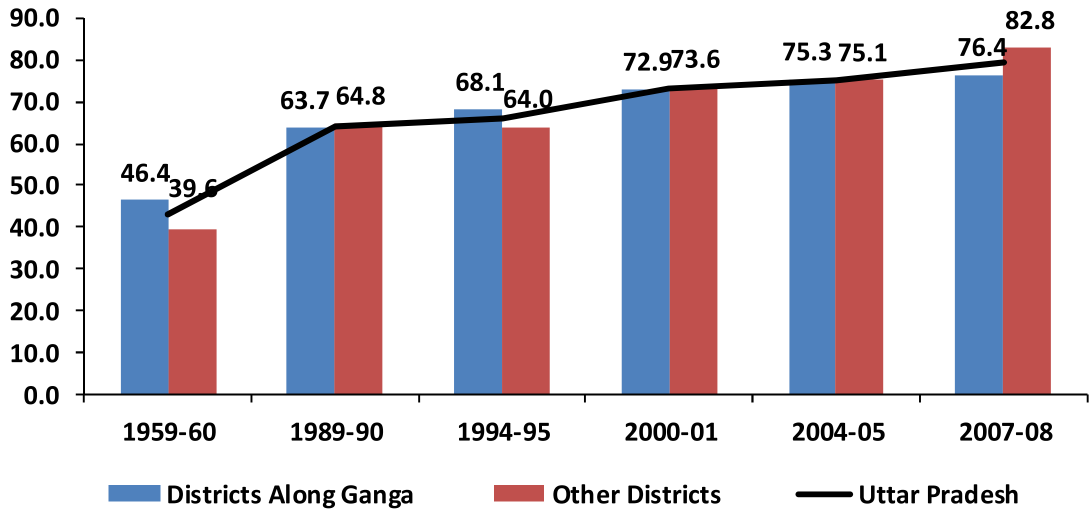

Figure 22: Trends in the share of tube-wells in total GIA in Ganga bank districts and non-bank districts

Trends in percentage distribution of districts by class of tube-well irrigated area are presented in Figure 23. The trend suggests that the number of districts with tube-well irrigation share in the range of 30-45 percent of GIA has declined during the last five decades. On the contrary, the number of districts having 70 percent and above share of tube-well mode of irrigation in the GIA has significantly increased during the same period. For example, the percentage share of districts having 70 and above percent of GIA under tube-well irrigation increased from 24.4 in 1959-60 to 78.6 in 2007-08, registering a more than three-fold increase.

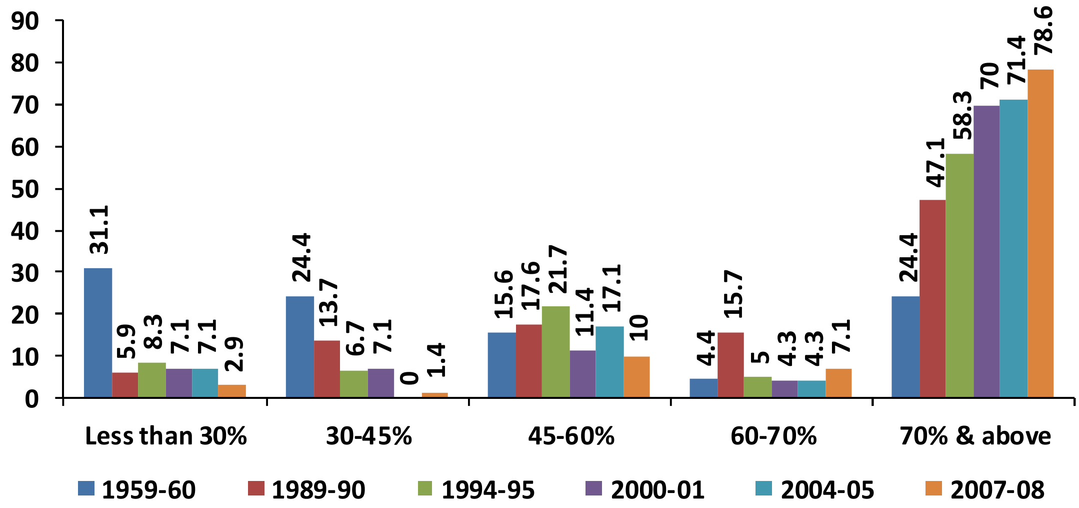

Figure 23: Proportion of districts by class of tube-well irrigated area

4.5.1 Region-wise growth of Shallow and Deep Tube-wells

As stated earlier, groundwater irrigation share is more than 80 percent of total GIA of the State. Over the period, number of both shallow and deep tube-wells has increased immensely. Figure 24 shows that between 1993-94 and 2000-01, number of shallow and deep tube-wells in the State has increased by 124 and 28 percent respectively. The number of shallow tube-wells increased much faster than deep tube-wells in all the regions of the State. However, the rate of increase varies significantly across regions. For instance, percentage increase in the number of shallow and deep tube-wells both is observed to be the highest in the water scarce southern region, followed by south upper Ganga plains region for shallow tube-wells and central region for deep tube-wells.

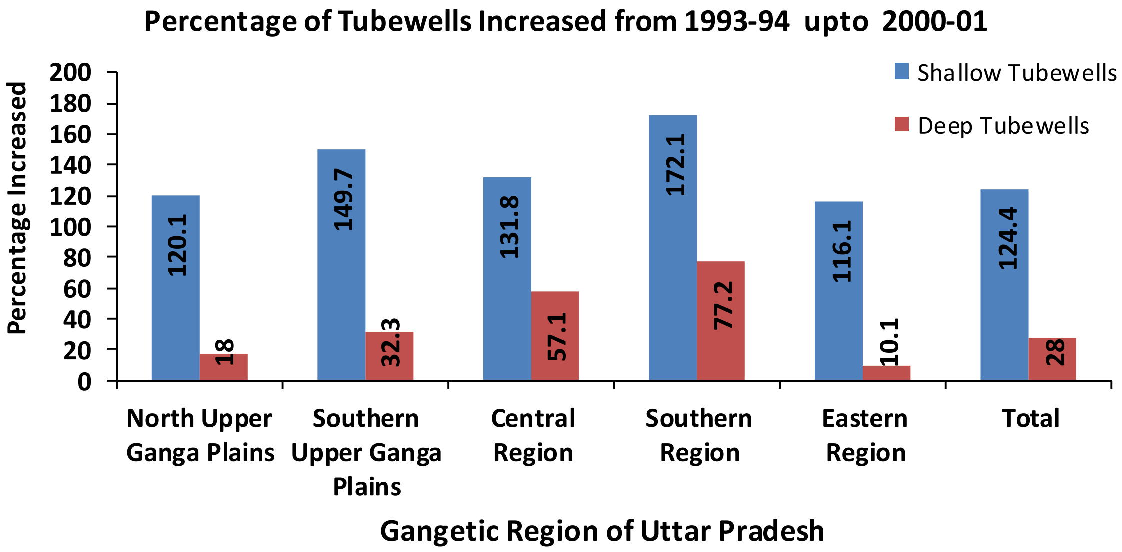

Figure 24: Region-wise percentage increase in number of shallow and deep tube-well between 1993-94 and 2000-01

4.5.2 Region-wise Distribution of Shallow Tube-wells by Size of Holdings

The distribution of shallow tube-wells by size of operational holdings shows that 50 percent of total number of shallow tube-wells in the State was owned by the marginal farmers. Small farmers possessed 32 percent of total number of shallow tube-wells of the State. Thus, about 82 percent of total shallow tube-wells of the State were possessed by the small and marginal farmers. However, the percentage varies extensively across regions (Table 1). It is found to be the highest in eastern region, followed by the central region and lowest in the southern region. The percentage of number of shallow tube-wells owned by medium and large farmers was found to be the highest in southern region, followed by north upper Ganga plains.

Table 1: Distributions of shallow tube-wells by size of operational holdings

(Values in Percentages)

S. No	Name of District	No. of Districts	Marginal (0-1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Big (>10 ha)	Total (3 to 7)
1	North Upper Ganga Plains	10	40.1	34.9	24.6	0.5	100.0
2	Southern Upper Ganga Plains	17	43.0	36.0	20.2	0.9	100.0
3	Central Region	9	52.6	30.0	16.5	0.8	100.0
4	Southern Region	7	23.0	33.2	40.5	3.2	100.0
5	Eastern Region	27	60.1	28.7	10.4	0.9	100.0
	Total	**70**	**50.0**	**32.1**	**17.0**	**0.8**	**100.0**

4.5.3 Distribution of Shallow Tube-wells according to water lifting devices

Electric and diesel pumps are the key water lifting devices used by the farmers for irrigation purposes. Table2 shows that at the State level, 84.5 percent of total shallow tube-wells used diesel pumps to lift groundwater, while electric pumps are installed only in 12.6 percent of the total tube-wells. However, the percentage share of electric operated tube-wells varies considerably across the regions. Most developed north upper Ganga plains region has the largest percentage of electric operated tube-wells (23.6%) among all the regions. It is distantly followed by south upper Ganga plains region (12.5%) and eastern region (11%). On the contrary, percentage share of diesel operated shallow tube-wells was observed to be the highest in southern region (93.7%), closely followed by central region (93.6%) and lowest in the upper Ganga plains region.

Table 2: Distribution of shallow Tube-wells according to water lifting devices

(Values in percentages)

S No.	Name of District	No. of Districts	Electric pumps	Diesel pumps	Wind mills	Solar pumps	Man/Ani. operated	Others	Total
1	North Upper Ganga Plains	10	23.6	70.1	0.2	0.0	0.1	6.0	100.0
2	Southern Upper Ganga Plains	17	12.5	84.3	0.3	0.0	0.7	2.1	100.0
3	Central Region	9	4.3	93.6	0.6	0.0	0.3	1.2	100.0
4	Southern Region	7	5.1	93.7	0.9	0.0	0.3	0.1	100.0
5	Eastern Region	27	11.0	87.6	0.7	0.0	0.2	0.5	100.0
6	Uttar Pradesh	70	12.6	84.5	0.5	0.0	0.3	2.1	100

Source: Minor Irrigation Census of Uttar Pradesh, 2001

4.5.4 Distribution of Shallow Tube-wells by Water Distribution System

As far as distribution of shallow tube-wells according to water distribution system is concerned, 97.5 percent of them used open channel to irrigate the crops while only 0.8 percent tube-wells used drip irrigation and another 0.5 percent used sprinkler irrigation system. However, the percentage varies across regions as is evident from the data presented in Table 3.

Table 3: Distribution of Shallow Tube-wells by Water Distribution System

(Values in percentages)

SNo.	Name of District	No. of Districts	Sprinkler	Drip Irrign.	Open Channel	Under gr. Channel	Others	Total
1	North Upper Ganga Plains	10	0.2	0.4	98.9	0.6	0.1	100.0
2	Southern Upper Ganga Plains	17	0.2	0.7	97.7	0.4	1.0	100.0
3	Central Region	9	0.4	1.7	96.3	0.4	1.2	100.0
4	Southern Region	7	1.9	1.1	91.8	0.9	4.3	100.0
5	Eastern Region	27	0.7	0.8	97.4	0.5	0.6	100.0
6	Uttar Pradesh	70	0.5	0.8	97.5	0.5	0.8	100.0

Source: Minor Irrigation Census of Uttar Pradesh, 2001

4.5.5 Distribution of Shallow Tube-wells according to Horse Power of Lifting Devices

In order to find out whether the farmers use over-sized pumps to draw groundwater from shallow tube-wells, percentage distribution of number of shallow tube-wells by horsepower of pumps used is estimated and the same is presented in Table 4. At the State level, about 58 percent of tube-wells are run by 6-8 HP pump-set which is considered an ideal size, while about 25 percent tube-wells used 8-10 HP pumps which may be considered over-sized and consume relatively more energy. It has been observed that a five HP electric pump is adequate to draw water using a shallow tube-well of four inch diameter water pipe, while an eight HP diesel pump is adequate for the shallow tube-well. Table 4 shows that about 46 percent shallow tube-wells used over-sized pumps. The percentage of such pumps is highest in southern region, followed by southern upper Ganga plains and central region.

Primary study conducted by WWF[1] in Kanpur branch of Lower Ganga Canal System reveals that most of the farmers used movable engines of 10 HP whereas only 4 HP engines are required to serve the purpose. The consumption of fuel was also higher than required. The study estimates that through proper selection of diesel pump and its piping, 377,747 tons of CO_2 and 141,928 kilo liters of diesel could be saved.

Table 4: Distribution of Shallow Tube wells according to Horse Power of Lifting Devices

(Values in percentages)

S No.	Name of District	No. of Districts	0-2	2-4	4-6	6-8	8-10	Above 10	un-specified	Total
1	North Upper Ganga Plains	10	0.3	0.1	21.4	58.1	11.9	1.9	6.3	100.0
2	Southern Upper Ganga Plains	17	0.7	0.3	8.9	48.4	37.3	0.5	3.9	100.0
3	Central Region	9	0.4	0.1	7.3	58.8	29.8	1.5	2.1	100.0
4	Southern Region	7	0.2	0.3	5.3	47.6	44.8	0.6	1.2	100.0
5	Eastern Region	27	0.5	1.6	13.5	64.4	18.3	0.3	1.4	100.0
6	Uttar Pradesh	70	0.6	0.7	12.6	57.7	24.6	0.8	3.1	100.0

Source: Minor Irrigation Census of Uttar Pradesh, 2001

4.5.6 Distribution of Deep Tube-wells according to water distribution system

Table 5 shows that 74.5 percent of deep tube-wells used open channel to irrigate the crops. The percentage of such tube-wells was found to be the highest in north upper Ganga plains region, followed by central region and lowest in eastern region. On the other hand, the percentage of deep tube-wells using underground channel was observed to be the highest in south upper Ganga plains region, closely followed by eastern region. Percentage share of deep tube-wells using sprinkler irrigation system was found to be the highest in southern

[1]Problems and Prospects of Saving Water and Energy in Agriculture in Upper Ganga River Basin, WWF, 2010.

region. A comparison of shallow and deep tube-wells water distribution system reveals that percentage share of deep tube-wells using underground channels to irrigate the crops is much higher than that of shallow tube-wells.

Table 5: Deep Tube-wells according to water distribution system in Uttar Pradesh

(Values in percentages)

SNo	Name of District	No. of Districts	Sprinkler	Drip Irrign.	Open channel	Under ground channel	Others	Total
1	North Upper Ganga Plains	10	1.4	0.6	87.2	10.0	0.8	100.0
2	South Upper Ganga Plains	17	2.3	0.4	67.5	28.6	1.1	100.0
3	Central Region	9	2.2	0.8	84.7	10.9	1.4	100.0
4	Southern Region	7	4.0	0.9	77.7	15.2	2.1	100.0
5	Eastern Region	27	1.9	1.6	68.0	28.1	0.4	100.0
6	Uttar Pradesh	70	2.3	1.0	74.5	21.3	1.0	100.0

Source: Minor Irrigation Census of Uttar Pradesh, 2001

4.5.7 Distribution of Deep Tube-wells according to water lifting Devices

Figure25 shows that at aggregate level, about three-fourth of total deep tube-wells used submersible pumps to draw groundwater. The percentage was observed to be the highest (92.6%) in central region, followed by southern region (73.9%) and eastern region (73.1%). Turbine pumps are also used in the deep tube-wells. The percentage of such pumps was found to be the highest in north upper Ganga plains, followed by eastern region.

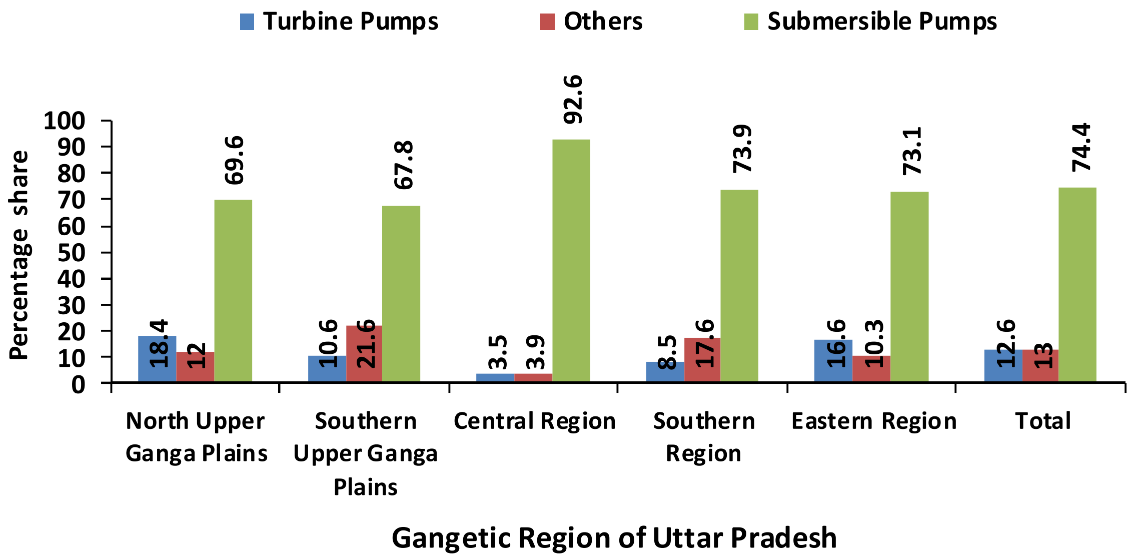

Figure 25: Distribution of deep tube-wells according to water lifting devices

4.5.8 Distribution of Deep Tube-wells by Sources of Finance

Table 6presents the distribution of deep tube-wells according to the sources of finance. About 78 percent of deep tube-wells were constructed with the state government funds.

The percentage was observed to be the highest in eastern region (91.6%) followed by south upper Ganga plains (81.6%) and north upper Ganga plains (80.8%). It was lowest in southern region. About 31 percent of deep tube-wells in the southern region were installed by the farmers' savings, while the corresponding percentage for eastern region was only 3.8. This shows that there exists a wide variation in the distribution of deep tube-wells by the sources of finance.

Table 6: Distribution of deep tube-wells according to sources of finance

(Values in percentages)

S No	Name of District	No. of Districts	Govt. Funds	Farmer's savings	Loan & Savings	Subsidy & Bank loan	Others	Total
1	North Upper Ganga Plains	10	80.8	16.3	1.2	0.5	1.3	100.0
2	South Upper Ganga Plains	17	81.6	14.4	2.0	1.0	0.9	100.0
3	Central Region	9	62.6	23.3	6.3	3.8	4.0	100.0
4	Southern Region	7	48.3	31.4	3.8	11.7	4.8	100.0
5	Eastern Region	27	91.6	3.8	1.6	2.6	0.4	100.0
6	**Uttar Pradesh**	**70**	**77.9**	**14.4**	**2.6**	**3.3**	**1.8**	**100.0**

Source: Minor Irrigation Census of Uttar Pradesh, 2001

4.6 Region-wise Groundwater Development

Table 7 shows that the State has 7,018,290 hectare meters (ham) of net availability of groundwater out of which 4,878,437 hectare meters are annually drafted. Thus, on an average, about 70 percent of groundwater has been exploited for various purposes. Region-wise net annual availability and annual draft of groundwater show that the stages of groundwater development in the State vary widely across regions. North upper Ganga plains region has the highest percentage of groundwater development (81%) in the State. It is followed by the south upper Ganga plains region (75.7%). The groundwater development was estimated to be the lowest in southern region, followed by the eastern region.

Table 7: Region-wise annual groundwater availability, draft and percentage of development

S No.	Regions	Net Annual Groundwater Availability(ham)	Total Annual Groundwater Draft (ham)	Groundwater Development (%)
1	Northern Upper Ganga Plains	1,064,396	860,759	80.9
2	South Upper Ganga Plains	1,786,986	1,353,195	75.7
3	Central Region	1,183,576	792,818	67.0
4	Southern Region	442,299	192,548	43.5
5	Eastern Region	2,541,032	1,679,114	66.1
	Uttar Pradesh	**7,018,290**	**4,878,437**	**69.5**

4.6.1 Region-wise Distribution of Villages by the Groundwater Level

Figure26 shows the region-wise distribution of villages according to their groundwater level in the State. The depth of groundwater table is classified into seven categories (refer Figure 26). About 70 percent villages in the State have water level below 10 meters. The percentage of such villages is found highest in eastern region (77%), followed by central region (67%) and north upper Ganga plains (66%). In the category of 10-15 meter depth of water level, the percentage share of villages is found to be the highest in southern region, closely followed by north upper Ganga plains. In all other categories of water level, the percentage of villages was quite low.

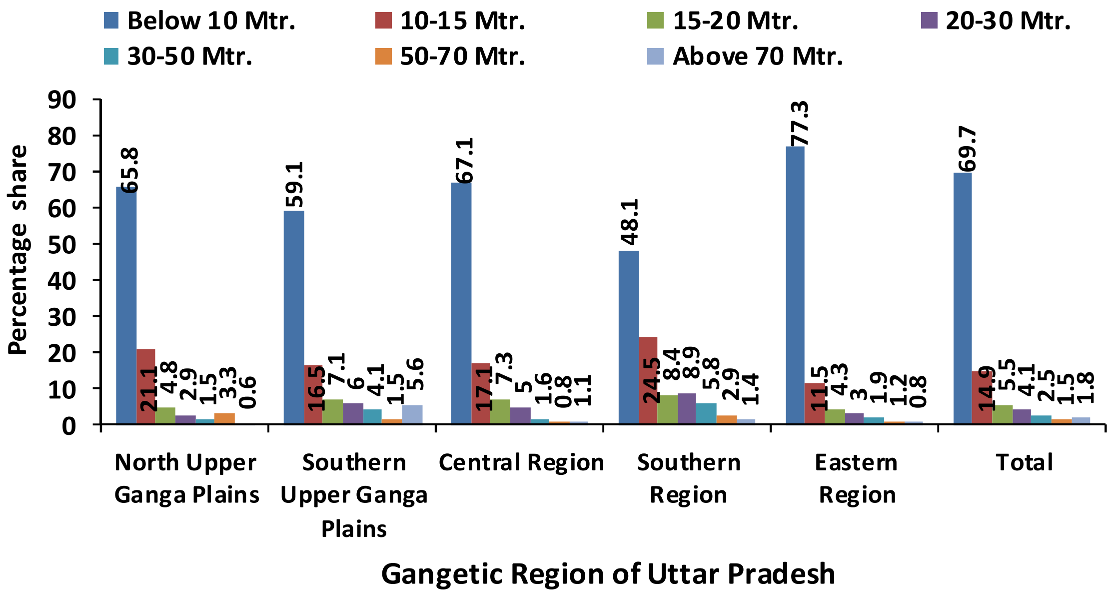

Figure 26: Region-wise percentage of number of Villages by their Groundwater Level

4.6.2 Region-wise Share of Groundwater Recharge in Monsoon and Non-monsoon Seasons

Region-wise groundwater recharge in monsoon and non-monsoon seasons is shown in Figure27. At the State level, about two-third of total water recharge occurred in the monsoon season while the remaining one-third during the non-monsoon season. The regional pattern of the groundwater recharge in the State, reveals that the percentage share of groundwater recharge during the monsoon season varies significantly across regions. Southern region has the highest percent (75.11%) of water recharge during the monsoon season. It is followed by eastern region (68.84%) and central region (64.34%). North upper Ganga plains region has the highest percentage share of groundwater recharge during non-monsoon region among all the regions, followed by south upper Ganga region. This shows that a substantial percentage share of groundwater recharge in Upper Ganga Plains occurs during the non-monsoon seasons.

