Ganga River Basin Management Plan-2015

Volume 8: Thematic Studies – Agricultural Practices and Trends

Centre for Ganga River Basin Management and Studies
Indian Institute of Technology Kanpur

VOLUME 8 OF 12

NATIONAL MISSION FOR CLEAN GANGA (NMCG)

NMCG is the implementation wing of National Ganga Council which was setup in October 2016 under the River Ganga Authority order 2016. Initially NMCG was registered as a society on 12th August 2011 under the Societies Registration Act 1860. It acted as implementation arm of National Ganga River Basin Authority (NGRBA) which was constituted under the provisions of the Environment (Protection) Act (EPA) 1986. NGRBA has since been dissolved with effect from the 7th October 2016, consequent to constitution of National Council for Rejuvenation, Protection and Management of River Ganga (referred to as National Ganga Council).

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cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this it is also responsible for introducing new technologies, innovations and solutions into India.

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ACKNOWLEDGEMENT

This document is a collective effort of a number of experts, institutions and organisations, in particular those who were instrumental in preparing the Ganga River Basin Management Plan which was submitted to the Government of India in 2015. Contributions to the photographs and images for this vision document by individuals are gratefully acknowledged.

SUGGESTED CITATION

GRBMP by cGanga and NMCG

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GANGA RIVER BASIN MANAGEMENT PLAN - 2015

Volume 8: Thematic Studies – Agricultural Practices and Trends

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Ganga river in
Himalayas mountains

Trends in Agriculture and Agricultural Practices in Upper Ganga Basin

Part I: Uttarakhand

GRBMP: Ganga River Basin 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 Frame Work 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 dialog 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

The Ganga river, being a perennial source of water, facilitates both surface and groundwater irrigation for agriculture. However, high population growth, rising per capita income, and as a result, increase in the living standard of people, have encouraged farmers to diversify agriculture towards high water intensive crops such as sugarcane, paddy and wheat which put more stress on the water resources of the basin area. Although, the Ganga and her tributaries flow across Uttarakhand, the use of river water in the agriculture of the state is quite limited due to sloppy and rocky terrain. Apart from minor irrigation works, there is hardly any possibility in the development of surface and ground water irrigation system in the hilly regions of the state. On the other hand, in the plain areas of the state, both surface and groundwater irrigation facilities are available. Agricultural productivity in the plain regions of the state is at par with that of Western Uttar Pradesh, Haryana, and Punjab, while in the hill regions, agricultural activities are mostly carried out at the subsistence level under rain-fed conditions.

For the effective and sustainable management of the basin, an understanding of growth and composition of population, sectoral composition of workforce, change in land and water use patterns, settlement patterns, livelihood patterns and their possible impact on the river water resources, inter alia, is imperative. Management of the basin is required to be viewed as a part of the broader environment and in relation to socio-economic demands and potentials, acknowledging the political and cultural context, as water is not only an economic resource but also a socio-cultural and environmental resource. Agriculture is the major livelihood activity of majority of rural population in the basin area. Thus, a comprehensive study needs an attention to document the dynamics of agriculture in the basin area, understanding the nature and extent of dependency on it, and to suggest alternative livelihood options to augment the income of rural workforce, reducing the stress on river water resources. Keeping these aspects in view, this report concentrates on the trends in agriculture in the Uttarakhand portion of the basin area and its implications for the river basin management.

The data and information presented in the present report are based on secondary sources available on website of Government of Uttarakhand (www.uk.gov.in) and Statistical Diary of both Garhwal and Kumaon Division for various years. For most of the agricultural indicators, the data and information are manipulated to present a scenario of at least 20 years in the state and its districts. The information on selected agricultural indicators are presented mainly in the form of proportions and averages during different periods and across the districts of Uttarakhand. Other specific methodology, if any, is presented in the relevant sections of the report.

2. A Brief Profile of the State of Uttarakhand

Uttarakhand is located between latitudes 29°5'-31°25'N and longitudes 77°45'-81°E covering a geographical area of 53,485 km^2 of which 93 percent is mountainous. The region comprises of two administrative units viz., Garhwal (northwest portion) and Kumaon (southeast portion). A separate state 'Uttaranchal' comprising the 13 districts of these two administrative regions and Haridwar district from Uttar Pradesh was created as the 27th state of the Republic of India on 9th November 2000. In January 2007, the name of the state was officially changed to Uttarakhand from Uttaranchal. Its capital is located at Dehradun. About 34,650 km^2 area is under forest cover. The recorded forest area constitutes 64.8 percent of the total reported area, though the actual cover based on remote sensing and satellite imagery information is only 44 percent[1].

As per the 2011 census, population density is 189 persons per km^2. More importantly, with over fifteen important rivers and over a dozen glaciers in the state, Uttarakhand is a valuable fresh water reserve. The average annual rainfall of the state, as recorded, is 1,547 mm. For the administrative purposes, the state has been divided into two sub-divisions, Kumaon and Garhwal. Kumaon division includes six districts, namely, Almora, Bageshwar, Champawat, Nainital, Pithoragarh, and Udham Singh Nagar; while Garhwal division consists of seven districts, viz., Dehradun, Haridwar, Pauri, Rudraprayag, Tehri and Uttarkashi. The state has 78 tehsils, 95 development blocks, 671 Nyaya Panchayats, 7,227 Gram Panchayats and 15,761inhabited villages[2]. Figure 1 depicts the geographical location of the state of Uttarakhand with all its 13 districts. The state shares the international boundary with Tibet in the wide northeast and with Nepal in the southeast. The state is also bounded by state of Himachal Pradesh in the north-west and Uttar Pradesh in the south.

According to Census 2011, the state accounts for 8.49 million population with 4.33 million males and 4.16 million females. Out of total 8.49 million population of the state, SC and ST constitute 1.52 million and 0.26 million respectively. The decadal growth rate of the population of the state has declined from 24.2% during 1981-91 to 19.2% during 2001-2011. It has sex ratio of 963 and has a literacy rate of 79.6 percent with 88.3 percent literacy among males and 70.7 percent among females. Literacy rates among SCs and STs are relatively lower at 63.4 percent and 63.2 percent respectively.

The workforce constitutes 37 percent of total population, of which 74 percent are main workers and 26 percent are marginal workers. Out of the total workforce, 1.57 million are cultivators (including main and marginal cultivators), 0.26 million are agricultural labourers, 0.07 million people work in household industries and 1.23 million people are engaged in other activities.

The major source of livelihood of the population in the state is agriculture. Almost 70 percent of the population is engaged in agriculture. Out of the total reported area, only 14 percent is under cultivation and over 55 percent of the cultivated land in the state is rain-fed with cropping intensity at 161 percent. Agriculture covers 7.81 lakh hectares of land, out of which 4.43 lakh hectares appear to be under Hill regions, which is around 56.8 percent of the total agricultural land while the plain region constitutes 3.37 lakh hectares (43.2%). Irrigated areas in the Hills are around 10 percent whereas it is around 85 to 90 percent in the plain areas. The average size of land holding is around 0.68 hectare in the hills and 1.77 hectare in the plains. Of the total 9.26 lakh farmers in the state, small and marginal farmers constitute around 88 percent. The subsistence nature of agriculture in the hill districts provides nothing but a low and unstable annual income to the people, causing a sizeable out-migration of male members from the family, leaving behind a large number of female-headed households. As per the BPL survey 2008, about 36.5 percent of the population of the state lives below poverty line.

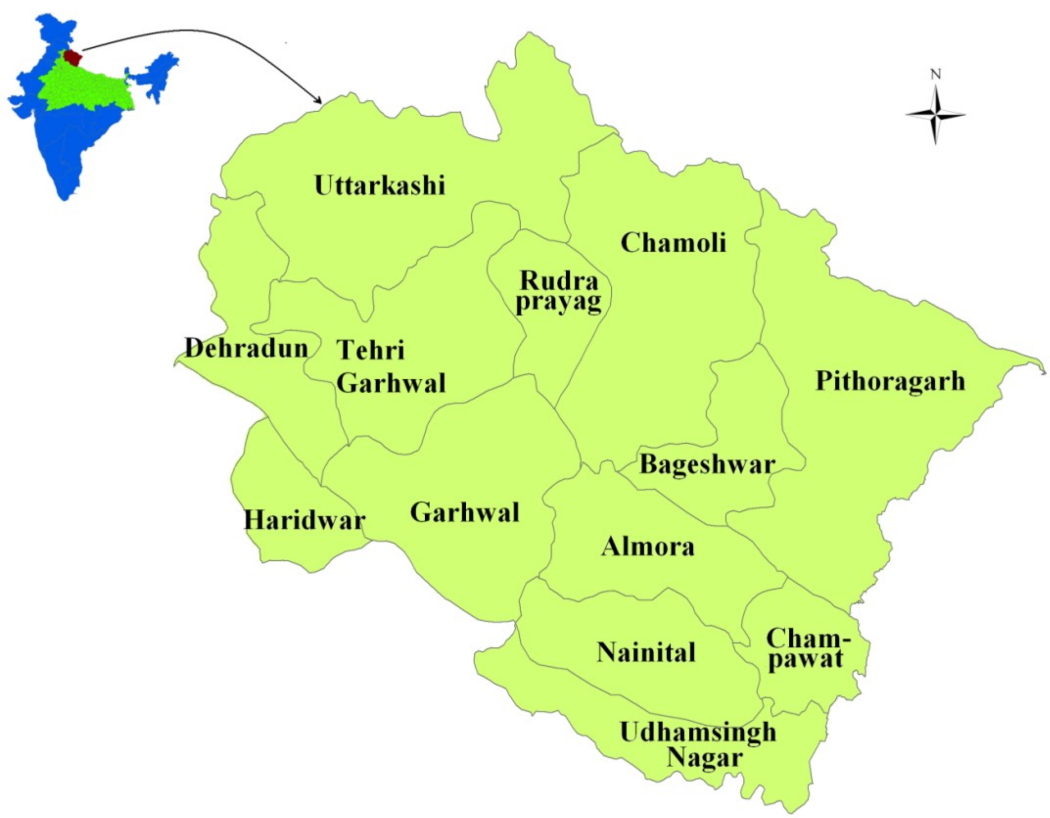

Figure 1: Location of Uttarakhand (with districts) in the Ganga Basin and in India

3. Trends in Sectoral Composition of GSDP

Trends in the sectoral composition of real gross state domestic product (GSDP) at factor cost are shown in Figure 2. Detailed data are given in Appendix. Primary sector comprises agriculture, forestry and logging, fishing, and mining and quarrying. Its share in the total GSDP steeply declined from 40.1 percent in 1993-94 to 20.5 percent in 2006-07.

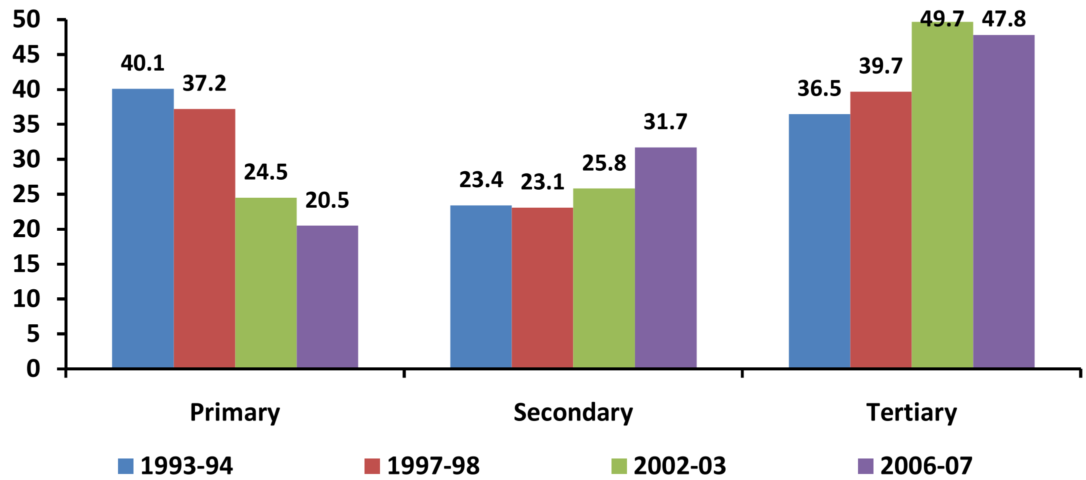

Figure 2: **Trends in Sectoral Composition (%) of Real GSDP at Factor Cost, Uttarakhand, 1993-94 to 2006-07**

The share of agriculture, including horticulture and livestock, has declined from 33.8 percent in 1993 to 17.8 percent in 2006-07. Secondary sector consists of manufacturing, construction, and electricity, gas and water supply. The contribution of this sector went up from 23.4 percent in 1993-94 to 31.7 percent in 2006-07. It is significant to note that the percentage share of manufacturing sector in the total GSDP has actually declined from 14.2 percent in 1993-94 to 12.4 percent in 2006-07. This implies that the increase in the share of secondary sector is due to the increase in the share of construction and electricity, gas and water supply. Although contribution of tertiary sector has increased from 36.5 percent in 1993-94 to 47.8 percent in 2006-07, there has been some decline in its share after 2001-02 (refer Appendix).

Figure 3 shows the occupational distribution of main workers according to 2011 Population Census. It is evident from the figure that more than 58 percent (farmers + agricultural workers) of main workforce directly depends on agriculture for their livelihood. The proportion of such workers is much higher in the hill region (61.8 %) than the plain region (48.7 %). As compared to Census 2001, there is a noticeable change in the proportion of workforce dependent on agriculture between these two regions. A growth of nearly 38 percent in the proportion of workforce directly dependent on agriculture was observed in plain region compared to a decline of 8 percent in hill region during 2001-2011.

It might be observed that the proportion of agricultural labour is almost negligible in hill region (3.3%) while it is about 22 percent in the plain region. Contrary to this, percentage share of farmers in the total workface is much higher (58.5%) in hill region than in plain region (26.4%). This implies that due to inadequate livelihood options available to the people of the hill regions, a majority of them depend on their small size of land holdings for the survival whereas in plain region, apart from developed agriculture, there are lots of other livelihood alternatives.

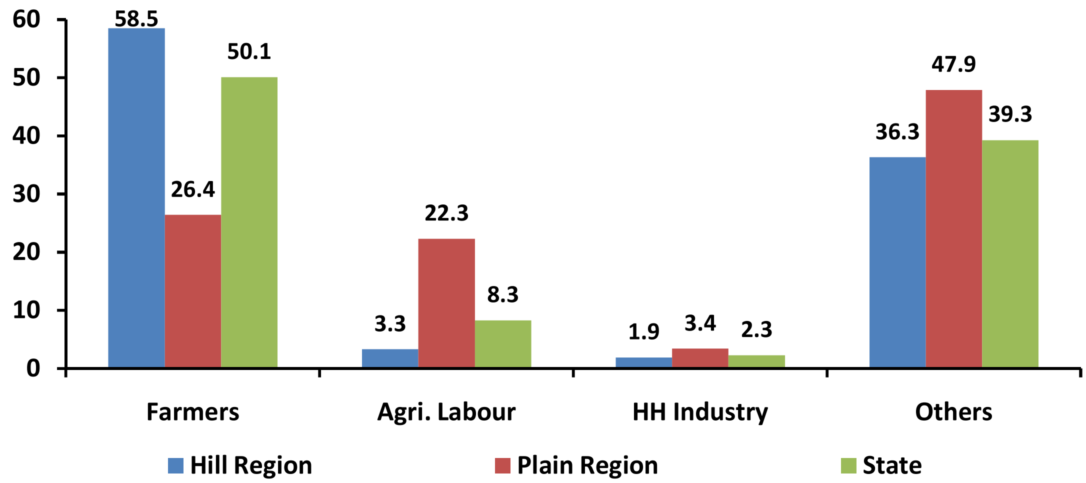

Figure 3: **Proportion (%) of Main Workers by Occupational Category, Uttarakhand, 2011**

This is also evident from the share of other workers in the total main workers, which is higher in plain region (47.9%) compared to the hill region (36.3%). However, at the state level, a decline of nearly 14 percent has been observed in the proportion of workforce in this category (others), compared to an increase of more than four times (63%) in the proportion of agricultural labour and 8 percent growth in the proportion of farmers during 2001-2011.Thus, the data suggests that although the income trajectory has gradually shifted from agriculture and allied activities to non-farm activities, there has not been a commensurate decline in the dependence of workers on agriculture. Consequently, the livelihood of people engaged in the agriculture has been marginalized vis-à-vis those engaged in secondary and tertiary sector.

4. Trends in Land Use Pattern

There may hardly be any remarkable change observed in the land use pattern of Uttarakhand during last 20 years. However, some changes can be noticed after 2000-01, when the northern hilly region of then Uttar Pradesh emerged as an independent state of Uttarakhand. As Figure 4 shows, there is a sharp change in the proportion of land used under different categories, which might be attributed largely to the inclusion of Haridwar in Uttarakhand.

Consequently, the land under agriculture (i.e. net sown area) grew by 10 percent, declining the proportion of forestland up to 7 percent from the level during 1995-96 to the level during 2000-01. During the same period, growth of nearly 16 percent in the proportion of land under non-agricultural use is also observed, which in subsequent periods appears to have declined again to the level as low as 4 percent during 2008-09. Area under forest and agriculture has especially remained same at 60 and 13-14% respectively during last 10 years in the state. The cultivable wasteland and the fallow land share a proportion of 1 to 2 percent in total reported area of the state, and record hardly any noticeable change during 2000-01 to 2008-09.

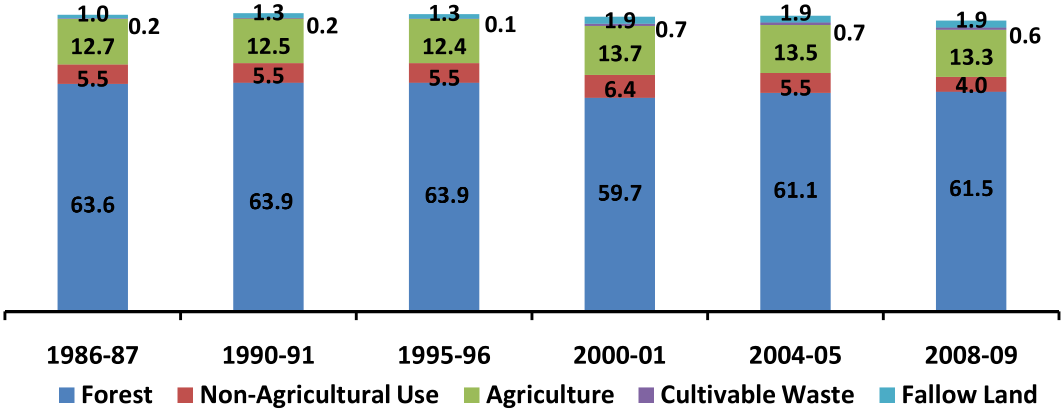

Figure 4: Land use pattern (%), Uttarakhand, 1986-87 to 2008-09

4.1. Area Under Forest

As observed from the data presented in Figure 4, the state has maintained a higher proportion (60% and above) of its land under forest since a long period. To a great extent, this is because of hilly terrain, where deforestation may cause serious threat to the day-to-day livelihoods. In addition, by losing vegetation, the people might not even assure to a better remuneration in terms of expanding agricultural lands, or using it for other purposes, as the development of land itself would be too costly to manage for them, if there is no government intervention. However, after the creation of the new state, all possible efforts were made to alterthe limited land area, as a result of which the forest cover of the relatively plain areas of the state were changed to accelerate agricultural growth.

Like other northern and eastern states of the country, the cultivation has been the main source of livelihoods in this region too. This is the reason that the districts of Haridwar and Udham Singh Nagar have almost half the forest cover of the state average (Figure 5). Other few districts that have the forest cover below state average are Almora, Bageshwar, Champawat, Dehradun, Garhwal, and Pithoragarh. Uttarkashi has maintained its area under forest cover as high as 89 percent since 1986-87 and even earlier.

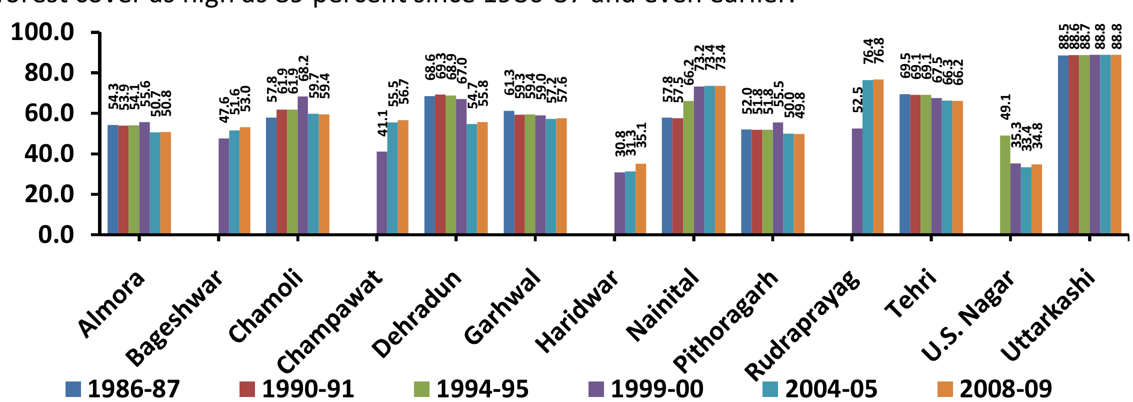

Figure 5: Area under Forest cover (%) by Districts of Uttarakhand, 1986-87 to 2008-09

The forest cover plays a vital role in maintaining the ecosystem and congenial climate of the region. As the state is full of highly steep river streams, which rapidly change the geomorphology of the area with large-scale weathering, erosion, landslides, etc., the role of vegetation becomes significant. Its importance is also well accounted for the sustenance of the rain-fed agriculture widely practiced in the hilly regions of the state.

4.2. Area Under Agriculture (Net Sown Area)

Haridwar and Udham Singh Nagar are the two districts in the plain region of the state, which share almost half of their total land area under agricultural use. Figure 6 shows the proportion of NSA across different districts of the state. As only 13 percent of the total reported land area of the state are sown (net), there are a very few districts in the state, apart from Haridwar and Udham Singh Nagar, where the proportion of the NSA exceeds the state average. Only Dehradun and Almora are the districts from the hill regions that operated 21 and 18 percent of their area under agricultural use (above state average) during 2008-09 respectively (Figure 6).

In the last decade, during 2004-05 to 2008-09, a decline of about 43 and 12 percent in the proportion of NSA was observed in districts of Garhwal and Pithoragarh respectively. However, in the plain region too, Udham Singh Nagar and Haridwar appear to reduce their land under agriculture by 9 and 3 percent respectively during 2008-09 compared to the level during 2004-05.

The issue for concern is that the NSA in Uttarakhand has been steadily decreasing over the years. Studies show that the already very small portion of NSA of this hilly state is reducing further, as most of the districts show a declining trend of the area. The increasing trend of all other major land use categories of the state is mainly contributing towards the decline of NSA as a whole. In a study by Rao and Nandi (2001), it was shown that while for Uttarakhand as a whole the decline was of the order of 3.7 percent during 1974-94, the district level figures varied between 24 to 2 percent[3].

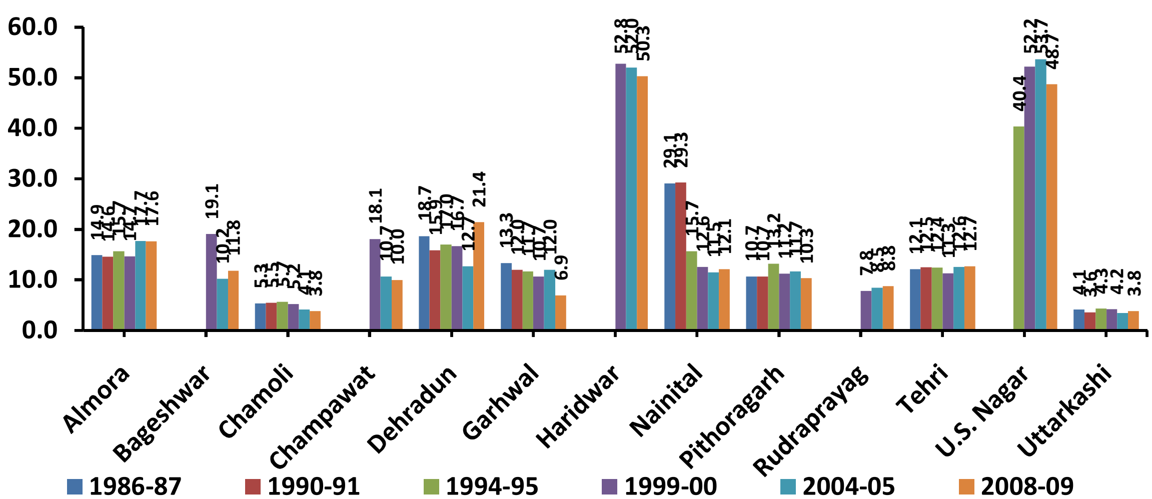

Figure 6: Net sown area (%) by Districts of Uttarakhand, 1986-87 to 2008-09

4.3. Area Under Non-Agriculture Use

The decline in the proportion of NSA in some of the districts (as mentioned earlier) is to some extent compensated with an increase in the proportion of land under non-agricultural use, although the data for the entire state does not corroborate this. Figure 7 illustrates the trend in the proportion of area under non-agricultural use across districts of Uttarakhand during 1986-87 to 2008-09. During 2004-05 to 2008-09, Chamoli has registered a sharp increase in the proportion of area under non-agricultural use from the level of just 1 percent to 7 percent. This may be, as the data suggests, due to a reduction of about 55 percent in the barren and uncultivable land area of the district. Chamoli has been the attraction for setting up hydroelectric and thermal-power plants as well as among the most sought places for tourism development during the recent past by the state govt.

Similarly, Udham Singh Nagar district shares a substantial proportion in gross state domestic product (GSDP) with both agricultural and non-agricultural activities. Due to abundant plain areas, transportation and market development in the district, people get benefitted in both agricultural and non-agricultural activities. This is the reason that Udham Singh Nagar district has been diverting its land under non-agricultural use considerably, as the proportion of area under non-agricultural use increased from the level of only 5 percent during 1994-95 to 11 percent during 2008-09. During 2004-05 to 2008-09, an increase of about 26 percent in the proportion of area under non-agricultural use was registered in the district. Haridwar also has a substantial proportion of non-agricultural land, although, during 2004-05 to 2008-09, the district showed decline in its share by 9 percent (Figure 7).

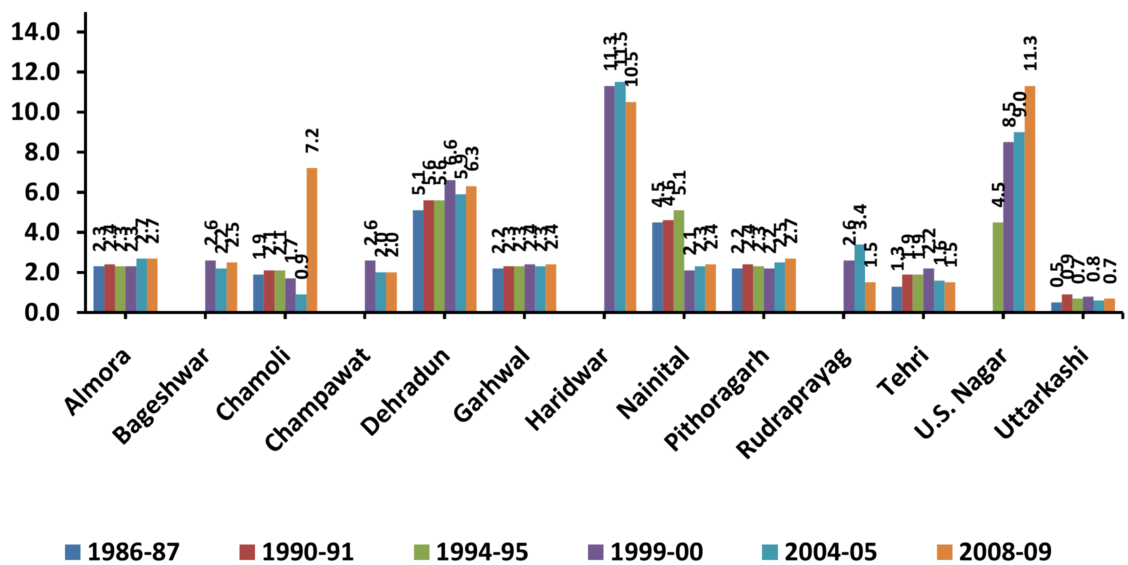

Figure 7: Area under non-agricultural use (%) by Districts of Uttarakhand, 1986-87 to 2008-09

5. Operational Holdings

Operational holding refers to the size of farm, which was operated for the agricultural purpose. It is broadly divided into five groups, namely marginal (less than 1 ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-10 ha), and large land holding (more than 10 ha). This might be an indirect indicator to evaluate the intensity and productivity of agriculture in any particular area. More the smaller and fragmented agricultural farms, lesser will be the productivity in the area in general.