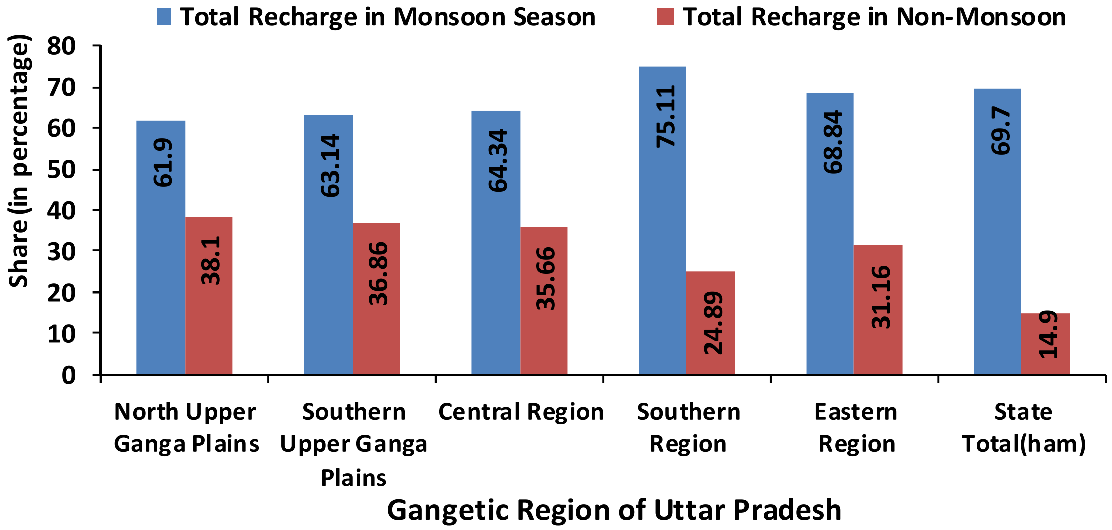

Figure 27: Region-wise Share of Groundwater Recharge in Monsoon and Non-monsoon Seasons

5. Trends in Consumption of Fertilizers and Pesticides

With the advent of green revolution in the Middle Ganga Basin in the 60s, use of chemical fertilizers in agriculture has tremendously increased. Although the green revolution technology made remarkable contribution to agricultural development and solved the problem of food security, it also led to serious environmental and ecological consequences. The chemicalization of agriculture has not only degraded the soil and water resources but also adversely affected the health of people consuming agricultural products. Figure 28 shows that while only 21,000 tons of chemical fertilizer was used in the agriculture in the State during 1950-51, its consumption increased to 1,151,000 tons by 1980-81 and further to 2,246,000 tons by 1990-91. Thus, between 1980-81 and 1990-91, the consumption of chemical fertilizer in the middle Ganga basin registered a rise of about 100 percent. Similarly, the quantity of chemical fertilizer used in agriculture augmented from 2,246,000 tons in 1990-91 to 3,756,000 tons by 2007-08, registering a net increase of 67 percent[2]. During the period 1980-81 to 2009-08, the use of chemical fertilizer has increased by 226 percent. Figure 28 also reveals the fact that although the percentage share of nitrogenous content in the total fertilizer has declined over the period, it is still high. Nitrogen comprised about 78 percent of total fertilizer consumption in agriculture; nevertheless, since 1999-00, the ratio of nitrogen to phosphorous remained more or less constant.

[2] Crop-wise fertilizer consumption is discussed in a separate section on costs and returns from agriculture.

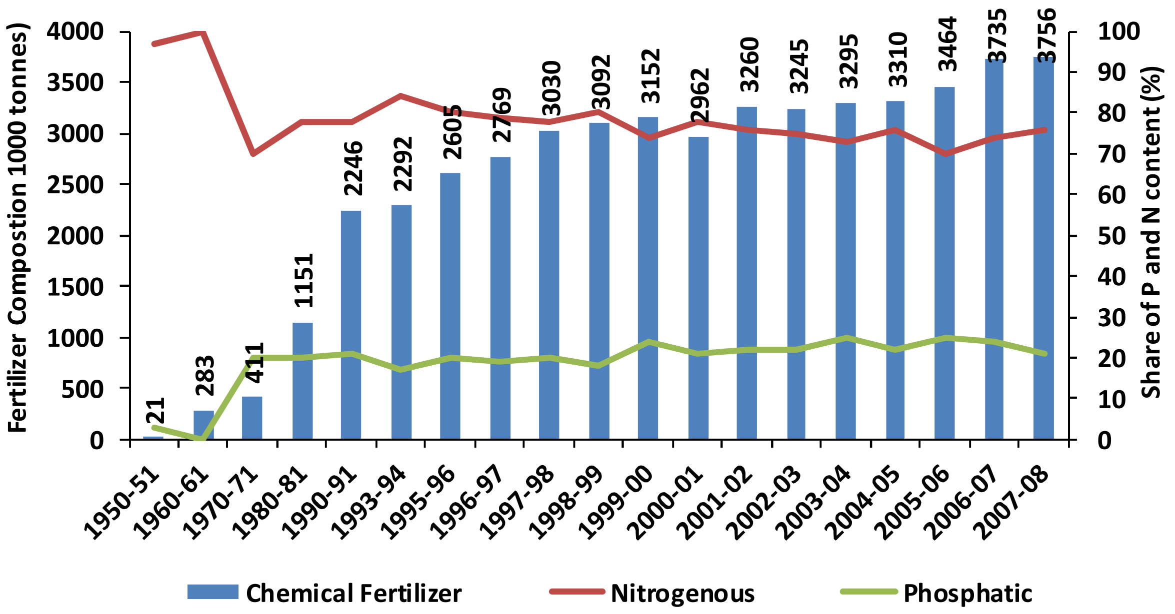

Figure 28: Trends in consumption of chemical fertilizer in Uttar Pradesh

Per hectare use of pesticide in agriculture is shown in Figure 29. A perusal of the consumption pattern of pesticides in agriculture of the State shows that use of pesticides in g/ha has increased up to the year 1990 and then showed fluctuations across years. The use of pesticides increased from 172 g/ha in 1980 to 362 g/ha in 1994 and then recorded a decline to 296 g/ha in 2000. The pattern of pesticides use in agriculture during the 20 years for which data are available does not evince any trend.

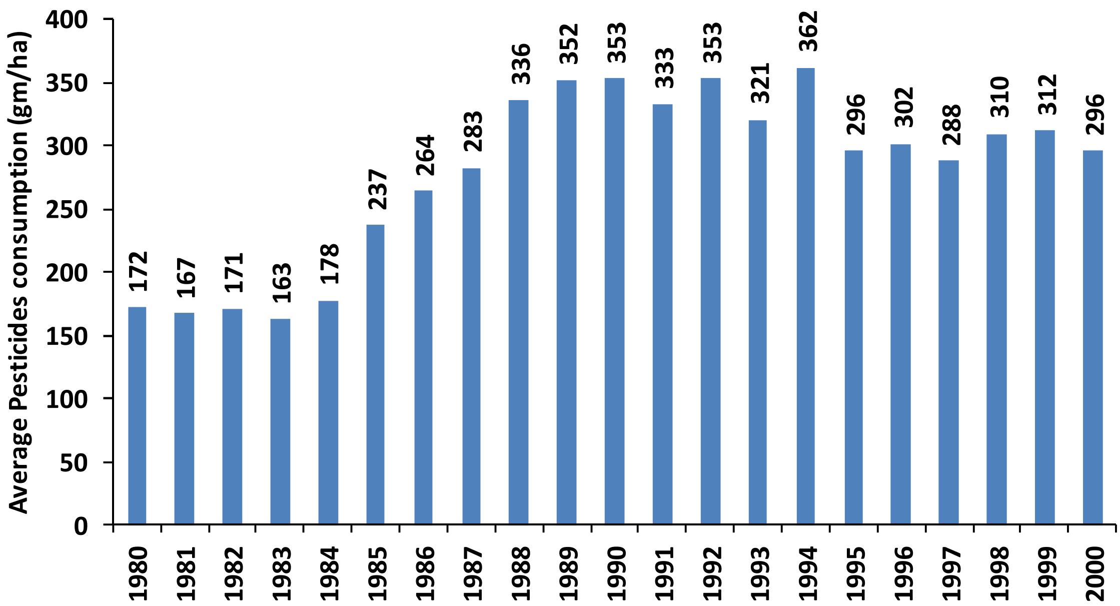

Figure 29: Trends in consumption of pesticides in Uttar Pradesh

Region-wise per hectare use of chemical fertilizer is also estimated and is presented in Figure 30. There has been exponential growth in the per hectare use of chemical fertilizer in the middle Ganga basin. North upper Ganga plains show highest intensity of fertilizer application among all the regions. It is followed by south upper Ganga plainsand the eastern region. Southern region has the lowest intensity of fertilizer consumption among all the regions. It may be noted here that use of chemical fertilizer in agriculture is positively associated with the use of irrigation water in the agriculture. More the frequency of irrigation to the crop; more would be the frequency of use of fertilizer to the crop. Since north upper Ganga plains are having better access to both surface and ground water as compared to other regions, the fertilizer consumption per unit of land is also higher in this region than that in other regions. In north upper Ganga plains, per hectare use of chemical fertilizer increased from 70.2 kg in 1980-81 to 182.1 kg in 2007-08, a more than 2.5 fold increase. In the eastern region, use of fertilizer increased from 48 kg/ha in 1980-81 to 167 kg/ha, a more than three-fold increase. Similar pattern of fertilizer consumption is observed in the south upper Ganga plains where per hectare use of fertilizer increased from about 50 kg in 1980-81 to 165 kg in 2007-08. Except for the southern region which does not have adequate irrigation facilities, in all other regions, use of fertilizer has significantly increased during the period under study.

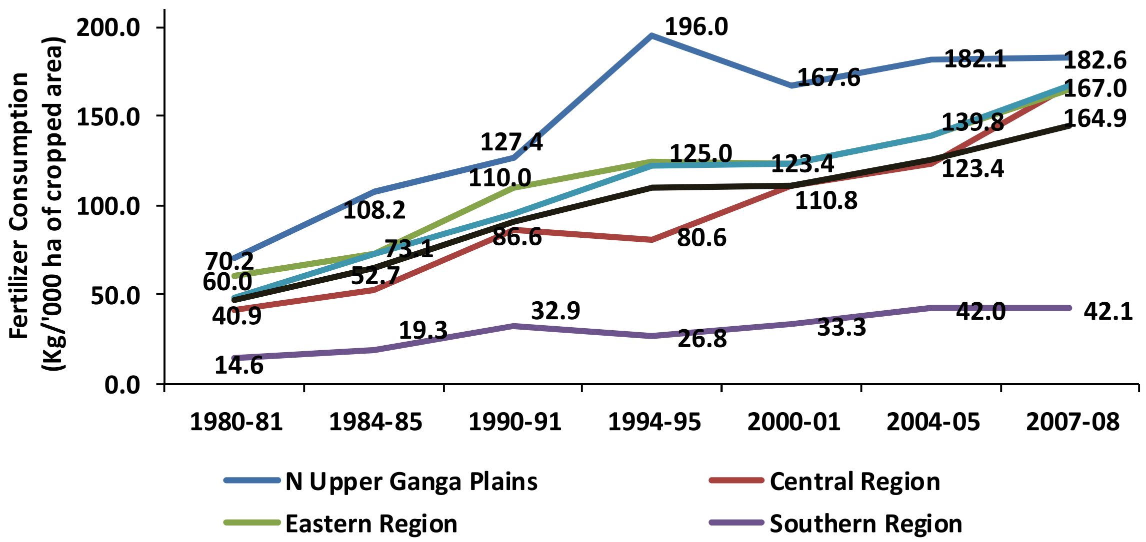

Figure 30: Region-wise trends in per hectare use of chemical fertilizer

Figure 31 shows that fertilizer consumption in agriculture was much higher in the Ganga bank districts than that in non-bank districts. For example, in 2007-08, as against 164.6 kg/ha use of fertilizer in the bank districts, the use of fertilizer in non-bank districts was only 133.8 kg/ha. This shows that, on an average, farmers in the bank districts used about 31 kg more fertilizer per hectare than their counterparts in the non-bank districts. It can be further observed that the use of fertilizer in both categories of districts has registered a rising trend.

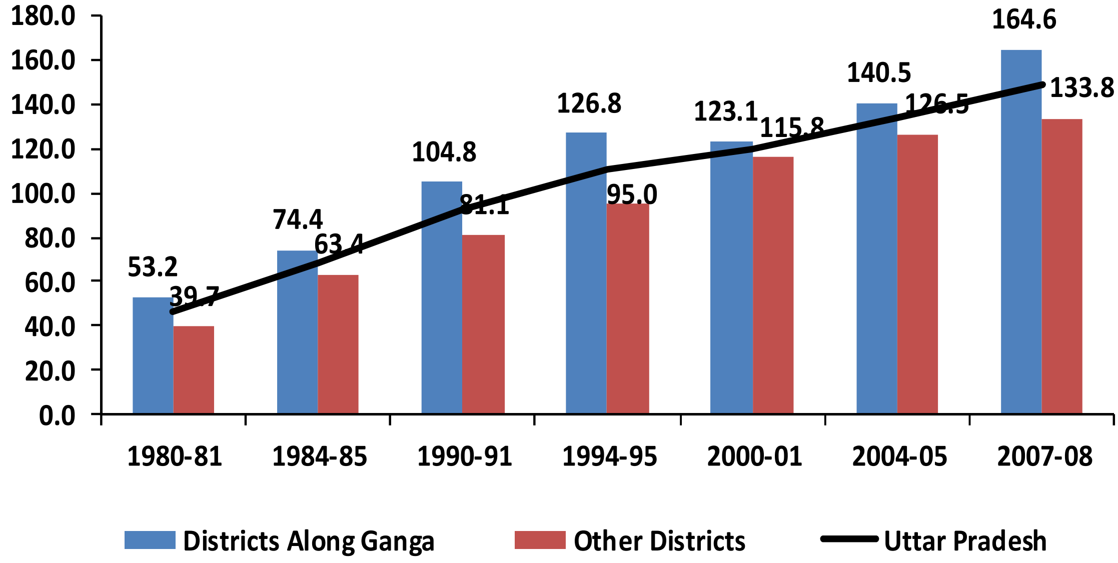

Figure 31: Trends in fertilizer consumption in the Ganga bank and non-bank districts

Analysis of data shown in Figure32 reveals that there has been exponential decline in number of districts having per hectare use of chemical fertilizer less than 75 kg. The percentage of districts having fertilizer consumption less than 75 kg/ha has declined from 95.7 in 1980-81 to 11.4 in 2007-08. On the contrary, the percentage of districts with consumption of fertilizer in the range of 150-200 kg/ha increased from 3.8 in 1980-81 to 27.1 in 2007-08. Farmers in more than 45 percent districts of the State used chemical fertilizers 150 kg/ha and above in 2007-08 while corresponding percentage of districts in 1980-81 was only 14.4.

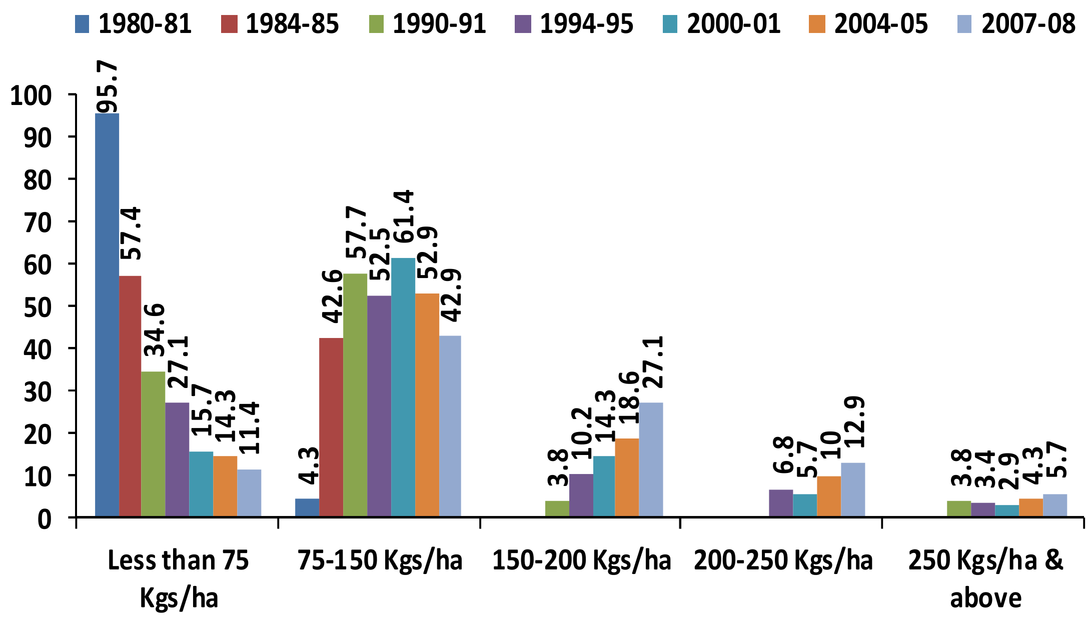

Figure 32: Percentage of number of districts using fertilizer in the stated range

6. Trends in Farm Mechanization

In order to understand the extent of mechanization in agriculture, the trends in number of tractors, electric pump sets (electric motors) and diesel engines (oil pump sets) have been examined. The numbers are taken per 1000 hectares of GCA. The trends are shown in Figure 33 which reveals that the number of tractors used in agriculture has drastically increased from about 5 per 1000ha in 1961 to 60 per 1000ha in 1988 and further to 135 per 1000ha in 1997 and thereafter number remained stagnant. Number of oil pump sets also increased rapidly during the last five decades i.e., from 3 per 1000ha in 1966 to 27 in 1978 and further to 144 per 1000ha in 1997. Thereafter, the number of pump-sets declined to 91 per 1000ha in 2003. Number of electric pump-sets also increased over the period. The number increased from 7.7 per 1000 ha in 1972 to 26.3 per 1000ha in 1997and after that it declined to 16.7 per 1000ha in 2003.

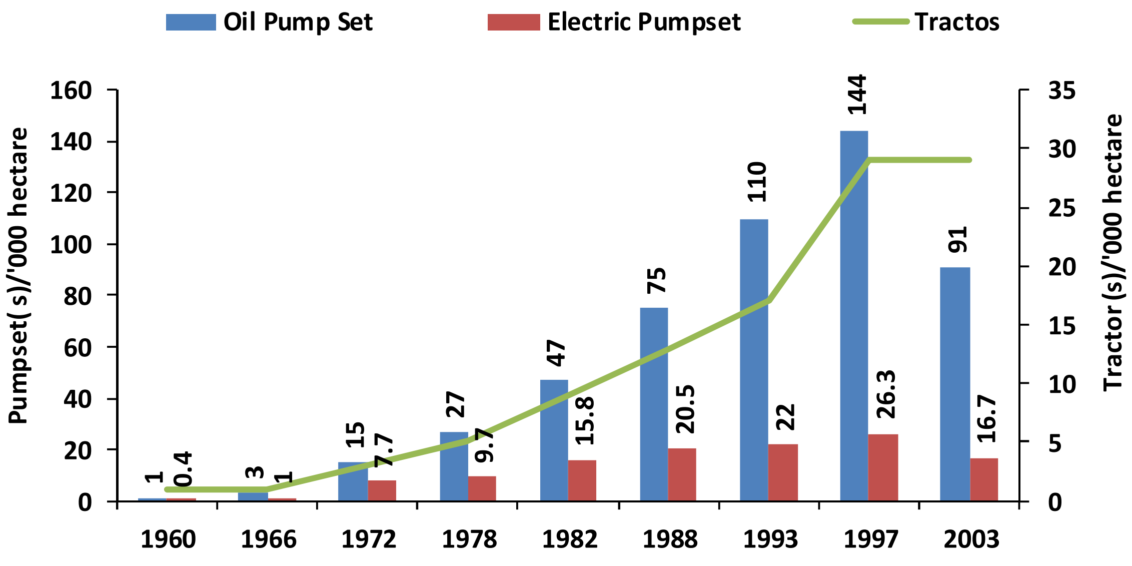

Figure 33: Trends in Farm Mechanization

Except for government tube-wells which used electric pump sets to extract groundwater; all other farm machines are under the private ownership. Figure 34 shows the regional trends in the number of pump sets used in agriculture. It suggests that the number of pump sets per 1000 ha of GCA has significantly increased in all the regions, except for southern region. In north upper Ganga plains, the number of pump sets increased from 46.1 per 1000 ha of GCA to 105.8 per 1000ha in 1991 and then declined to 94.6 per 1000ha in 1999. Similarly, in central region, the number of pump sets increased from 43.2 in 1980 to 148 in 1999. South upper Ganga plains also witnessed fast growth in the number of pump sets per 1000 ha of GCA as is evident from the data presented in Figure 34. In eastern region, the number of pump sets increased from 14.7 per 1000ha in 1980 to 129.4 per 1000ha in 1999. On an average, between 1980 and 1999, number of pump sets in the State has registered about five-fold increase. The rapid growth of number of pump sets per 1000 ha of GCA in the middle Ganga basin area has some implications for the sustainability of groundwater in the region. One major factor that contributed to the fast growth of pump-sets in the state is the flat rate electricity tariff system which encourages the farmers to extract more groundwater for irrigation as marginal cost of drawing extra unit of water is almost zero for them.

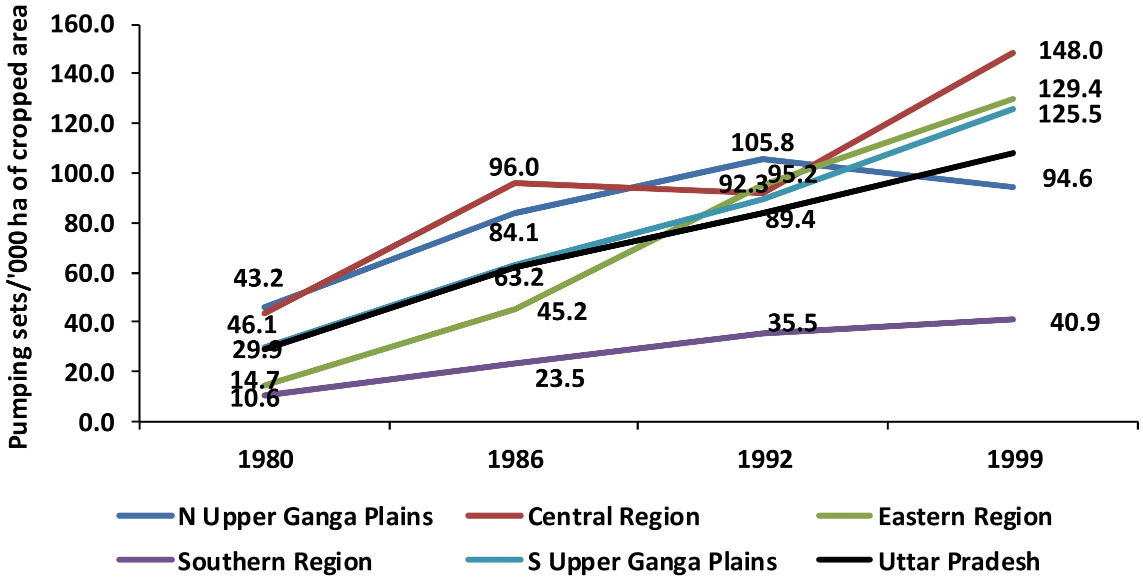

Figure 34: Region-wise total number of pump-sets in operation

Installing a tube-well in the canal command area has lesser cost than that in the non-canal command area. It has been observed that the number of pump-sets in operation has been much higher in the Ganga bank districts as compared to non-bank districts. Figure 35 shows that the number of pump sets per 1000ha of GCA in the bank districts increased remarkably from 29 in 1980 to 131.2 in 1999, while the corresponding increase in the non-bank districts was from 25.3 in 1980 to 98.1 in 1999.

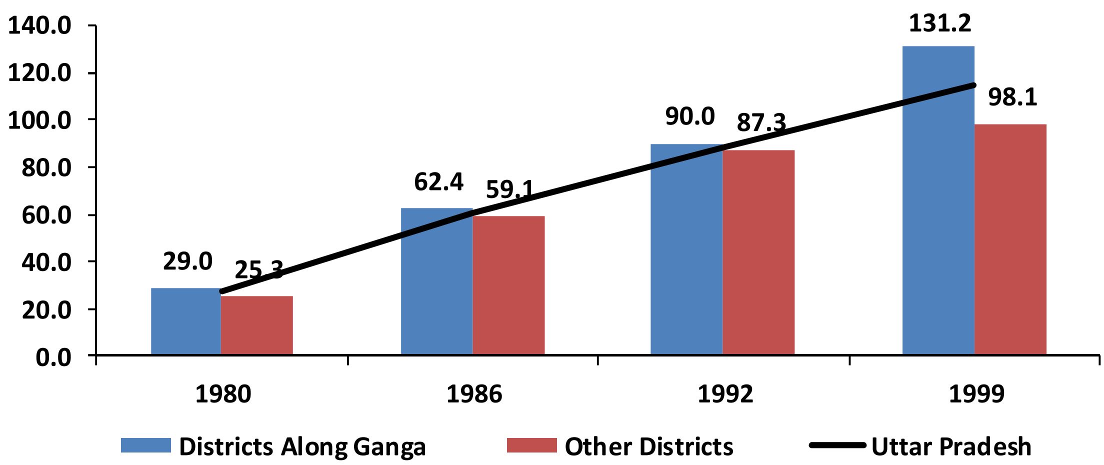

Figure 35: Trends in number of pump-sets per 1000ha of GCA in Ganga bank and non-bank districts

7. Trends in Area, Production and Yield of Major Crops

7.1 Trends in Area under Major Crops

Figure 36presents trends in the area under major crops of the State. The data presented brings to the fore that the share of rice in the total GCA increased from 19.3 percent in 1950-51 to 21.5 percent in 1980-81 and then to 23.3 percent in 2000-01. Since 2001-02, there has not been any increase in the area under rice. Area under wheat, which remained stable during pre-green revolution period, evinces a remarkable increase in the post-green revolution period. It increased from 16.8 percent in 1970-71 to 33 percent in 1980-81 and further to 37.1 percent in 2007-08. Wheat and rice together comprised 60 percent of total GCA in 2007-08. Both the crops are mostly grown on the irrigated land and shared more than 70 percent of total GIA. Pulses occupy the third rank in terms of their share in the total GCA. However, the area under pulses has registered a declining trend. For instance, their share in the total GCA declined considerably from 21.8 percent in 1950-51 to 11.6 per cent in 1980-81 and further to 9.0 percent in 2007-08. The share of pulses in the total GCA has declined sharply during the post-green revolution period.

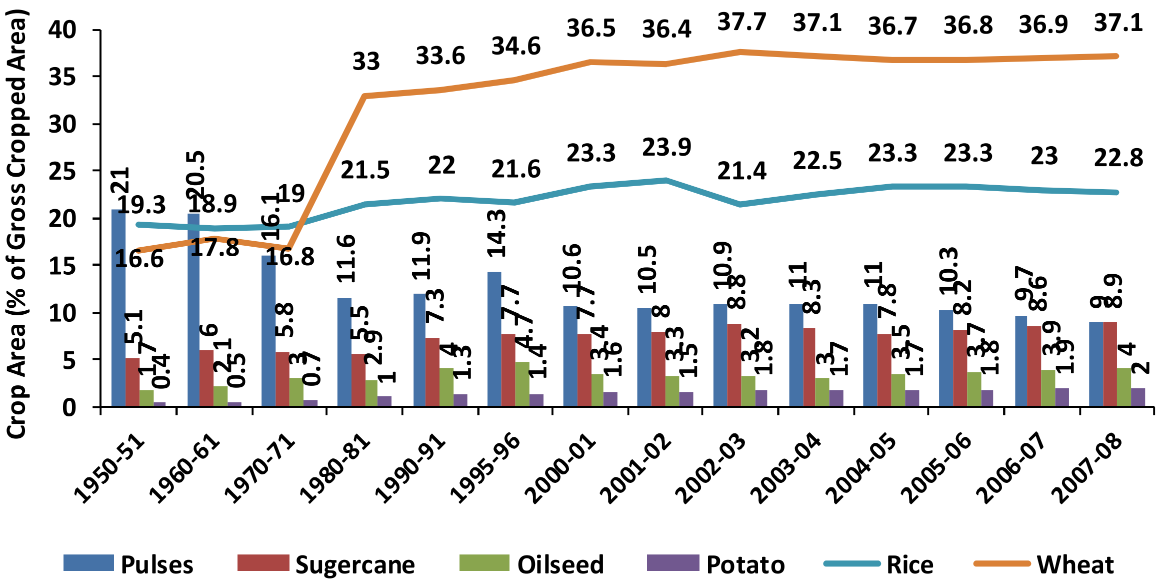

Figure 36: Trends in area under major crops in Uttar Pradesh

The area under sugarcane has grown steadily over the period of time (refer Figure 36). It increased from 5.1 percent in 1950-51 to 5.5 percent in 1980-81 and further to 8.9 percent in 2007-08. Thus, the area under sugarcane has increased by 75 percent between the year 1950-51 and 2007-08. Area under oilseeds increased up to the year 1995-96 and, thereafter, started declining till 2003-04 and then increased in the subsequent years. National Oilseeds Mission launched by the Government of India may be one of the reasons for increase in area under oilseeds. Another important crop i.e., Potato shared less than 2.0 percent of the total GCA of the State in 2007-08. The area under potato shows a rising trend during the period under study. For instance, its share increased from 0.4 percent in 1950-51 to 1.0 percent in 1980-81 and further to 2.0 percent in 2007-08.

7.2 Trends in Production of Major Crops in Uttar Pradesh

During the last six decades, there has been remarkable increase in the production of wheat in the State. Its production increased from a meager 2.7 million tons (MT) in 1950-51 to 13.4MT in 1980-81 and further to 26.3 MT in 2007-08. Between 1951 and 2007-08, production of wheat has registered 10 times increase. Evidently, Green Revolution has made significant contribution to raise the production and productivity of superior cereals such as wheat and rice. In regard of rice, the production increased from 2.0 MT in 1950-51 to 10.3 MT in 1990-91 and further to 12.9 MT in 2001-02. Thereafter, the production of rice did not show any notable increase. Figure 37 shows that in the recent years, annual production of rice remained below 12 MT. Stagnation in the production of rice may have serious implication for food security, as rice is the important part of staple diet of the people.

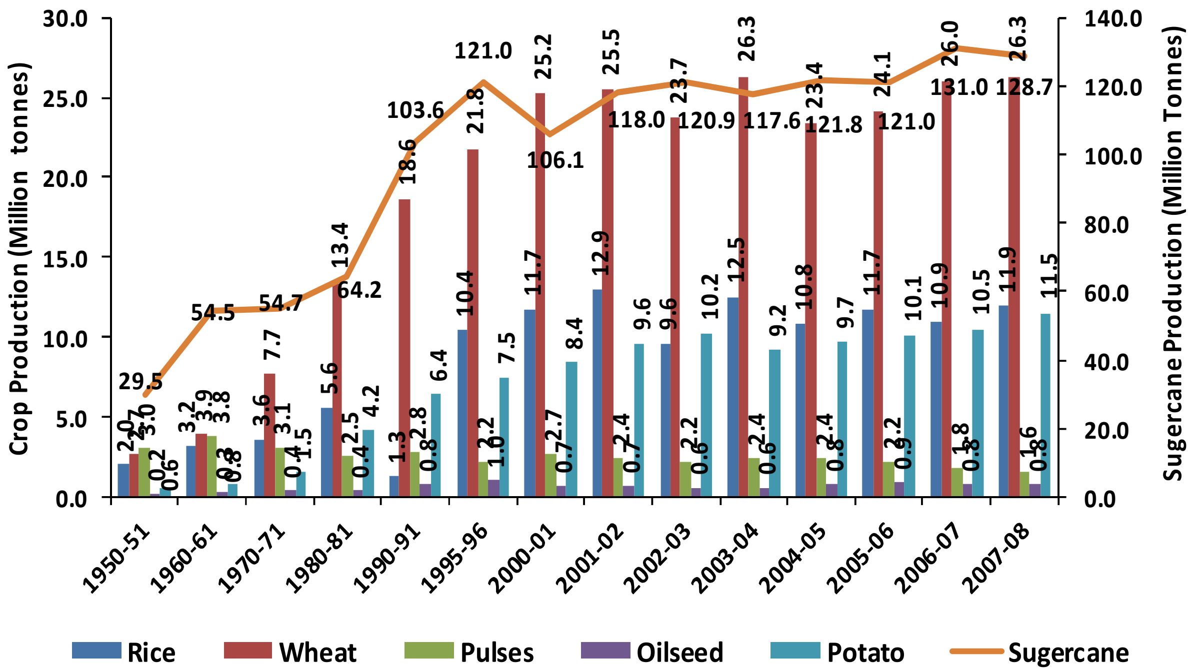

Figure 37: Trends in production of major crops, Uttar Pradesh, 1950-51 to 2007-08

Sugarcane production has been recording a rising trend throughout the period (Figure 37), though there were some fluctuations in the production across years which could be attributed mainly to the sugar cycle. The production of sugarcane increased from 29.5 MT in 1950-51 to 64.2 MT in 1980-81 and further to 128.7 MT in 2007-08. Production of sugarcane recorded more than four-fold increase between 1950-51 and 2007-08.

Production of pulses in the State has declined over the period. The production of pulses declined from 3.0MT in 1950-51 to 2.5 MT in 1980-81 and further to 1.6 MT in 2007-08. Thus, the production evinces a negative trend during the entire period. Pulses are the important sources of protein in the diet of vegetarians; a deceleration in their production has some implication for the nutritional level of the people. A perusal of Figure 37 reveals that production of oilseeds increased from 0.2 MT in 1950-51 to 1.0 MT in 1995-96 and thereafter it remained below 1.0 MT throughout period. Production of potato shows a rising trend throughout the period, though some fluctuations also occurred across the years. Its production increased from 0.6 MT in 1950-51 to 4.2 MT in 1980-81 and further to 11.5 MT in 2007-08. Production of potato recorded more than 16 times increase between period 1950-51 to 2007-08.

7.3 Trends in Per Hectare Yield of Major Crops

Figure 38presents the trends in per hectare yield of rice, wheat, pulses, oilseeds, sugarcane and potato. The average yield of rice ranges from 7 quintal per hectare (Q/ha) to 21 Q/ha. The yield of cereals increased from 5 Q/ha in 1950-51 to 8 Q/ha in 1970-71 and further to 21 Q/ha in 2007-08. After 2000-01, the yield remained more or less stagnant. Yield of wheat increased from 8Q/ha in 1950-51 to 17 Q/ha in 1970-71 and further to 28Q/ha in 2007-08. Yield of wheat also remained stagnant since 2000-01.Yield of pulses shows declining trend during the last six decades. Their yield declined steeply from 28Q/ha in 1950-51 to 23 Q/ha in 1980-81 and further to 8 Q/ha in 2007-08. Yield of oilseeds ranged from 5 Q/ha to 9 Q/ha. After 1990-91, no growth is seen in the yield of oilseeds. Potato shows a rising trends in its yield during the entire period. Its yield increased from 78 Q/ha in 1950-51 to 222 Q/ha in 2007-08. Productivity of sugarcane also evinces rising trend. It went up from 291 Q/ha in 1950-51 to 406 Q/ha in 1970-71. It reached at the peak (607 Q/ha) in 1995-96 and then decelerated to 549Q/ha in 2000-01. It can be inferred from the analysis of data shown in Figure38 that during the first decade of the current century, yields of various crops have either declined or remained stagnant.

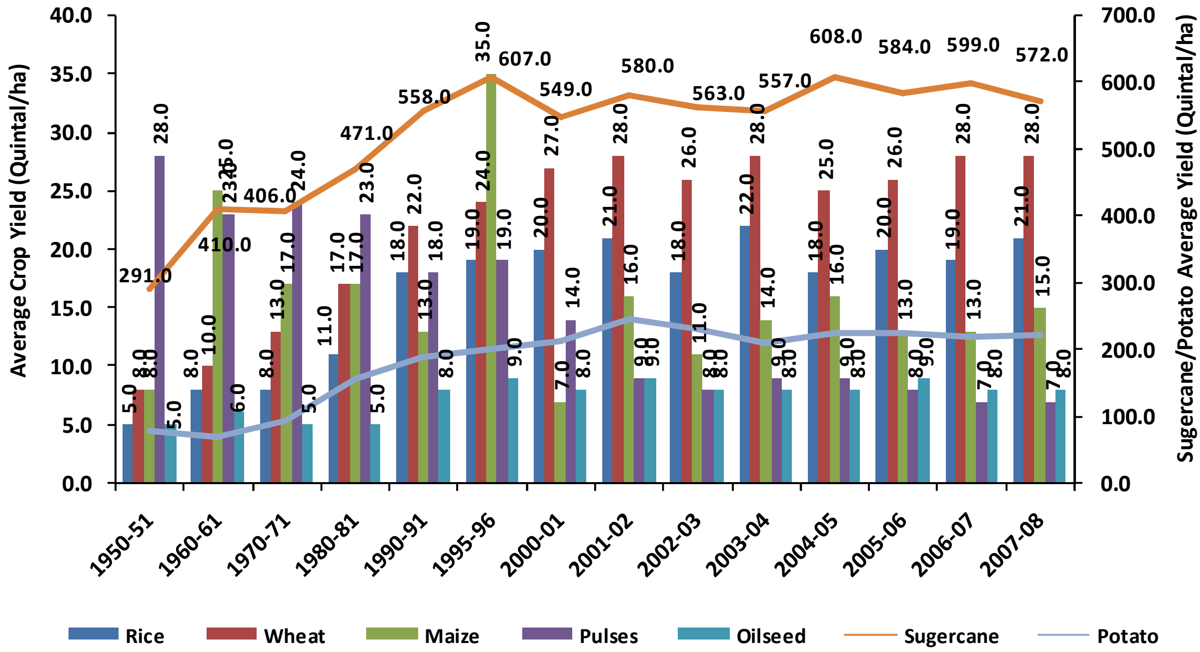

Figure 38: **Average yield of major crops, Uttar Pradesh, 1950-51 to 2007-08**

7.4 Trends in Cropping Intensity and Per Capita Net Sown Area

Trend in cropping intensity (CI) is shown in Figure 39. The CI increased from 123 percent in 1950-51 to 142.7 percent in 1980-81 and further to 150.4 in 2000-01. Between 2000-01 and 2007-08, CI has increased only by 4 percent. Between 1950-51 and 2007-08, CI has increased by 31 percent. Per capita NSA has declined steeply over the period, declining from 0.26 hectare in 1950-51 to 0.09 hectare in 2007-08. Since availability of land for cultivation has been declining due to conversion of agricultural land for non-agricultural uses, future requirements of agricultural product can be met only by increasing cropping intensity and productivity per unit of land and other resources, including water.

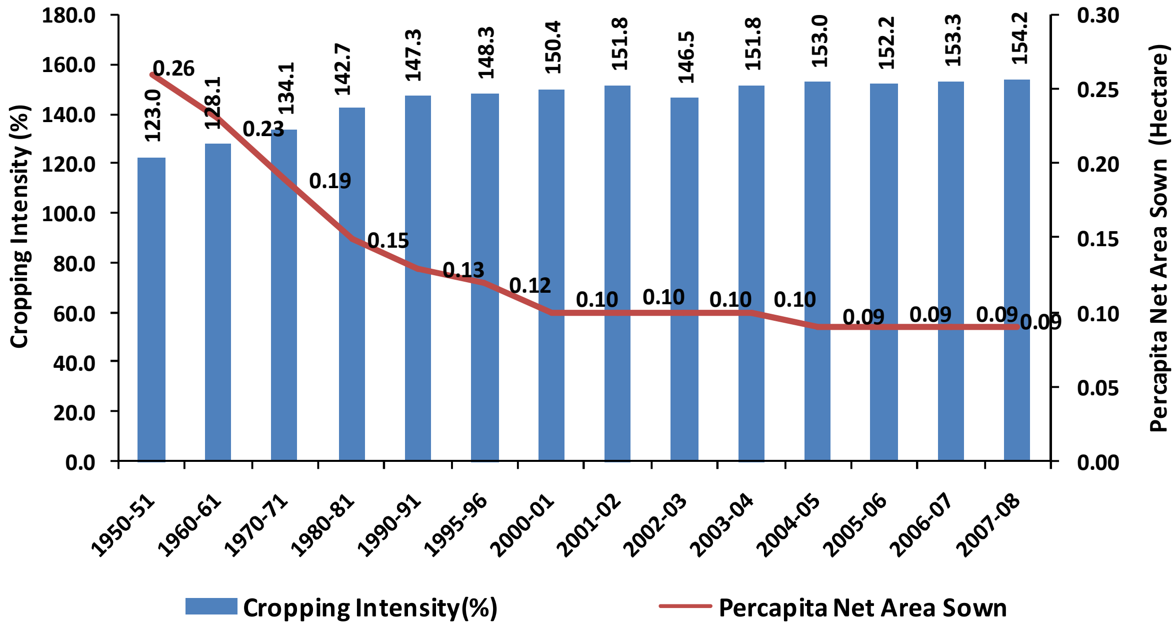

Figure 39: Trends in Cropping Intensity and Per Capita NSA in Uttar Pradesh

8. Region-Wise Trends in Productivity of Major Crops

8.1 Region-Wise Trend in Average Productivity of Rice

Rice, wheat and sugarcane are important crops grown in the middle Ganga Basin. These crops together accounted for 68.8 percent of total GCA, 83 percent of total GIA and 75 percent of chemical fertilizer consumption of the State in 2007-08. Figure 40 shows the regional pattern of yield of rice in the State. North upper Ganga plains have registered the highest productivity in rice amongst all the regions. It is followed by the south upper Ganga plains. In north upper Ganga plains, yield of rice has increased from 18.8 Q/ha in 1984-85 to 24.1 Q/ha in 2004-05. Thereafter, it did not evince any rise. Similar pattern is also observed in its yield in the south upper Ganga plains. In this region, the yield increased from 11.3 Q/ha in 1984-85 to 19.6 Q/ha in 1994-95 and further to 23.3 Q/ha in 2007-08. In the central region, yield of rice increased from 12.4 Q/ha in 1984-85 to 15.9 Q/ha in 1994-95 and further to 18.9 Q/ha in 2007-08. Yield of rice in the eastern region shows high magnitude of variation across years. Southern region has recorded lowest productivity in rice among all the regions as shown in Figure 40.

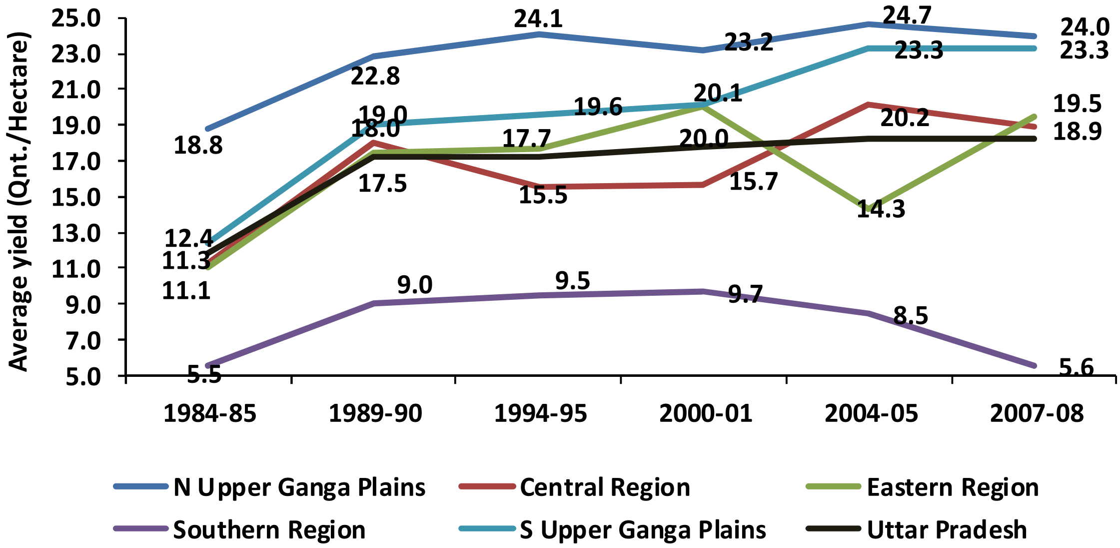

Figure 40: Region-wise trend in average yield of rice in Uttar Pradesh

Average yield of rice was found to be higher in the bank than that in non-bank districts. Figure 41shows that in 1984-85, average yield of rice in Ganga bank district was 12.7 Q/ha, while the corresponding yield in the non-bank districts was 10.7 Q/ha. Similarly, as against 20.5 Q/ha yield of rice in the bank districts in 2007-08, the yield in the non-bank districts was 18.5 Q/ha. A perusal of the Figure 41 reveals that during the period under study, yield of rice has increased in both the regions but the increase appears to be a little higher in the non-bank than that in the bank districts. Consequently the yield gap between the two regions has slightly declined.