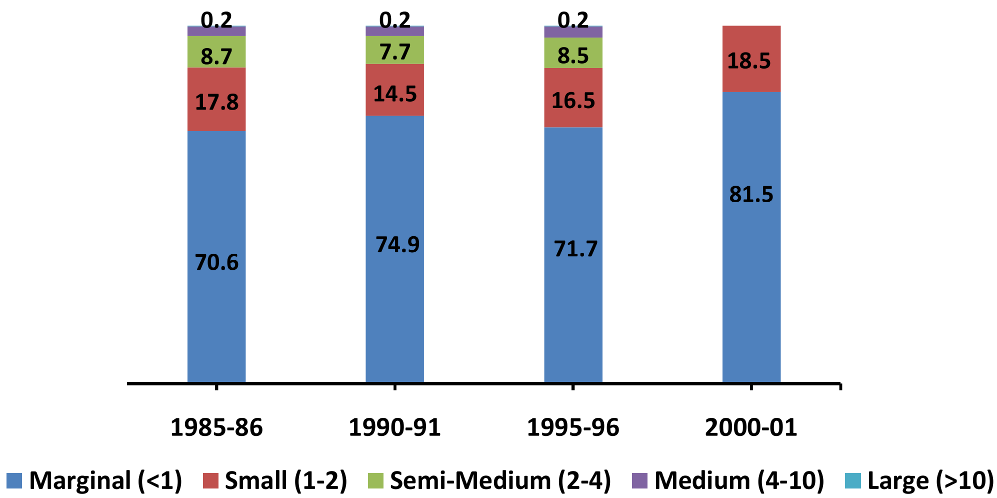

Figure 8: Proportion of operational holdings (%) by size class (ha) of agricultural land, Uttarakhand, 1985-86 to 2000-01

As shown in Figure 8,during the period 1985-86 to 2000-01 more than 70 percent of agricultural holdings are marginal (of size less than 1 ha). After becoming an independent state in 2000, the proportion of marginal holdings increased to about 81.5 percent and the remaining (18.5%) were small holdings (1-2 ha). This is a typical characteristic of agricultural lands in hilly areas, where terrace farming are performed, and due to paucity of extension of the land, small fragmented lands are managed to be developed for the agricultural purpose at different altitudes.

5.1. Number of Operational Holdings across Districts

This section presents a trend in the proportion of operational holdings (number) across the districts of Uttarakhand during 1985-86 to 2000-01. As Figure 9 illustrates, most of the hilly districts of the state like Almora, Bageshwar, Champawat, Pithoragarh, and Rudraprayag register the proportion of marginal holdings ranging between 75 and 80 percent, and even more. The lowest proportion of marginal holding during 2000-01, was recorded by Garhwal (51%), followed by Udham Singh Nagar (53%), Nainital (66%), and Haridwar, Chamoli, Uttarkashi (each with 68 percent of marginal holdings). Pauri Garhwal (28%) recorded the highest proportion of small (1-2 ha) land holdings during 2000-01, followed by Tehri Garhwal (22%), Udham Singh Nagar (20%), and Chamoli (20%). Other districts in the state had below 20 percent of small size land holdings. The proportion of medium size holdings was recorded the highest in Udham Singh Nagar (10%), followed by Nainital (5%), Garhwal and Haridwar (4% each), and Uttarkashi (3%) during 2000-01.

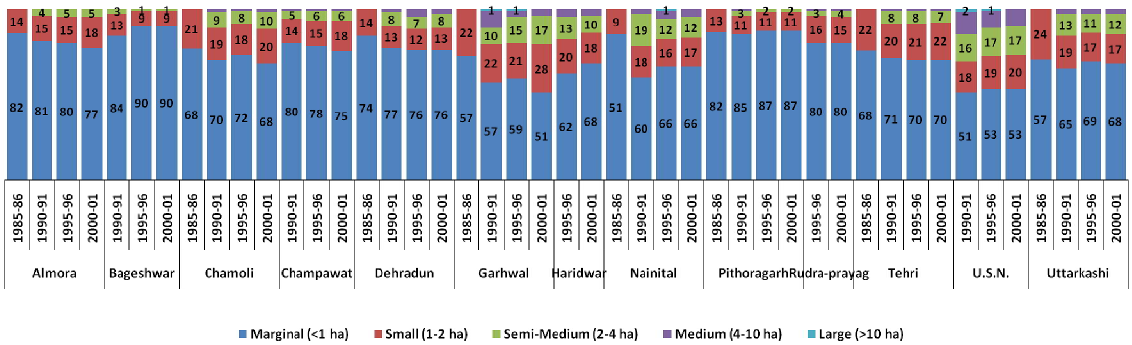

Figure 9: **Operational holdings (%) by size class (ha) across districts of Uttarakhand, 1985-86 to 2000-01**

5.2. Area of Operational Holdings across Districts

There are two different indicators to assess the proportion of operational holdings. In terms of number of operational holdings, most of the districts register their higher proportion of holdings in the marginal category, since the marginal holdings are very small (in size) but abundant in number in hilly areas. On the contrary, the large size holdings are larger in terms of area, but less in number. Figure 10 illustrates (differently from the Figure 9) that in the districts of plain region, in general, the proportion of area under medium and large holdings is higher than that under marginal and small size holdings. Udham Singh Nagar had only 13 and 16 percent area under marginal and small land holdings compared to 30 percent area under medium holdings and the highest proportion of area under large size holdings (14%) in the state during 2000-01. Other districts where the proportion of area under medium and large size holdings observed relatively higher were Nainital, Haridwar, and Dehradun during 2000-01. Bageshwar registered the highest proportion (66%) of area under marginal holdings during 2000-01, followed by Pithoragarh (59%), Almora (46%) and Champawat (39%).

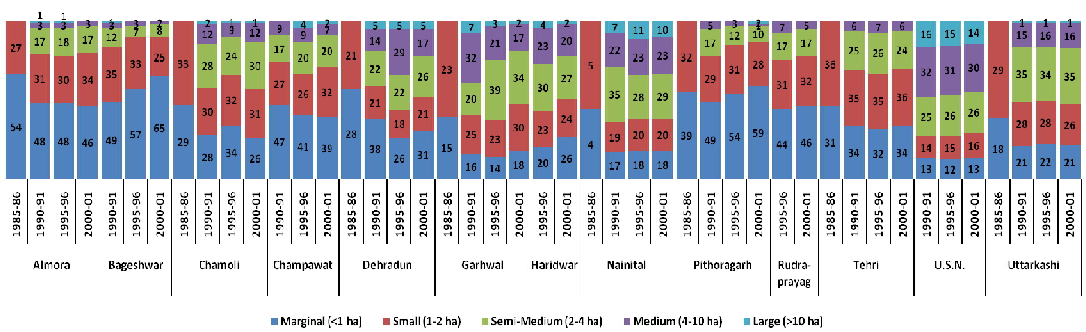

Figure 10: **Area of operational holdings (%) by size class (ha) across districts of Uttarakhand, 1985-86 to 2000-01**

6. Trends in Irrigation Pattern

Uttarakhand recorded an area of 3,40,129 ha under irrigation during 2008-09, which was about 45 percent of the total NSA (7,53,711 ha). Gross irrigated area (GIA) during the same period was recorded 569 thousand ha, which was 49 percent of the GCA (11.6 lakh ha). Figure 11 presents the proportion of GIA area to the GCA as well as the proportion of total irrigated area by major sources of irrigation in Uttarakhand during 1986-87 to 2008-09. However, it would be relevant to compare the datasince 2000-01 to avoid the influence of boundary changes in the state. During the period 2000-01 to 2008-09, an increase of about 9 percent has been observed in the proportion of GIA.

The share of tube-wells (about 60%) in total irrigated area has been the highest among other sources of irrigation. However, the contribution of UpperGangaCanal and other canals is also substantial, 28 percent (a decline of 3% from the level of 2000-01) of total irrigated area shared by canals irrigation during 2008-09. Since olden days, the main source of irrigation in this hill state has been the natural streams routing from mountain cleavages. Evenpresently, at least 10 percent of the total irrigation is done by stream water collected in ponds or other such mechanisms. Irrigation is done by conveying the water from streams through kuchha channels locally called Guhls to different terraces using the natural gravitational flow of water. The state constructed canals operate on the same principle, except in some situations electricity driven lift systems, pump sets, and hydraulic rams are installed. These, however, are limited to foothills and valleys. Thus, most of the crops in hills are raised under rain-fed conditions.

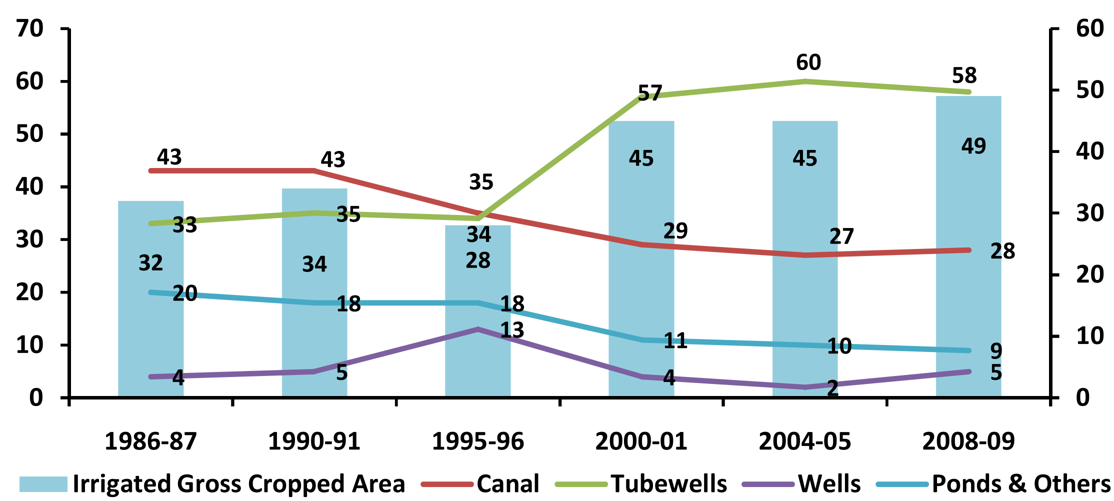

Figure 11: Total (Gross) Irrigated Area by source (%), Uttarakhand, 1986-87 to 2008-09

6.1. Irrigated Gross Cropped Area across Districts

Modern irrigation facilities are limited to the districts of plain region in the state. During 2008-09, a gross area of 2.59 ha (1.42 lakh ha net irrigated) was irrigated in Haridwar, which was 97 percent of the GCA and the highest among the districts of Uttarakhand (Figure 12). It was followed by the district of Udham Singh Nagar, which recorded about 91 percent of its agricultural land irrigated. Except these two districts of the plain region, only Nainital district (52%) is reported to have the proportion of gross irrigated area above the state average (49%) during 2008-09. Pauri Garhwal recorded a tremendous growth in the proportion of GIA during 2004-05 to 2008-09, while during the same period, a decline of around 72 percent was observed in the irrigated proportion of Dehradun. However, the fact is that Dehradun reported an increase of 69 percent in the NSA during this period, while the irrigation facilities could not be managed proportionately. In Almora, Chamoli, and Pithoragarh districts less than 10 percent agricultural land was recorded to beirrigated during 2008-09.

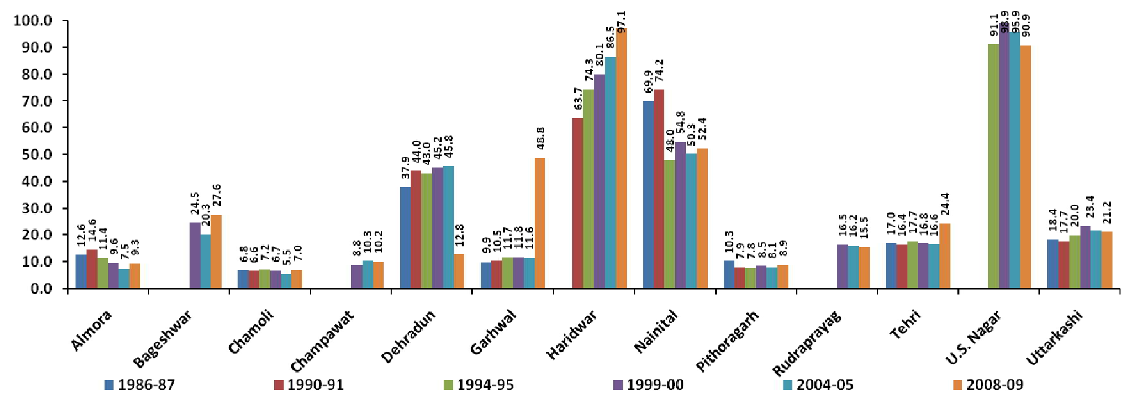

Figure 12: Total (Gross) Irrigated Area by Districts of Uttarakhand, 1986-87 to 2008-09

6.2. Sources of Irrigation

The major sources of irrigation in Uttarakhand are the canal system, tube wells, lift irrigation, guhls (hill channels), water-harvesting tanks (hauzas), hydrams, shallow tube wells, and deep tube wells in the Tarai belt. In most of the districts, especially in hilly region of the state, the main source of irrigation is natural streams. To irrigate the land on the hill slopes, water has traditionally been brought into the fields from rivers/rivulets by means of channels called 'guhls' cut along the contour line of the hills. The diversion work since earlier times has consisted of brushwood obstruction laid across the stream by which water is diverted into 'guhls' constructed at considerable effort and expense (Walton, 1928, Gazetteer, Almora, cited in U. C. Pandey, "Status of Irrigation in U. P. Hills- Past and Present", 1987). The Upper Ganga Canal system has also contributed a lot in the irrigation facilities in the state, especially in Haridwar. The canal system irrigates nearly 9,000 $km^2$of fertile agricultural land in ten districts of Uttar Pradesh and Uttarakhand. It starts at the Bhimgoda Barrage near Har ki Pauri at Haridwar, traverses to Meerut and Bulandshahr, and continues to Nanu in Aligarh district, where it bifurcates into the Kanpur and Etawah branches[4]. In the plain region, irrigation is also substantially performed by tubewells and wells using pumping sets.

6.2.1. Area Irrigated by Canals

Figure 13 illustrates that the hill districts of Bageshwar (86%), Nainital (83%), and Rudraprayag (74%) had more than two-third of the irrigation performed by canals. However, these canals are not to be confused by the long articulated canal systems like Ganga Canal system. In most of the hilly districts, these canals are locally administered narrow and short length channels diverted through several natural streams. Other districts, which recorded the higher proportion compared to the state average (28%) of irrigated area by canals during 2008-09 were Dehradun (64%), Almora (62%), and Uttarkashi (60%).

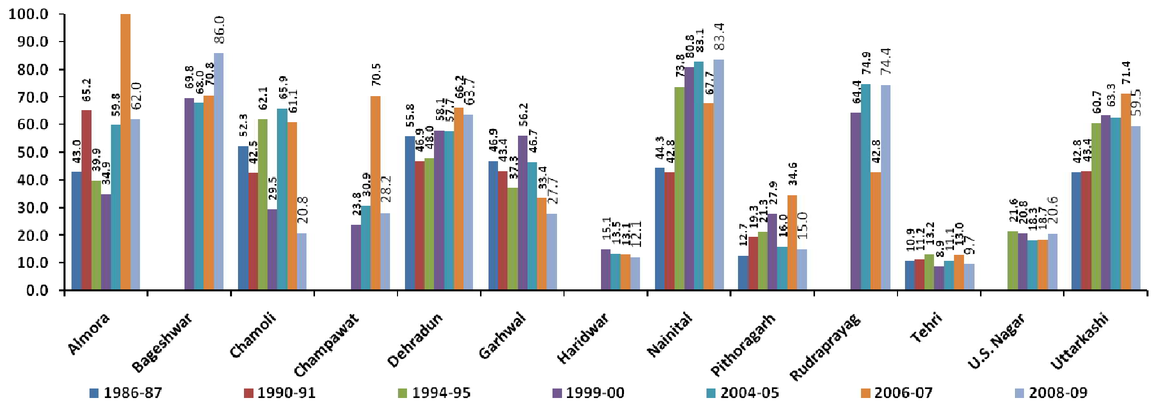

Figure 13: Area Irrigated by Canals (%) across Districts of Uttarakhand, 1986-87 to 2008-09

Up to a length of 1341 km, canals serve the agricultural land in Nainital, which is the longest coverage in the district compared to other districts in the state (Figure14). Udham Singh Nagar (925), Dehradun (864), and Pauri Garhwal (836) closely follow the Naintal district in terms of length of the canal in the district. The lowest length of canal serving agricultural fields was recorded in Champawat (224). Other districts are benefited by the canals up to even less than 500 km, except Tehri Garhwal, Uttarkashi, and Almora, where the length of the canals in the district was approximately706, 655, and 546 km respectively.

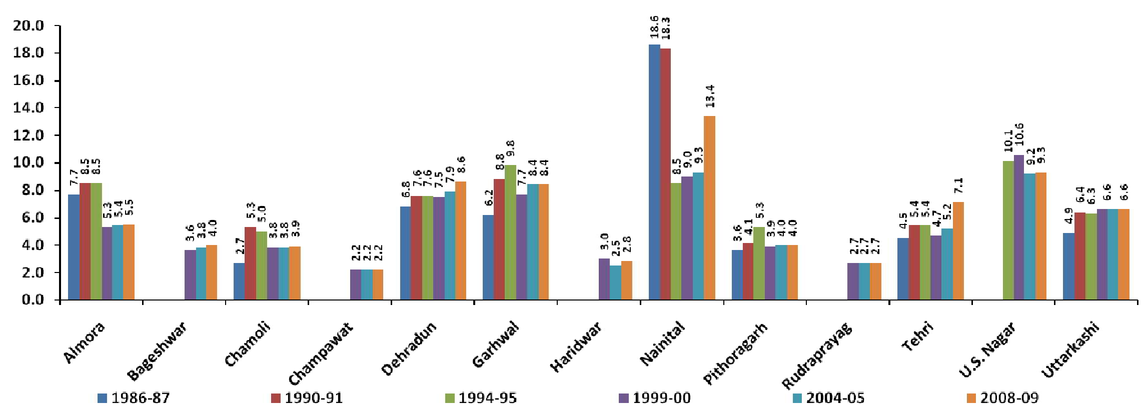

Figure 14: Length of Canals (in '00 kms) across Districts of Uttarakhand, 1987-88 to 2007-08

6.2.2. Area Irrigated by Tubewells/Wells

Compared to Figure 13, one can easily observe in Figure 15, that the tubewell/well irrigation is complementary to the canal irrigation system, and inversely proportionate to each other. As expected, the use of tubewell/well irrigation is very much popular in the districts of plain region in the state. Farmers in Haridwar and Udham Singh Nagar are the large beneficiaries of the tubewell/well irrigation. Almost 86 and 69 percent of total irrigation was performed by tubewells/wells in the districts of Haridwar and Udham Singh Nagar during 2008-09. The hill districts of Champawat in Kumaon region also appears to have nearly 72 percent of the agricultural land irrigated by tubewells/wells, which is a tremendous increase in the proportion compared to earlier years.

Since the declaration of this hill region as an independent state in 2000, the proportion of tubewell/well irrigation has been contributing as the main source of irrigation in the state as a whole. However, on an average over the entire state (58-60%) is primarily affected by the higher proportion of such irrigation in the districts of plain region. After all, these districts share nearly four-fifth of the total irrigated agricultural land in the district. Dehradun and Nainital districts too recorded 16 and 11 percent of total agricultural land irrigated by tube-wells/wells during 2008-09 respectively. Similarly, the Pauri Garhwal district had 8 percent of its agricultural land irrigated by tube-wells/wells during the same period.

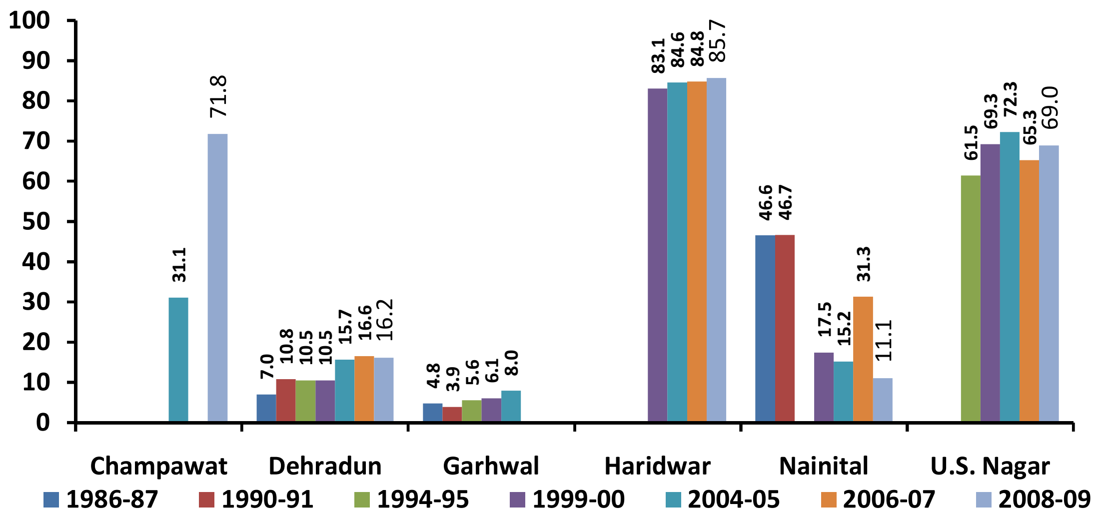

Figure 15: Area Irrigated by Tubewells/Wells (%) across Districts of Uttarakhand, 1986-87 to 2008-09

6.2.3. Area Irrigated by Other Sources

Apart from these two main sources (canal and the tubewell/well irrigation systems), a substantial proportion of agricultural land in hill region is irrigated by other sources managed by the local community. These mainly include guhl, hauz, hydrams, etc. Tehri Garhwal (90%), Pithoragarh (85%), and Chamoli (76%) districts in the hill region of the state has recorded almost three-fourth of the total irrigation contributed by other sources (Figure 16).

A traditional but effective canal irrigation system (guhls) is used to irrigate the fields using gravitational force, which brings water from a long distance (of the order of many kilometer). These guhls were maintained by the local beneficiaries until they were taken up by the minor irrigation department of the state government. Another traditional irrigation method, which is prominent in Uttarakhand, is water mills. The water mills, known as gharats in Uttarakhand, have traditionally been used for milling grain and extracting oil. The estimated number of water mills varies from 3,500[5] to 70,000. These water mills, with little technological upgradation, can also be employed for hydropower generation[6].

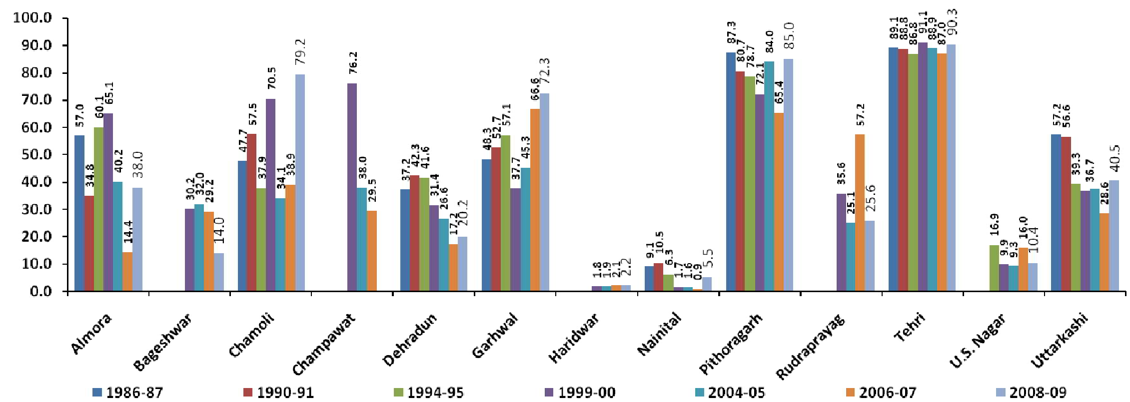

Figure 16: Area Irrigated by other sources (%) across Districts of Uttarakhand, 1986-87 to 2008-09

Figure 17 shows the number of guhls (hill channels) and water-harvesting tanks (hauzas) in thousand across districts of Uttarakhand. Tehri Garhwal district had the highest number of such tanks and channels (10,000) in the state during 2008-09, followed by Pauri Garhwal, Almora, Uttarkashi, Pithoragarh, and Chamoli. In the hill regions, the irrigation infrastructure is very poor. A large portion of the agricultural area is situated above rivers, with the result that they cannot be irrigated using the gravity system (surface water system) and can only be irrigated through lift irrigation. The lift irrigation technique is sophisticated and cost-effective; it is implemented through an automatic pumping device known as a hydraulic ram pump or hydram. Hydrams, which do not use any external energy or power such as diesel or petrol, work on the principle of the water hammer and convert the available static head to kinetic energy. Water can be carried to a height of 30 times above the available head. However, to make more water available for irrigation and to reduce the wear and tear on the plant, for the time being the irrigation department is trying to lift water only up to 15 times the available head. The lift irrigation technique can act as an important tool to improve the status of irrigation in Uttarakhand, in particular the hill districts. The advantage is that the land below the supply channel (guhls) can be irrigated directly from the supply channel; in addition, by increasing the scale of the supply channel, water mills for grinding wheat and other cereals can be driven. Consequently, dependence on power and diesel will be reduced, new employment opportunities will be created, the nutritional value of the cereals will remain intact. In addition, the maintenance expense is minimal and has no adverse impact on the environment (Mittal *et al.*, 2008).

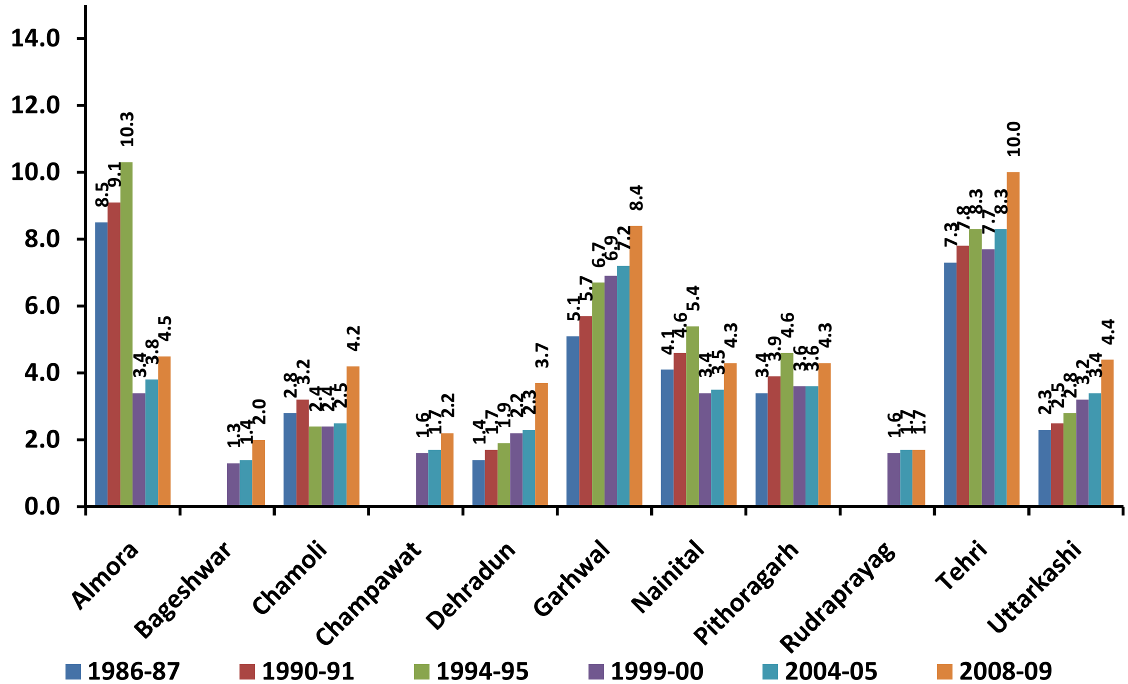

Figure 17: **Number of Hauz & Guhl (in '000) across Districts of Uttarakhand, 1987-88 to 2007-08**

6.2.4. Area Irrigated under Major Crops

Figure 18 illustrates the proportion of gross irrigated area under major crops, which indicates that more than 70 percent of the irrigated area is under traditional crops i.e. wheat and rice. About one fifth of the total irrigated area is under sugarcane, and the rest is shared by pulses, oilseeds, potato, and other crops. However, only 65 percent of agricultural land under rice and fifty percent area under wheat appeared to be irrigated during 2004-05 and 2006-07 (Figure 19). In addition, only 10 percent area under pulses was irrigated. Irrigation pattern in the agricultural land under oilseeds appears to show a declining trend, as compared to the level of 36 percent during 2004-05, the irrigated area under oilseeds has declined to 21 percent during 2006-07. However, during this period, the proportion of irrigated area under potato has increased. The irrigated area under sugarcane has been increasing substantially, and more than 95 percent of the area under sugarcane was observed irrigated.