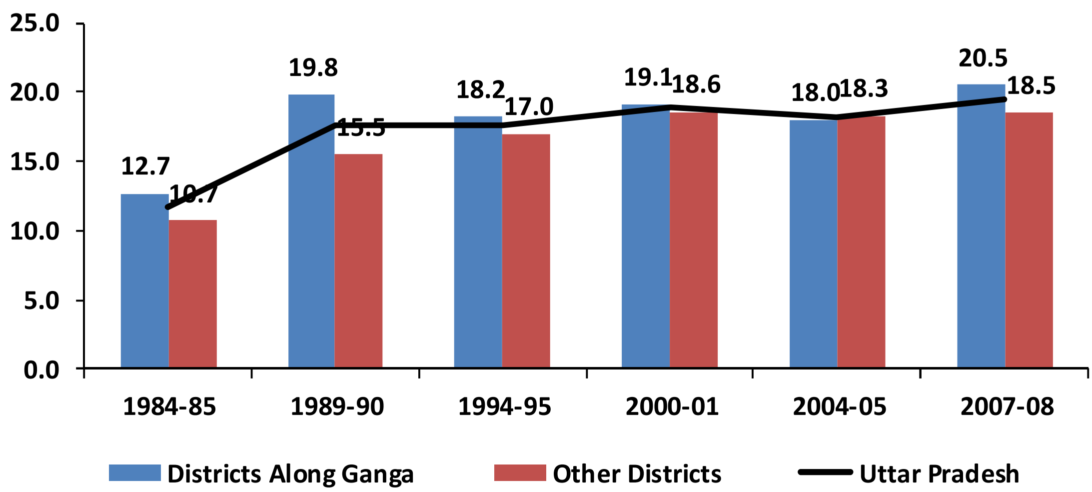

Figure 41: Average yield of rice in the Ganga bank and non-bank districts

Figure 42 shows the distribution of districts by class of average yield of rice. It is evident that the proportion of districts having productivity of rice below 15Q/ha has declined over the period while the proportion of districts having productivity level 20Q/ha and above has increased. For example, the percent of total districts having productivity of rice below 15Q/ha has declined drastically from 77 in 1984-85 to12.9 in 2007-08. On the contrary, proportion of districts having productivity of rice 20Q/ha and above has increased from 8.3 percent in 1984-85 to 51.4 percent in 2007-08. This implies that improvement of productivity spread more evenly across districts.

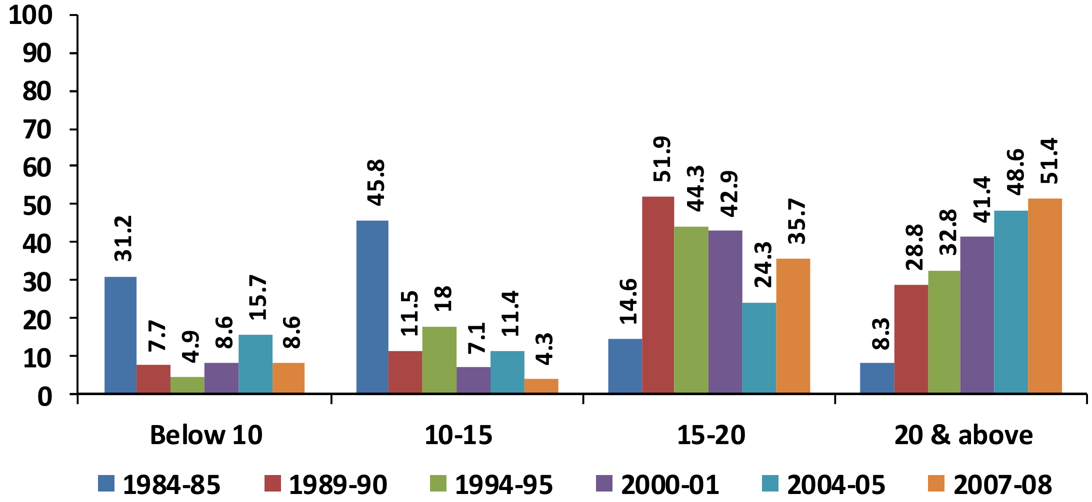

Figure 42: Proportion of districts by class of average yield of rice

8.2 Region-Wise Trend in Average Productivity of Wheat

Per heactre productivity of wheat is observed to be the highest in the north upper Ganga plains, followed by the south upper Ganga plains and central region. In the north upper Ganga Plains per heactre productivity of wheatincreased from 22.8 Q/ha in 1984-85 to 32.1 Q/ha in 1994-95 and further to 33.3 Q/ha in 2007-08 (Fugure 43). The productivity of wheat in the region increased by 41 percent duringthe period 1984-85 to 2007-08. In south upper Ganga plains, the yield increased from 21.5 Q/ha in 1984-85 to 29.3 Q/ha in 1994-95 and further to 32.1Q/ha. During the period 1984-85 to 2007-08, productivity of wheat in this region increased by 49 percent. In central region, the productivity increased from 17.8Q/ha in 1984-85 to 27.6 Q/ha in 2007-08, a net increase of 55 percent. Eastern region also shows a rising trend in its yield, though it varied across years. Southern region has shown considerable variation in the productivity of wheat, which appears to be indicative of the fact that productivity is more sensitive to the adequacy/non-adequacy of the rainfall.

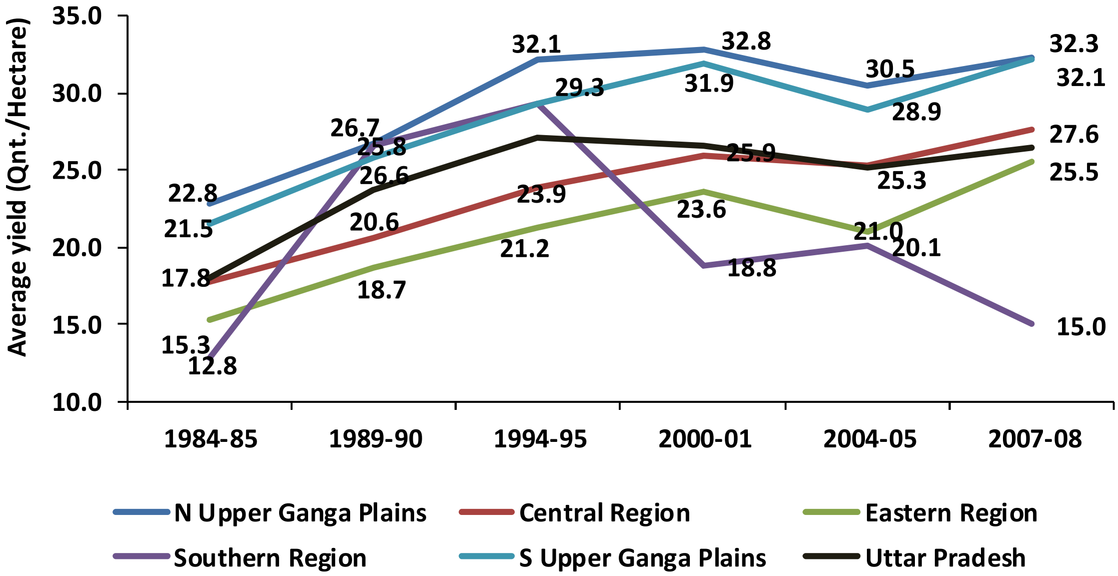

Figure 43: Region-wise average yield of wheat in Uttar Pradesh

In regard of the wheat crop, no trend in the productivity gap between the bank and non-bank districts is observed. It may be noted that in some years, productivity of wheat was found to be higher in the bank districts, while in some other years, non-bank districts showed higher yield. For instance, as is evident from Figure 44, in 1984-85, 1994-95 and 2007-08, the bank districts attained relatively higher yield of wheat whereas in 1989-90 and 2004-05, the non-bank districts have achieved the higher yield.

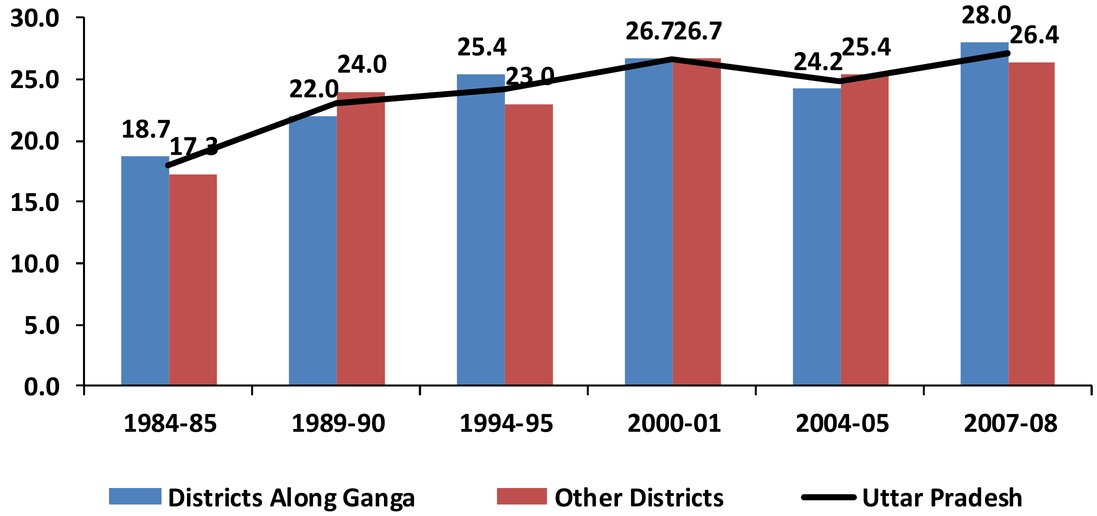

Figure 44: Trends in average yield of wheat in the bank and non-bank districts

Analysis of distribution of districts by class of average yield of wheat is presented in Figure 45. It is evident from the Figure that the proportion of districts having productivity of wheat below 20Q/ha has declined over the period while the proportion of districts having productivity level 25Q/ha and above has increased. For example, the percent of total districts having productivity of wheat below 20Q/ha has declined steeply from 64.6 in 1984-85 to12.9 in 2007-08. It is also observed that the percentage of districts having productivity of wheat in the range 20—25 Q/ha increased from 22.9 in 1984-85 to 47.5 Q/ha in 1994-95 and thereafter declined to 14.3 Q/ha in 2007-08. Notably, proportion of districts having productivity level of wheat 25 Q/ha and above has significantly increased from 12.5 percent in 1984-85 to 61.4 percent in 2000-01 and further to 72.9 percent in 2007-08. This shows that over the period, more and more districts have been joining the group of districts with higher level of productivity of wheat.

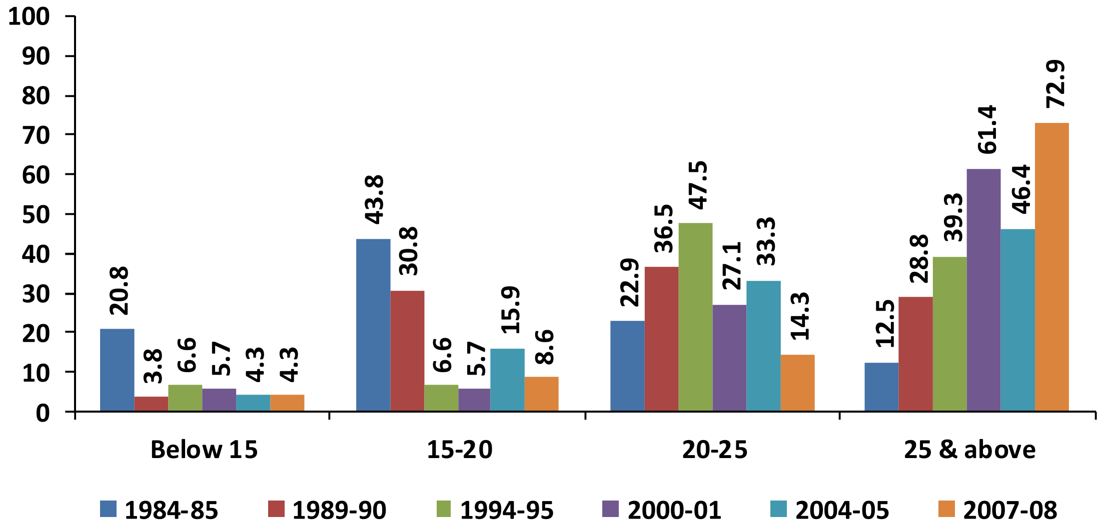

Figure 45: Proportion of districts by class of average yield of Wheat

8.3 Region-Wise Trend in Average Productivity of Sugarcane

Region-wise average yield of sugarcane in quintals per hectare is shown in Figure 46. North upper Ganga plains region occupies the first rank in terms of productivity of sugarcane. It is followed by south upper Ganga plains and central region. Western part of Uttar Pradesh, which comprises north and south upper Ganga plains, is the leading producer of sugarcane in the country. In north upper Ganga plains, average yield of sugarcane has increased from 527Q/ha in 1994-91 to 648.3Q/ha in 2004-05 and then decelerated to 625.2 Q/ha in 2007-08. Similarly, in south upper Ganga plains, the yield of sugarcane increased from 506.3 Q/ha in 1994-95 to 549 Q/ha in 2004-05, and then slightly declined to 540.8 Q/ha in 2007-08. Productivity of sugarcane in all the remaining regions has been below the state average. It was observed to be the lowest in southern region. The yield in this region also fluctuated significantly across years, mainly due to erratic behaviour of rainfall and inadequate irrigation facilities.

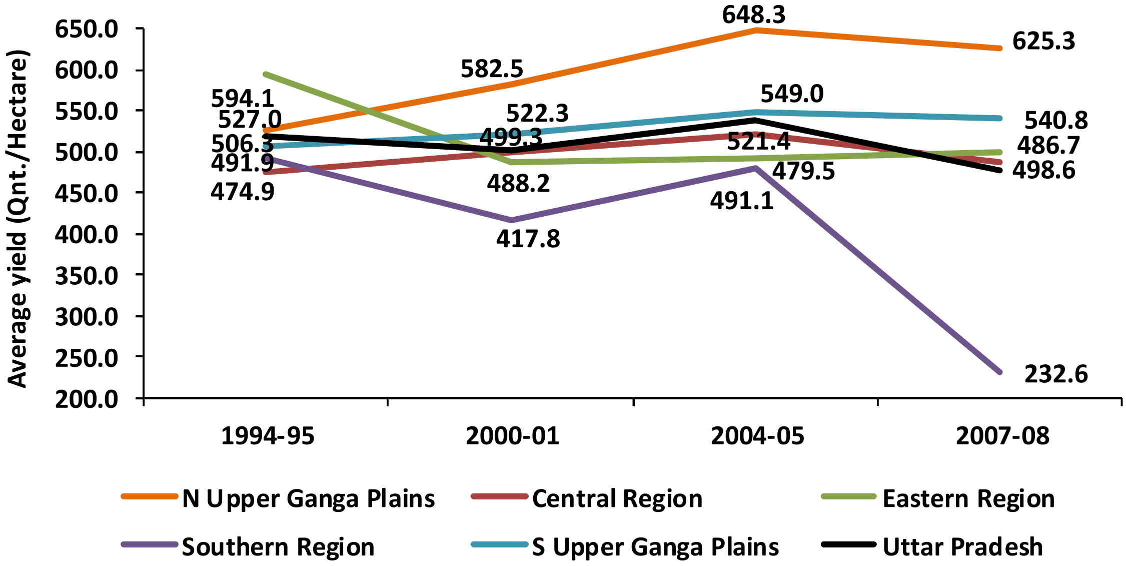

Figure 46: Average yield of Sugarcane across Regions of Uttar Pradesh

Figure 47 shows that the yield of sugarcane has been higher in the Ganga bank districts than that in non-bank districts. For example, in 1994-95, as against 561 Q/ha yield of sugarcane in the bank districts, the corresponding yield in the non-bank districts was 494, a net difference of 67 Q/ha. In 2007-08, the productivity of sugarcane in the bank districts was 34.5 Q/ha more than that was in the non-bank districts. Except for year 2004-05, in all other years, productivity of sugarcane in the bank districts was higher than that in the non-bank districts.

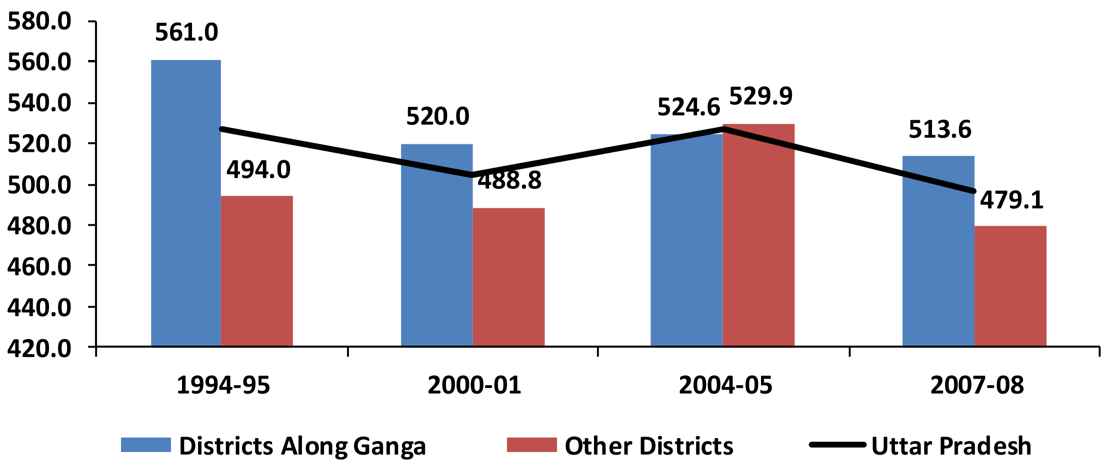

Figure 47: Average yield of sugarcane in the Ganga bank and non-bank districts

Figure 48 shows the distribution of districts by class of average yield of sugarcane. It is evident from the Figure that in 1994-95, about 26 percent of total districts observed the yield of sugarcane below 450 Q/ha while in 2007-08, only 18.6 percent of total districts achieved average yield of sugarcane below 450Q/ha. It is also observed that the proportion of districts having average yield of sugarcane in the range of 500 to 550Q/ha has increased appreciably from 16.4 percent in 1994-95 to 26.5 percent in 2004-05 and further to 41.4 in 2007-08. It is also observed that percentage of districts having sugarcane yield 550Q/ha and above varies significantly across years.

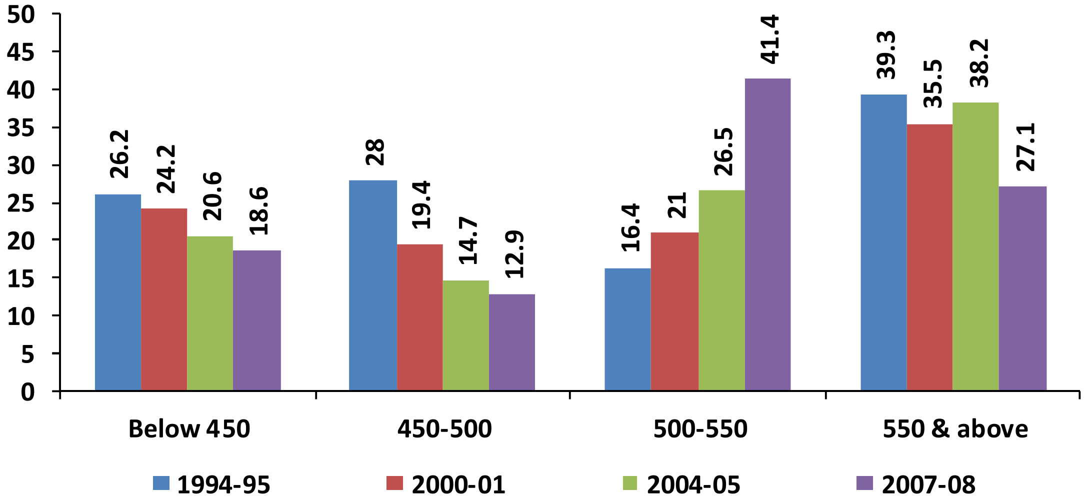

Figure 48: Proportion of districts by class of average yield of sugarcane

8.4 Region-Wise Trend in Yield of Pulses (Q/ha)

Pulses contributed 5.29 percent to the total value of agricultural output of the state in 2005-06. The main pulses grown are arhar, masur, urad, and gram. Figure 49 shows the region-wise trends in per hectare yield of pulses. The figure shows that there is high magnitude of variability in per hectare yield of pulses across years. On an average, productivity of pulses was highest in eastern region, followed by the south upper Ganga plains and the central region. However, the productivity differences across regions are found insignificant. Further, it is also observed that after 1994-95, there has been deceleration in the productivity of pulses.

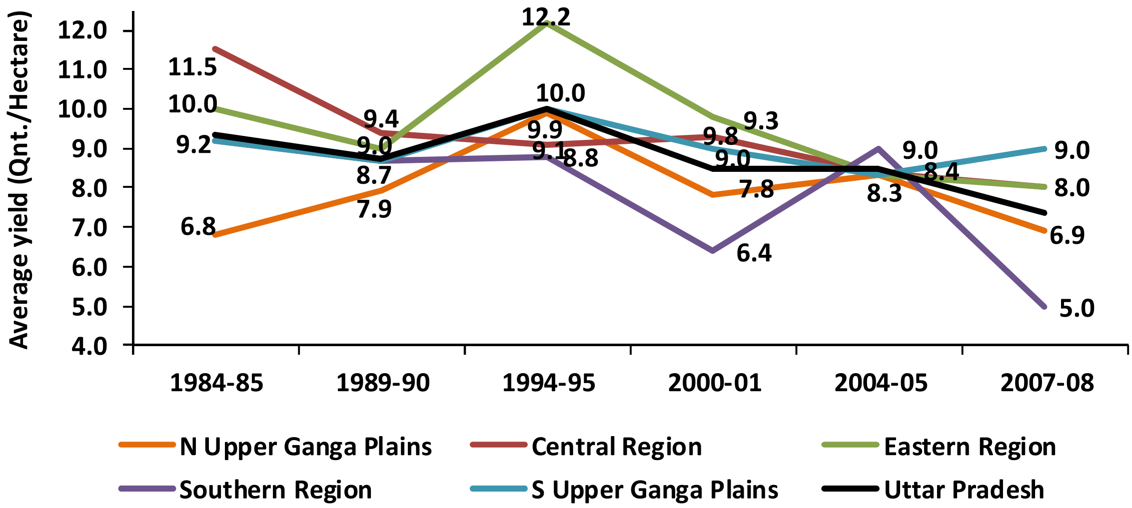

Figure 49: Region-wise trends in average yield of Pulses

Figure 50 shows the difference in the productivity level of pulses between Ganga bank and non-bank districts. It is obvious from the data shown in the figure that per hectare yield of pulses has been slightly higher in the bank districts than that in the non-bank districts. However, the difference is found to be insignificant. As pulses require relatively lesser quantity of water and some pulses such as arhar, gram, are mostly grown on the un-irrigated lands, the productivity differences are not expected to be as much as in the case of sugarcane, paddy and wheat which are mostly grown on the irrigated land.

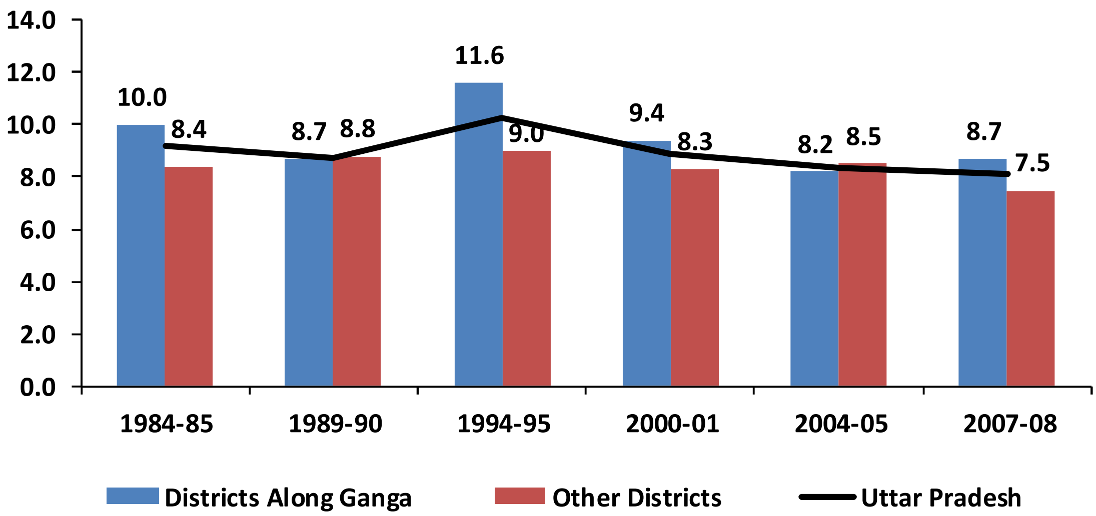

Figure 50: Trends in average yield of pulses in the Ganga bank and non-bank districts

Average yield of pulses in a majority of districts of the state ranged from 7Q/ha to 9Q/ha. For example, in 2007-08, 50 percent districts were having yield of pulses in the range of 7—9Q/ha. Figure 51 shows that the proportion of districts having yield 9 Q/ha and above increased from 41.7 percent in 1984-85 to 46.7 percent in 1994-95. After 1994-95, the percentage of districts having yield 9Q/ha has sharply declined from 42.9 in 2000-01 to 27.1

in 2007-08. These results also confirm that per hectare yield of pulses has declined during the first decade of this century.

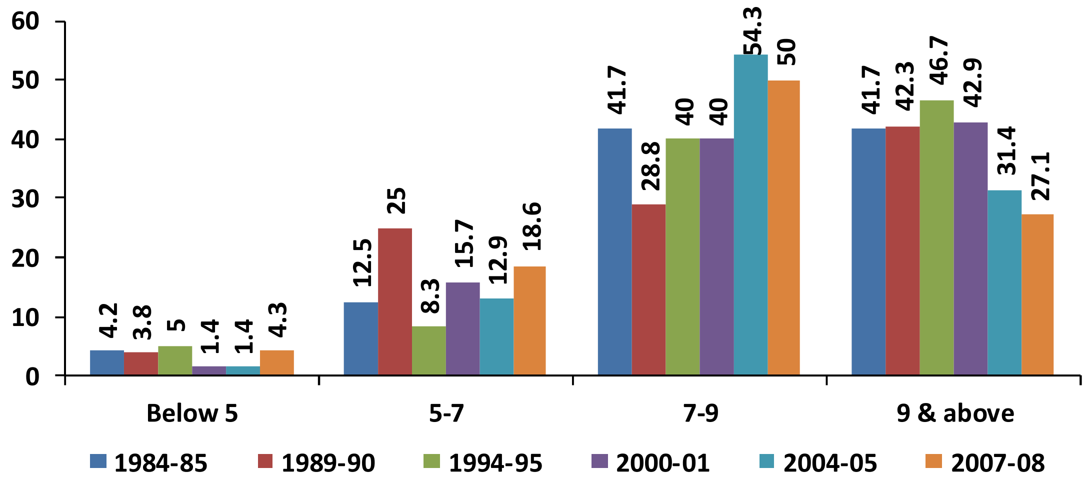

Figure 51: Proportion of districts by class of average yield of pulses

8.5 Region-Wise Trend in Yield of Oilseeds

Oilseeds contributed 2.34 percent to the total value of agricultural output in 2005-06. Figure 52 shows that per hectare yield of oilseeds was observed highest in the north upper Ganga plains, followed by the south upper Ganga plains. In these regions, the yield shows a rising trend. In north upper Ganga plains, the yield of oilseeds increased from 5.7 Q/ha in 1984-85 to 11.2 Q/ha in 1994-95 and further to 11.6 Q/ha in 2007-08. Similarly in south upper Ganga plains, the yield went up from 6.9 Q/ha in 1984-05 to 9.9 Q/ha in 1994-95 and further to 11.9 Q/ha in 2007-08. In central and eastern regions also, the yield of oilseeds has increased slightly after 2000-01. Southern region shows high variation and instability in the yield of oilseeds as is evident from Figure 52. The high magnitude of variability in the yield of this region is due to erratic pattern of rainfall and non-availability of irrigation facilities.

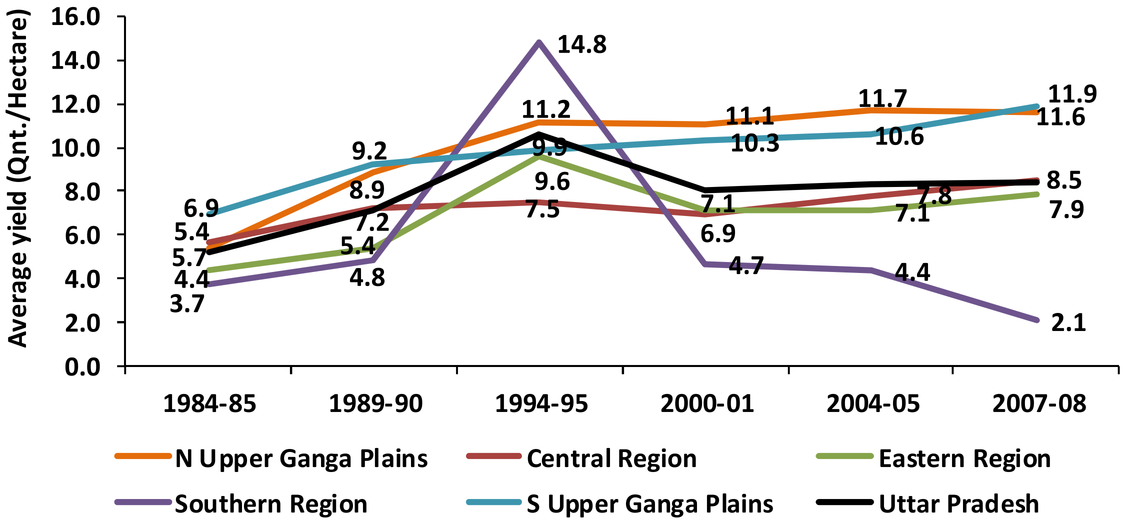

Figure 52: Region-wise trends in average yield of Oilseeds

No noticeable difference is observed in the yield of oilseeds between Ganga bank and non-bank districts (Figure 53). Yield of oilseeds in both the regions initially increased up to 1994-95 and then recorded decline in 2000-01 and, thereafter, improved in the subsequent years.

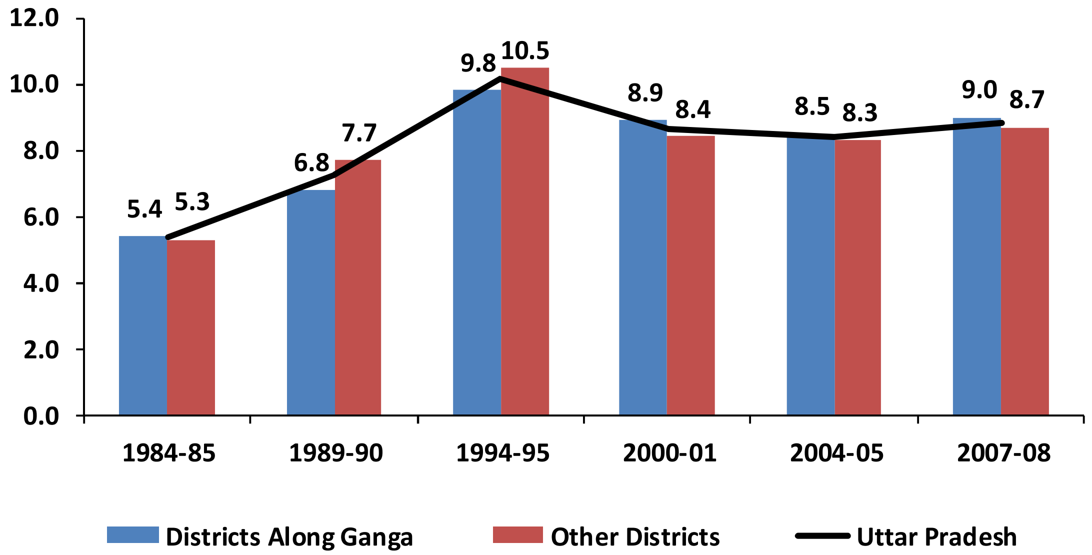

Figure 53: Trends in average yield of oilseeds in the Ganga bank and non-bank districts

Figure 54 shows the distribution of districts by class of average yield of oilseeds. It is apparent from the figure that in 1984-85, about 54 percent of total districts observed the yield of oilseeds below 5Q/ha while in 2007-08, only 15.7 percent of total districts achieved average yield of oilseeds below 5Q/ha. It is also observed that the proportion of districts having average yield of oilseeds 11Q/ha and above has increased appreciably from 9.9 percent in 1984-85 to 25.9 percent in 1994-95 and further to 34.3 percent in 2007-08. This implies that productivity improvement in the oilseeds, over the period, spread more evenly across districts.

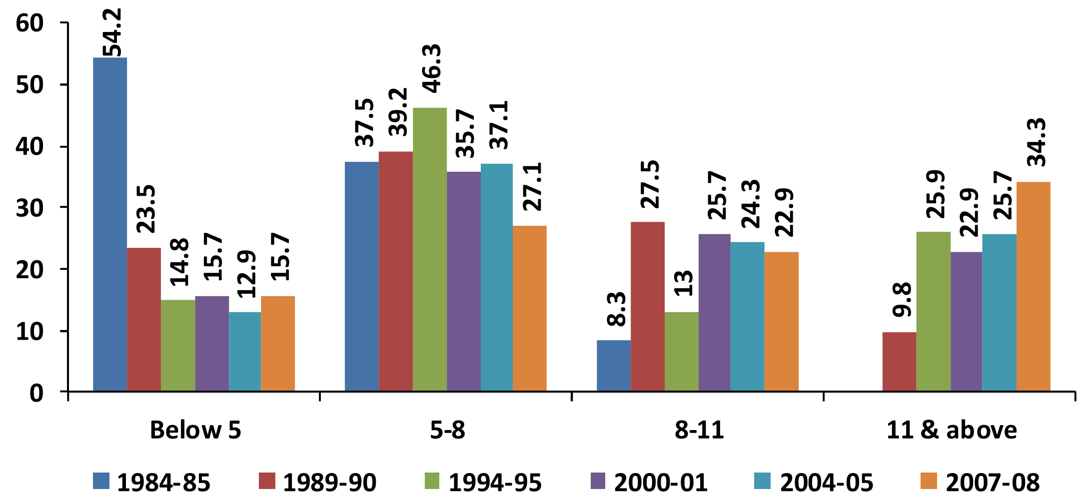

Figure 54: Proportion of districts by class of average yield of oilseeds

8.6 Region-Wise Trend in Yield of Potato (Q/ha)

Potato is also an important crop of the state. Regional pattern in its productivity reveals that it was highest in the south upper Ganga plains, followed by north upper Ganga plains. In the south upper Ganga plains, yield of potato increased from 167.5Q/ha in 1994-95 to 242.1 Q/ha in 2004-05 and then declined to 227.1 Q/ha in 2007-08. In north upper Ganga plains, the yield went up from 182.4 Q/ha in 1994-95 to 230.5 Q/ha in 2004-05 and then declined to 202 Q/ha in 2007-08. A perusal of Figure 55reveals that except in eastern region, in all other regions productivity of potato shows upward trend between 1994-95 and 2004-05.

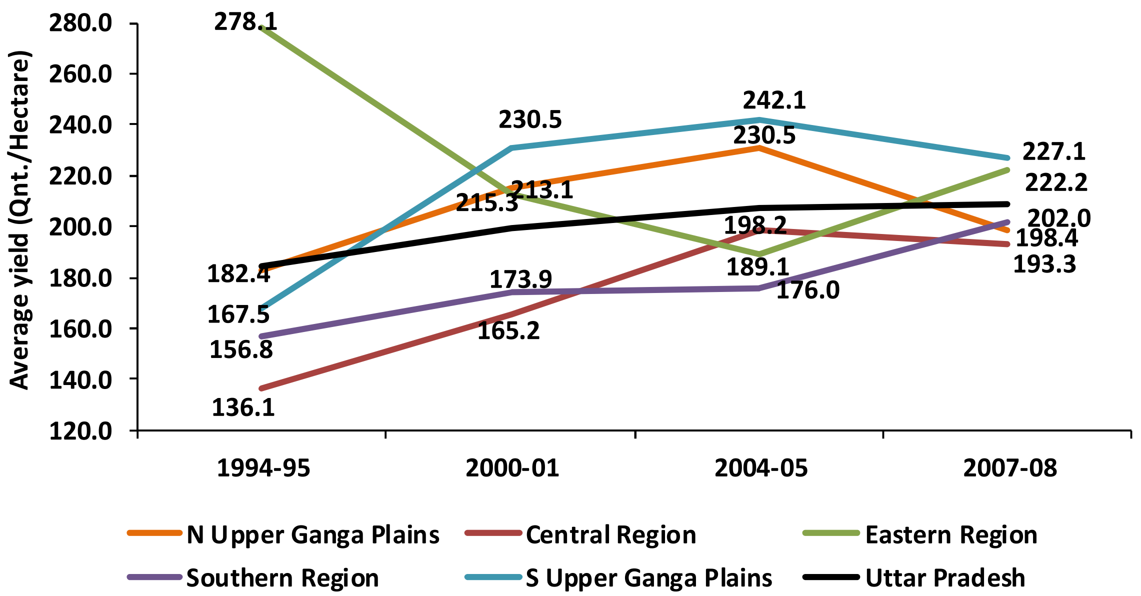

Figure 55: Average yield of Potato across Regions

Figure 56 compares the yield of potato in the Ganga bank and non-bank districts. It is observed from the figure that there was no much difference in the productivity of potato in these two types of districts. In fact, per hectare yield of potato was slightly higher in the non-bank districts than that in the Ganga bank districts.

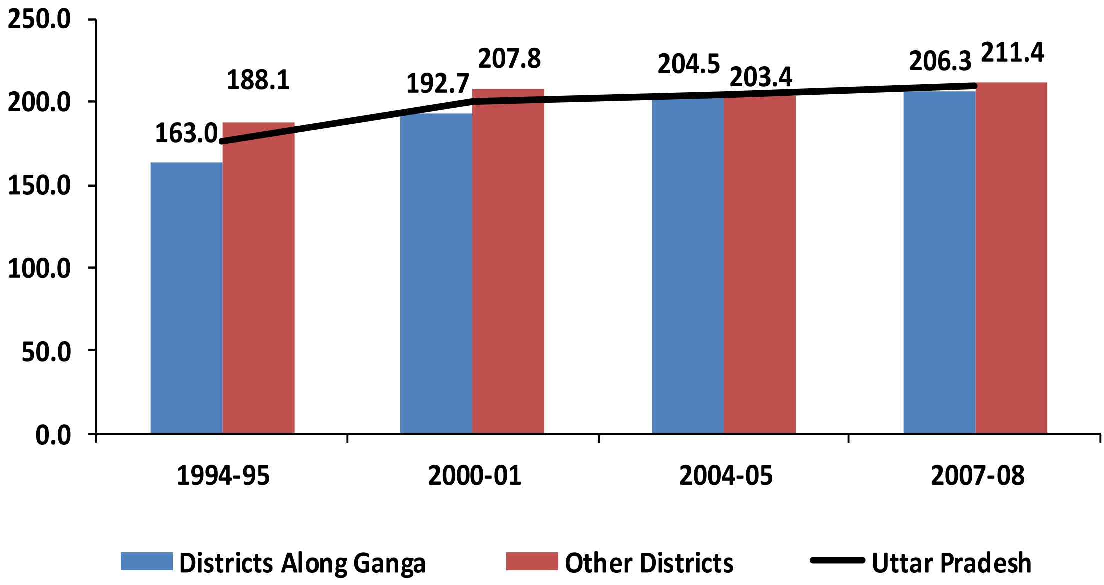

Figure 56: Average yield of Potato in the Ganga bank and non-bank districts

Distribution of districts, by class of average yield of potato, varies considerably across years. Figure 57 shows that the percentage of districts having average yield 'below 170Q/ha' declined sharply from 54.8 percent in 1994-95 to 17.1 percent in 2007-08. On the contrary, the percentage of districts having yield '220 Q/ha and above' has increased remarkably from 9.7 percent in 1994-95 to 54.7 percent in 2007-08. This implies that improvement in the yield of potato was more evenly distributed across the districts of the state.

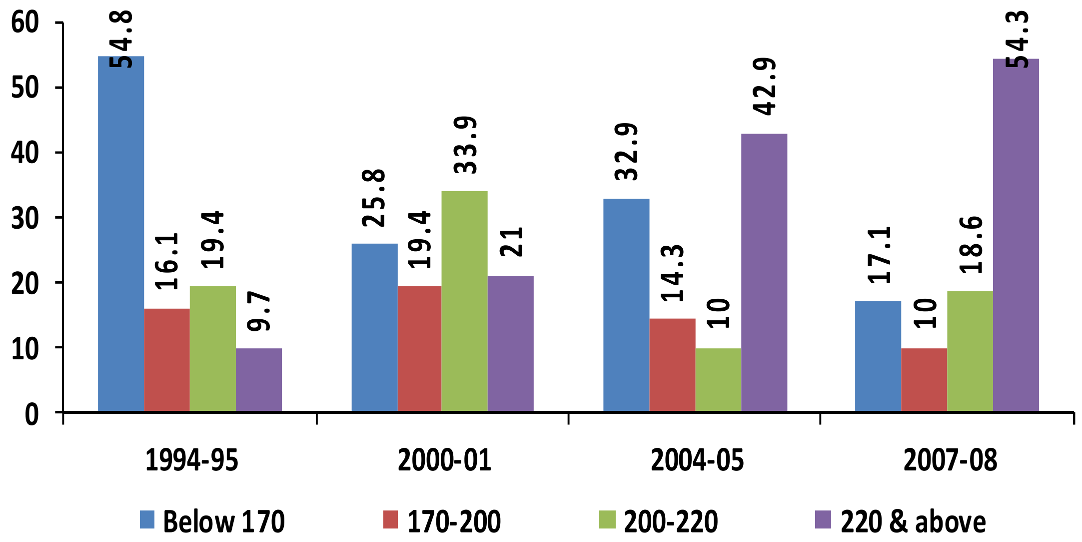

Figure 57: Proportion of districts by class of average yield of potato

9. Composition of Value of Agricultural Output

Figure 58 shows the relative contribution of major crop-groups to the total value of output of agriculture. Wheat + Paddy combine contributed about 39 percent to the total value of agricultural output in 2005-05. The percentage share of this group declined slightly during the last two years. If one looks at the share of total cereals in the total agriculture output, it can be discerned that coarse cereals contributed about 2-3 percent to the total output, the rest was contributed by wheat and paddy. Sugarcane shared a little over 18 percent of the total agricultural output in 2005-06. Thus, three crops, wheat, paddy and sugarcane together, which are grown on irrigated land, contributed 57.32 percent to the total agricultural output of the state in 2005-06. A perusal of the Figure 58reveals that there are no visible trends in the share of different crop-groups in the total output. The percentages vary across years. Fruits and vegetables are also important crops grown in the state. This group contributed about 15 percent to the total value of output. Oilseeds and pulses together have less than eight percent share in the total output. All remaining crops/crop-groups, such as fiber crops, indigo, dyes &tanning materials, narcotics & beverages, condiments & spices, kitchen garden products, etc, shared about 18 percent in the total value of output.