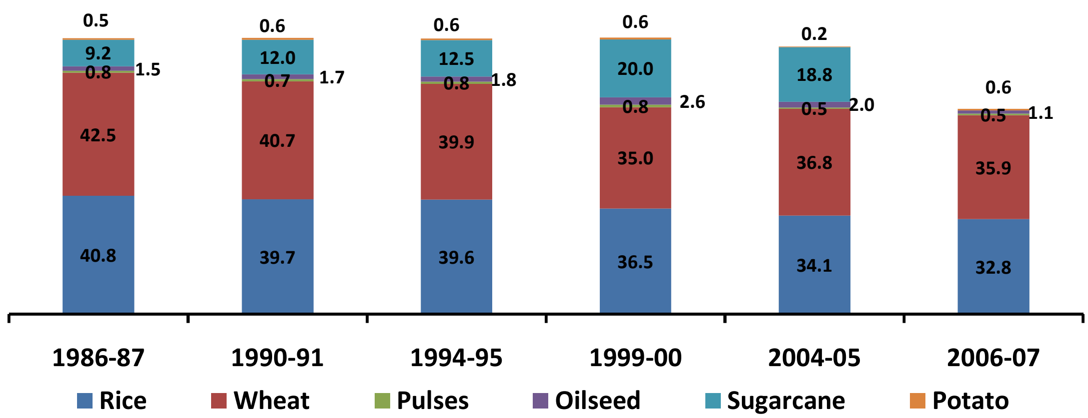

Figure 18: **Proportion (%) of Gross Irrigated Area under Major Crops Uttarakhand, 1986-87 to 2006-07**

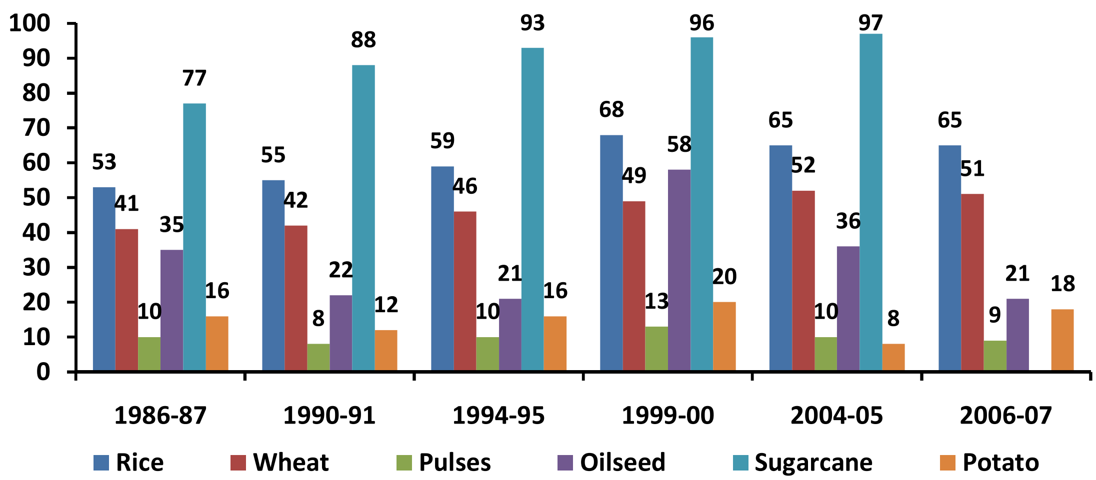

Figure 19: **Irrigated Area (%) by Major Crops Uttarakhand, 1986-87 to 2006-07**

6.2.5. Area Irrigated under Rice across Districts

Figure 20 illustrates the proportion of agricultural land under rice, which was irrigated across districts of Uttarakhand. As expected, the plain region districts like Udham Singh Nagar and Haridwar recorded almost hundred percent of the agricultural land under rice irrigated during 2006-07. Nainital (92%) and Dehradun (90%) districts too closely follow the plain districts in the state. However, other districts in Uttarakhand recorded a very less average of irrigated land under rice during the period, which was even less than the state average of 65 percent.

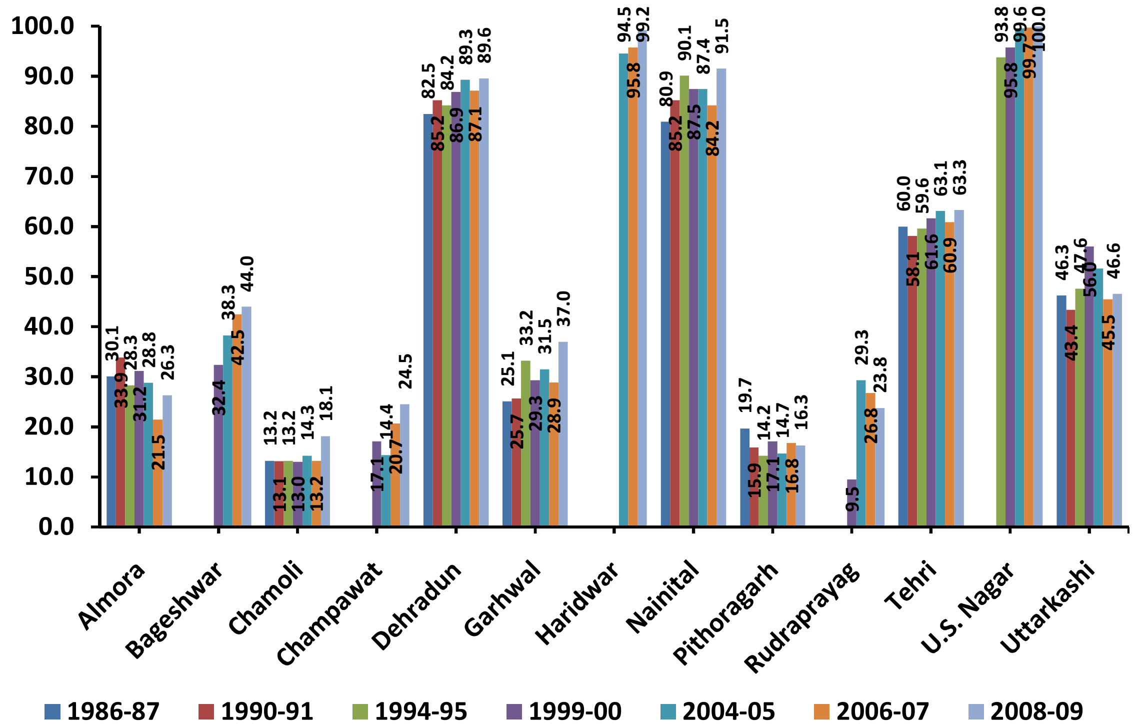

Figure 20: Irrigated Area (%) under Rice across districts of Uttarakhand, 1986-87 to 2006-07

6.2.6. Area Irrigated under Wheat across Districts

The irrigation pattern in the agricultural field under wheat (Figure 21) also emphasize the higher share of districts in the plain region i.e. Udham Singh Nagar and Haridwar with their 99.8 and 90.8 percent irrigated agricultural land under wheat cultivation. These districts are only closely followed by the district of Nainital with nearly 74 percent of irrigated land under wheat. Other districts recorded even less than 50 percent of their irrigated land under wheat cultivation, which is the state average.

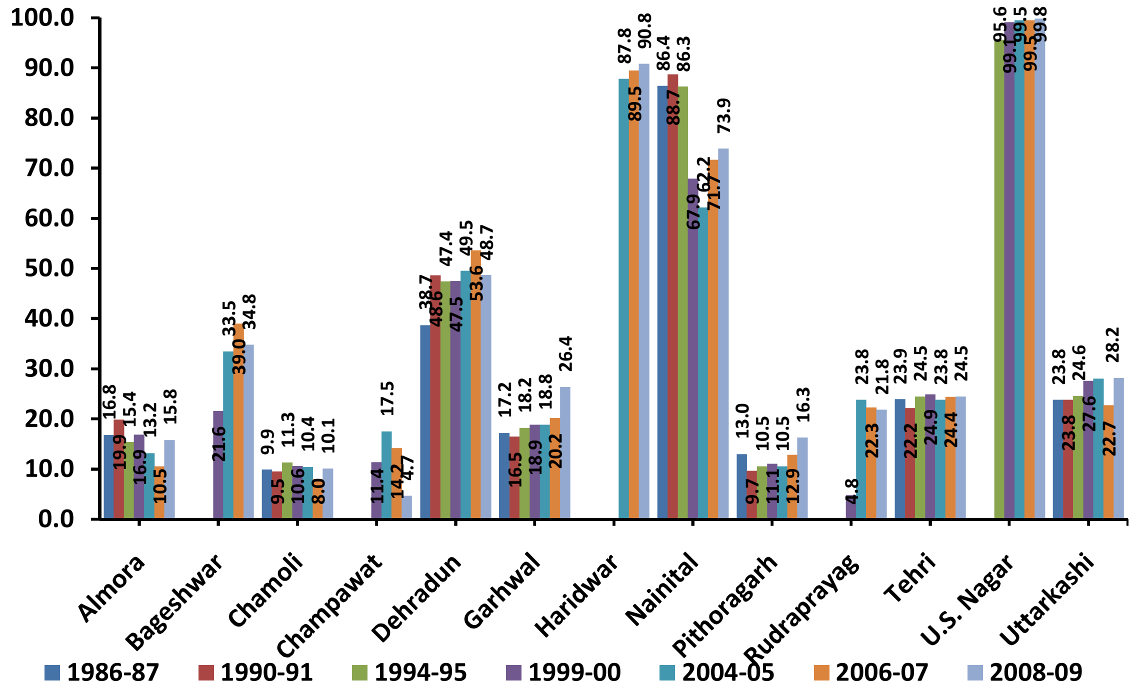

Figure 21: Irrigated Area (%) under Wheat across districts of Uttarakhand, 1986-87 to 2006-07

6.2.7. Area Irrigated under Pulses across Districts

A total of 31,941 ha agricultural land was operated for the cultivation of pulses (which include Urad, Moong, Gram, Lentil, Arhar, Pea, Moth etc.) in the state during 2006-07, of which only 2,863 ha was irrigated.

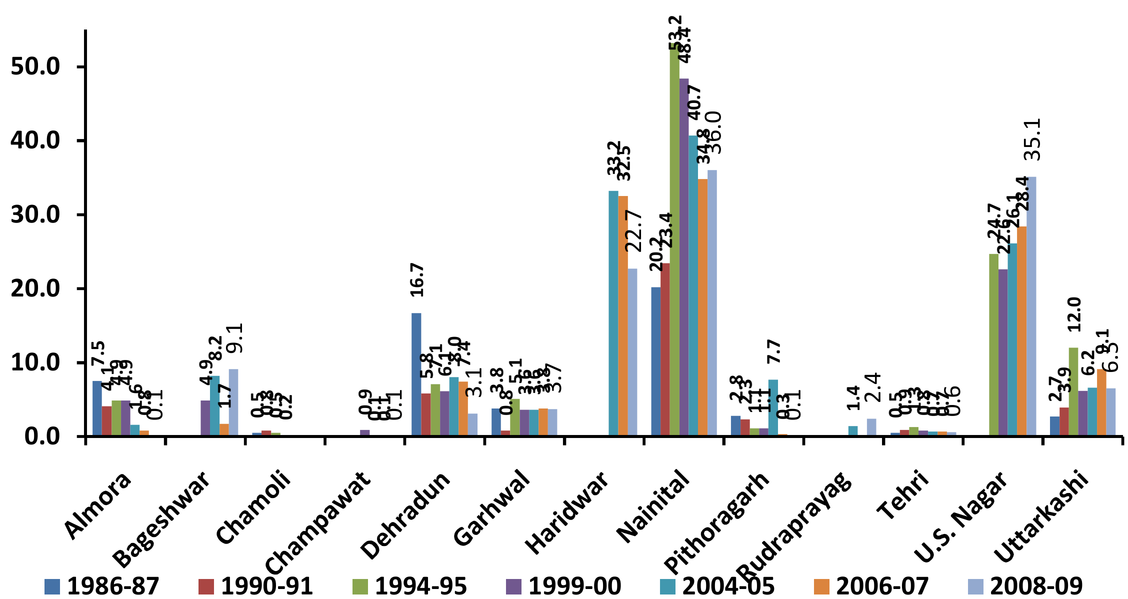

Figure 22: Irrigated Area (%) under Pulses across districts of Uttarakhand, 1986-87 to 2006-07

In absolute term, the larger area under pulses was irrigated in the district of Udham Singh Nagar (1202 ha), while it was only 35 percent of the total area cultivated for the production of pulses (Figure 22). Nainital (36%) recorded the highest proportion of irrigated land under pulses, while Haridwar, the other plain district had only 23 percent of irrigated land under pulses during 2006-07. Among rest of the districts, except Bageshwar, which recorded the proportion equal to the state average (9%), most of the districts had even less than 5 percent of irrigated land under pulses.

6.2.8. Area Irrigated under Oilseeds across Districts

A range of oilseeds like mustard, soybean, til, sunflower, groundnut, alsi etc. is produced in Uttarkhand. However, the dominant oilseed, which is cultivated throughout the state, is lahi/mustard with a total agricultural area of 15,925 ha (2006-07), of which only one-third area (5,931 ha) was irrigated. Other main oilseeds of the states like soybean and til recorded a total area of 8,504 and 2,065 ha under cultivation during 2006-07 respectively, but cultivation of both these oilseeds was largely rain-fed. The highest proportion of irrigated agricultural land under oilseeds was recorded in the district of Udham Singh Nagar (49%), closely followed by Dehradun (43%), and Nainital (31%) during 2006-07 (Figure 23). Most of the other districts except Haridwar (24%) were recorded with lesser proportion of irrigated land under oilseeds than that of the state average (21%) during 2006-07.

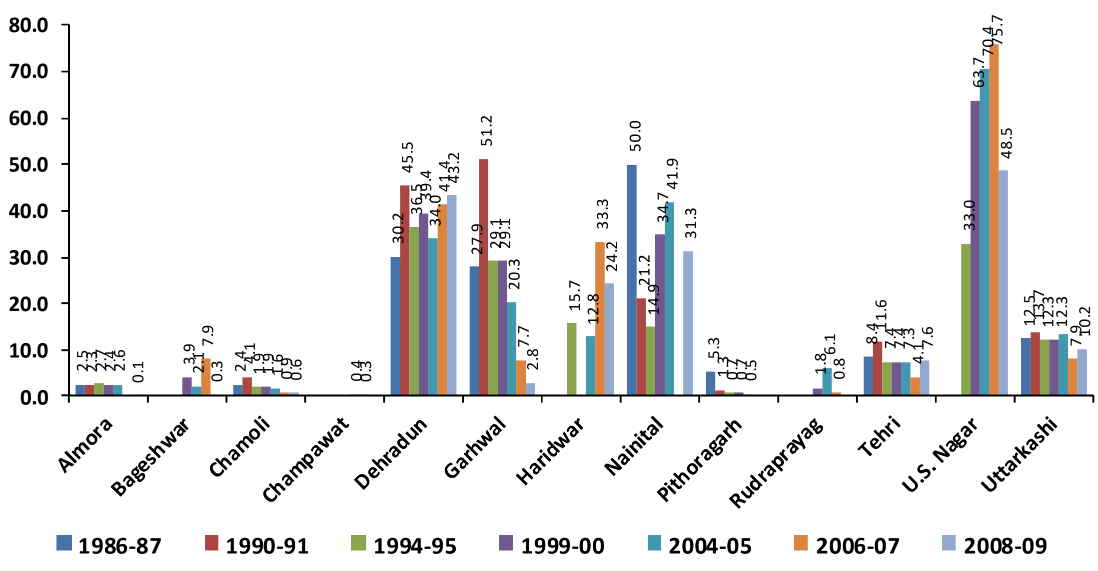

Figure 23: **Irrigated Area (%) under Oilseeds across districts of Uttarakhand, 1986-87 to 2006-07**

7. Consumption of Fertilizers and Pesticides

Uttarakhand is the part of Indo-Gangetic Plain, which constitutes mainly the alluvial soils (fluvisols). The latter are derived from the deposition of silts by numerous river systems. These soils are deficient in nitrogen (N), phosphorus, and organic matter. Generally, alluvial soils range from near neutral to slightly alkaline in reaction. The hill region has always been dependent upon the natural manures and organic farming, but to increase the agricultural production and to meet the requirements of the expanding population, it became imperative for the state to change the traditional methodologies, especially during the green revolution. Animal husbandry, once an integral and valued part of agriculture, is relegated to secondary importance, as chemical fertilizers replace dung, compost, mulch, etc.

The trend of fertilizer usage started in the late 60s with the green revolution. In Uttarakhand, the plain areas of Bhabhar and Tarai caught up fast with the trend of using high yielding varieties and agrochemical usage. However, the hills did not start using them in a big way. The use of fertilizers still is not very high in magnitude in the cereals but as far as vegetables are concerned, the usage of various agrochemicals is fast catching up with that of the plains[7]. The crop wise per hectare consumption of chemical fertilizers in the hill districts like Bageshwar, Pauri Garhwal, Uttarkashi, Nainital etc. are as high as 406 kg/ha in tomato, 365 kg/ha in sugarcane, 334 kg/ha in cabbage, 242 kg/ha in potato, 193 kg/ha in capsicum, 162-168 kg/ha in beans and pea etc. However, proportionately lower consumption of fertilizer was observed in the cultivation of paddy (97 kg/ha) and wheat (141 kg/ha).

The excessive use of chemical fertilizer, as more than 100 thousand tons of chemical fertilizer were consumed annually by the state during 1980's, contributed in the reduction of natural fertility of the soil, as well as the destruction of soil structure, aeration and water holding capacity. It also contributed in the indiscriminate killing of useful insects, microorganisms, and predators that naturally check excess crop damage by insects and pests; poisoning the food with high toxic pesticide residues; and the change in the natural taste of the produce. Figure 24 shows the level of fertilizer consumption and proportion of its constituent during 1980-81 to 2007-08. The graph clearly indicates that there has been a tremendous increase in the consumption of chemical fertilizer in the state from a level of only 37 thousand tons during 1980-81 to about 125 thousand tons during 2007-08. The contribution of nitrogenous among other compositions of the fertilizer has always been higher (more than 65%).

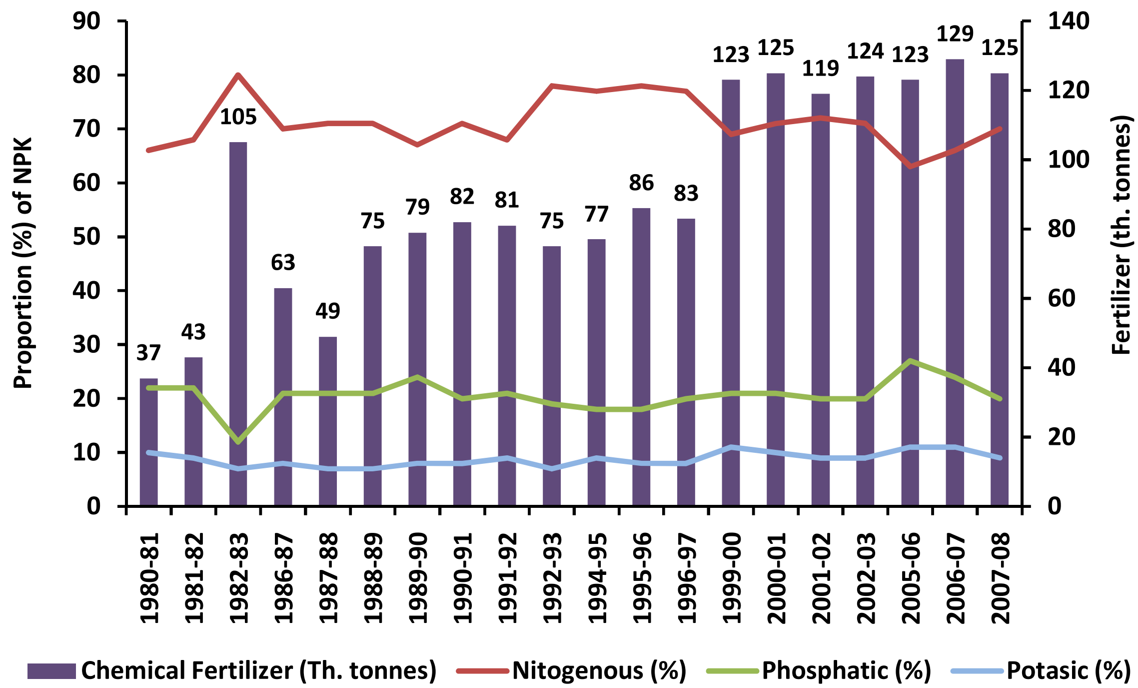

Figure 24: Consumption of Chemical Fertilizer, Uttarakhand, 1980-81 to 2007-08

Although, the level of pestiside consumption is very low compared to fertilizer and compared to other adjoining states during 2004-05, around 132 tonnes of pesticides were consumed by the state in total, compared to 310 tones in Himachal Pradesh[8]. Figure 25 shows the consumption of pesticides in g/100 ha of gross cropped area in Uttarakhand during 2000-01 to 2004-05. The consumption of pesticides in the state during 2002-03 and 2004-05, has been approximately 11g/100 ha of gross cropped area.

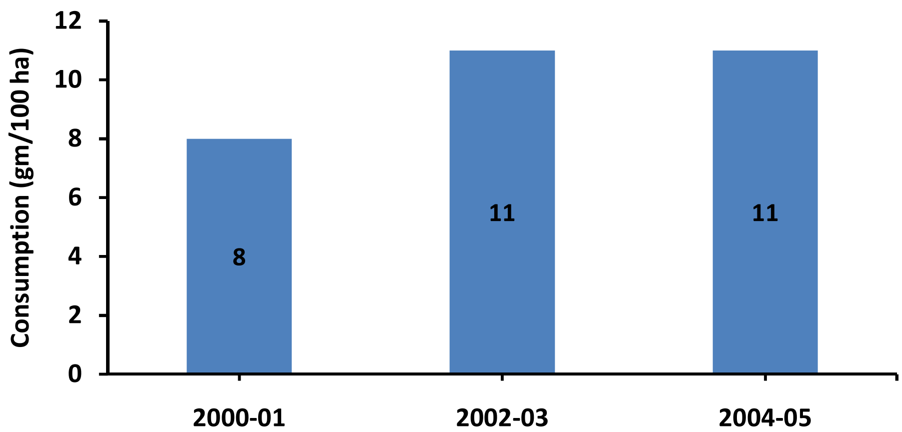

Figure 25: Consumption of Pesticides (gm/100 ha of GCA), Uttarakhand, 2000-01 to 2004-05

7.1. Consumption of Fertilizers across Districts

Figures 26a and 26b show the proportion of three main chemical fertilizers i.e. nitrogenous, phosphorous, and potasic consumed across the districts of Garhwal region and Kumaon region respectively. The highest proportion of nitrogenous fertilizer was consumed in Haridwar (76%) during 2007-08, closely followed by Pauri Garhwal (74%), Dehradun (73%), Udham Singh Nagar and Almora (70% each). However, the larger proportion of phosphorous fertilizer in total chemical fertilizer was consumed in Uttarkashi (55%) during 2007-08, followed by Chamoli (44%), Tehri Garhwal (38%), and Rudraprayag (35%). Potasic fertilizer was reportedto be consumed mostly in Champawat (12%), followed by Udham Singh Nagar (11%), Uttarkashi (10%), Nainital (9%), and Pithoragarh (7%).

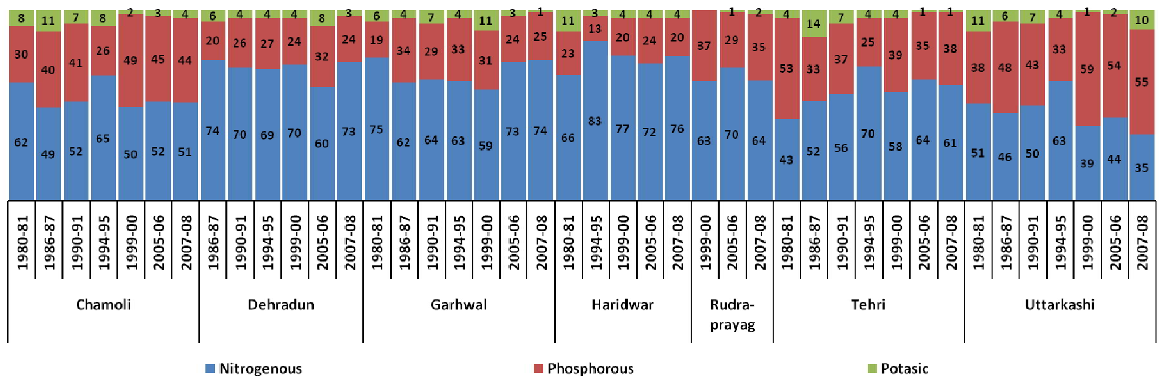

Figure 26a: Fertilizer consumption (%) across Districts of Uttarakhand (Garhwal Region), 1980-81 to 2007-08

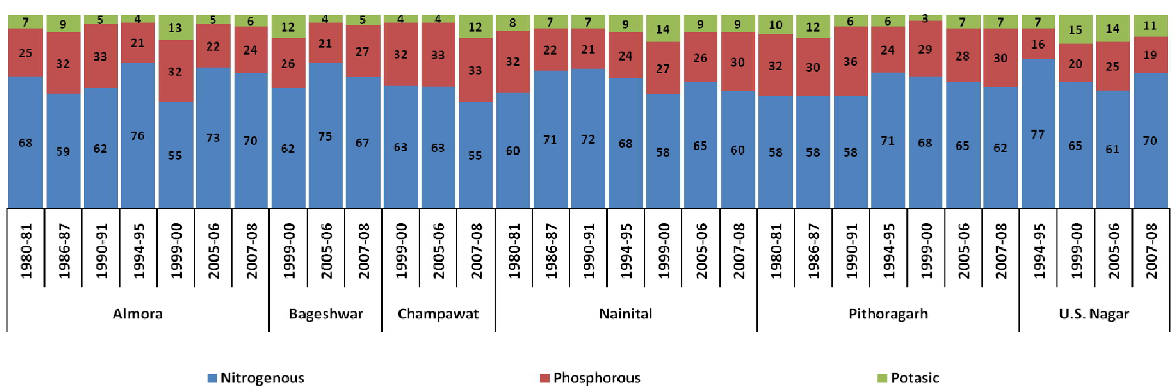

Figure 26b: Fertilizer consumption (%) across Districts of Uttarakhand (Kumaon Region), to 2007-08

8. Mechanization and Power Resources

Quinquennial census of agricultural equipments and other farm machines (Figure 27) suggest that there has been a continuing growth in the number of tractors and sprayers per thousand ha of gross cropped area.

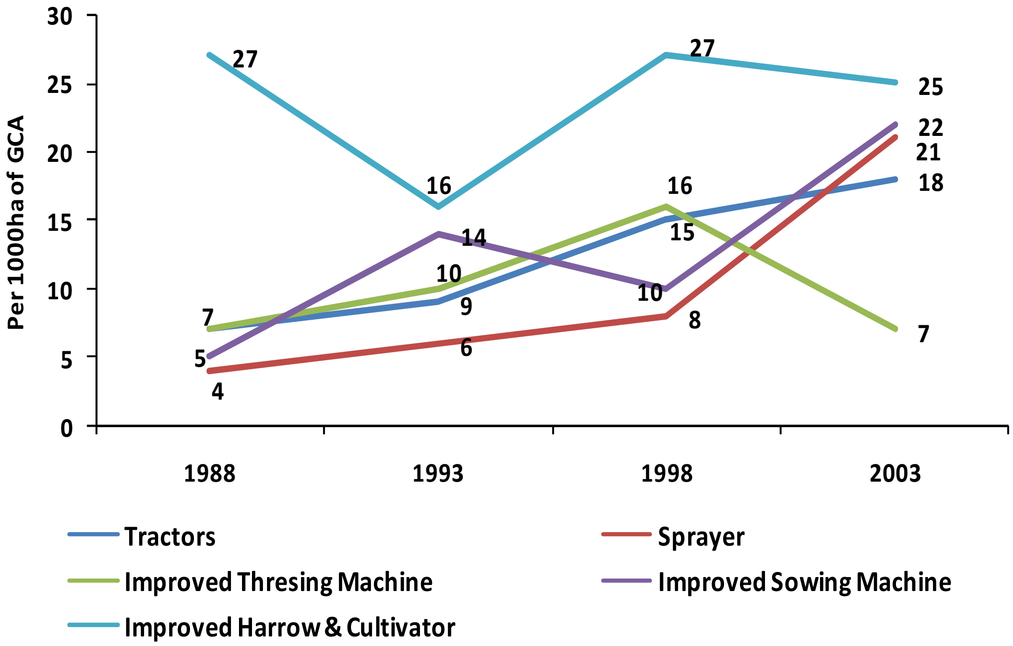

Figure 27: **Use of Tractors, Sprayers & Improved Farming Machines, Uttarakhand, 1988-2003**

Figure 28 shows the use of pump-sets and tube-wells per 1000 ha of gross cropped area in Uttarakhand. The graph suggests a tremendous increase in the level of boring pump-sets per 1000 ha in the state. It grew from a level of 18 per 1000 ha during 1987-88 to 40 per 1000 ha during 2007-08. However, the number of tube-wells and pumping sets per 1000 ha has been growing almost steadily, barring a few exceptions. The number of tube-wells per 1000 ha has been nearly 6 to 7, while the data for pumping sets indicate that it has been maintaining with 1 pumping set per 1000 ha of gross cropped area in the state since 1991-92.

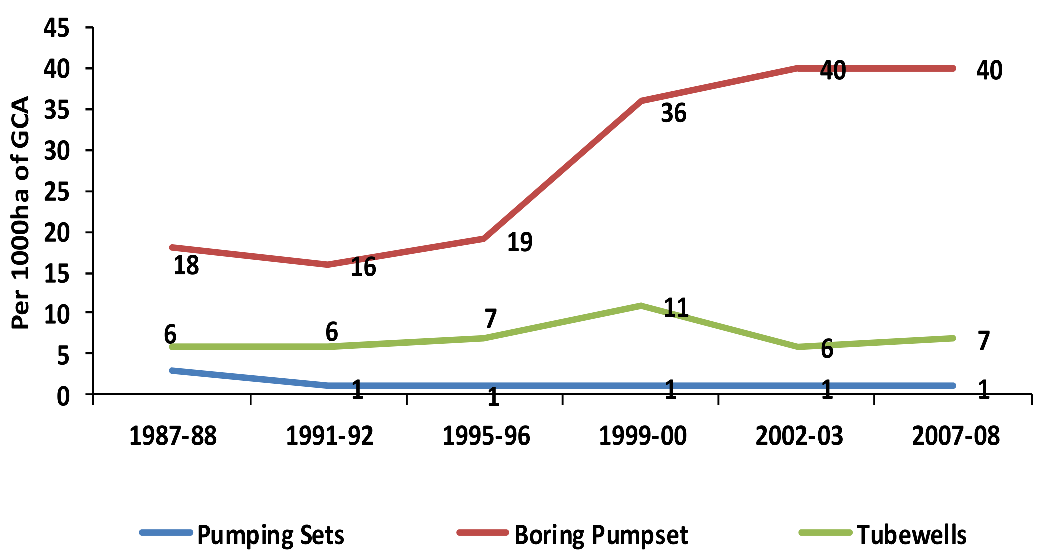

Figure 28: **Use of Pump-sets & Tube-wells, Uttarakhand, 1987-88 to 2007-08**

8.1. Operation of Tube-wells

As the higher proportion of tube-well irrigation in the districts of plain region has been reported, Udham Singh Nagar with the highest number of tube-wells operated during the cultivation confirm the same. Figure 29 illustrates that the district of Udham Singh Nagar has continuously been recording more than seven thousand of tube-wells operated during each agricultural season compared to a very low number observed in the other districts of the states. Only Nainital and Dehradun seem to be closely following the level of Udham Singh Nagar with approximately 500and 300 numbers respectively.

Although the data for Haridwar could not be shown in the graph due to lack ofdata for all selected years, nonetheless, the district has also approximately 500 tube-wells operating in the recent agricultural seasons. While Tehri Garhwal has a steady rate of growth in the number of tube-wells operated during each agricultural season, Champawat and Pauri Garhwal districts appear to show an increasing trend in the use of tube-wells.

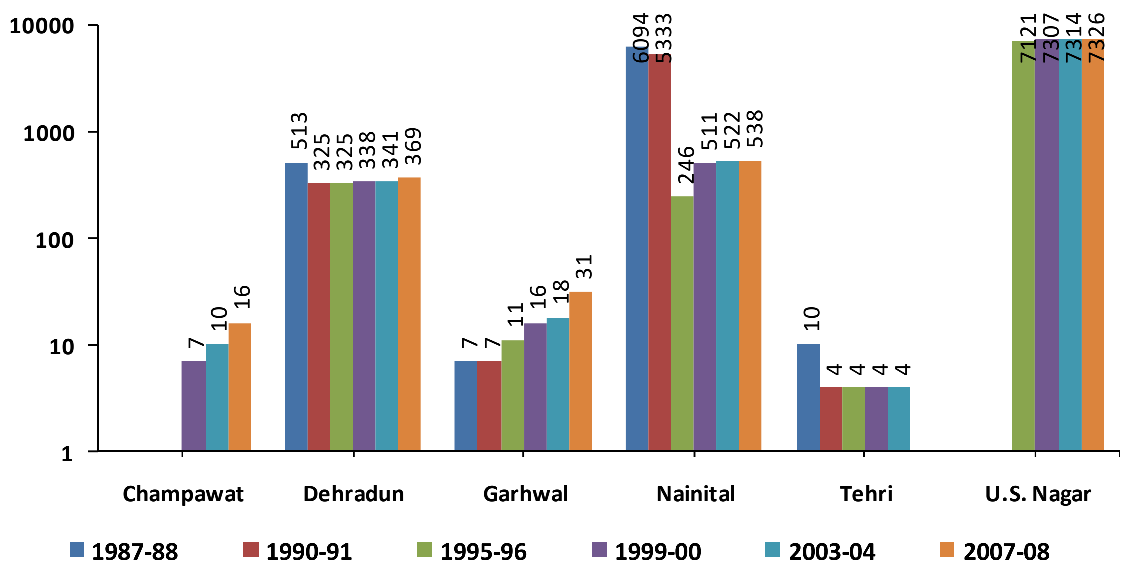

Figure 29: Tube-wells operated (No.) across Districts of Uttarakhand, 1987-88 to 2007-08

8.2. Operation of Pumping Sets

Figure 30 shows the number of boring or pumping sets operated in each agricultural season across districts of Uttarakhand. Haridwar leads with almost 26,593 pumping sets during 2007-08, closely followed by Udham Singh Nagar with 20,655 pumping sets. Other districts with more than 500 pumping sets operated during the agricultural season 2007-08 were Nainital (891) and Dehradun (632). However, as per the trends (Figure 30), the growth in number of pumping sets has been very small over the period with no apparent change since the level of 1995-96.

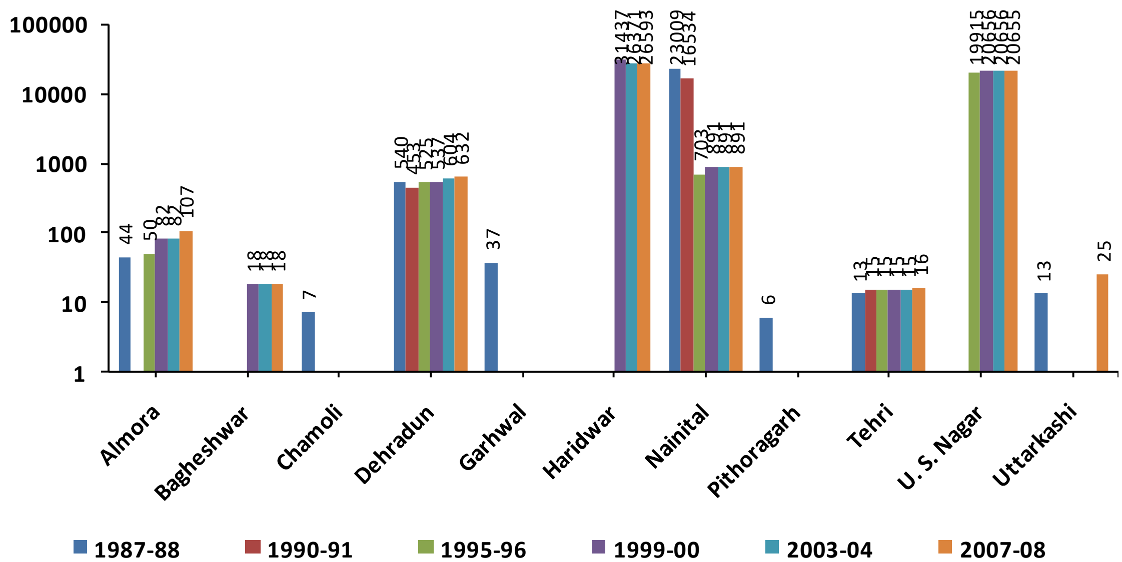

Figure 30: **Boring Pumpsets/Pumping sets operated (No.) across Districts of Uttarakhand, 1987-88 to 2007-08**

9. Crop Output

Cropping intensity is an indicator of intensive use of agricultural land. Figure 31 suggests that the cropping intensity in general, even in hilly region of the state, is very high. More than one crop is sown in an agricultural field in a season. Pithoragarh recorded the highest crop intensity of 184 percent during 2003-05, followed by Bageshwar (180), Udham Singh Nagar (171), and Nainital (169). It is important to note that Haridwar, even being the district in the plain region, had the lowest cropping intensity of only 144 percent compared to other districts in the state. This is due to the fact that the district has a significant area under sugarcane, and sugarcane is an annual crop, which is harvested once in a year.

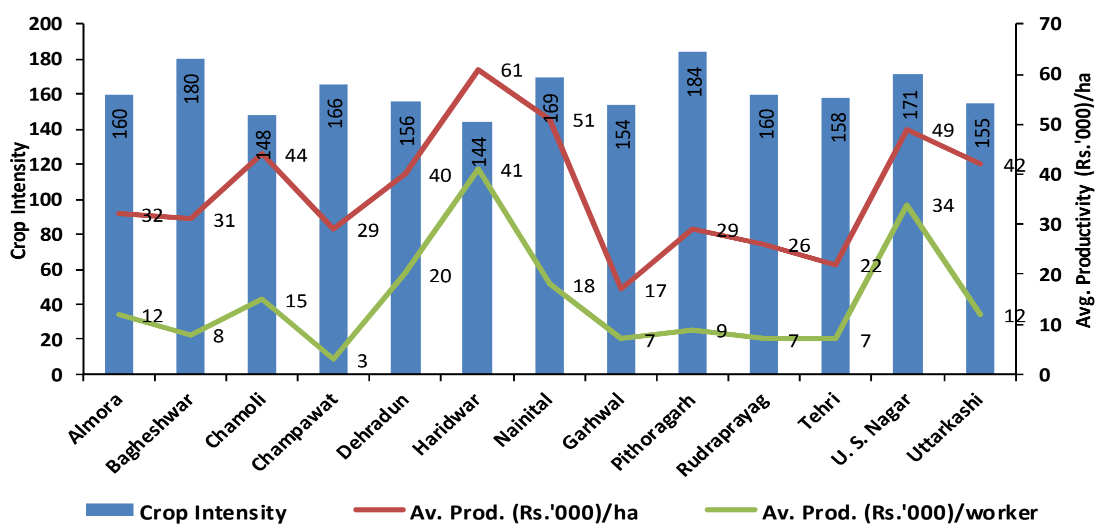

Figure 31: **Crop Intensity and Average Productivity across Districts of Uttarakhand, 2003-05**

Figure 31 also illustrates the average productivity across districts of Uttarakhand in terms of monetary gain with respect to agricultural area and the agricultural workers involved during the agricultural season 2003-05. Haridwar stood out among the other districts of the state with an average productivity of Rs 61,000 per hectare and Rs 41,000 per worker during 2003-05, closely followed by Udham Singh Nagar with an average productivity of Rs 49,000 per hectare and Rs 34,000 per worker.

The crop output may, to some extent, be correlated with the crop intensity. However, thisis not the case instances. Productivity of the crop not only depends upon the use of agricultural fields to produce the crop, but also depends upon various factors like soil fertility, use of fertilizer, variety of seeds, irrigation facilities, etc. The yield of the crop is a direct indicator of crop productivity. Figure 32a shows the average yield of different crops in the state during 1986-87 to 2009-10. The trend suggests that the productivity of the two main and traditional crops of the state i.e. rice and wheat has the highest productivity among major food grains and crops over the years. During 2009-10, the average yield of wheat was recorded 2,140 kg/ha, compared to 2,090 kg/ha of rice. Other two major food grains barley and maize had an average yield of 1,100 and 1,400 kg/ha respectively. Pulses was recorded with lowest average yield of 700 kg/ha, while the oilseeds recorded around 1,100 kg/ha during the same period.

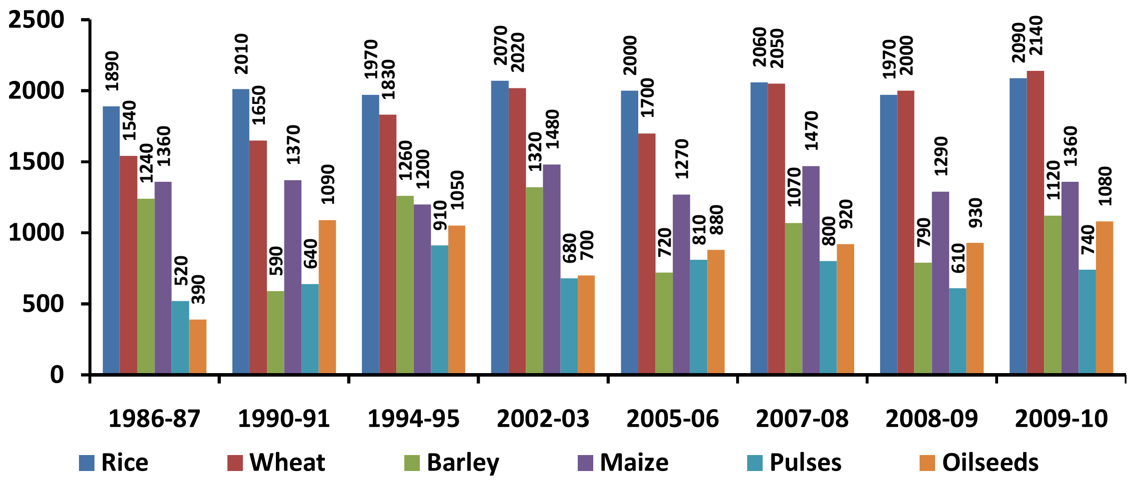

Figure 32a: Average yield (kg/ha) of major crops, Uttarakhand, 1986-87 to 2009-10

The most productive crop in the state, which has generated impressive monetary benefits to the farmers of the plain region in the state, is no doubt, the sugarcane. Figure 32b shows the average yield of sugarcane in the state during 1986-87 to 2009-10, and the datasuggests that the sugarcane has been recording an average yield of more than 50,000kg/ha over the period. The production of sugarcane, however, is limited to a few districts in the state like Haridwar, Udham Singh Nagar, Nainital, Dehradun, Pauri Garhwal, etc. Although, the recent data for the other very productive crop or vegetable i.e. potato was not available, the average yield of potato has been around 15,000kg/ha in the state, and grown almost in all the districts of the state.

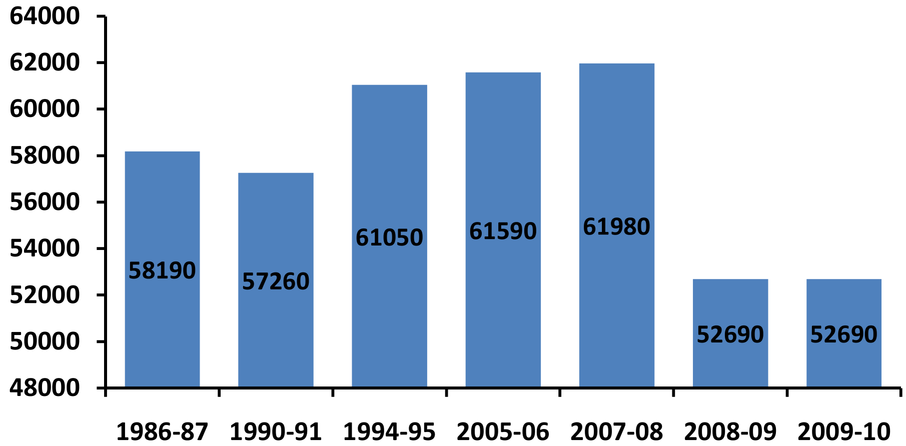

Figure 32b: Average yield (kg/ha) of Sugarcane, Uttarakhand, 1986-87 to 2009-10

9.1. Rice

Figures 33a and 33b represent the average yield of rice (kg/ha) across districts of the Kumaon and the Garhwal region of Uttarakhand during 1986-87 to 2005-06 respectively. However, there is no specific reason in presenting the yield of rice for districts by two separate regions (and the other crops too in succeeding sections), except the separation would provide a more clear picture and trend. During 2005-06, the highest average yield of rice was recorded by Udham Singh Nagar (2,800 kg/ha), closely followed by Nainital (2,700 kg/ha), and Dehradun (2,100kg/ha). Among the rest, except Haridwar (1,800 kg/ha) which was somewhat closer to the state average (2,000kg/ha), all other districts were quite below the average yield level of rice in the state. While, most of the districts show not a clear trend over the years with highs and lows, Haridwar stands out with continuously decreasing average yield of rice in the state.

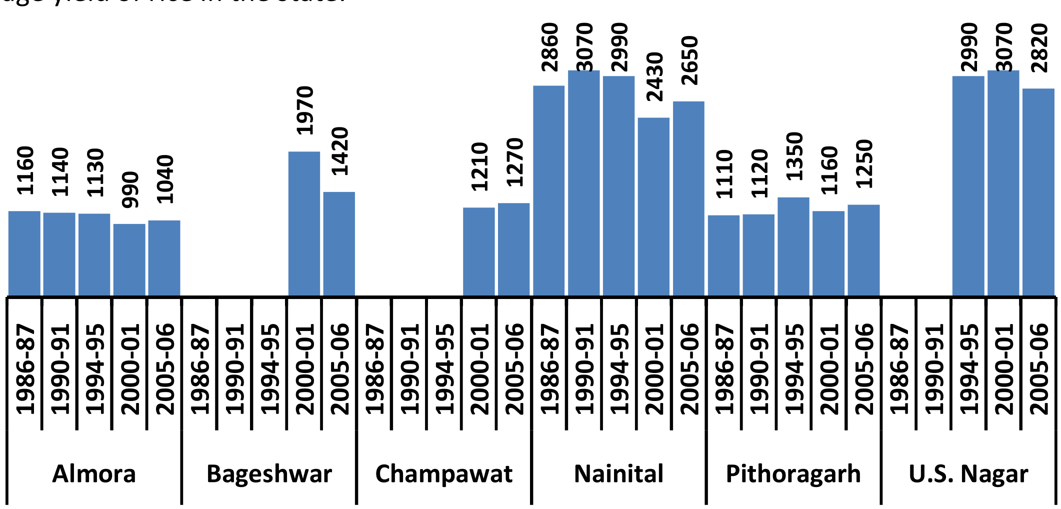

Figure 33a: Average yield of Rice in kg/ha across Districts of Uttarakhand (Kumaon Region), 1986-87 to 2005-06

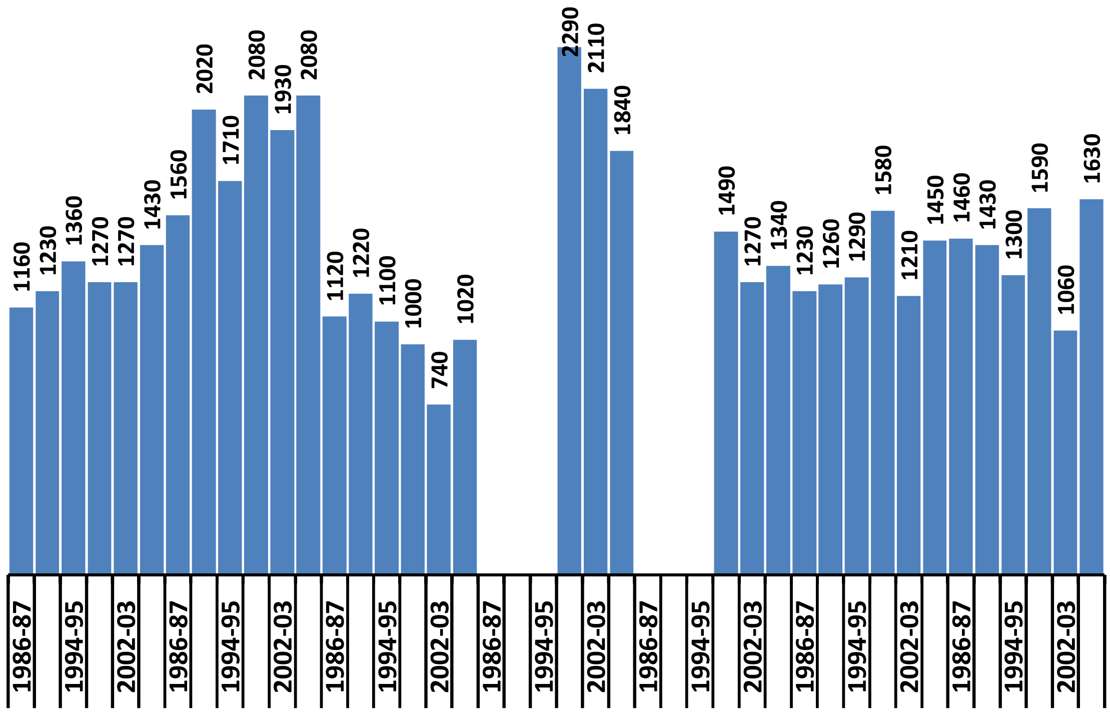

Figure 33b: **Average yield of Rice in kg/ha across Districts of Uttarakhand (Garhwal Region), 1986-87 to 2005-06**

9.2. Wheat

There were only three districts in the state namely Udham Singh Nagar, Haridwar, and Nainital, which recorded an average yield of wheat more than the state average of 1,700kg/ha. These districts in order recorded an average yield of wheat as 3,000 kg/ha, 2,400 kg/ha, and 2,200 kg/ha respectively. Other districts which recorded more than the average yield of 1,000 kg/ha, were Dehradun with 1,500 kg/ha, Champawat and Pithoragarh with 1,200kg/ha each, Uttarkashi (1,100 kg/ha), Tehri Garhwal and Rudraprayag with 1,000 kg/ha each.

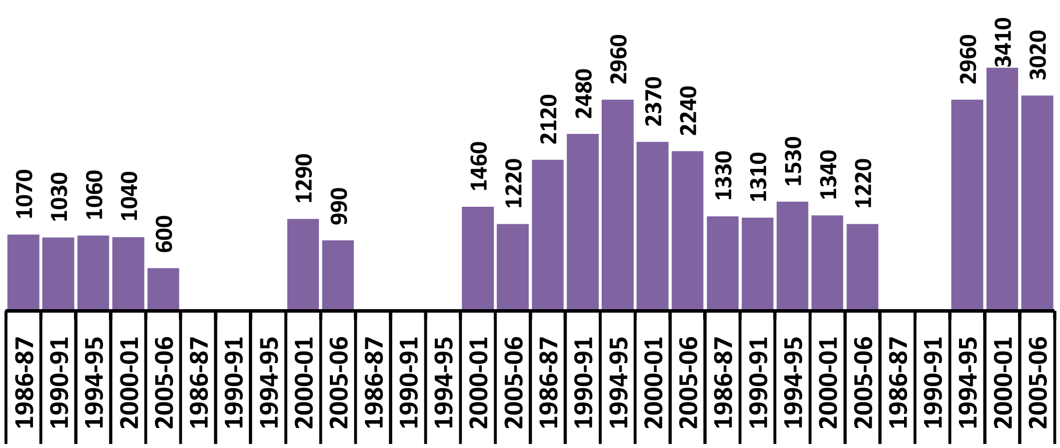

Figure 34a: **Average yield of Wheat in kg/ha across Districts of Uttarakhand (Kumaon Region), 1986-87 to 2005-06**

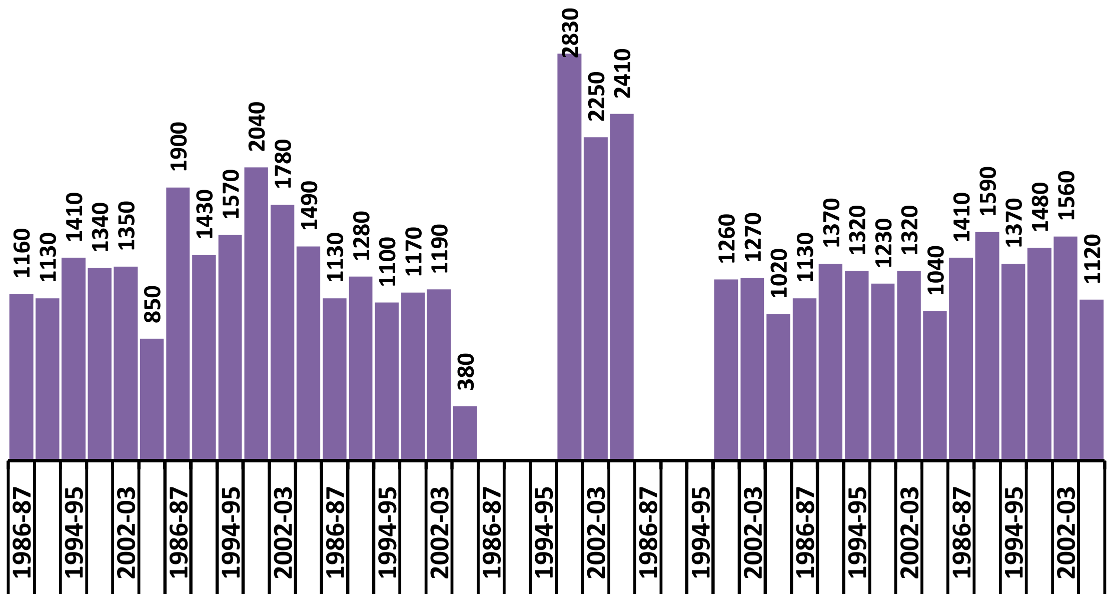

Figure 34b: **Average yield of Wheat in kg/ha across Districts of Uttarakhand (Garhwal Region), 1986-87 to 2005-06**

9.3. Pulses

During 2005-06, the only district, which managed to make an increase in the state average yield of pulses, was Tehri Garhwal with a tremendous increase in the productivity of pulses with an average yield of 2,700kg/ha. Other districts had a very low yield compared to the state average (800kg/ha).