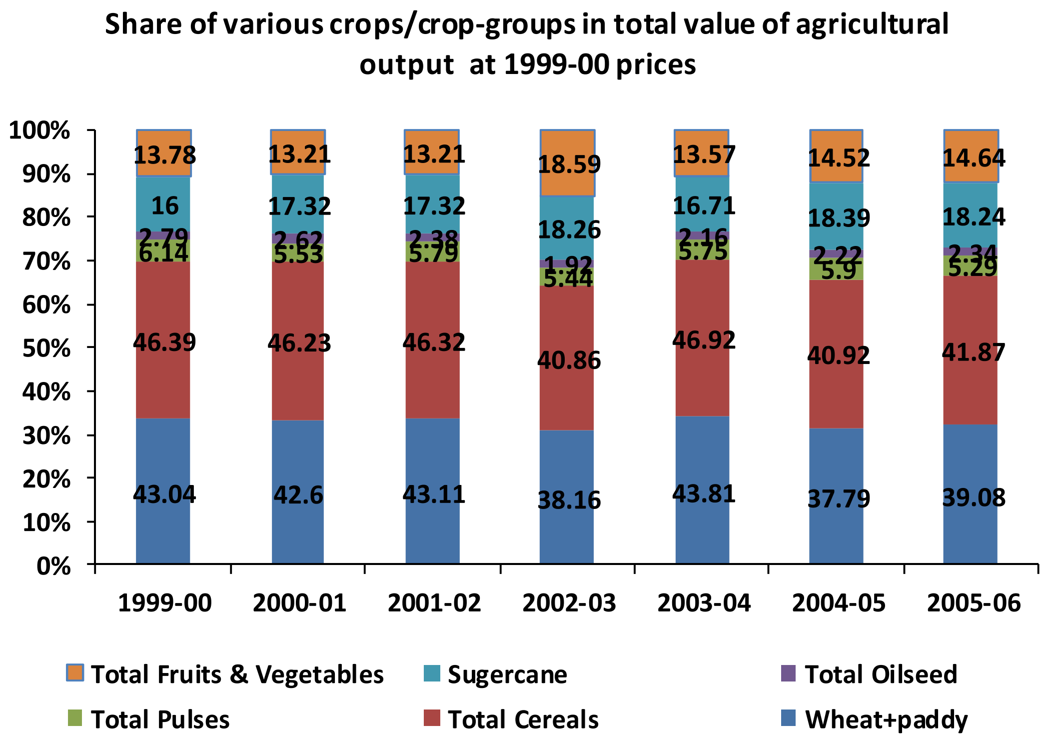

Figure 58: Share of various crops/crop-groups in total value of agricultural output

Figure 58 presents information about agricultural output. There are some agricultural allied activities, such as livestock based activities (dairy, poultry, meat, etc.), forestry and fishery. Figure59 shows percentage share of each of these activities. Agriculture contributed about 68.26 percent to the total value of output of agriculture and allied activities. It is pertinent to note that the share of agriculture in the total value of output has gradually declined from 73.24 percent in 1999-00 to 68.26 percent in 2005-06, a net decline of 5 percent point while the share of livestock has significantly increased from 23.15 percent to 27.60 percent during the same period. This implies that livestock economy of the state has been growing faster than the agricultural economy. Share of forestay ranges between 2.74 percent and 3.06 percent. The share of fishery marginally increased from 0.87 percent in 1999-00 to 1.17 percent in 2005-06.

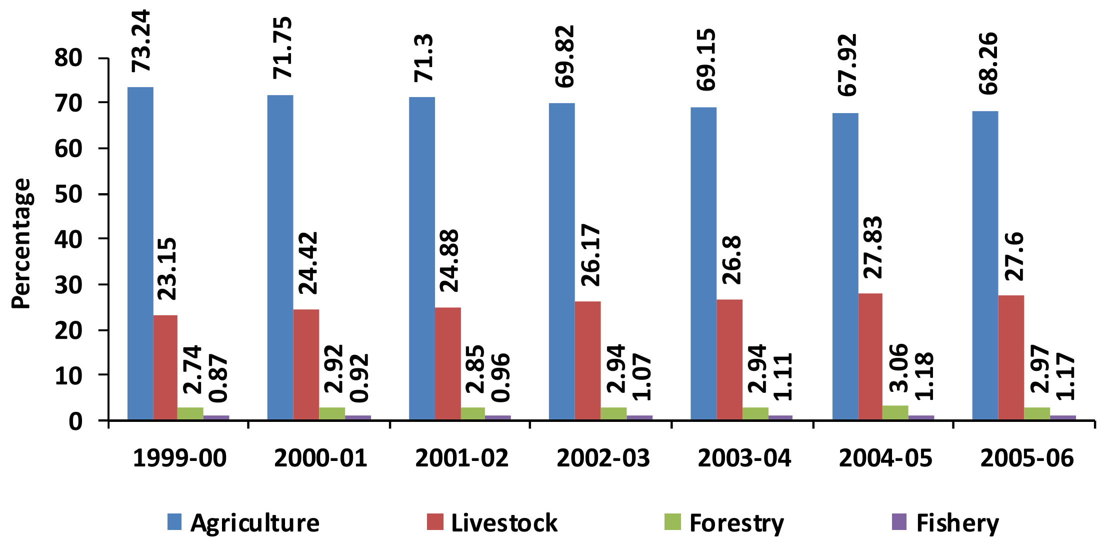

Figure 59: Share of Agriculture, Livestock, Forestry, and Fishery in Total Output of Agriculture and Allied Sector

10. Trends In Costs, Returns And Profitability In Agriculture

Per hectare net income earned from individual crops is one of the key factors in the allocation of scarce land resources among various crops. Sugarcane, paddy and wheat are the major crops grown in the middle Ganga basin area, though some coarse cereals such as bajra, maize, barley, pulses and oilseeds are also grown. In this section, the focus of discussion shall be the costs, returns and profits in the major crops, use of human labour, draught, power and chemical fertilizer in the important crops. The main purpose of the analysis is to find out the most profitable crop and/or crop combination. The data for this purpose are taken from indiastat.com, statistical abstract of Government of Uttar Pradesh and Ministry of Agriculture, Government of India.

10.1 Cost and Returns in Sugarcane Cultivation

Sugarcane is one of the most important crops grown by the farmers in middle Ganga basin area. It is grown mostly on irrigated land and requires relatively greater frequency of irrigation as compared to other competitive crops. Availability of ground and surface water in the Ganga canal command and remunerative minimum support prices (MSP) appears to have motivated the farmers to bring more cultivated areas under sugarcane crops. Table8 shows the cost and returns in the sugarcane crops for the last 17 years. As the table reveals, both per hectare value of sugarcane output (main product + by-product) and per hectare cost (C2) in nominal terms have considerably increased over the period. Though, net income, shows fluctuations across years, it has been positive in all the years. The trend in the net income indicates that cultivation of sugarcane in the basin area has remained profitable to the farmers during the entire span of 17 years. The ratio of value of output (VOP) to C2 is calculated to find out the returns on cost. The ratio is found lowest (1.29) in 2002-03 and highest in 2006-07 (1.73). A ratio of 1.73 suggests that Rs.1 spent on the cultivation of sugarcane, brings a return of Rs.1.73, thus giving a net profit of Rs.0.73.

The information regarding annual compound growth rates in regard of VOP, C2 and other variables are shown in the last row of Table8.As is evident from the table, while VOP grew at the rate of 8.47 percent per annum during the period under study; C2 increased by a rate of 8.81 percent per annum during the same period. This implies that the cost of cultivation rose faster than the returns realized. Consequently, net income from sugarcane cultivation recorded relatively a slower growth rate (7.67%) than those achieved in VOP and C2. Further, the ratio of VOP to C2 achieved a negative rate of growth, though the difference was not found statistically significant. This shows that there has not been any growth in the returns on investment in sugarcane cultivation.

Since land is a limited resource and has competing uses in farm as well as non-farm activities, it is desirable that increase in the production of any crop should come by augmenting per hectare yield of various crops. Table 8 indicates that per hectare average yield of sugarcane in the basin area is quite low. It ranges between 412 quintals in 1991-92 to 567 quintals by 2006-07. Per hectare yield of sugarcane has increased only by 1.47 percent per annum over the period.

It appears that there is a wide gap between what the scientist gets in the experimental farm and what a farmer gets in his farm. There also seems to be a wide gap between the “best practice” farmers and the common run of farmers. Knowledge deficit in agriculture is required to be removed through effective training and lab-to-land demonstrations; effective linkages of farms with research institutions, farmer-to-farmer knowledge and technology transfer, and establishment of Farm Schools, etc. (National Commission on Farmers, Government of India, 2007). The provision of basic education as well as formal or informal training for developing and upgrading skills is crucial for farmers, as they, equipped with sufficient knowledge and skills are better prepared to respond to new technology, market opportunities, and risks. The educated farmers not only enhance their income and profitability but also facilitate to improve the productivity of those who follow their practices (Singh & Sharma, 2003). As per the NSS report (GOI, 2007), about 60 percent of the farmers do not have access to any source of information for advanced agricultural technologies resulting in adoption gap. Due to knowledge deficit, technology transferred to the farmers’ fields quite often fails to provide the desired yield on the field. For example, Uttar Pradesh alone has the potential to produce about 25 million tons of additional sugarcane production if the improved farm practices are followed.

Table8: Cost and Returns from Sugarcane Crop (Rs./ha)

Year	Value of Output (VOP)	Cost of cultivation (C2)	Net income	Ratio of VOP to C2	Yield Q/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1990-91	18081	10965	7116	1.65	452	119	1266	60
1991-92	18102	11299	6803	1.60	412	120	1257	44
1992-93	19433	11557	7876	1.68	413	109	1182	54
1993-94	27295	17094	10201	1.60	468	142	1327	50
1994-95	31940	21431	10509	1.49	481	170	1310	61
1995-96	30098	21311	8787	1.41	470	156	1321	46
1996-97	33073	22219	10854	1.49	480	175	1259	22
1997-98	38711	22945	15767	1.69	502	166	1218	27
1999-00	39140	27484	11655	1.42	445	176	1209	30
2000-01	40436	28444	11992	1.42	451	174	1179	31
2001-02	43144	30851	12292	1.40	452	191	1223	29
2002-03	42047	32650	9397	1.29	494	189	1285	20
2003-04	42620	29672	12948	1.44	490	166	1138	13
2004-05	56512	36300	20212	1.56	530	174	1234	12
2005-06	70853	41445	29408	1.71	569	198	1412	17
2006-07	71209	41193	30016	1.73	567	190	1331	20
2007-08	58867	40844	18023	1.44	523	182	1363	24
CAGR	8.47*	8.81*	7.67*	-0.31	1.47*	2.96*	0.24	-8.20*

* Significant below 1% level of significance.

Due to inefficient and insufficient public extension infrastructure and inadequate farmers' knowledge, most of the farmers do not get access to the information on applying the right doses of NPK inputs. The vacuum created thus has been filled up by the private input dealers who generally encourage the farmers to make extensive use of inputs, such as fertilizers, pesticides. The unbalanced uses of these inputs not only deteriorate soil health and environment but also affect economic sustainability of farming due to high cost of cultivation (Singh, 2010). Table8 shows that consumption of chemical fertilizer in sugarcane crop has significantly increased over the period. The consumption was found to be the lowest in 1992-93 (109 kgs/ha) and highest in 2005-06 (198 kgs/ha). The fertilizer consumption grew at the rate of 2.96 percent per annum whereas the yield increased only by 1.47 percent per annum. Thus, chemical fertilizer consumption increased much faster than the per hectare yield of sugarcane.

On an average, one hectare of sugarcane cultivation absorbs about 1266 human hours of labour which works out to about 161 days of works for a person. The labour absorption was found to be the lowest (1138 hrs/ha) in 2003-04 and highest (1412 hrs/ha) in 2005-06. Although per hectare labour use in sugarcane recorded a positive growth but it is not found statistically significant. Therefore, there does not appear to be any growth in the labour absorption in the sugarcane. As far as draught power (pair of bullocks/he-buffalo) use in sugarcane is concerned, it is evident from Table8 that there has been drastic decline in the animal hours used in the sugarcane cultivation. The estimated CAGR indicates that per hectare use of animal hours declined by 8.20 percent per annum during the last 17 years.

In order to know the contribution of these three inputs, namely, fertilizer, human labour and animal labour, to the yield of sugarcane, yield elasticity with respect to these inputs was estimated. However, the variable representing draught power had to be dropped from the analysis as it was found to be highly correlated with the variable 'fertilizer' (multi-collinearity problem). The final results are shown in Table 2.9. The value of R^{-2} shows that about 59 percent variations in the yield of sugarcane are explained jointly by these two inputs. The F-value is quite high and statistically significant which indicates the robustness of the model. The magnitudes of individual coefficients reveal that both the inputs contribute significantly to the yield of sugarcane. The coefficient of elasticity of yield with respect to variable fertilizer implies that 100% increase in fertilizer use would increase the yield by 31.60 percent. Similarly, an increase in labour hours by 100 percent shall increase the yield by 63.20 percent.

Table9: Impact of Chemical Fertilizer and Human Labour on Sugarcane Productivity (log-linear model)

	Coefficients	SE Error	t Stat	P-value
Intercept	0.060	1.89	0.026	0.979
Fertilizer	0.316	0.087	3.64	0.002
Human Labour	0.632	0.274	2.30	0.037
R^{-2}	0.59			
F-value	12.36			
N	17			

10.2 Cost and Returns in Wheat Cultivation

Wheat is another important crop grown in the area. Table10 shows the cost and returns from the wheat cultivation. As is evident from the aforementioned Table, VOP has been greater than the cost of production in all the years. Net income, which is worked out by deducting C2 from the VOP, has been found to be positive throughout the period, though it shows fluctuations across years. It was found to be the lowest in 2004-05 and highest in 2007-08. The ratio of VOP to C2 also indicates the return on the expenditure incurred on the cultivation of wheat. The ratio ranges from 1.04 in 2004-05 to 1.52 in 2007-08 and has a high magnitude of variation across the years. Per hectare yield of wheat is recorded to be the highest (34 Q/ha) in 2003-04 and lowest in (26 Q/ha) in 1990-91. The yield estimates do not demonstrate any trend. As per the 11th Plan estimate, about 20 million tones of additional wheat can be produced in the region if improved farm practices are followed by the farmers.

Per hectare use of chemical fertilizers in wheat crop has significantly increased over the period. It went up from 114 kg/ha in 1990-91 to 164 kg/ha in 2006-07, thus recording a net increase of 50 kg per hectare. Human labour absorption shows a declining trend, though the number of labour hours fluctuates across years. The number of labour hours was recorded to be the highest (535 hrs/ha) in 1990-91 and lowest (445 hrs/ha) in 2002-03. On an average, one hectare of wheat cultivation provides about 60 days of employment. Draught power use in the wheat cultivation has significantly declined during the period, as is evident from the figures shown in Table10.

Table10: Cost and Returns in Wheat Crop (Rs./ha)

Year	Value of output (VOP)	Cost of cultivation (C2)	Net income	Ratio of VOP to C2	Yield Q/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hours/ha
1990-91	8223	7157	1066	1.15	26	114	535	92
1995-96	13942	11750	2192	1.19	30	134	523	51
1996-97	19676	13971	5705	1.41	32	133	524	52
2001-02	19822	16273	3549	1.22	31	138	466	27
2002-03	21528	18593	2935	1.16	31	153	445	13
2003-04	23090	19241	3848	1.20	34	152	452	16
2004-05	21609	20813	796	1.04	29	156	447	15
2005-06	25325	22822	2503	1.11	29	155	469	22
2006-07	33826	24689	9137	1.37	32	164	480	22
2007-08	39197	25864	13333	1.52	33	159	511	15

Source: Compiled from Indiastat.com database and Ministry of Agriculture

10.3 Cost and Returns in Paddy Cultivation

Table11 shows the trend in cost and returns from the paddy cultivation. The nominal values of both VOP and C2 have increased significantly during years. The paddy cultivation recorded negative profit in 1990-91, 2001-02, 2002-03, 2004-05 and 2005-06. In the remaining years, profits from the paddy were quite low. This shows that paddy is not as profitable as wheat crop in the region. The ratio of VOP to C2 is found to be the lowest in 2002-03 (0.89) and highest (1.29) in 1996-97. Per hectare yield of paddy ranges between 29 Q/ha in 1992-93 to 38 Q/ha in 2003-04.

As is also evident from Table11, per hectare use of chemical fertilizer in paddy has increased significantly from 79 kg/ha in 1991-92 to 130 kg/ha in 2007-08, a net increase of 40 kg/ha. It is significant to note that the ratio of yield to fertilizer consumption has declined over the period. This implies that the marginal productivity of fertilizer has declined over the period. It may be noted here that the human labour absorption in paddy cultivation is much higher than that in wheat cultivation. On an average, one hectare of paddy cultivation provides about 104 days of employment while the corresponding employment in wheat is only 60 days. Animal labour (a pair of bullocks) use in paddy shows a drastic decline over the period.

The number of hours declined from 82 in 1990-91 to only 19 in 2003-04 and then increased in the subsequent years.

Table11: Cost and Returns in Paddy Crop (Rs./ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield qntl/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1990-91	6146	6733	-587	0.91	30	79	836	82
1991-92	8993	7723	1270	1.16	30	73	844	67
1992-93	8899	8219	680	1.08	29	90	818	46
1996-97	14560	11301	3259	1.29	34	104	814	46
1997-98	13389	12472	917	1.07	32	101	829	40
1998-99	13764	12514	1250	1.10	30	108	775	34
1999-00	16454	14543	1910	1.13	33	115	840	30
2000-01	15117	14761	356	1.02	33	110	840	31
2001-02	15641	15844	-203	0.99	33	112	824	28
2002-03	16454	18439	-1985	0.89	31	121	874	22
2003-04	20031	18477	1554	1.08	38	121	853	19
2004-05	18878	19802	-924	0.95	32	122	854	19
2005-06	20742	20861	-119	0.99	34	130	855	24
2006-07	20830	20338	492	1.02	31	121	847	29
2007-08	27686	22301	5385	1.24	35	130	827	28

Source: Compiled from Indiastat.com database and official website of Ministry of Agriculture

10.4 Cost and Returns in Maize Cultivation

Maize cultivation is not found profitable for the farmers. Information presented in Table12suggestsloss to the farmers. The cost has remained much higher than the returns. The ratio of VOP to C2 is estimated to be the lowest (0.59) in 2003-04 and highest (0.87) in 2006-07. The yield of maize ranges between 8 Q/ha to 17 Q/ha which is quite low. A further look at information given in Table 12 reveals that both cost and returns in the maize cultivation are much lower than what they are in regard of wheat and paddy crops. However, the returns remained much lower than the cost and consequently farmers growing maize incurred heavy losses. Average consumption of chemical fertilizer in maize is worked out to be about 53 kg/ha which is much lower than that in paddy and wheat crops.

The absorption of human labour was found to be relatively higher in Maize than in wheat. On an average, one hectare of maize cultivation provides about 87 days of works. Use of animal labour has significantly declined in maize cultivation also. However, it shows rise and fall over the period.

Table12: Cost and Returns in Maize Crop (Rs./ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield Q/ha	Chemical Fertilizer kg/ha	Human labour hrs/ha	Draught power hrs/ha
1990-91	3968	4792	-824	0.83	15	50	774	80
1991-92	4699	5949	-1249	0.79	15	35	742	63
1992-93	4751	5876	-1125	0.81	14	49	760	65
1996-97	6311	7671	-1360	0.82	13	54	702	34
1997-98	6213	8534	-2320	0.73	14	51	690	31
1998-99	6939	8409	-1470	0.83	11	41	594	38
1999-00	9021	10568	-1546	0.85	15	74	710	32
2000-01	7788	10993	-3205	0.71	16	58	766	37
2001-02	7644	11240	-3596	0.68	17	44	780	33
2002-03	6509	11109	-4600	0.59	8	54	647	7
2003-04	8410	13379	-4969	0.63	14	59	796	6
2004-05	9879	13016	-3137	0.76	17	55	727	18
2006-07	11894	13748	-1854	0.87	16	65	620	25
2007-08	13584	16709	-3125	0.81	15	50	470	78

10.5 Cost and Returns in Barley Cultivation

Barley is a competitive crop of wheat as it is grown in the Rabi season. Table13 shows the cost and returns from the barley crops. On an average, both cost and returns from this crop is found to be much lower than the wheat crop. The net income has remained negative in two consecutive years (2004-05 and 2005-06). The ratio of VOP to C2 shows high fluctuation across years. Low market price and high fluctuation in yield are the main reasons for the low profitability from the barley crop. Per hectare yield of this crop is found to be lowest (23 Q/ha) in 1990-91 and highest (30 Q/ha) in 2005-06 and 2007-08.

Table13: Cost and Returns in Barley Crop (Rs./ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield Q/ha	Chemi. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1990-91	7533	5623	1910	1.34	23	56	519	85
1995-96	11020	9795	1226	1.13	24	83	469	44
1996-97	15319	10400	4918	1.47	24	78	453	48
2001-02	17119	13563	3555	1.26	29	69	438	43
2002-03	17066	16063	1003	1.06	26	92	417	20
2003-04	17352	15982	1370	1.09	29	99	400	17
2004-05	15730	16886	-1156	0.93	24	91	412	28
2005-06	21849	22843	-995	0.96	30	119	554	39
2006-07	24681	23333	1348	1.06	27	133	549	69
2007-08	32023	25634	6389	1.25	30	121	550	51

As is evident from Table13, the consumption of chemical fertilizer has substantially increased in the recent years, from 56 kg/per hectare to 133 kg per hectare. On an average, one hectare of barley cultivation provides about 60 days of employment to the farm workers. The labour absorption is observed to be the highest in 2005-06 and lowest in 2003-04. There has not been much decline in draught power use in the barley cultivation, though the number of hours of pair of bullocks varies significantly across years.

10.6 Cost and Returns in Bajra Cultivation

Bajra is grown mostly on un-irrigated land and is not a profitable crop as is evident from the data on cost and returns shown in Table14. Out of 12 years, only in five years, farmers earned positive net income. During all the remaining years, they have incurred losses in regard of this crop. The ratio of VOP to C2 is observed to be the lowest (0.74) in 2001-02 and highest (1.18) in 2006-07. A value of 0.74 of the ratio indicates that an investment of Rs. 100 by a given farmer brings a return of only Rs.74. Per hectare yield of bajra ranges between 12 Q/ha to 22 Q/ha and it varies significantly across years.

Table14: Cost and Returns in Bajra Crop (Rs./ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield Q/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1996-97	6568	6264	304	1.05	12	39	444	35
1997-98	6891	6980	-88	0.99	18	44	443	22
1998-99	8446	8118	328	1.04	17	44	504	12
1999-00	10514	9919	595	1.06	18	51	536	25
2000-01	7614	8569	-955	0.89	17	33	481	22
2001-02	6778	9218	-2441	0.74	16	34	481	8
2002-03	8282	10709	-2427	0.77	12	35	455	15
2003-04	9367	10734	-1366	0.87	18	41	447	10
2004-05	10160	11004	-844	0.92	18	44	432	11
2005-06	10015	11371	-1356	0.88	15	48	376	6
2006-07	16902	14296	2606	1.18	20	50	483	20
2007-08	17179	15647	1532	1.10	22	59	488	13

Fertilizer use in this crop ranges between 33 kg/ha to 59 kg/ha. A high variation in per hectare use of fertilizer in Bajra may be attributed to the variation in the rainfall as fertilizer application in any crop is positively associated with the availability of water for the crop. On an average, one hectare of Bjara cultivation provides about 60 days of employment to the farm workers. The human labour utilization in this crop varies from 443 hr/ha in 1997-98 to 536 in 1999-00. No definite trend is observed in regard of the labour absorption in this crop. Animal labour utilization has also declined over the period.