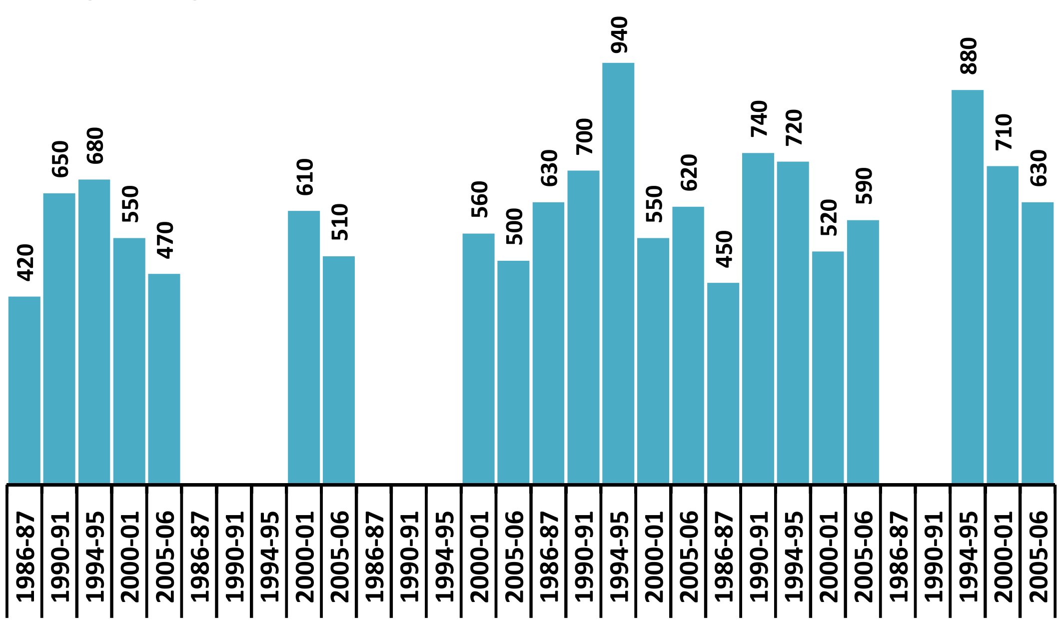

Figure 35a: **Average yield of Pulses in kg/ha across Districts of Uttarakhand (Kumaon Region), 1986-87 to 2005-06**

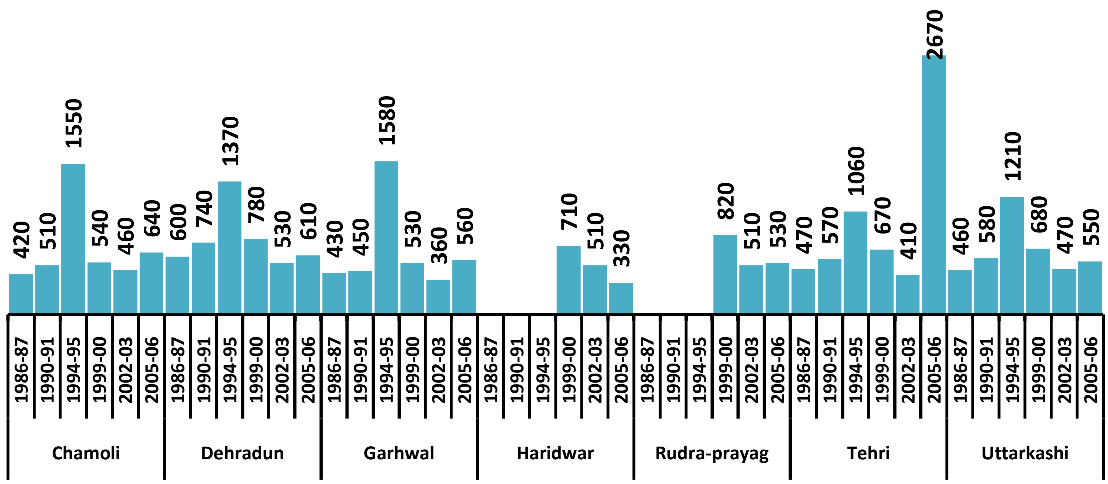

Figure 35b: **Average yield of Pulses in kg/ha across Districts of Uttarakhand (Garhwal Region), 1986-87 to 2005-06**

9.4. Oilseeds

The highest average yield of oilseeds was observed in the district of Pithoragarh in Uttarakhand during 2005-06, which was around 1,400kg/ha. Other districts which were close to this yield were Tehri Garhwal and Nainital districts with around 1,200 kg/ha each. Rest of the districts in the state appeared to record an average yield lower than the state average of nearly 900 kg/ha (see Figure 36a and 36b).

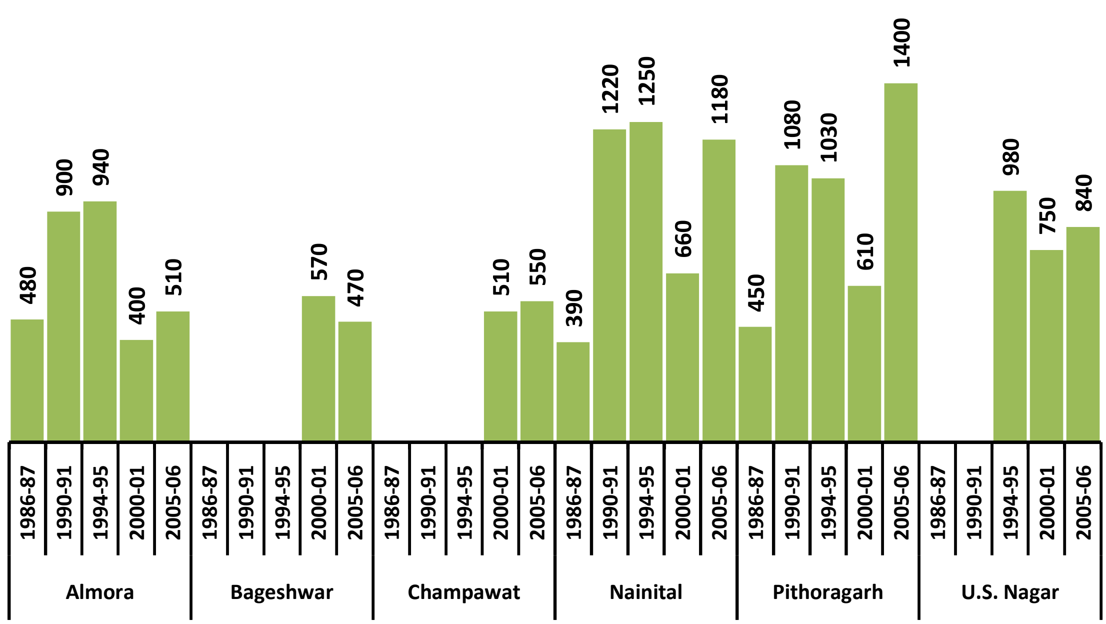

Figure 36a: **Average yield of Oilseeds in kg/ha across Districts of Uttarakhand (Kumaon Region), 1986-87 to 2005-06**

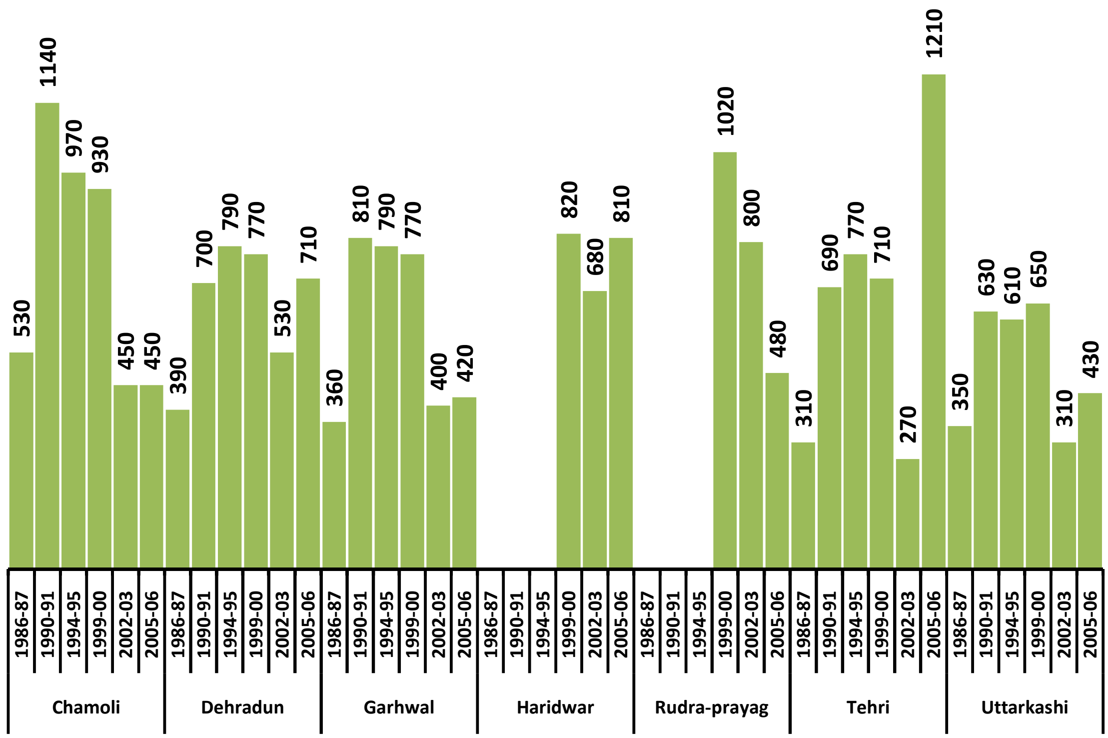

Figure 36b: Average yield of Oilseeds in kg/ha across Districts of Uttarakhand (Garhwal Region), 1986-87 to 2005-06

9.5. Sugarcane

The highest productivity among all crops grown in the state is considered to be of sugarcane. However, the cultivation of sugarcane is limited to only half of the districts in the state as shown in Figure 37. The average yield of sugarcane in the state is around 60,000kg/ha, which does not differ largely across the state. As per Figure 37, the highest average yield of sugarcane was recorded by Dehradun (65,800 kg/ha) during 2005-06, closely followed by Haridwar (62,200kg/ha) and Pauri Garhwal (61,000kg/ha). During the same period, Udham Singh Nagar and Nainital observed an average yield of 59,600kg/ha each.

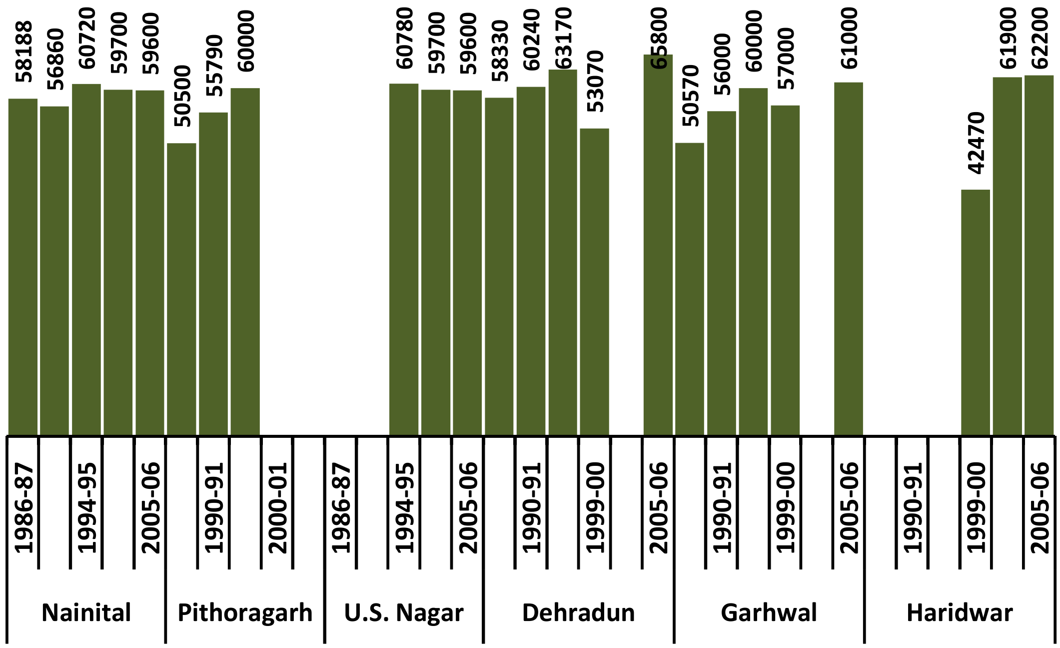

Figure 37: **Average yield of Sugarcanein kg/ha across Districts of Uttarakhand, 1986-87 to 2005-06**

9.6. Potato

Figures 38a and 38b represent the average yield of potato across the districts of Kumaon and Garhwal region during 1986-87 to 2005-06 respectively. The highest average yield of potato in the state was recorded by the district of Chamoli (19,000 kg/ha) during 2005-06, followed by Haridwar, Udham Singh Nagar, and Pauri Garhwal with 17,500kg/ha each.

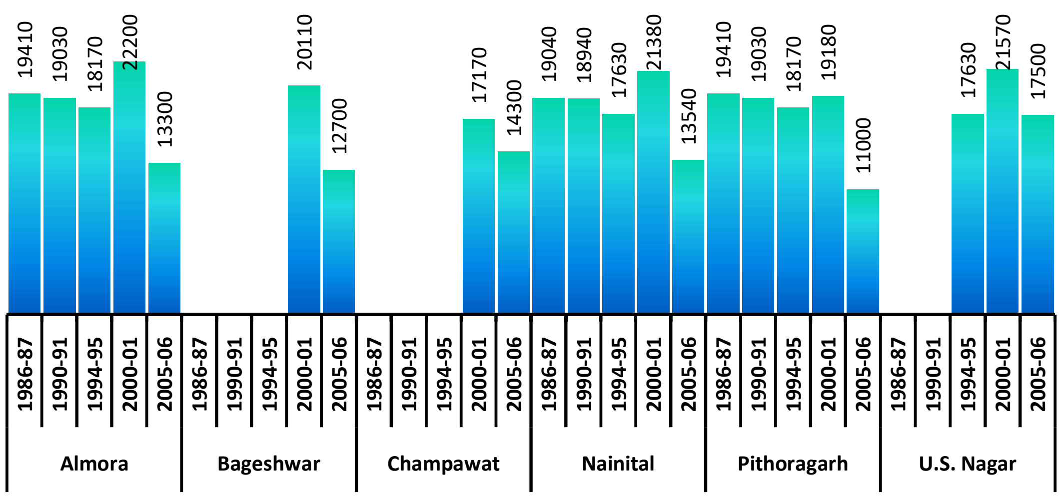

Figure 38a: **Average yield of Potato in kg/ha across Districts of Uttarakhand (Kumaon Region), 1986-87 to 2005-06**

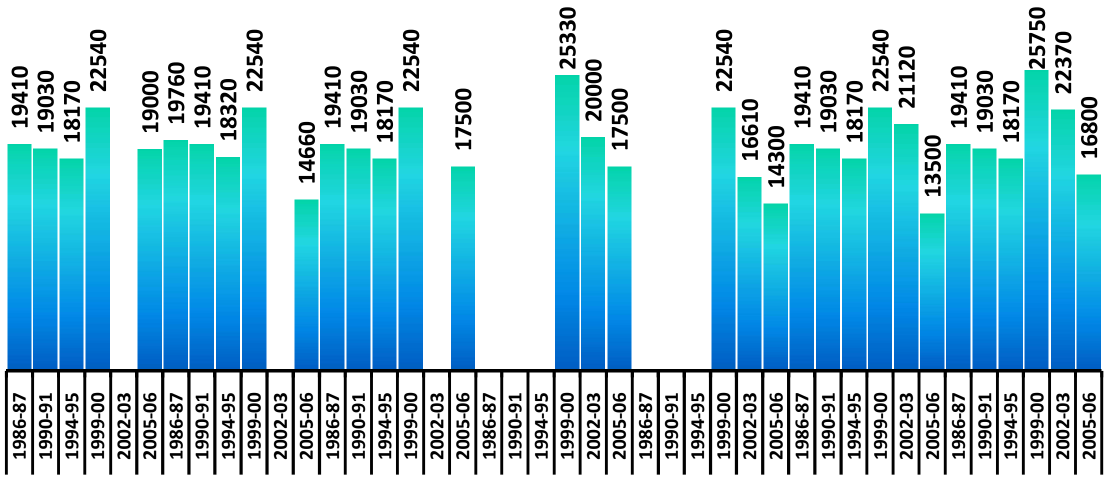

Figure 38b: **Average yield of Potato in kg/ha across Districts of Uttarakhand (Garhwal Region), 1986-87 to 2005-06**

10. Cost and Returns in Major Crops

In this section, data, information and analysis on costs and returns in major crops, fertilizer consumption, human labour and draught power utilization are presented. The main intent is to arrive at the most profitable crop (cropping pattern) from the point of view of farmers and sustainable agriculture. Data for this purpose are collected from www.indiastat.com.

10.1. Economics of Sugarcane Cultivation

Sugarcane is one of the most important crops grown by the farmers in the plain region of the state. It is grown on irrigated land and requires relatively more number of irrigation cycles as compared to other competitive crops. Availability of ground and surface water in the Ganga canal command and sugarcane price policy motivate the farmers to bring more cultivated areas under sugarcane crops. Apart from a number of small-scale units of sugarcane processing, there are about 11 sugar mills working in the state. Table 1 shows the cost and returns in the sugarcane crops for the last 5 years. As the table reveals, both per hectare value of sugarcane output (main product + by-product) and per hectare cost (C) in nominal term have significantly increased over the period. The trend in the net income indicates that cultivation of sugarcane in the basin area has remained profitable to the farmers. Net returns from the crop have increased from Rs 21,173 in 2002-03 to Rs 33,234 in 2006-07. However, the increase was mainly due to rise in sugarcane prices, as per hectare yield of sugarcane has actually declined during the period. During 2007-08, per hectare yield has significantly increased over the preceding year, but net income declined mainly due to decline in the per unit price. The ratio of value of output (VOP) to C is calculated to know the returns on investment. The ratio was found to be lowest (1.69) during 2002-03 and the highest (2.01) during 2005-06. A ratio of 2.01 indicates that if a farmer spends Rs 1 on the cultivation of sugarcane, he/she gets Rs 2.01.

Table 1: Costs and Returns in Sugarcane, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of Cultivation (C), Rs	Net Income,Rs	Ratio of VOP to C	Yield, kg./ha	Chemical Fertilizer, kg/ha	Human labour, hours/ha	Draught power, hours/ha
2002-03	52,018	30,845	21,173	1.69	57,900	264	1159	-
2003-04	52,093	25,164	26,928	2.07	59,200	134	991	-
2004-05	57,079	29,568	27,511	1.93	50,400	315	1145	-
2005-06	62,343	30,995	31,349	2.01	49,100	134	1009	3
2006-07	63,421	33,234	30,187	1.91	46,100	192	1051	-
2007-08	61,629	32,716	28,913	1.88	52,600	87	727	0.51

Consumption of chemical fertilizer in sugarcane crop varies across years. It was found to be the lowest (87 kg/ha) in 2007-08 and the highest (315 kgs/ha) during 2004-05. On an average, one hectare of sugarcane cultivation absorbs about 1,014 human hours of labour, which is equivalent to 127 man-days. The labour absorption was observed to be the lowest (727 hrs/ha) during 2007-08 and the highest (1,159 hrs/ha) during 2002-03.

10.2. Economics of Wheat Cultivation

Wheat is another important crop grown in the area. It is grown in the entire state. Table 2 shows the cost and returns from the wheat cultivation. As is evident from the table, VOP has been greater than the cost of production only in three out of the five years. Net income is negative during 2002-03 and 2004-05. The ratio of VOP to C indicates that except for the last three years, the farmers growing wheat did not get any profit from wheat crop. The loss was observed to be the highest during 2002-03. Per hectare yield was quite low. It ranges from 2,200 kg/ha to 2,600 kg/ha. Fertilizer consumption was also found low as is obvious from Table 2. Human labour absorption does not show any trend. The number of labour hours was recorded the highest (496 hrs/ha) during 2003-04 and the lowest (423 hrs/ha) during 2005-06. On an average, one hectare of wheat cultivation provides about 58 days of employment. Draught power use in the wheat cultivation was the highest during 2003-04 and the lowest during 2005-06.

Table 2: Costs and Returns in Wheat, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C), Rs	Net income, Rs	Ratio of VOP to C	Yield, kg/ha	Chemical Fertilizer, (kg/ha)	Human labour (hours/ha)	Draught power (hours/ha)
2002-03	17,681	18,923	-1242	0.93	2,200	56	484	122
2003-04	18,710	18,644	66	1	2,400	51	496	123
2004-05	20,824	20,,934	-110	0.99	2,600	77	478	114
2005-06	21,041	20,114	927	1.05	2,300	48	423	58
2006-07	25,854	24,998	856	1.03	2,500	49	445	72
2007-08	31,573	25,152	6421	1.26	2,600	43	470	60

10.3. Economics of Paddy Cultivation

Table 3 shows cost and returns in paddy cultivation. The paddy cultivation recorded negative profit in the first two years and then generated profit in the subsequent years. The ratio of VOP to C was observed to be the lowest during 2002-03 (0.97) and the highest (1.34) during 1997-98. Per hectare yield of paddy ranges from 2,800 kg/ha to 3,800 kg/ha. Per hectare use of chemical fertilizer in paddy varies from 55 kg/ha to 91 kg/ha. On an average, one hectare of paddy cultivation provides about 88 days of employment. Animal labour (a pair of bullocks) use in paddy shows variation across years. It shows rise and fall over the period.

Table 3: Costs and Returns in Paddy, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C)	Net income, Rs	Ratio of VOP to C	Yield kg/ha	Chemical Fertilizer (kg/ha)	Human labour (hours/ha)	Draught power (hours/ha)
2002-03	17,201	17,690	-489	0.97	2,800	80	778	114
2003-04	18,144	18,560	-417	0.98	3,100	91	790	95
2004-05	19,855	18,553	1302	1.07	3,100	62	691	90
2005-06	22,557	21,308	1249	1.06	3,500	79	659	52
2006-07	26,134	21,896	4238	1.19	3,800	66	672	37
2007-08	26629	19811	6818	1.34	33	55	632	44

10.4. Economics of Barley Cultivation

Table 4 shows the cost and returns from the barley crops. Farmers growing barley crops incurred heavy losses during 2003-04 and 2004-05, as value of output was much lower than the cost of cultivation during both the periods. The ratio of VOP to C was as low as 0.47 during 2003-04. This indicates that if a farmer spends Rs 1 for growing barley, he/she gets only Rs 0.47 as value of output. Low productivity (1,200 to 1,400kg/ha) and lack of remunerative prices are the main reasons for the negative profitability in barley cultivation. Labour absorption in the cultivation of barley ranges between 682 hours/ha to 698 hours/ha. Animal power utilization is relatively higher in barley than that in wheat.

Table 4: Costs and Returns in Barley, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C)	Net income, Rs	Ratio of VOP to C	Yield, kg/ha	Chemical Fertilizer, kg/ha	Human labour, hours/ha	Draught power, hours/ha
2003-04	8,780	18,806	-10,026	0.47	1,200	Not Available	682	280
2004-05	11,819	19,248	-7,428	0.61	1,400	Not Available	698	200

10.5. Economics of Mustard Cultivation

Costs and returns from mustard (oilseed) crop are shown in Table 5. As is evident from the data presented in the table, VOP from mustard crop has been higher than C during 2002-03, 2003-04 and 2007-08. As a result, farmers growing this crop during these two years earned profit. However, the farmers growing this crop during 2004-05 incurred losses, as VOP was much lower than C. The ratio of VOP to C varies significantly across years, indicating to the volatility in the net income of farmers from the crop. Yield of mustard ranges between 500kg/ha to 1,100kg/ha. Low yield during 2004-05 is the main reason for the negative profitability. Fertilizer consumption was also much lower during 2007-08 than during 2002-03. Human labour and animal labour use in mustard varies across years.

Table 5: Costs and Returns in Mustard, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C)	Net income, Rs	Ratio of VOP to C	Yield kg/ha	Chemical Fertilizer, kg/ha	Human labour, hours/ha	Draught power, hours/ha
2002-03	26,169	10,955	15,214	2.39	1,000	61	353	63
2003-04	11,456	10,898	558	1.05	600	-	666	20
2004-05	7,955	11,819	-3,864	0.67	500	32	309	65
2007-08	23,840	14,661	9,179	1.63	1,100	11	279	6

10.6. Economics of Gram Cultivation

Gram is mostly grown on rain-fed farms. Table 6 shows that per hectare VOP declined from Rs 15,258 during 2003-04 to Rs 15,022 during 2004-05. Similarly, C declined from Rs 12,114 to Rs 11,893. Consequently, net returns remain almost the same. Profitability and yield of the crop remained the same during both the periods. However, labour utilization slightly declined and animal labour slightly increased during 2004-05 over the preceding years.

Table 6: Costs and Returns in Gram, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C)	Net income, Rs	Ratio of VOP to C	Yield kg/ha	Chemical Fertilizer, kg/ha	Human labour, hours/ha	Draught power, hours/ha
2003-04	15,258	12,114	3,145	1.26	900	Not Available	343	5
2004-05	15,022	11,893	3,129	1.26	900	Not Available		8

10.7. Economics of Maize Cultivation

Maize cultivation is not found profitable for the farmers. As Table 7 indicates, in all the years under study, there has been net loss to the farmers. The cost has remained much higher than the returns. The ratio of VOP to C was estimated the lowest (0.51) during 2003-04 and 2004-05. It was estimated the highest (0.85) during 2005-06, followed by 2007-08. The yield of maize ranges between 1,200kg/ha to 1,600kg/ha which is quite low. The data presented in the table suggest that both cost and returns in the maize cultivation are much lower than that are in 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 55 kg/ha. On an average, one hectare of maize cultivation provides about 80 days of works. Use of animal labour varies from 55 hours/ha to 78 hours/ha.

Table 7: Costs and Returns in Maize, Uttarakhand (Rs /ha)

Year	Value of Output (VOP)	Cost of cultivation (C)	Net income, Rs	Ratio of VOP to C	Yield,kg/ha	ChemicalFertilizer, kg/ha	Human labour, hours/ha	Draught power, hours/ha
2002-03	7,033	13,714	-6,681	0.51	1,339	67.64	821.90	61.34
2003-04	7,635	13,245	-5,610	0.58	1,307	71.81	809.74	64.24
2004-05	6,276	12,262	-5,986	0.51	1,206	58.44	596.62	55.06
2005-06	10,650	12,814	-2,164	0.83	1,419	41.34	557.85	62.19
2006-07	11,602	14,803	-3,201	0.78	1,641	42.18	500.00	62.21
2007-08	13,584	16,551	-2,967	0.82	1,502	50.12	470.00	77.93

11. Organic Farming

Uttarakhand is the first State of India to be declared an organic state. The Uttarakhand Organic Commodity Board (UOCB) has been constituted to promote organic farming in the state. About 10,000 hectare of land is under organic farming, covering about 15,000 farmers and 45 crops[9]. The state has ideal conditions for the organic farming, especially in the hill regions where chemical fertilizer consumption in various traditional cereal crops such as millets, barley, pulses, etc. is quite low due to various constraints. Promotion of organic farming is desirable for maintaining soil fertility, checking the groundwater degradation, protecting human health, reducing water requirement of crops, and finally decreasing the non-point sources of pollution of rivers. The major challenge before the state is to improve the livelihood of the people without losing out its biodiversity and other natural resources, including water resources. In this context, organic farming could be a viable option if the state encourages and supports the farmers by protecting their farm income, developing marketing infrastructure, putting in place the institution of certification, quality check branding, and training of farmers. It is observed that when a farmer shifts from conventional farming to organic farming, the initial level of productivity declines. However, later on, the productivity increases. In order to encourage farmers to adopt this alternative system of farming, their net income should be insured at least for two to three years either though providing subsidized inputs or through direct transfer of subsidies. This transfer could be much lower than the environmental and health costs that the society bears due to chemicalization of agriculture. In this section, an attempt is made to examine the cost and returns from organic as well as conventional farming in the state. The analysis is based on the data compiled from the studies conducted by the other researchers.

Table 8: Economics of Organic vs. Conventional Farming in Uttarakhand, 2008-09

Crop	Yield, kg/acre		Farm gate Price, Rs /kg		Value of Output, Rs /acre		Cost, Rs /acre		Net Return	
	OF	CF	OF	CF	OF	CF	OF	CF	OF	CF
Basmati	900	1,050	34.0	30.0	30,600	31,500	7,690	8,390	22,910	23,110
Non-basmati	1,620	1,800	8.5	8.5	13,770	15,300	7,600	7,800	6,170	7,500
Wheat	1,140	1,380	11.0	10.50	12,540	14,490	6,500	7,400	6,040	7,090
Finger millet	1,050	1,000	7.0	6.85	7,350	6,850	2,800	3,150	4,550	3,700
Maize	1,800	1,700	6.0	5.9	10,800	10,030	3,800	4,200	7,000	5,830
Barley	730	600	8.0	7.7	5,840	4,620	3,320	3,600	2,520	1,020
Sugarcane	28,700	30,000	1.5	1.4	43,050	42,000	13,740	14,500	29,310	27,500
Peas	3,600	3,800	18.0	17.0	64,800	64,600	10,870	10,070	53,930	54,530
Tomato	4,100	4,500	4.75	4.5	19,475	20,250	9,400	9,400	10,075	10,850
Potato	4,500	4,200	10.0	9.9	45,000	41,580	8,200	8,500	36,800	33,080
Cauliflower	4,200	4,400	4.50	4.3	18,900	18,920	9,980	9,180	8,920	9,740
Ginger/Turmeric	2,700	2,500	3000	28.0	81,000	70,000	5,500	5,400	75,500	64,600
Chilli green/red	2,500	2,800	7.0	6.5	17,500	18,200	7,800	8,600	9,700	9,600
Tulsi green	2,000	2,000	7.0	7.0	14,000	14,000	3,700	3,700	10,300	10,300
Coriander green*	2,800	2,500	20.0	19.0	56,000	47,500	7,800	8,350	48,200	39,150
French beans	3,000	2,750	9.0	8.5	27,000	23,375	4,000	4,500	23,000	18,875
Soybean	500	400	21.0	20.0	10,500	8,000	4,000	4,500	6,500	3,500
Rajma	550	500	54.0	52.0	29,700	26,000	4,000	4,500	25,700	21,500
Arbi	3,000	2,700	8.0	8.0	24,000	21,600	5,700	5,900	18,300	15,700
Mustard	600	650	20.0	18.0	12,000	11,700	4,500	4,200	7,500	7,500
Onion	11,000	10,500	5.5	5.5	60,500	57,750	8,450	8,350	52,050	49,400
Avaregae	3,857	38,920	14.0	13.29	28,777	27,060	6,636	6,866	22,142	20,194

Source: Prepared from Singh J. (2009), Impact Assessment study of Center of Organic Farming I &II, Uttarakhand State http://www.srtt.org/institutional_grants/pdf/COF.pdf

* Typically this year the price of coriander green was exceptionally high.

Singh (2009)[10] conducted a study on organic versus conventional farming in Uttarakhand. The study was based on a sample survey of 310 farmers collected from 13 development blocks, namely, Gadarpur, Bajpur, Kashipur, and Jaspur in Udham Singh Nagar district; Raipur, Kalsi, Sahaspur, and Vikasnagar in Dehradun district; Doiwala and Narsan in Hardwar district; Betalghat and Ramgarh in Nainital district; and Tarikhet in Almora district. Table 8 shows the comparison of costs and returns in organic and conventional farming among 21 crops. Per acre yield, farm gate prices, total value of output per acre, cost per acre and finally net income per acre are examined in case of these crops. A perusal of Table 8 reveals that out of 21 crops, nine crops have slightly lower yield per acre from organic farming compared to conventional farming. These crops are paddy (both basmati and non-basmati), wheat, sugarcane, peas, tomato, cauliflower, chili, and mustard. Millet, barley, maize, potato, ginger, coriander, French beans, soybean, rajma, arbi, and onion achieved higher yield under organic farming than that in conventional farming. There were no differences observed in the yield of rest of the crops.

As far as farm gate prices of various crops are concerned, it was observed that prices of 18 commodities were higher under organic farming than the conventional farming. This shows that the premium prices were received by the farmers growing organic products. However, the difference is insignificant in case of most of the crops as is evident from the data shown in Table 8. Per acre cost of cultivation is higher in conventional farming than that in organic farming in case of most of the crops as shown in Table 8. Thus, higher market prices and lower cost of cultivation of organic crops are the major advantages of the organic farming. However, net returns in some of the crops are lower under organic farming than conventional farming mainly due to yield differences. On an average, one acre of land under organic farming provides net income of Rs 22,142, whereas the corresponding net income from conventional farming is Rs 20,194. This implies that in spite of lower average productivity of land under organic farming, the net returns are higher because of lower cost and premium prices.

Singh andSingh (2006)[11] compared the costs and returns in paddy and wheat crops under organic farming vis-à-vis non-organic farming in Kashipur block of Udhamsingh Nagar district of Uttarakhand. The study was based on primary data collected from 90 farmers (45 organic and 45 non-organic) during 2004-05. The costs and returns from these two crops are shown in Table 7. The yields from organic and non-organic paddy have been found as 2,686 kg/ha and 3,274 kg/ha, respectively. However, farmers could realize relatively higher prices for organic (Rs 13.80/ kg) produce than non-organic (Rs 11.61/kg.). Net returns over cost C have been found higher in organic farming than in non-organic farming mainly because of lower C and higher premium prices of organic paddy. In case of wheat, per hectare yield was much lower (1,985 kg/ha) in organic farming than in non-organic farming (2,812 kg/ha). Cost C in organic wheat was lower (Rs 16,138/ha) than that in non-organic wheat (Rs 20,847/ha). However, the price per kgof organic wheat has been higher (Rs 8.75/kg) than that in non-organic wheat (Rs 7.80/kg). Although per hectare cost of cultivation of organic wheat was lower than that of non-organic, the high yield difference between the two makes the organic wheat farming non-profitable for the farmers.

12. Conclusions

- Net Sown Area as percentage of the total area has declined in the recent years. This is a matter of concern from the point of view of food security and sustainability of livelihood of people.
- At the State level, area under non-agricultural uses has increased significantly, especially in the plain districts of the state.

- There has been marginalization of agricultural holdings in the State. Percentage of number of marginal holdings has remarkably increased whereas number of all other categories of holdings has declined.
- Percentage of GIA to GCA has also significantly increased, with highest percentage of GIA shared by the groundwater resources in the plain districts of the State.
- Sugarcane, wheat and rice together comprise the largest share in the GIA. These crops consume the maximum quantity of available water. Huge quantity of water could be saved by changing the cropping pattern from these crops to the 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 use in rice, wheat and sugarcane crops.
- The use of chemical fertilizer in agriculture has increased significantly. Further, fertilizer consumption was found much higher in the plain districts than that in the hill districts.
- Number of pump sets per 1000 ha of GCA has increased over the period, particularly in the plain districts. The rapid growth of number of pump sets in the basin area has some implications for the sustainability of groundwater. The flat rate electricity tariff system prevailing in the State encourages extraction of more groundwater for irrigation as marginal cost of drawing extra unit of water is almost zero for farmers.
- The trend in cropping pattern indicates that the cropping pattern is dominated by sugarcane, wheat, and rice in the plain districts of the state, while in the hill regions most of the farmers grow traditional food crop, soybean, medicinal plants, and vegetables.
- Productivities of most of the crops including wheat, rice and sugarcane were observed to be the higher in the plain areas than that in the hill areas.

13. Suggestions

- Scope of modern input-intensive agriculture in the hill districts of the state is quite limited due to physical, environmental and economic reasons. Farmers of hill regions have natural advantage of cultivation of organic farming. Organic farming should be promoted in the state, including the plain areas through state support. Since, in case of most of the crops net returns from organic farming is lower than the non-organic farming. Farmers willing to adopt organic farming system must be compensated initially either through input-subsidization or through direct transfer.
- 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-farming and organizational skills.

- 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.
- 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 compensated by providing subsidy on procurement of modern water saving technology, such as, sprinkler and drip irrigation in these blocks.
- 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 efficient use of scarce land and water resources. Rice-wheat-sugarcane system of farming being adopted in plains of the Ganga basin would not be 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.
- Horticulture and agro-forestay have the potential to generate additional livelihood opportunities to the rural households. There is need to converge the scheme of NHM with the activities of MGNREGS. Annual Action plans and labour budget prepared for 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.
- Apart from horticulture and agro-forestry, dairy, poultry and fishing are other alternative livelihood options within the agriculture and allied sector that could be included as components in the overall basin management plan. There is need to construct a network of ponds, even on the private land, especially in the agriculturally developed plain districts of the state. These ponds, if planed properly, would help not only in 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 execute works related to horticulture, minor irrigation, land development, construction of ponds, etc. on the private land too. Field surveys carried out in five districts of the states, namely, Chamoli, Champawat, Tehri, Udhamsingh Nagar and Haridwar district to review the systems and assess the

impact of MGNREGS revealed that there is scope for development of horticulture and fishery in the state through effective dovetailing and convergence of MGNREGS with other schemes.

- District-wise land-use pattern reveals that the area under pastureland has been shrinking and not adequate for supporting the livestock of the state. It is necessary to initiate for development programme at large scale in the hill districts to grow more fodder on forest land (both under panchayat and forest department) and on waste and barren land. Community participation through PRIs is required to manage and share the benefit of fodder development programme.
- Transportation of agricultural commodities from the remote hill villages to the market places is the major problem. It is therefore, necessary to diversify the hill agriculture from traditional crops to high value and low volume products, such as herbal and medicinal plants, aromatic plants, mushroom, spices, soybean and pulses, off-season vegetables and fruits. Primary processing of some of the above mentioned products can be done in the village itself and secondary and tertiary processing may be done in the industrial clusters. This would not only help in reducing the volume but also make value addition to the growers. Self-help groups (SHGs) could be formed and trained to do the primary processing.

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Appendix

Table A1: Trend in sectoral distribution of GSDP product at factor cost and constant prices

Year	Agriculture (%)	Forestry (%)	Primary (%)	Manufacturing (%)	Secondary (%)	Tertiary (%)	GSDP (Rs Lacs)
				At 1993-94 Prices			
1993-94	33.84	4.72	40.1	14.19	23.36	36.54	568557
1994-95	32.82	4.07	38.59	18.46	26.97	34.44	618735
1995-96	35.24	4.46	41.21	12.36	22.24	36.54	617420
1996-97	33.37	3.44	37.86	15.34	24.77	37.38	657128
1997-98	32.6	3.75	37.22	12.63	23.1	39.67	668874
1998-99	32.82	4.61	38.67	9.19	21.46	39.86	679984
				At 1999-00 Prices			
1999-00	27.09	2.72	30.99	9.18	18.55	50.46	1278613
2000-01	26.21	1.97	28.89	11.33	21.62	49.5	1427911
2001-02	23.36	1.94	26.09	9.87	23.24	50.66	1505644
2002-03	21.88	1.92	24.5	11.96	25.76	49.73	1648873
2003-04	21.51	1.83	24.84	12.01	25.26	49.9	1776023
2004-05R	20.44	1.76	23.43	12.38	27.04	49.53	1954003
2005-06P	19.04	1.5	22.01	12.08	29.47	48.51	2137194
2006-07Q	17.83	1.44	20.52	12.39	31.65	47.83	2330396

Table A2: Land use pattern and irrigated area, Uttarakhand, 1986-87 to 2008-09

Year	Reported Area[1]	Forest	Cultivable Barren Land	Current Fallow	Other Fallow	Barren & Uncultivable land	Non-Agri-cultural Land	Grazing Land	Miscellane-ous[2]	Net Sown Area	Area sown more than once	Gross Cropped Area	Land pre-pared for Sugarcane	Net Irrigated Area	Gross Irrigated Area
1986-87	5404114	3435922	318809	11818	44900	298917	124432	272275	208097	688891	223274	1150309	309	226055	362457
1987-88	5376163	3424218	319289	11513	45094	298659	125225	272260	208594	671308	215115	1102772	480	247917	359020
1988-89	5384093	3424218	319867	11042	45925	298477	125669	272247	208364	678280	428450	1106730	99	223085	363976
1989-90	5372625	3438767	301781	7537	60553	284628	131035	211586	204891	731769	167975	1188398	117	344673	383274
1990-91	5358595	3424857	317014	8198	63423	295518	136497	227393	216588	669107	171002	1099306	285	228610	373304
1991-92	5358704	3424725	315905	9445	63615	297953	135791	227989	218542	664739	166561	1088833	152	224305	374317
1992-93	5458847	3426526	315900	8394	64317	296671	136977	227498	219936	662629	436870	1099498	48	209497	389148
1994-95	5369589	3435513	312158	7918	62968	290644	135076	218998	214059	692255	449379	1141635	29	245064	395152
1995-96	5361708	3428633	316407	7764	63896	294935	137156	229113	217974	665830	418165	1083995	26	225210	389469
1996-97	5362433	3428810	317786	7491	64407	297497	137578	227305	218084	663475	413409	1076834	56	238476	391051
1997-98	5387231	5309588	321908		64574	298033	138722	230696	221559	661215	408807	1069165	52	229752	391397
1998-99	5592361	3498447	324443	11257	67044	294756	166324	228940	217033	784117	475272	1248651	1413	342283	551054
1999-00	5614332	3514954	321871	13738	69153	293520	166256	221979	216452	797571	460533	1247583	3883	347813	546758
2000-01	5627061	3356895	314827	37339	70853	362200	227234	234060	251512	772141	453250	1211881	1838	343556	538896
2002-03	8415909	5080752	496859	47188	110421	558052	227957	232636	253783	758720	451433	1201691	3166	340944	532832
2004-05	5670120	3465057	308473	41683	68432	311817	229995	228944	248979	766737	467809	1234546	981	345224	549545
2006-07	5666878	3465057	366713	44064	64068	311849	160649	220286	250140	765150	447159	1212314	1600	345020	554013
2008-09	5672568	3485797	303144	35161	70967	224480	216534	198737	383987	753711	407451	1161162	—	340129	569719

[1]Total reported Area for land utilization

[2] Land under miscellaneous trees, crops, grooves etc. not included in net area sown

Table A3: Land use pattern and irrigated area across districts of Uttarakhand, 1999-2000

S. No.	Districts	Reported Area1	Forest	Cultivable Waste	Current Fallow	Other Fallow	Barren & Uncultivable land	Non-Agricultural Land	Grazing Land	Miscellane-ous2	Net Sown Area	Area Sown than Once	Gross Cropped Area	Net Irrigated Area	Gross Irrigated Area
1	Almora	589478	327733	46797	503	6079	25031	13573	47226	36158	86378	51850	138228	6915	13252
2	Bageshwar	139221	66236	12381	133	1609	6623	3590	12495	9566	26588	18684	45272	6070	11111
3	Chamoli	643957	438982	20767	57	1006	102716	11269	13593	22023	33544	17500	51044	1782	3406
4	Champawat	160419	65965	15057	314	3514	7243	4232	22772	12330	28992	15402	44394	2553	3914
5	Dehradun	316135	211691	13889	4373	5957	2076	21010	32	4440	52667	25420	78087	24246	35298
6	Garhwal	752364	443977	46127	151	18541	35584	18182	44998	63987	80817	44490	125307	7667	14837
7	Haridwar	230296	70873	2075	3702	3361	1989	26035	63	522	121676	58814	180490	101400	144581
8	Nainital	413394	302474	25502	997	4196	2853	8691	1147	15467	52067	32824	83038	29655	45475
9	Pithoragarh	476781	264385	36547	763	8530	17579	10274	55275	29928	53500	35751	89251	4662	7559
10	Rudraprayag	242708	127340	11670	32	656	57715	6332	7638	13375	19041	10020	29061	2413	4787
11	Tehri Garhwal	545240	367897	78515	61	9145	13179	11847	3074	24	61569	35547	97118	8506	16272
12	U. S. Nagar	286708	101111	3633	2609	2767	1196	24463	18	1154	149757	96432	237519	145703	234867
13	Uttarkashi	817631	726290	8911	43	3792	19736	6758	13648	7478	30975	17799	48774	6241	11399

[1] Total reported Area for land utilization

[2] Land under miscellaneous trees, crops, grooves etc. not included in net area sown

Table A4: Land use pattern and irrigated area across districts of Uttarakhand, 2004-05

S. No.	Districts	Reported Area1	Forest	Cultivable Waste	Current Fallow	Other Fallow	Barren & Uncultivable land	Non-Agricultural Land	Grazing Land	Miscellane-ous2	Net Sown Area	Area Sown than Once	Gross Croppe d Area	Net Irrigated Area	Gross Irrigated Area
1	Almora	465858	236179	42411	948	7783	25635	12625	30461	27211	82605	48659	131264	4988	9832
2	Bageshwar	213542	110160	16874	1954	3133	6829	4717	27486	20671	21718	17462	39180	4003	7943
3	Chamoli	847580	506100	48115	491	1096	158580	8021	49808	40500	34869	17896	52765	1585	2928
4	Champawat	238378	132337	15200	2917	6773	5426	4704	19078	26543	25400	16358	41758	2381	4283
5	Dehradun	368996	201831	64027	7720	7530	3638	21815	329	15131	46972	26537	73509	20864	33660
6	Garhwal	672852	385099	38453	7832	18246	35838	15472	35179	56056	80677	42832	123509	7707	14271
7	Haridwar	231117	72431	2061	2601	3905	2488	26656	51	758	120166	53473	173639	107164	150269
8	Nainital	406433	298336	26801	3338	3018	1251	9277		17828	46584	33307	79891	28016	40153
9	Pithoragarh	410692	205239	40599	1275	4363	20848	10079	53326	26891	48072	39517	87589	3962	7056
10	Rudrapryag	235421	179895	3004	686	680	7257	8008	4308	11600	19983	11457	31440	2617	5100
11	Tehri Garhwal	485766	322051	5304	7056	5776	5469	7812	593	146	61256	37987	99243	8519	16496
12	U. S. Nagar	281070	93738	3285	2512	2894	986	25275	46	1262	151072	107944	259016	148358	248470
13	Uttarkashi	812415	721661	2339	2353	3235	37572	5231	8279	4382	27363	14380	41743	5060	9084

[1]Total reported Area for land utilization
[2] Land under miscellaneous trees, crops, grooves etc. not included in net area sown

Table A5: Land use pattern and irrigated area across districts of Uttarakhand, 2008-09

S. No.	Districts	Reported Area[1]	Forest	Cultivable waste	Current Fallow	Other Fallow	Barren & Uncultivable land	Non-Agricultural Land	Grazing Land	Miscellane-ous[2]	Net Sown Area	Area Sown than Once	Gross Cropped Area	Net Irrigated Area	Gross Irrigated Area
1	Almora	464942	236184	38269	1529	6950	25235	12527	28319	33989	81940	40097	122037	5759	11351
2	Bageshwar	207902	110160	14024	1902	1530	6267	5129	19801	24635	24454	17871	42325	5866	11689
3	Chamoli	851764	506100	10302	308	697	71116	61209	27865	141500	32667	14424	47091	1692	3286
4	Champawat	233225	132337	13516	2690	9301	6173	4589	17395	23997	23227	13323	36550	2012	3720
5	Dehradun	364830	203659	44870	8684	21945	3975	22868	34310	59469	78220	32587	110807	7368	14152
6	Garhwal	669055	385044	32078	5770	8092	33330	15925	14753	14596	46247	20117	66364	19382	32374
7	Haridwar	286495	100648	3056	2941	3368	1573	30079	30	814	143986	123210	267196	141533	259446
8	Nainital	406308	298236	22280	1681	2066	1569	9683	118	21606	49069	27694	76763	28045	40214
9	Pithoragarh	411883	205299	39588	2430	5262	20573	11016	45673	39477	42565	30756	73321	3597	6506
10	Rudraprayag	234796	180365	2578	195	367	6876	3460	4623	15677	20655	12841	33496	2608	5205
11	Tehri Garhwal	485517	321564	78007	3536	5670	5568	7181	477	1970	61544	8089	69633	8824	17009
12	U. S. Nagar	243162	84537	1716	2761	3780	2773	27395	68	1756	118376	52488	170864	108241	155272
13	Uttar Kashi	812689	721664	2860	734	1939	39452	5473	5305	4501	30761	13954	44715	5202	9495

[1]Total reported Area for land utilization
[2] Land under miscellaneous trees, crops, grooves etc. not included in net area sown

Table A6: Number and area of operational holdings by size class (ha.) of agricultural land, Uttarakhand, 1985-86 to 2000-01

Year	Marginal Holdings (Less than 0.5 ha.)		Marginal Holdings (0.5 to 1 ha.)		Marginal Holdings (Less than 1 ha.)		Small Holdings (1-2 ha.)		Semi-Medium Holdings (2-3 ha.)		Semi-Medium Holdings (2-4 ha.)	
	Number	Area	Number	Area	Number	Area	Number	Area	Number	Area	Number	Area
1985-86	—	—	—	—	519874	180029	117711	161230	45941	112648	—	—
1990-91	399234	100627	184392	114264	583626	214891	133942	187211	25484	61189	69013	170635
1995-96	591487	97600	199417	136167	790904	233767	152701	213899	—	—	81402	229992
2000-01	420877	95945	206990	146477	627867	242422	158402	220727	—	—	77415	212385

Table A7: Number and area of operational holdings by size class (ha.) of agricultural land, Uttarakhand, 1985-86 to 2000-01 (contd.)

Year	Holdings (3-5 ha.)		More than 5 ha.		Medium Holdings (4-10 ha.)		Large Holdings (More than 10 ha.)		All Holdings	
	Number	Area	Number	Area	Number	Area	Number	Area	Number	Area
1985-86	32082	121699	30653	329219	—	—	—	—	745261	904823
1990-91	15693	58629	5509	39990	25127	126392	1893	37788	807661	737880
1995-96	—	—	—	—	28813	158624	1840	43850	928480	880132
2000-01	—	—	—	—	24163	132199	1421	35628	890667	1026631

Table A8: Number and area of operational holdings by size class (ha.) of agricultural land across districts of Uttarakhand, 2000-01

S. No	Districts	Marginal Holdings (Less than 1 ha.)		Small Holdings (1-2 ha.)		Semi-Medium Holdings (2-4 ha.)		Medium Holdings (4-10 ha.)		Large Holdings (More than 10 ha.)		All Holdings	
		Number	Area	Number	Area	Number	Area	Number	Area	Number	Area	Number	Area
1	Almora	94273	39424	21798	29646	5734	14610	501	2561	16	385	122322	86626
2	Bageshwar	49798	16400	4673	6137	761	1970	68	379	3	41	55303	24927
3	Chamoli	26399	8944	7607	10881	3848	10364	810	4222	19	395	38683	34806
4	Champawat	26890	10736	6444	8777	2106	5486	371	1954	27	466	35838	27419
5	Dehradun	50419	17287	8460	12085	5226	14430	1740	9535	140	2999	65984	56336
6	Garhwal	43839	20440	24412	34965	14627	39356	3552	19111	129	1773	86559	115645
7	Haridwar	78690	31609	20981	28637	12034	33193	4462	24347	177	2929	116344	120715
8	Nainital	32733	10626	8362	11903	6196	17091	2371	13516	261	5604	49923	58739
9	Pithoragarh	75256	27420	9663	12947	1898	4839	164	856	14	276	86995	46338
10	Rudraprayag	25493	9352	4726	6539	1347	3481	168	919	6	79	31713	20369
11	Tehri Garhwal	56053	23471	17927	24897	5206	16426	875	4522	18	269	80079	69575
12	U.S. Nagar	43908	19333	17055	24236	14014	39008	8009	44718	584	20078	83570	147373
13	Uttarkashi	24543	7381	6294	9078	4418	12131	1072	5559	27	334	36354	34483

Table A9: Total agricultural area and irrigated area (ha) under major crops, Uttarakhand, 1986-87 to 2006-07

Year	Rice		Wheat		Barley		Maize		Madua		Sawa		Total Food grains	
	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1986-87	277985	147841	376465	154095	35122	996	34777	736	—	—	—	—	442975	75275
1987-88	261265	141439	362227	149775	32346	1239	32078	952	—	—	—	—	397098	72191
1988-89	261041	141771	362221	152247	30624	882	35186	1310	—	—	—	—	412690	77194
1989-90	283108	151192	391186	161600	34405	1114	34204	453	—	—	—	—	1318937	74487
1990-91	267646	148233	359053	152111	27367	884	29892	482	—	—	—	—	392616	71201
1991-92	252273	142556	353481	153809	29798	990	34283	564	—	—	—	—	—	—
1992-93	259440	150923	358378	162079	27686	1072	29162	631	—	—	—	—	379063	73281
1993-94	260649	154274	362587	165514	27416	829	31850	528	145309	1182	22026	0	898063	322328
1994-95	280470	160024	371392	160347	28407	837	31681	529	145482	111	77613	8	935055	321856
1995-96	261414	154133	341822	155573	29725	880	28781	466	139867	184	71876	6	873493	311242
1996-97	259699	153988	339778	151467	26968	652	30981	664	137150	20	71838	5	866426	306796
1997-98	267018	162123	337573	144973	26978	380	33259	607	131617	68	67492	6	863944	308722
1998-99	305053	199934	386697	191094	27100	656	35683	325	283094	39	72040	28	961006	392085
1999-00	295106	199742	387807	191638	18172	629	34096	924	137190	58	68035	42	945744	392653
2002-03	275409	174429	374802	191058	25664	496	12378	158	74071	16	34642	0	868679	359900
2004-05	288987	187663	387102	202353	24180	536	29575	482	131006	39	67272	1	917416	388550
2006-07	281181	181865	391345	198734	25597	581	31552	965	108999	0	67854	14	1003061	382117

Table A10: Total agricultural area and irrigated area (ha) under major crops, Uttarakhand, 1986-87 to 2006-07 (contd.)

Year	Urad		Moong		Lentil		Gram		Pea (Matar)		Arhar		Total Pulses	
	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1986-87	7758	61	213	8	16789	1097	2760	865	1940	800	1673	5	31123	3060
1987-88	7846	90	191	8	16134	1046	2489	786	1673	808	1707	7	30042	2899
1988-89	7827	101	179	9	16253	1079	2116	842	1226	513	1722	1	27395	2697
1989-90	7283	318	4	0	15848	910	1871	753	1439	475	267	4	18443	2201
1990-91	7063	0	4	0	15920	988	1905	706	1722	607	1680	0	31360	2536
1991-92	6921	67	72	0	15084	980	1765	824	2160	793	1530	13	30729	2972
1992-93	6873	68	0	0	14484	952	1566	844	1628	615	1509	12	29425	2744
1993-94	9978	163	195	117	14235	1004	1560	801	1626	496	1627	134	29275	2715
1994-95	9347	194	163	101	15226	869	1770	1064	2322	828	1744	8	24008	2962
1995-96	9420	174	202	143	15284	852	1568	849	2528	920	1735	28	30781	2966
1996-97	9590	214	205	120	15273	801	1410	678	2212	995	1748	8	30837	2816
1997-98	9343	163	85	82	14414	792	1146	553	2234	1021	1763	10	28987	2620
1998-99	10571	1422	161	144	16677	807	1179	527	2385	1118	1801	18	32776	4036
1999-00	10194	1227	165	141	15829	1060	1073	511	3019	1257	1769	3	32022	4199
2002-03	10606	1040	124	72	14451	439	954	465	3550	1305	1793	3	32719	3324
2004-05	11237	253	20	16	11803	487	823	536	3848	1662	1833	3	29879	2957
2006-07	12129	275	3	3	13518	513	879	675	3541	1397	1794	1	31941	2863

Table A11: Total agricultural area and irrigated area (ha) under major crops, Uttarakhand, 1986-87 to 2006-07 (contd.)