10.7 Cost and Returns in Mustard Cultivation

Costs and returns from mustard (oilseed) crop are shown in Table15. VOP from mustard crop has been much higher than the C2. As a results, farmers growing this crop earned profit in all the years under study. The ratio of VOP to C2 was found to be extensively varying across years, pointing to the volatility in the net income of farmers from the crop. Yield of mustard ranges between 9 Q/ha to 14 Q/ha and it does not show any trend. Fertilizer consumption varies from 78kg/ha in 2003-04 to 93 kg/ha in 2004-05. The Table 15 also does not suggest any trend in the fertilizer consumption in mustard crop. Similarly, human labour use in this crop does not evince any trend. The number of hours of human labour is found to be the highest in 2007-08 and lowest in 1996-67. Animal labour has registered a decline from 42 hrs/ha in 1995-96 to 14 hrs/ha in 2004-05 and then increased to 26 hrs/ha in 2007-08.

Table15: Cost and Returns in Mustard Crop (Rs/ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield Q/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1995-96	14334	9338	4996	1.54	13	86	397	42
1996-97	13293	9405	3888	1.41	11	86	390	40
2001-02	15031	13518	1513	1.11	13	86	391	17
2002-03	14225	12953	1272	1.10	9	81	411	24
2003-04	17693	13982	3711	1.27	10	78	731	24
2004-05	16820	14569	2251	1.15	11	93	397	14
2005-06	20923	16604	4319	1.26	13	80	390	25
2006-07	26144	17681	8463	1.48	14	82	434	23
2007-08	33753	20413	13340	1.65	13	82	508	26

10.8 Cost and Returns in Gram Cultivation

Gram is generally grown on rain-fed land. Table 16 reveals that nominal VOP and C2 have increased notably over the period. Per hectare VOP increased from Rs.7970 in 1990-91 to Rs. 25622 in 2007-08. Similarly, C2 increased from Rs. 5664 in 1990-91 to Rs. 18256 in 2007-08. It is obvious that C2 has steadily increased over the period, while VOP shows a high magnitude of variation across years which may be due to volatility in the realized prices of the output.

It is important to note that the farmers growing gram have achieved positive net income from this crop throughout the period. The ratio of VOP to C2 is found to be the highest (1.63) in 2005-06 and lowest (1.19) in 2002-03. Per hectare output from gram ranges from 9.00 quintal to 13.00 quintal. Fertilizer use in the crop, though is quite lower than other crops, has increased in the recent years. One hectare cultivation of gram generates about 47 days of human labour employment and 5 days of animal labour employment. Animal labour absorption in the gram cultivation has declined over the period.

Table16: Cost and Returns in Gram Cultivation (Rs./ha)

Year	Value of output (VOP)	Cost of cultivation (C2)	Net income	Ratio of VOP to C2	Yield Q/ha	Chem. Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1990-91	7970	5664	2305	1.41	12	9	439	86
1995-96	8917	7691	1226	1.16	9	9	472	81
1996-97	13574	8915	4659	1.52	11	17	393	70
2001-02	17375	11957	5418	1.45	11	7	354	32
2002-03	14937	12520	2417	1.19	10	25	307	29
2003-04	15439	12096	3343	1.28	10	16	320	31
2004-05	16975	12116	4858	1.40	10	30	317	22
2005-06	24537	15093	9444	1.63	13	26	365	22
2006-07	20828	15724	5104	1.32	9	39	370	17
2007-08	25622	18256	7366	1.40	10	35	456	17

10.9 Cost and Returns in Masur Cultivation

Masur is also a rain-fed crop and requires less quantity of water. Both cost and returns are much lower in this than the crops such as wheat and paddy. Fertilizer consumption is also found to be lower than that in most of the other crops. Table17 shows that net income has remained negative in two out of the seven years for which data are available. Ratio of VOP to C2 is found to be the lowest in 2004-05 and highest in 2005-06. Yield of masur varies from 6 Q/ha to 18 Q/ha. This shows that there is no stability in the crop yield. Human labour absorption varies from 328 hrs/ha to 379 hrs/ha while animal labour utilization varies 16 hrs/ha to 60 hrs/ha.

Table17: Cost and Returns in Masur Crop (Rs./ha)

Year	Value of output (VOP)	Cost of cultivation (C2)	Net income	Ratio of VOP to C2	Yield Q/ha	Chemical Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
2001-02	10125	10694	-569	0.95	7	9	351	60
2002-03	13763	11971	1791	1.15	9	28	344	24
2003-04	11990	11854	137	1.01	8	16	359	28
2004-05	10542	11419	-877	0.92	6	31	328	16
2005-06	18487	14035	4452	1.32	10	28	379	31
2006-07	17747	14204	3543	1.25	8	31	371	41
2007-08	24205	14941	9264	1.62	18	25	359	57

10.10 Cost and Returns in Potato Cultivation

Potato is important crop grown in the region. C2 is quite high and so is VOP. Net income from the crop is more susceptible to the market risk and crop failure. Farmers growing potato sometimes incur heavy losses either due to low harvest price or due to crop failure. Table18 shows that there is higher variation in VOP than C2. In three out of 10 years, the farmers, growing potato, incurred losses. The ratio of VOP to C2 was lowest (0.81) in 2002-

03 and highest (1.52) in 2001-02. This clearly indicates that net income from potato is volatile across years. Average yield is about 185 Q/ha, with highest yield realized in 2005-06 (216 Q/ha) and lowest in 2003-04 (154 Q/ha).

Table18: Cost and Returns in Potato Crop (Rs/ha)

Year	Value of output	Cost of cultivation	Net income	Ratio of VOP to C2	Yield Q/ha	Chemical Fertilizer kg/ha	Human labour hours/ha	Draught power hrs/ha
1998-99	42684	37470	5215	1.14	185	265	1015	45
1999-00	30164	31222	-1058	0.97	183	254	1205	19
2000-01	45792	30572	15220	1.50	167	245	1085	26
2001-02	62540	41264	21276	1.52	187	178	1013	26
2002-03	33456	41345	-7889	0.81	166	285	1109	28
2003-04	35638	36929	-1292	0.97	154	373	1032	33
2004-05	59814	44555	15259	1.34	195	272	1039	30
2005-06	93507	52261	41246	1.79	216	388	1077	33
2006-07	76777	54472	22305	1.41	183	356	951	22
2007-08	84784	58770	26014	1.44	215	329	972	21

Average consumption of fertilizer in potato is about 294 kg per hectare. It was found as high as 373 kg/ha in 2003-04. Potato is only a three-month crop and is the most labour intensive crop, as is evident from the number of hours of human labour used in this crop. On an average, it generates about 131 days of employment for the farm workers. The number of hours of human labour used in potato is observed to be the highest in 1999-00 (1205 hrs/ha) and lowest (951 hrs/ha) in 2006-07. Animal labour utilization in potato cultivation is quite low.

11. Economics of Various Crop-Combinations

Sugarcane is annual crop while all other crops are only one season crops (Kharif or Rabi). Therefore, sugarcane is considered separately and other crops are taken in a combination (Kharif + Rabi). The eight crop-combinations, namely (1) Sugarcane (2) Paddy + Wheat (3) Maize + Wheat (4) Paddy + Gram (5) Maize + Barley (6) Paddy+ Barley (7) Bajra +Wheat and (8) Paddy+ Mustard have been considered for the purpose of analysis. One of the many problems faced by the farmer is to keep human and bullock labour busy for as long a period as possible. It is in view of this that estimates of utilization of human and animal (pair of bullock) labour hours per hectare for different crop-combinations have also been taken.

Table19 exhibits the relative profitability of various crop-combinations. In case of sugarcane cultivation net income (gross value of output minus cost C2) has remained much higher than the other crop combinations during all the years, except for 2007-08. Paddy + wheat combination is an important crop combination in the region. Net income from this combination is found to be much lower than the sugarcane. The variations in net income among various crop-combinations are found considerably large. In 1990-91, the net income was highest for sugarcane followed by paddy + gram and lowest for maize + wheat. In 1996-97, sugarcane ranked first, followed by paddy + wheat, paddy +gram and paddy + mustard. Crop-combination maize + barley provided the lowest net income to the farmers. In 2001-02, except for sugarcane, paddy + gram and paddy+ wheat combinations, the net incomes generated from the other crop-combinations were quite less. Year 2003-04 was a bad year for the farmers growing maize+ wheat, maize +barley and paddy + barley as they got negative income from these crop-combinations. Year 2007-08 was good year for the farmers growing all crop combination as net income from each combination is much higher than the corresponding net income received in the preceding year. On an average, sugarcane occupies first rank in terms of net income, followed by paddy +wheat and paddy + mustard.

Table19: Net Income from various crop-combinations (Rs/ha)

Year	Sugarcane	Paddy + Wheat	Maize + Wheat	Paddy + Gram	Maize + Barley	Paddy + Barley	Bajra + Wheat	Paddy + Mustard
1990-91	7116(I)	479(V)	242(VI)	1718(II)	1086(III)	499(IV)	-	-
1996-97	10854(I)	8964(II)	4345(VIII)	7918(III)	3558(VIII)	6817 (V)	6009(VI)	7147(IV)
2001-02	12292(I)	3346(III)	344(VII)	5215(II)	350(VI)	147(VIII)	1108(V)	1310(IV)
2003-04	12948(I)	5402(II)	-1121(VI)	4897(IV)	-3599(VIII)	-2045(VII)	2482(V)	5265(III)
2004-05	20212(I)	-128(V)	-2341(VII)	3934(II)	-4293(VIII)	-2080(VI)	-48(IV)	1327(III)
2006-07	30016(I)	9629(III)	7283(V)	5596(VI)	-506(VIII)	1840(VII)	11743(II)	8955(IV)
2007-08	18023(III)	18718(II)	10208(VII)	12751(V)	3264(VIII)	11774(VI)	14865(IV)	18725(I)
Average	**18698 (I)**	**7393 (II)**	**2875 (VI)**	**6479 (IV)**	**-957 (VIII)**	**1927 (VII)**	**6030 (V)**	**7116(III)**

Figures in parentheses are ranks of individual combination in terms of net income

The following points emerge from the above analysis:

- Sugarcane cultivation is most profitable among all the crops under study.
- Wheat cultivation is more profitable than paddy cultivation.
- Level of profitability varies considerably across years and crop-combinations.
- Apart from variation in the yields of various crops, especially crops grown in rain-fed conditions, such as maize, bajra, barley, gram, fluctuation in the realized prices of these crops is the crucial factor in causing variation in the net income from these crops.

12. Employment Generation under Different Crop-Combinations

Understanding of labour absorption in different crop-combination is necessary from the point of view of livelihood in the basin area. It is significant to note that although sugarcane provides the highest profit to the growers among all the crop-combination, it did not generate the commensurate employment to the farm workers, as can be seen from the data presented in Table 20.

Table20: Comparison of Human Labour Absorption in various crop Combinations

Year	Sugarcane	Paddy + Wheat	Maize + Wheat	Paddy + Gram	Maize + Barley	Paddy + Barley	Bajra + Wheat	Paddy + Mustard
1990-91	1266(VI)	1371(I)	1309(III)	1275(V)	1293(IV)	1355(II)	-	-
1996-97	1259(III)	1338(I)	1226(IV)	1207(V)	1155(VII)	1267(II)	968(VII)	1204(VI)
2001-02	1223(IV)	1290(I)	1246(III)	1178(VI)	1218(V)	1262(II)	947(VIII)	1215(VI)
2003-04	1138 (VII)	1305(II)	1248(IV)	1173(VI)	1196(V)	1253(III)	899(VIII)	1584(I)
2004-05	1234(IV)	1301(I)	1174(V)	1171(VI)	1139(VII)	1266(II)	879(VIII)	1251(III)
2006-07	1331(III)	1327(II)	1100(VII)	1217(V)	1169(VI)	1396(I)	963(VIII)	1281(IV)
2007-08	1363(II)	1338(III)	981(VIII)	1283(V)	1020(VI)	1377(I)	999(VII)	1335(IV)
Average	**1259(IV)**	**1324(I)**	**1183(VI)**	**1215(V)**	**1170(VII)**	**1311(III)**	**943(VIII)**	**1312(II)**

Note: Figures in parentheses are ranks of individual combinations

In 1990-91, one hectare of land used in cultivation of paddy+ wheat generated about 171 days (1371 hours) of employment while corresponding number of days of employment generated in sugarcane stood only at 158 days (1266 hours). Other crop-combinations such as Maize+ wheat, Maize+ barley, paddy+ gram, etc. provided more days of employment than sugarcane. A perusal of the Table 20reveals that employment generation in sugarcane farming declined up to 2003-04 and, thereafter,it has increased. On an average, bajra+ wheat combination provides the least number of hours of employment while paddy+ wheat combination provides the maximum level of employment to the farm workers. On an average, paddy + wheat combination provides maximum employment to the farm workers, followed by paddy + Mustard, and paddy + barley. In these combinations, contribution of paddy was much higher than the other crops. Paddy cultivation is more labour intensive and, therefore, requires more manpower per unit of land.

13. Draught Power Use in Different Crop-Combinations

Table21 shows the per hectare use of animal labour in different crop-combinations. A perusal of the table reveals that draught power use in agriculture has significantly declined over the period. In case of sugarcane, the number of hours of animal labour declined from 60 in 1990-91 to 12 in 2004-05 and thereafter increased during the remaining period, as is evident from Table 21.

Table21: Comparison of draught power use in various crop-combinations

(Number of hours of animal labour (pair of bullocks) per hectare

Year	Sugarcane	Paddy + Wheat	Maize + Wheat	Paddy + Gram	Maize + Barley	Paddy + Barley	Bajra + Wheat	Paddy + Mustard
1990-91	60(VI)	174(I)	172(II)	168(III)	165(V)	167(IV)	-	-
1996-97	22(VIII)	98(II)	86(V)	116(I)	82(VII)	94(III)	87(IV)	86(V)
2001-02	29(VIII)	55(V)	60(III)	60(III)	76(I)	71(II)	35(VII)	45(VI)
2003-04	13(VIII)	35(IV)	22(VII)	50(I)	23(VI)	36(III)	26(V)	43(II)
2004-05	12(VII)	34(IV)	33(VI)	41(III)	46(II)	47(I)	26(VII)	33(VI)
2006-07	20(VIII)	51(IV)	47(V)	46(VI)	94(II)	98(I)	42(VII)	52(III)
2007-08	24(VIII)	43(VI)	93(II)	45(VI	129(I)	79(III)	28(VII)	54(IV)
Average	**26(VIII)**	**70(V)**	**73(IV)**	**75(III)**	**88(I)**	**85(III)**	**41(VII)**	**52(VI)**

Note: Figures in parentheses are ranks of individual combinations

A perusal through Table 21also reveals that animal labour use in paddy + wheat combination steeply went down from 174 hours in 1990-91 to 34 in 2004-05 and then increased to 70 hours/ha in 2007-08. More or less similar pattern is also observed in case of other crop-combinations. As far as individual crop-combinations are concerned, it is observed that, on an average, maize+ barley combination provides maximum employment to the draught animal, followed by paddy+ barley and paddy + gram. It is sugarcane which provides the lowest level of employment to the draught animal.

At all-India level, the share of manpower and draught animal power in agriculture has significantly declined while mechanical and electrical powers have tremendously increased. The ratio of agricultural worker in the total power consumption declined from 15.11 percent in 1971-72 to 8.62 percent in 1991-92 and further to 5.77 percent in 2005-06. Similarly, the share of draught animal power declined sharply from 45.26 percent in 1971-72 to 15.55 percent in 1991-92 and further to 8.02 percent in 2005-06. On the other hand, the share of tractor in the total power in agriculture went up remarkably from 7.49 percent in 1971-92 to 46.70 percent in 2005-06. Per hectare power use in agriculture also increased from 0.759 kW in 1991-92 to 1.502 kW in 2005-06 (Singh, 2010).

14. Use of Chemical Fertilizer in Different Crop-Combinations

Chemical fertilizer consumption in different crop-combinations is presented in Table22. It is evident from the table that Paddy+ wheat combination has the highest level of fertilizer consumption among all the combination throughout the period. Further, the quantities of fertilizer used in paddy and wheat crops have significantly increased from 193 kg/ha in 1990-91 to 289 kg/ha in 2007-08, a net increase of 96 kg/ha. In other crop-combinations also, consumption of fertilizer substantially increased over the period.

Table22: Fertilizer use in various crop-combinations (kg/ha)

Year	Sugarcane	Paddy + Wheat	Maize + Wheat	Paddy + Gram	Maize + Barley	Paddy + Barley	Bajra + Wheat	Paddy + Mustard
1990-91	119(IV)	193(I)	164(II)	88(VI)	106(V)	135(III)	-	-
1996-97	175(V)	237(I)	187(III)	121(VIII)	132(VII)	182(IV)	172(VI)	190(II)
2001-02	191(III)	250(I)	182(IV)	119(VII)	113(VIII)	181(V)	172(VI)	198(II)
2003-04	166(VI)	273(I)	211(III)	137(VIII)	158(VII)	220(II)	193(V)	199(IV)
2004-05	174(VI)	278(I)	211(IV)	152(VII)	146(VIII)	213(III)	200(V)	215(II)
2006-07	190(VII)	285(I)	229(III)	160(VIII)	198(VI)	254(II)	214(IV)	203(V)
2007-08	182(VI)	289(I)	209(V)	165(VII)	171(VIII)	251(II)	218(III)	212(IV)
Average	**171(VI)**	**258(I)**	**199(IV)**	**135(VIII)**	**146(VII)**	**205(II)**	**195(V)**	**203(III)**

Note: Figures in parentheses are ranks of individual combinations

As can be seen from Table 22, the consumption of fertilizer in case of sugarcane has increased from 119 kg/ha in 1990-91 to 191 kg/ha in 2001-02 and then declined to 166 kg/ha in 2004-05 and thereafter increased to 190 in 2006-07. Although, ranking of individual crop-combinations varies across time period, paddy+ wheat combination continued to occupy the first rank during the entire period, while paddy+ gram and maize+ barley combinations continued to have last and second last positions among all the groups. On an average, per hectare use of chemical fertilizer was found to be the highest in paddy + wheat combination, followed by paddy + barley, paddy + Mustard and maize + wheat. In these crop-combinations, paddy and wheat are the main consumers of chemical fertilizers.

Chemicalization of agriculture has become the critical issue in context of maintaining the soil health and fertility. The government has been providing huge subsidy on fertilizer which crowds out the real investment in agriculture and promotes an overuse of chemical fertilizers and thereby degrades the land and water resources. A recent Greenpeace India report, "*Of Soils, Subsidies and Survival*," based on social audits conducted in five Indian States, has revealed that 96 percent, out of the 1,000 farmers surveyed, were of the opinion that the use of chemical fertilizers has led to soil degradation but they continue to use them as there was no other option. Ninety-four per cent of the farmers surveyed believed that only organic fertilizers can maintain soil health. However, only one per cent of the farmers received any kind of support for production and the use of organic fertilizers. Ninety-eight per cent of the farmers surveyed were ready to use organic fertilizers if they are subsidised and made easily available. The report says, *"Indiscriminate use of chemical fertilisers is murdering our soil and threatening our food security. It's time to move away from them and nurture our soil the ecological way".*

14.1 Trends in Crop-wise Fertilizer Consumption

Table 23presents the trend in consumption of chemical fertilizer in nine important crops of the state. These nine crops together consumed 2970 thousand tones of chemical fertilizer in 2007-08. It is notable that paddy and wheat together consumed more than 75 percent of total fertilizer used in these nine crops. Share of wheat was more than 50 percent of total fertilizer consumption. Share of sugarcane in the total fertilizer consumption was 14 percent in 2007-08. Table 23 reveals that out of nine crops, three crops, namely, wheat, paddy, and sugarcane are the major consumers of chemical fertilizers in the state. These crops are mostly grown on irrigated land and irrigation is one of key factors in the use of chemical fertilizer. These crops together comprised about 83 percent of total GIA in the state.

Table23: Crop wise use of chemical fertilizer[1] (in 1000 Tons)

Year	Paddy	Wheat	Maize	Bajra	Mustard	Potato	Gram	Barley	Sugarcane	Total
1990-91	443.72	976.72	57.13	30.62	NA	NA	11.48	0.02	221.10	1741
	(25.49)	(56.11)	(3.28)	(1.76)	-	-	(0.66)	(0.0)	(12.70)	(100)
1996-97	578.27	1198.90	58.78	28.35	72.11	NA	15.58	0.02	369.36	2321
	(24.91)	(51.65)	(2.53)	(1.22)	(3.11)	-	(0.67)	(0.0)	(15.91)	(100)
2001-02	679.99	1277.32	40.97	34.88	48.71	69.16	5.88	0.02	388.66	2546
	(26.71)	(50.18)	(1.61)	(1.37)	(1.91)	(2.72)	(0.23)	(0.0)	(15.27)	100
2003-04	693.06	1435.35	49.69	NA	41.82	164.79	12.35	0.02	350.28	2747
	(25.23)	(52.24)	(1.81)	-	(1.52)	(6.00)	(0.45)	(0.0)	(12.75)	100
2006-07	716.32	1539.88	55.25	NA	47.02	170.21	25.53	0.03	415.84	2970
	(24.12)	(51.85)	(1.86)	-	(1.58)	(5.73)	(0.86)	(0.0)	(14.0)	100

Note: 1. Estimated by multiplying the average consumption of fertilizer with area under the individual crop.
2. Figures in parentheses are percentages to the total.

Figure 60 shows trends in the share of paddy, wheat and sugarcane in the total GIA of the state. It is evident from the figure that share of wheat in the total GIA has declined from 58.47 percent in 1980-81 to 48.01 percent in 2007-08, while the corresponding share of paddy has increased significantly from 10.72 in 1980-81 to 23.79 percent in 2007-08. Percentage share of sugarcane in the total GIA has also increased over the period (Figure 60). Its share went up from 9.56 percent in 1980-81 to 10.95 percent in 2007-08. Thus, paddy, wheat and sugarcane consumed more than 75 percent of fertilizer and over 80 percent of irrigated water in the state.