Year	Total Foodgrains		Laahi/Sarson		Aalsi		Til Pure		Groundnut		Sunflower		Soyabean	
	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1986-87	975821	304653	11553	5281	306	21	3559	135	147	0	—	—	9987	0
1987-88	922773	294380	11532	5723	225	10	2886	129	170	0	—	—	10666	0
1988-89	936527	296995	11674	5878	194	3	2742	127	160	0	—	—	10419	0
1989-90	579553	240080	8496	4015	163	8	334	5	47	0	—	—	13031	36
1990-91	910511	302133	12913	6152	146	6	2736	240	239	0	—	—	12985	44
1991-92	894663	298449	15117	7309	125	1	2775	239	278	3	147	117	14461	91
1992-93	901430	315179	11687	5776	56	2	2794	263	51	1	0	0	15773	139
1993-94	927304	570210	11505	5980	25	4	2903	283	37	0	209	190	16950	253
1994-95	959063	324818	12885	6125	22	2	2590	110	257	0	211	185	18685	252
1995-96	904274	314208	13180	6226	27	4	2241	118	45	1	554	298	17488	233
1996-97	897263	131392	13573	6971	27	6	2228	112	30	0	500	230	13268	228
1997-98	892932	311342	13546	7252	18	3	2462	115	299	15	402	353	6875	283
1998-99	993873	396121	13454	7808	35	6	3001	113	3356	29	1994	397	3757	190
1999-00	987766	397852	13309	6870	14	0	3128	127	3855	29	273	236	4684	123
2002-03	901399	363185	11423	5291	189	78	2125	49	1179	21	86	28	9975	73
2004-05	958251	394031	14820	7627	21	14	2035	86	1625	97	205	204	11347	227
2006-07	965000	384981	15925	5931	0	0	2065	1	1491	0	38	38	8504	1

Table A12: Total agricultural area and irrigated area (ha) under major crops, Uttarakhand, 1986-87 to 2006-07 (contd.)

Year	Total Oilseeds		Sugarcane		Potato		Tobacco		Total Rabi Fodder		Total Kharif Fodder		Total Jayad Fodder	
	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1986-87	15565	5437	43610	33409	11342	1864	319	76	5019	4482	6493	125	3195	2938
1987-88	14813	5862	49671	39110	11494	1768	319	76	4930	4692	6250	219	3196	2997
1988-89	14770	6008	51083	41362	11579	2090	434	129	4691	4301	6122	142	3539	3343
1989-90	22076	4064	43780	36898	6531	1162	128	13	4614	4154	6505	136	3540	3376
1990-91	29020	6442	51061	44725	13039	2077	236	55	6469	5670	7387	207	3742	3509
1991-92	32898	7760	53127	47214	13104	2153	236	55	6582	6194	8438	902	3657	3432
1992-93	15469	6328	51445	46257	13038	2147	235	55	7373	5633	7461	1835	3562	3402
1993-94	32256	6690	44188	39364	13017	2159	236	55	6904	6462	8735	901	3740	3611
1994-95	34652	6675	47913	43489	14418	2309	129	32	6790	6352	8438	827	3714	3587
1995-96	33535	6880	52530	48597	14611	2298	129	32	6171	5735	8955	946	3722	3595
1996-97	29626	7547	55867	52444	14595	2431	129	32	6317	5834	8647	1231	3590	3406
1997-98	23603	8028	51988	49069	14380	2250	129	37	6026	5503	7922	1194	3566	3517
1998-99	25598	14623	112459	107858	15120	3073	216	119	10976	10106	21809	1993	8473	8213
1999-00	24263	14190	114059	109525	15284	3036	250	110	11031	10195	22378	2410	8272	8077
2002-03	24656	12674	122453	117050	7352	824	5	0	1771	1435	2002	274	524	428
2004-05	29973	10774	106267	103256	13388	1081	31	20	25135	13665	28590	11218	445	402
2006-07	28068	5997	120939	0	17194	3110	3	1	24790	605	659	178	445	402

Table A13: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 1999-2000

S. No	Districts	Rice		Wheat		Barley		Maize		Madua		Sawa		Urad		Lentil	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	23583	6783	44956	5953	2998	50	2211		36053	26	16538	7	948	3	1328	26
2	Bageshwar	15535	5946	14623	4905	2384	38	515	25	7557	5	934				1108	93
3	Chamoli	12341	1764	15311	1589	1218	1	194		10888		2327		419		62	
4	Champawat	9426	1359	14456	2531	2152	15	1213		8212		1697				984	1
5	Dehradun	13621	12158	24191	11983	1327	39	11463	55	2822	4	1069	1	530	16	940	76
6	Garhwal	21217	6687	36548	6887	981	104	2122		27096	3	18503		3160	90	645	16
7	Haridwar	25099	23721	47012	41265	81	71	2545	385					1096	1037	2452	64
8	Nainital	15507	13549	29374	18270	900	81	7958	50	3500	20	615	2	617	24	636	264
9	Pithoragarh	28174	4135	26331	2757	3537	40	2680	58	12889		1212		1127	5	4442	428
10	Rudraprayag	8203	2401	9770	2321	81	41	233	132	5989		1993				142	2
11	Tehri Garhwal	13333	8414	30395	7223	2232	87	1710	197	16693		20824	32	1422		961	19
12	U.S. Nagar	108017	107636	83029	82651	69	44	704	22					172	49	1759	46
13	Uttarkhashi	10050	5189	11811	3303	212	18	548		5491		2323		703	3	370	25

Table A14: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 1999-2000 (contd.)

S. No	Districts	Gram		Pea		Total Pulses		Total Foodgrains		Laahi/Sarson		Total Oilseeds		Sugarcane		Potato	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	13		38	9	2339	38	128678	12857	504	13	1041	27			1653	230
2	Bageshwar	10		12		1130	93	42678	11012	141	3	141	3			297	47
3	Chamoli			9		607		42886	3354	542	11	706	11			3080	16
4	Champawat	36		59		1079	1	38235	3906	357	1	357	1			808	2
5	Dehradun	156	23	243	34	1972	158	56501	25544	1120	622	1907	649	6296	5753	1256	828
6	Garhwal	82	47	26	6	4439	159	116375	13895	506	54	871	177	1	1	461	56
7	Haridwar	88	17	236	128	3990	1324	78743	66513	488	463	3773	482	63094	59869	554	552
8	Nainital	461	416	448	181	2178	887	60032	32859	1882	1674	4007	1677	6565	6565	1837	192
9	Pithoragarh	14		61	1	5650	434	80473	7424	404	3	1912	10	5		1205	21
10	Rudraprayag					142	2	27236	4765	179	11	179	11			117	1

11	Tehri Garhwal	6	1	242	3	3303	23	88482	15779	789	115	1611	117			1384	150
12	U.S. Nagar	202	7	1484	829	3771	986	195590	191339	5411	3646	5859	4122	38098	37337	733	685
13	Uttarkhashi	5		161	66	1422	94	31857	8605	986	254	1899	256			1899	256

Table A15: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 2002-03

S. No	Districts	Rice		Wheat		Barley		Maize		Madua		Sawa		Urad		Lentil	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	23828	5132	45193	4749	3402	5	1917	4	34578	16	14134		839	1	1265	17
2	Bageshwar	13348	5679	14306	5585	2070	24	573	10	5770		504		101		986	19
3	Chamoli	11321	1500	14750	1187	1467	2							277		49	
4	Champawat	8625	1783	10351	1466	1372	10	778	24	4879		750		243	1	1172	
5	Dehradun	13106	11419	23295	12496	1256	99							704	52	785	32
6	Garhwal	24263	7006	34679	6989	7233	65							3112	106	972	3
7	Haridwar	16208	15523	41267	36936	31	20							792	735	1613	56
8	Nainital	12040	10135	26423	18951	1149	38	3903	70	5079		875		938	18	445	224
9	Pithoragarh	23911	4012	27462	3553	3518	19	3290	25	9135		891		699		4369	14
10	Rudraprayag	8675	2324	9579	2140	1236	8							230		29	
11	Tehri Garhwal	12742	7764	26962	6567	2620	137	1641		14630		17488		1524		960	33
12	U.S. Nagar	98291	98035	88050	87604	60	49	276	25					554	127	1461	31
13	Uttarkashi	9051	4117	12485	2835	250	20							593		345	10

Table A16: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 2002-03 (contd.)

S. No	Districts	Gram		Pea		Total Pulses		Total Foodgrains		Laahi/Sarson		Total Oilseeds		Sugarcane		Potato	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	31		40		2175	18	125227	9924	390		853				1120	189
2	Bageshwar			14		1101	19	37672	11311	99		191	15			674	
3	Chamoli			6		400		40818	2689	502	7	803	7				
4	Champawat	63		14		1492	1	29025	3308	399		1500				719	8
5	Dehradun	109	8	540	79	2299	171	56400	24354	1252	724	1990	823	6071	5097	986	
6	Garhwal	66	63	3		4510	172	121815	14289	382	17	767	59				
7	Haridwar	78	7	229	67	2739	890	61507	53565	545	513	1613	537	72498	68874	422	414
8	Nainital	431	375	148	87	2027	706	51496	29900	641	551	7464	604	6403	6401	2420	212
9	Pithoragarh	70		116		5254	14	73461	7623	321							
10	Rudraprayag			2		310		29183	4472	213	2	256	2			196	1

11	Tehri Garhwal	26		206	2	4843	35	52010	7766	820	86	2097	86				
12	U.S. Nagar	76	12	1890	947	4105	1165	190785	186879	4806	3245	5279	3994	37481	36678	815	
13	Uttarkashi	4		342	123	1464	133	32000	7105	1053	146	1837	146				

Table A17: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 2006-07

S. No	Districts	Rice		Wheat		Barley		Maize		Madua		Sawa		Urad		Lentil	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	24133	6336	50601	7990	3028	50	2041	0	37887	0	16802	0	1029	0	1006	3
2	Bagheshwar	15439	6788	16794	5837	2485	45	384		5382		466		69		1375	136
3	Chamoli	13490	2443	16927	1707	1547	9	18474	1716	13730		3789		356		75	
4	Champawat	9379	2299	11915	560	1792	0	876	0	7703	0	1289	0	514	0	1162	1
5	Dehradun	12170	10899	22660	11027	867	29	23527	11056	2196		580		642		559	23
6	Garhwal	24261	8977	37608	9941	7019	92	44627	10033	2066		19043		3544		1087	37
7	Haridwar	11654	11555	41888	38030	12	8	41900	38038					382	262	1137	81
8	Nainital	12381	11327	24715	18270	775	72	5306	0	2949	0	771	0	948	0	339	183
9	Pithoragarh	21022	3432	24981	2622	3501	4	3898	0	9470	0	1273	0	989	0	4686	8
10	Rudraprayag	10394	2477	10882	2370	1235	41	12117	2411	6111		2477		214	10	21	
11	Tehri	12820	8112	29412	7203	2940	148	32352	7351	14430		19012	14	1921	3	1173	11
12	U.S. Nagar	101292	101284	89532	89386	1	0	1168	0	0	0	0	0	688	0	508	14
13	Uttarkhashi	12746	5936	13430	3791	395	83	13825	3874	7075		2352		833		390	16

Table A18: Total agricultural area and irrigated area (ha) under major crops across districts of Uttarakhand, 2006-07 (contd.)

S. No	Districts	Gram		Pea		Total Pulses		Total Foodgrains		Laahi/Sarson		Total Oilseeds		Sugarcane		Potato	
		Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1	Almora	0	0	6	0	2043	3	136535	14379	532	1	1017	1			775	201
2	Bagheshwar	17	1	54	1	1516	138	42466	12808	555	2	766	2			403	21
3	Chamoli			27	1	551		50330	4160	885	11	1894	11			4095	
4	Champawat	18	0	68	0	1762	1	34716	2860	1331	1	2400	1	8		772	0
5	Dehradun	44	3	206	23	1558	49	50695	22004	1112	595	1376	595	4417		1064	945
6	Garhwal	153	151	41		5062	188	123895	19198	424	28	1001	28			456	51
7	Haridwar	10	1	1	1	1533	348	56373	50847	619	561	2319	561	76636		300	300
8	Nainital	579	518	180	61	2118	762	49015	30431	1017	918	2936	918	6038		2191	55
9	Pithoragarh	18	0	130	0	5834	8	69979	6066	699	1	2123	1			1063	2
10	Rudraprayag			7		418	10	31697	4914	231		358				99	

11	Tehri	25	0	104	10	4141	25	85504	15503	1146	142	2237	170			1411	36
12	U.S. Nagar	13	0	2212	1188	3421	1202	195414	191872	6133	3414	7123	3452	33840		1209	1205
13	Uttarkhashi	2	1	505	112	1984	129	38381	9939	1241	257	2518	257			3356	294

Table A19:Area irrigated (ha) by sources of irrigation, Uttarakhand, 1986-87 to 2008-09

Year	Canal	Public Tubewells	Pvt Tubewells	Total Tubewells	Wells	Ponds	Others
1986-87	97815	74422	—	74422	8385	25	45408
1987-88	93747	2912	—	75230	10940	23	57977
1988-89	95342	2555	—	76068	13907	157	37611
1989-90	97671	15841	58031	73872	10383	364	45796
1990-91	99440	19475	61572	81047	11828	154	41139
1991-92	88320	21562	63042	84604	11696	115	39570
1992-93	78468	13429	64070	77499	15278	174	38078
1994-95	81904	17742	81029	98771	21819	5051	37494
1995-96	79341	17179	58618	75797	29176	104	40792
1996-97	100307	23964	151572	175536	19618	75	44533
2000-01	98395	23682	168325	192007	12136	513	35234
2002-03	98799	23477	172055	195532	12338	551	37027
2003-04	92704	25509	182274	207783	10577	1239	36203
2004-05	94799	23906	182943	206849	7528	1001	35047
2006-07	95205	26593	172895	199488	18389	254	31801
2008-09	95922	—	—	198193	15587	770	29657

Table A20: Area irrigated (ha) by sources of irrigation across districts of Uttarakhand, 2000-01

S.No.	Districts	Canal	Public Tube-wells	Pvt Tube-wells	Total Tube-wells	Wells	Ponds	Others	Total
1	Almora	2560						2344	4904
2	Bageshwar	1458						2635	4093
3	Chamoli	425						1225	1650
4	Champawat	759	728		728		488	196	2171
5	Dehradun	11459	2899	378	3277	37		7432	22205
6	Garhwal	4756	591		591		5	2373	7725
7	Haridwar	15633	4965	80747	85712			1006	102351
8	Nainital	23963	3600	1598	5198			494	29655
9	Pithoragarh	1762						2881	4643
10	Rudraprayag	1555						858	2413
11	Tehri Garhwal	1164						5490	6654
12	U.S. Nagar	30224	10899	85602	96501	12099	20	6582	145426
13	Uttarkashi	2677						1718	4395

Table A21:Area irrigated (ha) by sources of irrigation across districts of Uttarakhand, 2004-05

S.No.	Districts	Canal	Public Tubewells	Pvt Tubewells	Total Tubewells	Wells	Ponds	Others	Total
1	Almora	2982						2006	4988
2	Bageshwar	2724						1279	4003
3	Chamoli	1044					118	423	1585
4	Champawat	736	740		740		401.4	503.6	2381
5	Dehradun	12038	2889	377	3266		325	5235	20864
6	Garhwal	3602	613		613			3492	7707
7	Haridwar	14476	4581	86086	90667		96	1925	107164
8	Nainital	23292	2965	1297	4262			462	28016
9	Pithoragarh	633						3329	3962
10	Rudraprayag	1961						656	2617
11	Tehri Garhwal	947						7572	8519
12	U.S. Nagar	27198	12118	95183	107301	7528	61	6270	148358
13	Uttarkashi	3166						1894	5060

Table A22: Area irrigated (ha) by sources of irrigation across districts of Uttarakhand, 2006-07

S.No.	Districts	Canal	Public Tube-wells	Pvt Tube-wells	Total Tube-wells	Wells	Ponds	Others	Total
1	Almora	5883						990	6873
2	Bageshwar	3783						1559	5342
3	Chamoli	872						556	1428
4	Champawat	546	1656					229	775
5	Dehradun	13877	3078	403	3481			3602	20960
6	Garhwal	3008						6001	9009
7	Haridwar	14063	5078	86284	91362		117	2164	107706
8	Nainital	19110	6148	2690	8838			262	28210
9	Pithoragarh	1185						2239	3424
10	Rudraprayag	993						1326	2319
11	Tehri Garhwal	1025						6841	7866
12	U.S. Nagar	26956	10633	83518	94151	18389	137	4467	144100
13	Uttarkashi	3904						1565	5469

Table A23: Area irrigated (ha) by sources of irrigation across districts of Uttarakhand, 2008-09

S. No.	Districts	Canal	Public Tube-wells	Pvt Tube-wells	Total Tube-wells	Wells	Ponds	Others	Total
1	Almora	3570						2189	5759
2	Bageshwar	5043						823	5866
3	Chamoli	352						1340	1692
4	Champawat	567			1445				2012
5	Dehradun	12337			3135	118		3792	19382
6	Garhwal	2039					422	4907	7368
7	Haridwar	13097			92816			2328	108241
8	Nainital	23396			3105	1214		330	28045
9	Pithoragarh	541					105	2951	3597
10	Rudraprayag	1941						667	2608
11	Tehri Garhwal	855						7969	8824
12	U.S. Nagar	29090			97692	14255	243	253	141533
13	Uttar Kashi	3094						2108	5202

Table A24: Consumption of Chemical Fertilizer (tones), Uttarakhand, 1980-81 to 2007-08

Year	Nitrogen	Phosphorous	Potasic	NPK (Total)
1980-81	24370	8618	3878	36866
1981-82	28857	10003	3883	42743
1982-83	85121	13737	5910	104768
1986-87	44538	13975	4744	63257
1987-88	34901	10712	2890	48503
1988-89	54007	16814	4235	75056
1989-90	54049	19465	5019	78533
1990-91	59015	17909	5508	82432
1991-92	56340	18494	6001	80835
1992-93	57267	13741	4252	75460
1994-95	57396	14033	5679	77108
1995-96	65206	15124	6002	86332
1996-97	61763	15966	5581	83310
1999-00	84042	25797	13659	123498
2000-01	87833	25698	11270	124811
2001-02	86990	23150	9228	119368
2002-03	89584	24707	9462	123753
2005-06	78446	31066	13415	122926
2006-07	84557	29954	14410	128921
2007-08	88307	25956	10988	125251

Table A25: Consumption of Chemical Fertilizer (tones) across districts of Uttarakhand, 2002-03

S. No	Districts	Nitrogenous	Phosphorous	Potasic	NPK (Total)
1	Almora	305	120	11	436
2	Bageshwar	163	51	6	220
3	Chamoli	133	114	8	255
4	Champawat	114	45	6	165
5	Dehradun	3158	767	218	4143
6	Garhwal	159	80	2	241
7	Haridwar	19005	5061	798	24864
8	Nainital	5881	2094	692	8667
9	Pithoragarh	276	138	7	421
10	Rudraprayag	76	44		120
11	Tehri Garhwal	158	94	2	254
12	U.S. Nagar	59957	15814	7710	83481
13	Uttarkashi	199	285	2	486

Table A26: Consumption of Chemical Fertilizer (tones) across districts of Uttarakhand, 2005-06

S. No	Districts	Nitrogenous	Phosphorous	Potasic	NPK (Total)
1	Almora	226	68	15	309
2	Bagheshwar	269	75	15	359
3	Chamoli	127	110	8	245
4	Champawat	116	61	8	185
5	Dehradun	2802	1512	354	4668
6	Garhwal	272	91	12	375
7	Haridwar	20128	6740	1151	28019
8	Nainital	3067	1244	424	4735
9	Pithoragarh	147	64	15	225
10	Rudraprayag	76	32	1	109
11	Tehri Garhwal	141	76	2	219
12	U.S. Nagar	50885	20757	11401	83043
13	Uttarkashi	190	236	9	435

Table A27: Consumption of Chemical Fertilizer (tones) across districts of Uttarakhand, 2007-08

S. No	Districts	Nitrogenous	Phosphorous	Potasic	NPK (Total)
1	Almora	239	84	20	343
2	Bageshwar	257	105	21	383
3	Chamoli	121	104	10	235
4	Champawat	150	90	34	274
5	Dehradun	2536	835	95	3466
6	Garhwal	342	116	5	463
7	Haridwar	22719	5952	1211	29882
8	Nainital	6478	3225	1011	10714
9	Pithoragarh	180	88	21	289
10	Rudraprayag	84	46	2	132
11	Tehri Garhwal	161	100	2	263
12	U.S. Nagar	54779	14808	8484	78071
13	Uttarkashi	261	403	72	736

Table A27: Use of agricultural machineries and implements, Uttarakhand, 1978- 2003

Year	Plough		Improved Harrow & Cultivator	Improved Thresing Machine	Sprayer	Improved Sowing Machine	Tractors
	Wooden	Iron					
1978	466635	54161	23343	3579	5557	444	4023
1982	499490	73229	27978	5695	4042	5222	7199
1988	537180	74291	30301	7981	4738	6024	7992
1993	564431	72397	17369	10715	6804	14998	10164
1998	565204	83560	33633	19881	10526	13067	18595
2003	479976	59872	30213	7879	24771	26855	22041

Table A29: Use of agricultural machineries and implements across districts of Uttarakhand, 2003

S. No	Districts	Plough		Improved Harrow & Cultivator	Improved Thresing Machine	Improved Sowing Machine	Sprayer	Tractors
		Wooden	Iron					
1	Almora	72280	3370	98	20	536	137	9
2	Bagheshwar	21914	500	627	1	14	13	
3	Chamoli	52544	630	4289	1			
4	Champawat	22405	4033	856	23	528	556	20
5	Dehradun	20231	8900	2601	454	158	4401	1223
6	Garhwal	63735	3259	2733	92	4161	11	151
7	Haridwar	2963	13154	7055	4490	232	2208	8777
8	Nainital	22865	12415	2509	2083	13675	6998	3163
9	Pithoragarh	47513	261	643	1	3186	53	181
10	Rudraprayag	36129	1201	455		3600		
11	Tehri Garhwal	73160	1513	975	14	129	991	1
12	U.S. Nagar	2644	10122	3554	596	636	8022	8516
13	Uttarkashi	41593	514	3818	104		1381	

Table A30: Progress of state tubewells and other minor irrigation works (No.) in Uttarakhand, 1987-88 to 2007-08

Year	Canal (Length in kms)	Govt. Tube-wells (No.)	Masonary Wells (No.)	Persian Wheels (No.)	Pumping Sets (No.)	Boring Pump set (No.)	Pvt Tube-wells (No.)	Hauj (No.)	Guhl (in kms)	Hydram (No.)
1987-88	5493	279	620	125	3524	20145	6345	25763	8976	—
1988-89	5980	299	620	125	3527	21341	6869	26645	9249	—
1989-90	6198	335	621	125	3531	22617	7090	27715	9498	—
1990-91	6439	367	49	5	861	16141	5302	28463	9959	206
1991-92	6621	369	49	5	908	17259	5707	29043	10266	474
1995-96	6642	393	36	6	917	20292	7314	30584	11752	849
1999-00	7003	653	43	6	1301	44697	13252	26397	11543	1027
2000-01	7065	663	43	6	1301	52336	14898	25723	11338	1075
2001-02	6962	678	43	6	1301	47609	13920	26185	11822	1126
2002-03	6502	684	43	2	1289	47657	6862	23908	10792	1089
2003-04	7096	686	30	2	1609	47028	8022	26517	12935	1228
2005-06	7484	728	30	2	1441	47172	8060	27361	14925	1373
2006-07	7734	733	30	1	1683	47203	8060	28640	17018	1407
2007-08	7830	773	30	1	1687	47250	8055	30207	19647	1449

Table A31: Progress of state tube-wells and other minor irrigation works (No.) across districts of Uttarakhand, 2000-01

S. No	Districts	Canal (Length in km)	Govt. Tube-wells (No.)	Pvt Tube-wells (No.)	Total Tube-wells (No.)	Masonary Wells (No.)	Persian Wheels (No.)	Pumping Sets (No.)	Boring Pump set (No.)	Hauj (No.)	Guhl (in km)	Hydram (No.)
1	Almora	534						82		2263	1136	73
2	Bagheswar	362						18		730	578	67
3	Chamoli	383								1626	743	116
4	Champawat	217	7		7					1186	397	21
5	Dehradun	748	72	266	338	30	1	8	529	1198	967	155
6	Garhwal	769	16	0	16	0	0	0	0	5357	1505	135
7	Haridwar	300	228	7150	7378	0	0	0	31437	0	0	0
8	Nainital	904	91	420	511		1	331	560	2204	1161	114
9	Pithoragarh	386								2665	907	127
10	Rudraprayag	269	0	0		0	0	0	0	942	644	15
11	Tehri Garhwal	473	0	4	4	13	0	0	15	5893	1774	147
12	U.S. Nagar	1063	249	7058	7307		4	861	19795			
13	Uttarkashi	657	0			0	0	1	0	1659	1526	105

Table A32: Progress of state tube-wells and other minor irrigation works (No.) across districts of Uttarakhand, 2003-04

S. No	Districts	Canal (Length in km)	Govt. Tube-wells (No.)	Pvt Tube-wells (No.)	Total Tube-wells (No.)	Masonary Wells (No.)	Persian Wheels (No.)	Pumping Sets (No.)	Boring Pump set (No.)	Hauj (No.)	Guhl (in km)	Hydram (No.)
1	Almora	538						82		2359	1398	91
2	Bagheswar	382						18		761	644	81
3	Chamoli	383								1683	866	124
4	Champawat	217	10		10					1227	517	35
5	Dehradun	786	75	266	341	30	1	75	529	1208	1056	168
6	Garhwal	835	18		18					5422	1740	158
7	Haridwar	253	225	274	499			242	26129		10	
8	Nainital	928	102	420	522		1	331	560	2249	1240	133
9	Pithoragarh	401								2692	953	149
10	Rudraprayag	269								967	748	33
11	Tehri Garhwal	519		4	4				15	6244	2067	147
12	U.S. Nagar	924	256	7058	7314			861	19795			
13	Uttarkashi	661								1705	1696	109

Table A33: Progress of state tube-wells and other minor irrigation works (No.) across districts of Uttarakhand, 2007-08

S. No	Districts	Canal (Length in km)	Govt. Tubewells (No.)	Pvt Tubewells (No.)	Total Tubewells (No.)	Masonary Wells (No.)	Persian Wheels (No.)	Pumping Sets (No.)	Boring Pumpset (No.)	Hauj (No.)	Guhl (in km)	Hydram (No.)
1	Almora	546	0	0		0	0	107	0	2571	1951	137
2	Bagheshwar	396	0	0		0	0	18	0	930	1032	87
3	Chamoli	385								2386	1838	157
4	Champawat	224	16	0	16	0	0	0	0	1433	816	56
5	Dehradun	864	103	266	369	30		103	529	1418	2290	168
6	Garhwal	836	31		31					5721	2725	210
7	Haridwar	278	237	311	548			242	26351		27	
8	Nainital	1341	118	420	538	0	1	331	560	2681	1600	171
9	Pithoragarh	401	0	0		0	0	0	0	2905	1410	172
10	Rudraprayag	273								967	748	33
11	Tehri Garhwal	706		0					16	7056	2948	147
12	U.S. Nagar	925	268	7058	7326	0	0	861	19794	0	0	0
13	Uttarkashi	655						25		2139	2262	111

Table A34: Number of live stocks and poultry in Uttarakhand, 1978-2003ddd

Year	Cattle (Desi)				Cattle (Cross Breed)				Buffalo			
	Males Above 3 years	Females Above 3 years	Young Stock	Total	Males Above 2.5 years	Females Above 2.5 years	Young Stock	Total	Males Above 3 years	Females Above 3 years	Buffalo Young Stock	Total
1978	807998	665067	499768	1972833	—	—	—	—	26047	491648	181637	699332
1982	672868	604507	558314	1835689	37919	28026	28295	94240	29413	487745	250323	767481
1988	729254	624586	506924	1860764	27349	35174	18675	81198	31996	524050	270993	827039
1993	810202	650315	603408	1014832	27833	46534	44545	118912	27268	592040	307204	926512
2003	694808	711539	588010	1994357	31242	136861	63081	231184	70986	843115	350447	1264548

Table A35: Number of livestocks and poultry in Uttarakhand, 1978-2003 (contd.)