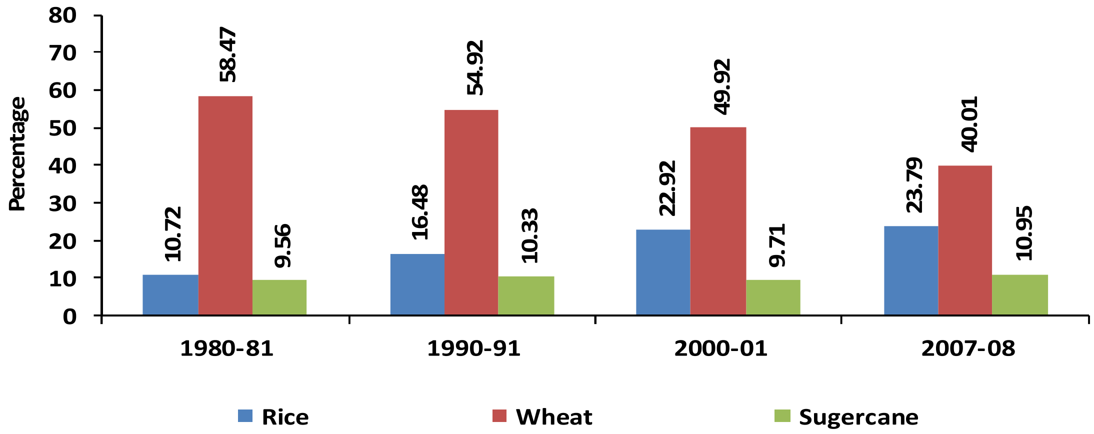

Figure 60: Share of Paddy, Wheat, and Sugarcane in Total GIA in Uttar Pradesh

15. Economics of Organic Vs Conventional Farming

Organic farming is basically a holistic management system which promotes and improves the health of agro-ecosystem. It is based on the use of organic manures, green manure and management of pests and diseases through the use of non-synthetic pesticides and practices. It prohibits the use of harmful chemicals and promotes the use of renewable organic resources to maintain the soil fertility without harming human health, wildlife, domestic animals, and environment. Therefore, while comparing the cost and returns of organic versus conventional farming, environmental aspects must also be taken into consideration. While, increasing chemicalization of agriculture has some ecological and environmental issues, concerns are also raised about the viability of organic farming. Therefore, it is essential to examine the performance of organic vis-à-vis conventional agriculture.

A primary survey study conducted by Charyulu and Biswas (2010) shows cost and returns from organic and conventional farming of paddy (basmati), wheat and sugarcane, three most important crops grown in the Ganga River Basin. Since study is based on sample survey, the findings need to be generalized with caution. However, it throws some light on the comparative economics of two farming options. The finding is relevant for GRBMP as organic farming reduces the point and non-point sources of pollution in the Ganga river water.

Table24: Economics of Organic Vs Conventional Farming in Uttar Pradesh (Rs per acre)

Items	Paddy (Basmati)			Wheat			Sugarcane		
	OF	CF	CF=100	OF	CF	CF=100	OF	CF	CF=100
Total cost of cultivation	13231	14446	92	9418	10223	92	22399	23099	97
Yield (Kg)	1518	1807	84	1519	1682	90	27364	24333	112
Price (Rs)	15.8	16.9	93	13.4	10.5	128	1.95	2.02	97
Total revenue	24719	31636	78	23463	20324	115	53360	49153	109
Net returns	11488	17190	67	14045	10101	139	30961	26054	119

Source: Charyulu and Biswas (2010)

A perusal of Table24 reveals that cost of cultivation as well as returns from the organic paddy was much lower than that from the conventional paddy. Total revenue from the organic paddy is just 78 percent of the paddy produced from conventional method. Consequently, net income from OF paddy was much lower than the CF paddy. Two factors seems to be responsible for relatively lower net income from the OF. First, per acre yield from OF was lower than the CF. Second, price per kg was also lower from the OF than the CF. Farmers growing organic paddy did not get premium price. This implies that no sincere efforts were made to develop the market institutions and regulation system for organic basmati rice. In case of wheat crop, cost and yield of OF were lower than that of CF, however, price of organic wheat was 28 percent higher than the price of CF wheat. Consequently, net income from organic wheat was 39 percent higher than the CF wheat.

Table 24 also brings to the fore that the cultivation of sugarcane was more profitable under organic farming than the conventional farming. One acre of sugarcane crop under OF generated Rs. 53360 revenue whereas corresponding revenue from CF was only Rs. 49153. The difference in the revenue generation is mainly due to higher yield and lower cost of OF than the CF. Net income from organic sugarcane was 19 percent higher than the sugarcane produced under CF. It is significant to note that profitability of organic sugarcane could further be increased if premium prices are fixed for the same.

16. Summary of Findings, Issues and Suggested Actions

16.1 Summary of Findings

- Analysis of data on land-use pattern indicates that NSA as percentage to the total reported area has increased significantly during the period 1950-51 to 2004-05 and after that it declined. Recent decline in NSA is a serious issue for food security and sustainability of livelihood of people dependent on agriculture.
- The percentage of NSA is found to be the highest in the north upper Ganga plains, followed by the south upper Ganga plains. After 1990-91, percentage of NSA, in almost all the regions, increased till 2004-05 and then it recorded deceleration. Percentage of NSA is observed to be higher in the Ganga bank than non-bank districts. On an average, Ganga bank districts have 2.5 to 3.0 percent point more NSA than their counterparts.

- At the state level, area under non-agricultural uses has increased by 33 percent between 1990-91 and 2007-08. North upper Ganga plains have the highest percentage share of land in non-agricultural uses, followed by the eastern region. In general, area under non-agricultural uses shows a rising trend in all the regions. However, there is not much difference between Ganga bank and non-bank districts when it comes to the use of land for non-agricultural purposes.
- There has been marginalization of agricultural holdings in the state. Percentage of number of marginal holdings in the total operational holdings has remarkably increased

during the period 1970-71 to 2000-01, whereas number of all other categories of holdings has declined during the same period. Marginal and small holdings together comprised 91 percent of the total operational holdings of the state. Making agriculture economically a viable venture for these holdings is a big challenge in the context of the GRBEMP.

- Percentage of GIA to GCA has significantly increased during period 1950-51 to 2007-08. Currently 76 percent of GCA is under irrigation. Tube-wells/wells consisted of 80 percent of total GIA of the state.
- Wheat claims for the largest share in the total GIA of the state. Its share has increased significantly from 31 percent in 1950-51 to 63 percent in 1990-95 and thereafter it declined to 48 percent in 2007-08. Share of rice went up from 8 percent in 1950-51 to 26 percent in 1990-95 and then declined to 24 percent in 2007-08. In 2007-08, wheat, rice and sugarcane jointly shared 83 percent of GIA of the state. These crops consume the maximum quantity of water available in the basin. Huge quantity of water could be saved by diversification of cropping pattern from these crops to less water consuming crops. Further, technological improvement and change in the agricultural practices in general and irrigation practices, in particular, could also help to reduce the water consumption in rice, wheat and sugarcane crops.
- North upper Ganga plains have the largest percent of GIA to GCA, followed by south upper Ganga plains. Except for the southern region, in all other regions, percentage of GIA shows a rising trend over the period.
- Although the percent of GIA in the Ganga bank districts was higher than that in the non-bank districts, the gap between the two has narrowed down over the period.
- Share of canal irrigation in the total GIA has declined significantly in all the regions during the last five decades. In the north upper Ganga plains, its share went down from 48.6 percent in 1959-60 to 10.2 percent in 2007-08. More than 90 percent of GIA in this region is shared by tube-wells/wells. In south upper Ganga plains, the share of canal went down from 45 percent in 1959-60 to 17.3 percent in 2007-08. The decline in the share of canal is observed to be higher in the Ganga bank than in the non-bank districts
- At the state level, about 25 percent tube-wells used 8-10 HP pumps which may be considered over-sized and consume relatively more energy.
- Percentage share of deep tube-wells using underground channels to irrigate the crops was observed much higher than that of shallow tube-wells
- North upper Ganga plains region has the highest percentage of groundwater development (81%) in the state. It is followed by the south upper Ganga plains region (75.7%).
- About 70 percent villages in the state have water level below 10 meters. The percentage of such villages is found highest in eastern region (77%), followed by central region (67%) and north upper Ganga plains (66%).

- North upper Ganga plains region has the highest percentage share of groundwater recharge during non-monsoon region among all the regions, followed by south upper Ganga region.
- During the period 1980-81 to 2009-08, the use chemical fertilizer in agriculture has increased by 226 percent. The north upper Ganga plains region has the highest intensity of fertilizer consumption among all the regions. It is followed by south upper Ganga plains and the eastern region. Except for the southern region which does not have adequate irrigation facilities, in all other regions, use of fertilizer has significantly increased during the period under study. Further, fertilizer consumption was found much higher in the Ganga bank districts than that in the non-bank districts. On an average, farmers in the Ganga bank districts used about 31 kg more fertilizer per hectare than their counterparts used in the non-bank districts.
- Per hectare use of pesticides in agriculture shows an increasing trend till the year 1990 and thereafter it shows fluctuations across years. The use of pesticides increased from 172 g/ha in 1980 to 362 g/ha in 1994 and then declined to 296 g/ha in 2000.
- Number of pump sets per 1000 ha of GCA has significantly increased in all the regions, except for the southern region. The rapid growth of number of pump sets per 1000 ha of GCA in the basin area has some implications for the sustainability of groundwater. The flat rate electricity tariff system prevailing in the state encourages the farmers to extract more groundwater for irrigation as marginal cost of drawing extra unit of water is almost zero for them.
- The number of irrigation pump sets in operation has been found to be much higher in the Ganga bank districts as compared to the non-bank districts.
- The trend in cropping pattern indicates that area under wheat, which remained stable during pre-green revolution period, achieved a remarkable increase in the post-green revolution period. The area went up from 16.8 percent in 1970-71 to 37.1 percent in 2007-08. Share of rice in the total GCA has increased from 19.3 percent in 1950-51 to 23.3 percent in 2000-01. Thereafter it does not evince any increase. It is significant to note that wheat and rice together comprise 60 percent of total GCA of the state.
- Area under sugarcane increased by 75 percent during the period 1950-51 to 2007-08. These three crops (wheat, rice and sugarcane)jointly share 69 percent of the GCA of the state. The area under potato also shows a rising trend during the same period. Areas under pulses and oilseeds have either declined or remained stagnant over the period.

- Cropping intensity has increased from 123 percent in 1950-51 to 154 percent in 2007-08. During this period, it has increased only by 31 percent point. Per capita NSA has declined steeply from 0.26 hectare in 1950-51 to 0.09 hectare in 2007-08.
- During the period 1950-51 to 2007-08, production of wheat has increased by about 10 times. The production went up from a meager quantity of 2.7 MT in 1950-51 to 26.3 MT in 2007-08. Production of rice increased from 2.0 MT in 1950-51 to 12.9 MT in 2001-02. Thereafter, it does not show any notable increase in the subsequent years.

- Sugarcane production evinces a rising trends throughout the period, though there were some fluctuations in the production across years.
- Production of pulses shows a negative trend during the entire period. It went down from 3.0MT in 1950-51 to 1.6 MT in 2007-08. Production of oilseeds has increased in the recent years.
- Production of potato shows a rising trend throughout the period, though some fluctuations are notable across the years
- Per hectare yields of wheat, rice, sugarcane, and potato have increased significantly in the post-green revolution period. However, during the first decade of this century, yields of most of these crops have either declined or remained stagnant.
- North upper Ganga plains region has the highest productivity of rice among all the regions. It is followed by the south upper Ganga plains. Further the productivity of rice was observed to be higher in the Ganga bank districts than that in other districts. However, productivity grew a little faster in the other districts than that in the Ganga bank districts and as a result the yield gap has slightly declined.
- Productivities of wheat as well as sugarcane were observed to be the highest in the north upper Ganga plains, followed by the south upper Ganga plains and central region. However, there is not much of the difference in yield of wheat between the Ganga bank districts and the other districts. Butproductivity of suagcane is found to be higher in the Ganga bank districts than that in the other districts. On an average, the yield of sugarcane was 34.5 Q/ha more in the Ganga bank districts than that in the other districts.
- Productivity of pulses has been found to be the highest in eastern region, followed by the south upper Ganga plains and the central region. However, the productivity differences across regions are found to be insignificant. Further, it is also observed that after 1994-95, there has been deceleration in the productivity of pulses.
- Per hectare yield of oilseeds was highest in the north upper Ganga plains, followed by the south upper Ganga plains. In these regions, the yield shows a rising trend.
- Analysis of the regional pattern of productivity of potato reveals that it was highest in the south upper Ganga plains, followed by north upper Ganga plains. There was not much difference in the productivity of potato in the Ganga bank districts and the other districts.

- Three crops, wheat, paddy and sugarcane, which are mostly grown on irrigated land, contributed 57.32 percent to the total agricultural output of the state in 2005-06.
- The share of agriculture in the total value of output of primary sector has gradually declined from 73.24 in 1999-00 to 68.26 in 2005-06, a net decline of 5 percent point while the share of livestock has significantly increased from 23.15 percent to 27.60 percent during the same period. This implies that livestock economy of the state has been growing faster than the agricultural economy. Share of forestry ranges between 2.74 percent and 3.06 percent. The share of fishery marginally increased from 0.87 percent in 1999-00 to 1.17 percent in 2005-06.

- Paddy, wheat and sugarcane are important crops grown in the middle Ganga Basin. These crops together share 68.8 percent of total GCA, 83 percent of total GIA and 75 percent of chemical fertilizers consumption in agriculture of the state in 2007-08. Out of these three crops, sugarcane and wheat continue to generate profits to the growers while paddy did not consistently provided profits to the farmers.

16.2 Actionable Measures for Achieving Substantial Reduction in Water/Energy Use in Agriculture and Non-Point and Direct Pollution in River and Groundwater

As has been discussed in the preceding sections, green revolution which essentially rode on the package of chemical fertilizers, high yielding variety seeds, pesticides and weedicides, along with the improved irrigation facilities, has revolutionized the Indian agriculture to the extent that a food deficient country transformed into a food surplus one. However, it has also led to the overuse of the ground and surface water and gross wastage of energy through the installation of an ever increasing number of power inefficient agricultural pump-sets. The increasing doses of chemical fertilizers and other inputs have also become non-point sources of water pollution.

The measures suggested below are not only expected to optimize the water and energy use in agriculture sector but also aim at reviving an otherwise almost stagnated agriculture because of the absence of any induced action on the part of various stakeholders. The push provided by the green revolution has, by and large, saturated and unless something of same magnitude is done again, there is little hope of agricultural sector recording the same growth as witnessed during the green revolution.

Issue 1: Inefficient use of water and energy in the agricultural sector

Uneven agricultural fields requiring use of more water and power to ensure that the entire stretch of the field gets irrigated. Unleveled fields cause significant loss of fertilizer nutrients in the process of leaching. Irrigation water and rainwater flows toward low lying areas along with nutrients and subsequently moves downward which in turn significantly reduce the fertilizer use efficiency.

Actionable Measures: Use of laser land leveling technology

The use of laser-land-leveling technology is estimated to curtail irrigation application losses up to 50 per cent. The cumulative water saving, whether that of Ganges and its canals or of ground water resources or both, over a period of time, therefore, would be highly significant and shall release water for other priority areas. The other major benefits of using this technology are:

- Reduction in the cost of production because of near optimum use of inputs such as fertilizers, irrigation, seed, pesticides etc., and minimization of labour required for irrigation.

- Increase in crop yield approximately by 20 per cent (observation based upon interaction with the farmers using such a technology), leading to better farm returns and employment generation.
- Control of water-logging and salinity,
- Facilitation in efficient use of agricultural machinery.
- The uniform germination of seeds also facilitate other agricultural practices such as hoeing, weeding, spraying and harvesting because in such cases crop plants are of equal heights.
- Minimization of pre and post harvest losses as crop is likely to mature uniformly.
- Enhancement in cultivated area by reducing dikes and ditches.

Actionable Measures: Growing up of water intensive crops with better technology

Paddy, wheat and sugarcane are the main water consuming crops in the state. Zero tillage technology is most suitable for paddy-wheat cropping system. Its use would not only reduce the cost of cultivation but also save the irrigation water. Punjab and Haryana are using this technology but it is not currently being used in Uttar Pradesh, except for Tarai area by some big farmers. Market for custom hiring of this technology should be developed with government intervention.

Issue-2: Chemicalization of Agriculture owing to ever increasing doses of Chemical fertilizers, pesticides and weedicides

Consumption of chemical fertilizer has been increasing over time in order to improve the farm production and productivity which, in turn, has severely affected soil fertility, water use intensity and creating non-point source of water pollution to the River Ganga. These inputs are also applied in heavy doses to the production of vegetables and fruits along the river beds of Ganges and its major and minor tributaries, throughout the length and breadth of the Ganga River Basin and have become a major source of direct pollution.

Actionable Measures: The Case for Organic Farming

Promotion of organic farming is desirable for maintaining soil fertility, arresting the groundwater degradation, protecting human health, reducing water requirement of crops, and finally decreasing the non-point sources of pollution of river. It may be further noted that organic farming reduces external inputs such as chemical fertilizers, pesticides, weedicides, etc. besides reducing the demand for water for irrigation purposes. It is based on a holistic approach to farming. This reduces the input costs, making agriculture far more profitable.

The period of convergence of conventional farming to organic farming is about three years. During this period, per hectare yield remains lower than what is achieved under conventional farming. Farmers willing to adopt organic farming system should be compensated initially either through input-subsidization or through direct cash transfer per unit of land converted into organic farming. There is a need to take care of the absence of linkages between the farmers and markets, and support from the governments. This support would be much lower than the environmental and health costs that the society bears due to chemicalization of agriculture. The policy framework to support organic farming is very important to push up the spread of organic methods. Strong marketing networks linking the farms, processing and distribution and the organization of production with the support of local NGOs with stringent certification programmes are other measures that could contribute to the growth of organic farming.

- Training and capacity building infrastructure at the block level should be created to enhance the knowledge and skills of farmers through effective training programmes related to organic farming, composting techniques, bio-pesticides and bio-fertilizer, value addition techniques, group-forming and organizational skills.
- Animal dung is the main sources of cooking energy in the rural households. In order to save the animal dung for preparing manure for organic farming, the rural households may be provided subsidized LPG connections for meeting out their cooking energy needs.

Issue-3: Fast Growth in Groundwater Exploitation

Fast growth of individual tube well in the basin area should be arrested and alternative arrangement is made. This would not only reduce the power consumption due to economies of scale but also save the groundwater as flat rate tariff system prevailing in the state encourage the farmers to over-irrigate the crops.

Actionable Measures: Alternative Arrangement to Individual Tube Well

- While restrictions on the number of private tube wells in the river basin may improve groundwater table, there is also need to revive and renovate the traditional water bodies in the basin area. Efforts are required to be made to create a network of ponds, even on the private land. These ponds, if planed properly, would help not only in the development of fisheries but also serve the purpose of storing rainwater and recharging groundwater. Recently, the Government of India extended the scope of MGNREGS works to the small and marginal farmers land. This provides an ample opportunity to plan and executive works related to horticulture, minor irrigation, land development, construction of ponds, etc. on the private land also.
- The electricity tariff system in agriculture should be shifted from flat-tariff to meter-tariff, initially in the over-exploited blocks. However, farmers should be appropriately compensated for procurement of modern water saving technology, such as, sprinkler and drip irrigation in these blocks.
- Responsibility of billing and collecting water charges may be handed over to Gram Panchayat (GP). For this, GP should have some share in the revenue collection. This would not only be one of the sources of income generation of these local bodies but it would also reduce transaction cost and corruption in billing. The problem of tampering with meter, bribing of linemen and over-billing can largely be solved with their active participation and installation of tamper-resistant electronic meters.

Issue-4: Reduction in the Net Sown Area

Recent decline in the NSA in the basin may have serious implications for food security and livelihood of the cultivators. Since, the scope of bringing more area under cultivation is negligible, future growth in agriculture should obviously come through raising the productivity per unit of land, water and other resources and increasing the cropping intensity.

Actionable Measures: Increasing Cropping Intensity

- There is a scope of raising cropping intensity, especially in the central and southern regions of the state through water and soil conservation activities under MGNREGS and watershed development programmes.

Issue-5: Marginalization of Agricultural Holdings

Number of marginal holdings has increased exponentially over the period. More than 90 percent of operational holdings in the state are below two hectare. Making these holdings economically viable is a major issue in context of basin management plan.

Actionable Measures: Group Farming

- In this regard, efforts are required to be made to promote “Group Farming” by constituting self help groups of small and marginal farmers who can pool their land holdings and other resources, including farm machinery and implements such as tractors, tube-wells and threshers, etc.

Issue-6: Increasing land area under non-agricultural uses

Area under non-agricultural uses has increased by 33 percent since 1990-91. Land demand for non-agriculture uses would further increase in future with the fast growth of non-farm sectors. So far we do not have any comprehensive policy on conversion of agricultural land into non-agricultural uses.

Actionable Measures: Appropriate Measures for Change in Land Use

- Speculative demand for urban land has to be restricted through framing of appropriate land policy.

Issue-7: Except for sugarcane and wheat, profitability in crop husbandry is quite low or negative

Profitability in any crops depends on two factors: first the cost of production and second the per hectare level of productivity. Our analysis indicates that in the recent years cost of cultivation has increased significantly while per hectare productivity either declined or remained stagnant in most of the crops. Efforts are to be made to reduce cost of cultivation and improve productivity.

Actionable Measures: R & D and Policy Change

- There is a need to develop a market for custom hiring of costly agricultural implements.
- Investments in agriculture infrastructure including agriculture R&D, marketing, warehousing, storage, power and transportation should be increased.

- Horticulture and agro-forestay have the potential to generate additional livelihood opportunities for the rural households. There is need to converge the scheme of NHM with the activities of MGNREGS. Annual Action plans and labour budget of the MGNREGS should be prepared by integrating the schemes of district line departments, such as agriculture, irrigation, forest, horticulture, etc. so that livelihood component be effectively integrated in the plan with other components such as development, environment, water and soil conservation, regeneration of natural capital, etc.

Issue-8: Slow pace of agricultural diversification

Possibility of horizontal expansion of area under cultivation is quite low. Most promising options to augment farm income and employment are diversification of agriculture and intensive use of scarce land and water resources. Currently a big chunk of land is used in the cultivation of wheat, paddy and sugarcane which are more water guzzling and consume more chemical fertilizer. There is need to diversify the agriculture from these crops to other remunerative and water saving crops. Rice-wheat system of farming being adopted in the basin would not be economically and environmentally sustainable for a longer period. Price signals and market conditions are main determinants of diversification which can be influenced through appropriate agricultural price policy.

Actionable Measures: Promotion of Horticulture and Livestock

- Horticulture and livestock are two emerging sectors within agriculture which have enormous potential for raising the farm income and employment, especially for small and marginal farmers. Vegetable cultivation and livestock rearing may be suitable activities for marginal landholders as they have relatively more availability of family labour per unit of land.

Issue 9: Reduction in labour absorption in agriculture

- Alternative livelihood options, including rural non-farm activities be planned in the basin area

Issue 10: Knowledge-Deficit in Agriculture

- Irrigation Literacy of farmers should be improved through electronic and print media to optimize the water use in agriculture.
- Information database comprising information on rainfall, groundwater recharge and utilization, water demand for difference purposes, land use pattern, cropping intensity and cropping pattern, customary water rights, irrigation system and practices, etc. should be available at block level. It should be linked with national level database through MIS in the same manner as is being done in case of MGNREGS. It would help to make region-specific basin management plan.

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