Year	Sheeps	Sheeps (Cross Breed)	Total	Total Goats	Horses & Ponies	Pigs (Desi)	Pigs (Cross Breed)	Total Pig	Other Livestock	Total Livestock	Poultry	Other Poultry
1978	405375	—	405375	948404	13731	6820	—	6820	118373	4164868	340193	15989
1982	334434	73402	407836	864932	13941	8016	3302	11318	9278	3984715	488184	23882
1988	273197	75041	348238	903485	18601	11817	1361	13178	138537	4191040	603836	9465
1993	319850	56747	376597	1149043	23106	8934	2530	11464	199818	4900577	663880	113658
2003	203771	90568	294339	1166084	20330	28018	6417	34435	221892	5227169	1973375	16715

Trends in Agriculture and Agricultural Practices in Middle Ganga Basin

Part II: Uttar Pradesh

GRBMP: Ganga River Basin 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 Frame Work 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 dialog 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.

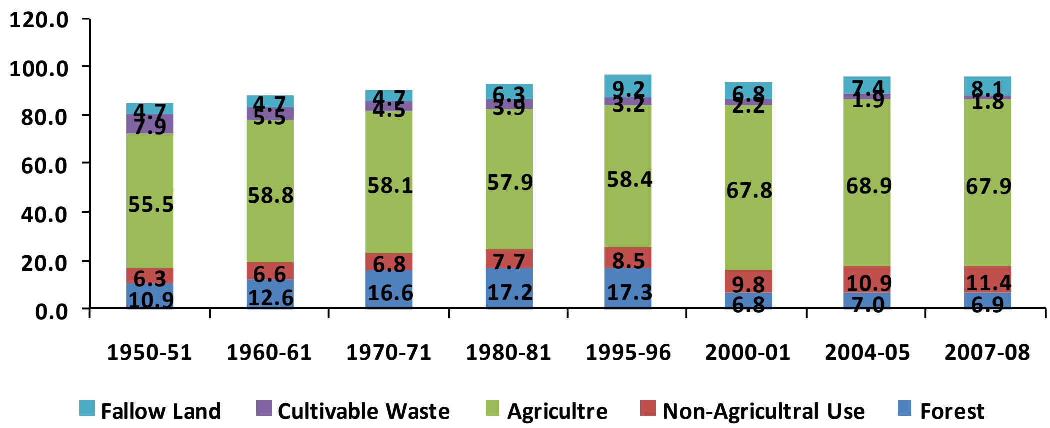

Figure 1: Trends in percentage distribution in land use for various purposes in Uttar Pradesh (in %)

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.

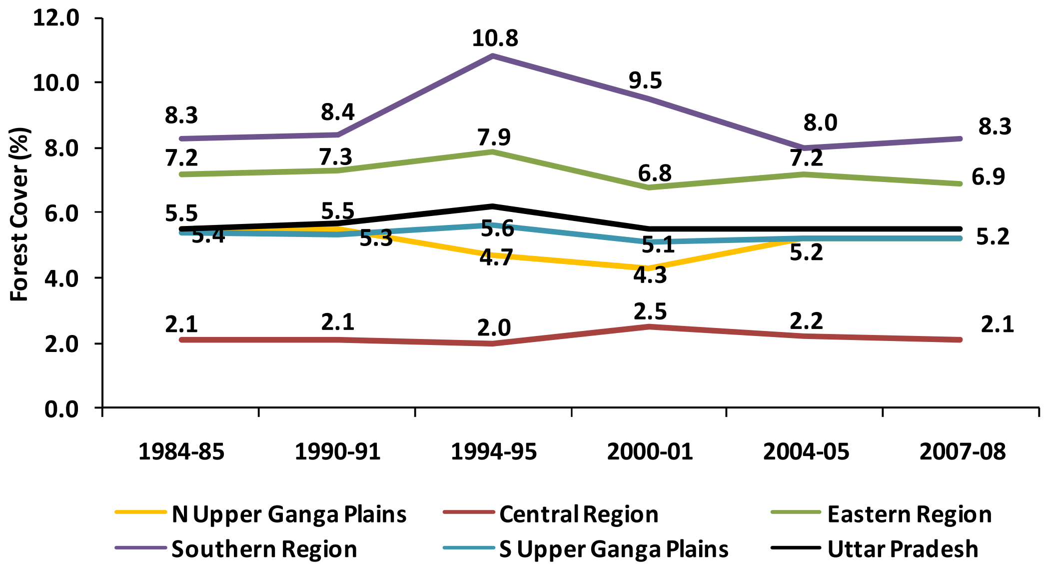

Figure 2: Region-wise trend in forest cover

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.

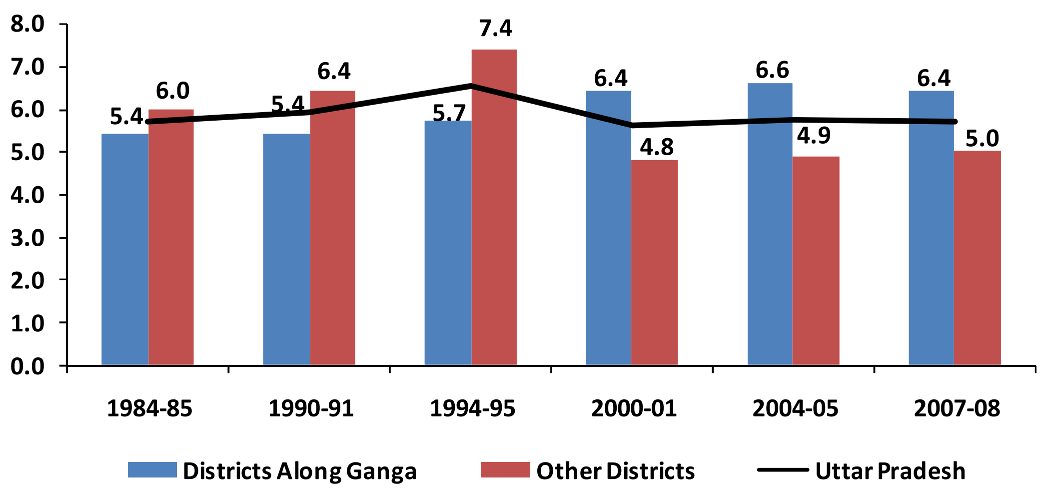

Figure3: Percentage of area under forest covers in Ganga bank districts and non-bank districts

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.

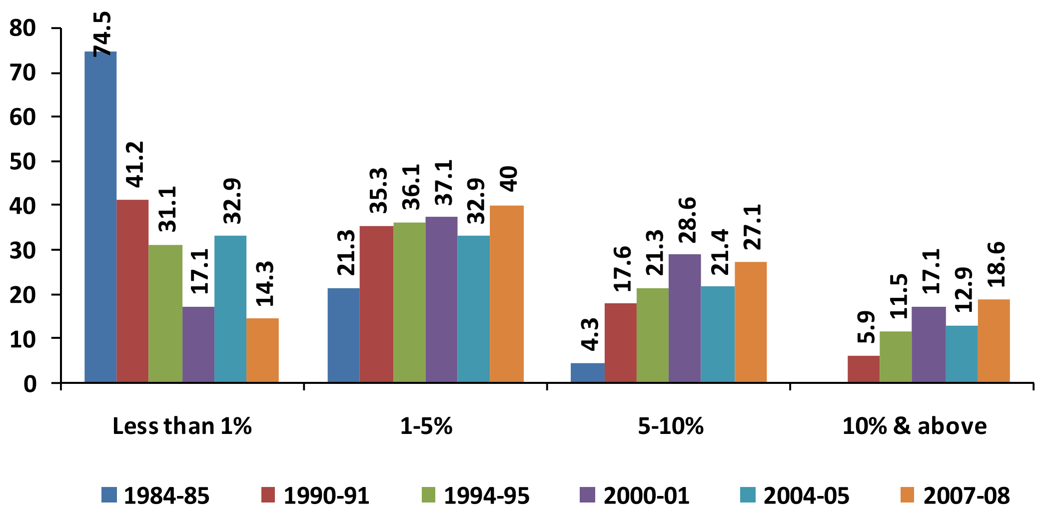

Figure 4: Proportion of districts by class of forest cover

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.

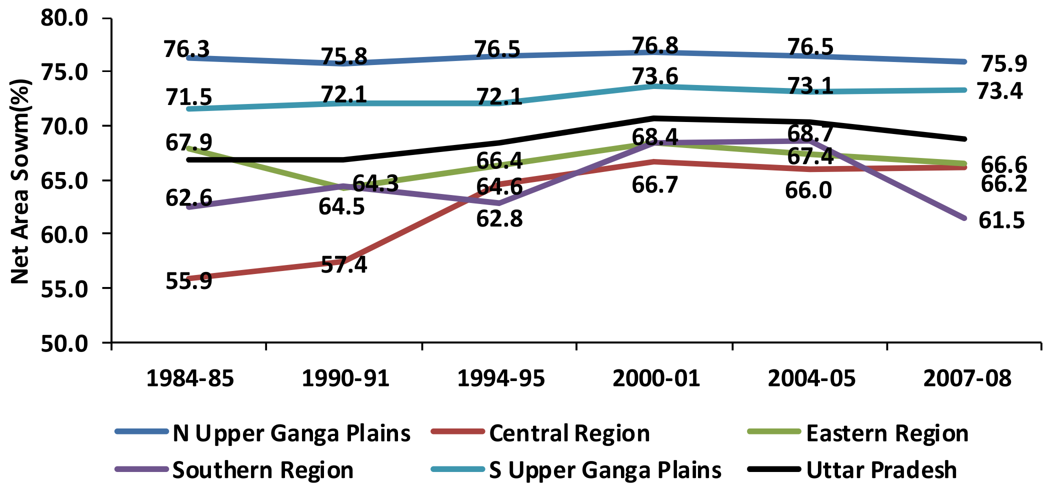

Figure5: Region-wise trends in net sown area (in %)

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.

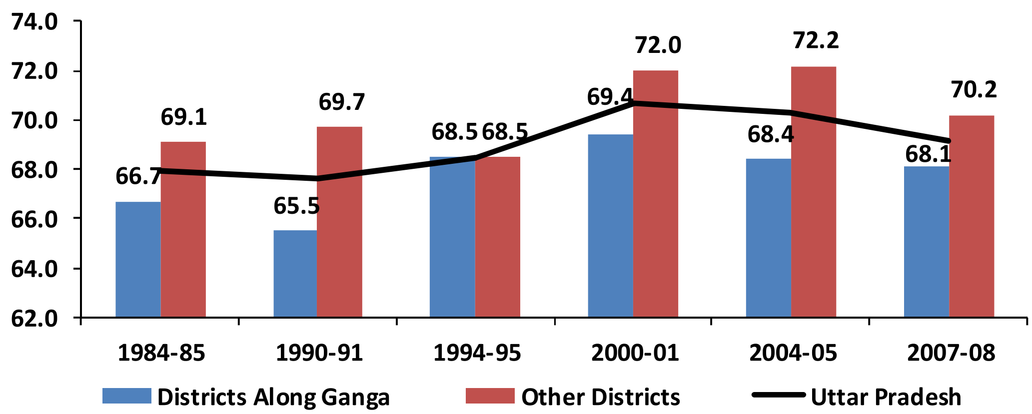

Figure6: Percentage of NSA in Ganga-bank and non-bank districts

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.

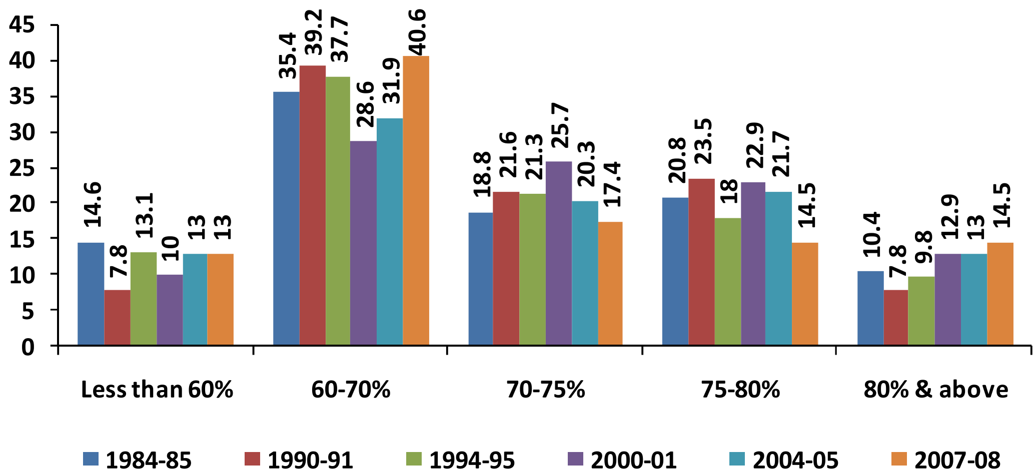

Figure7: Percentage distribution of districts by category of NSA

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.

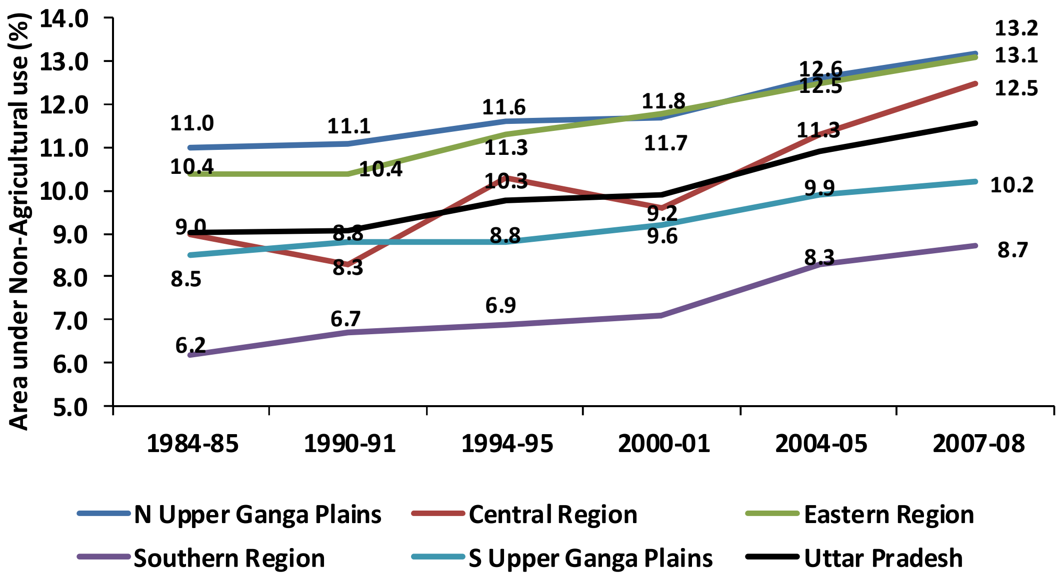

Figure8: Region-wise trends in area under non-agricultural uses

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.

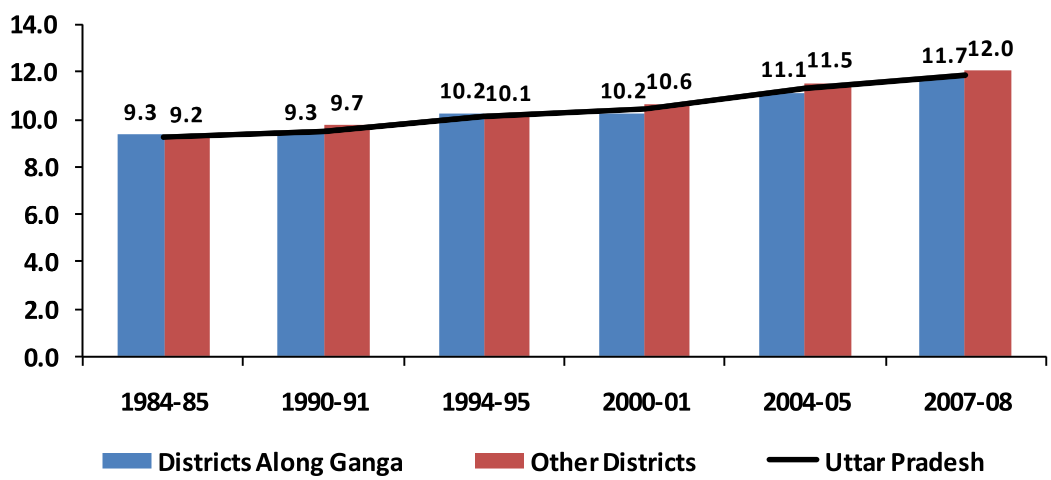

Figure9: Trends in area under non-agricultural use in Gangabank districts and non-bank districts

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.

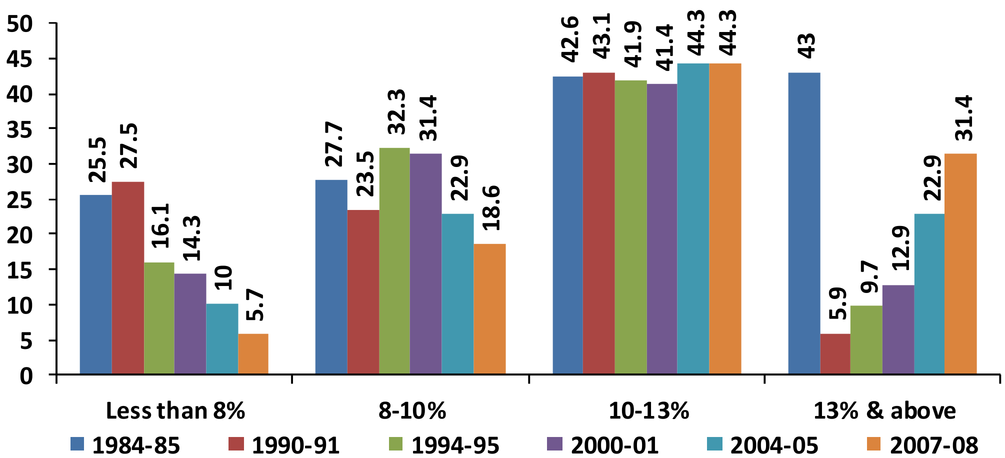

Figure 10: Trends in proportion of districts by class of area under non-agricultural use

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.

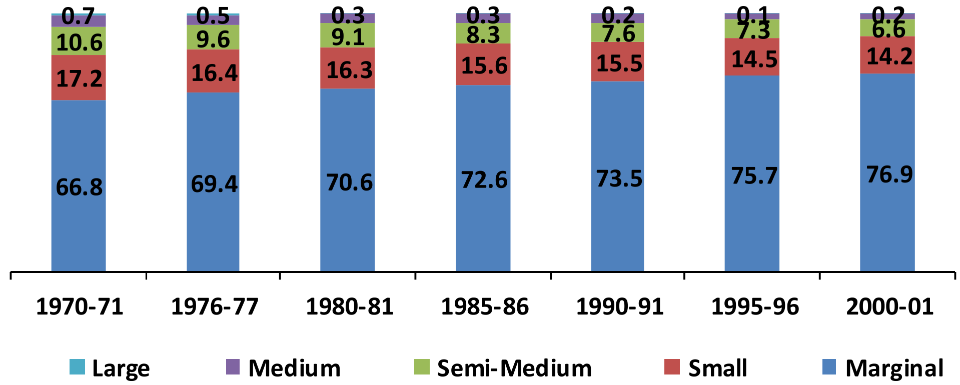

Figure11: Trends in percentage share of number of operational holdings by size class

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.

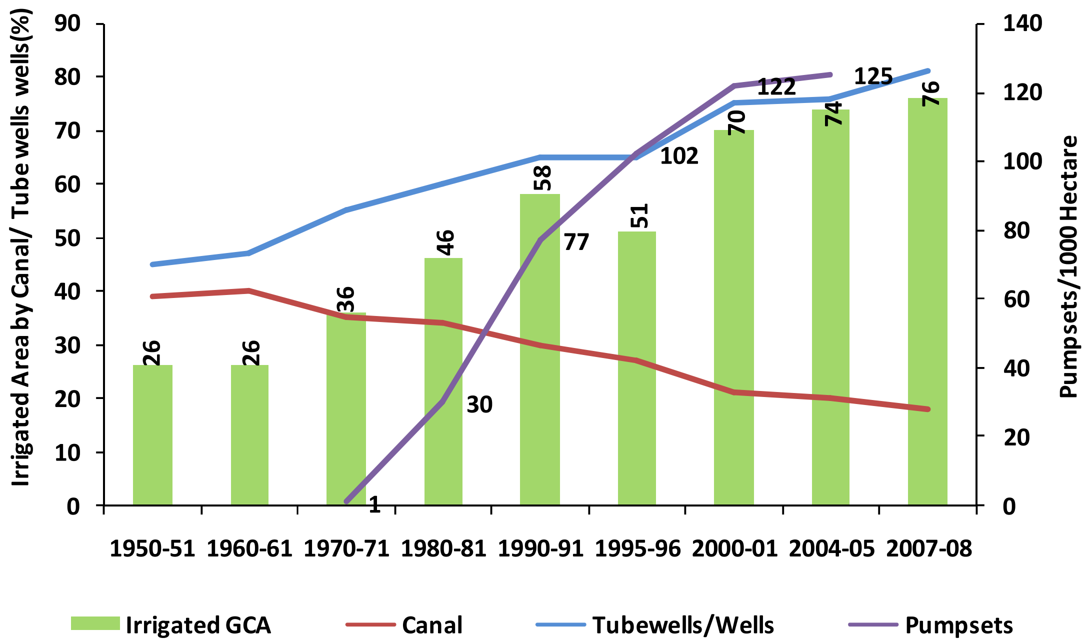

Figure 12: **Trends in gross irrigated area by sources of irrigation and number of pump sets in operation in Uttar Pradesh**

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.

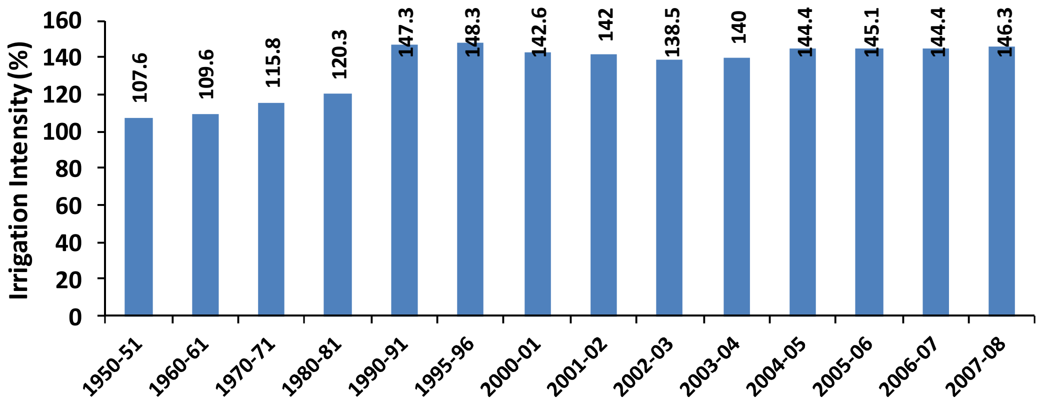

Figure 13: Trends in Irrigation Intensity

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.

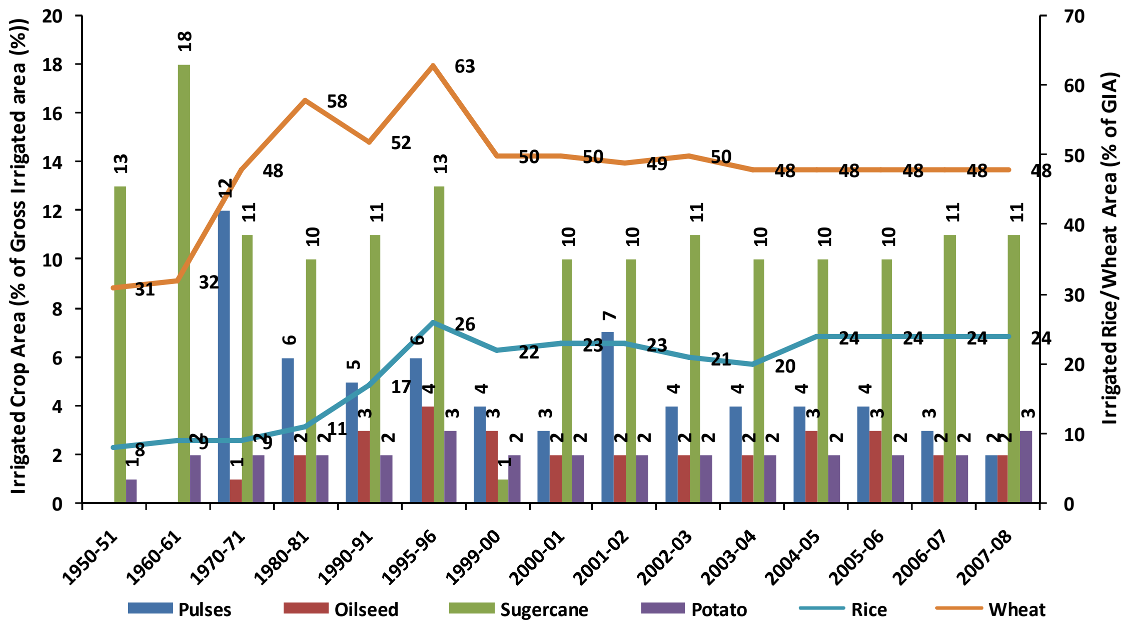

Figure 14: Percentage share of major crops in the total GIA in Uttar Pradesh

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.

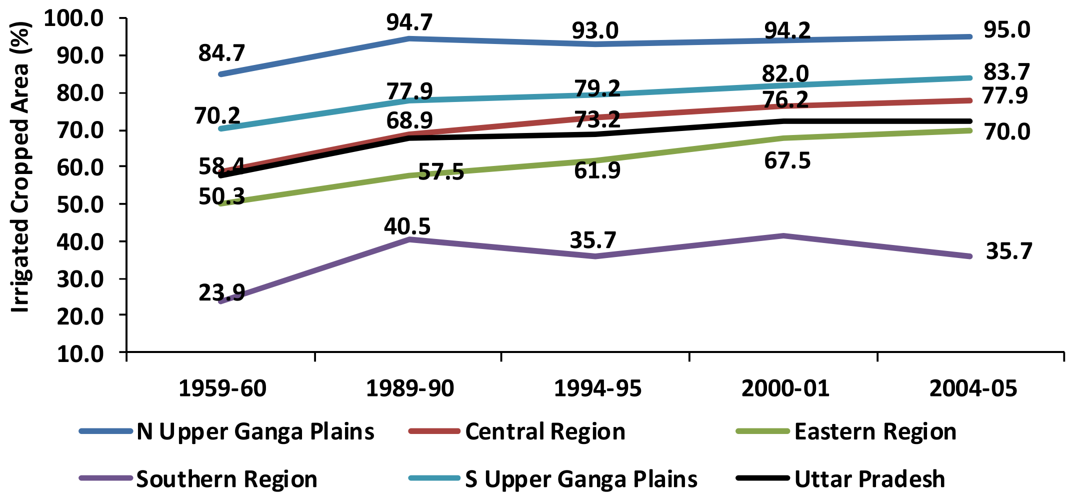

Figure 15: Region-wise trends in percentage of GIA

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.

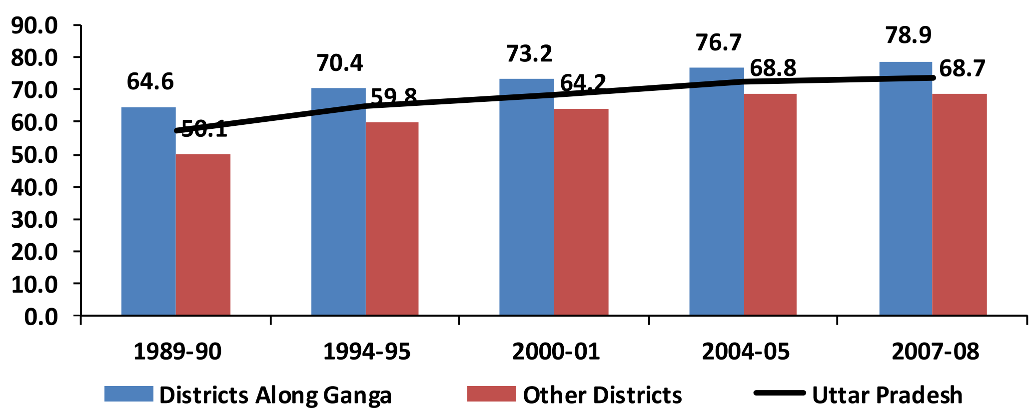

Figure 16: Comparison of percentage of GIA in Ganga bank districts with non-bank districts

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.

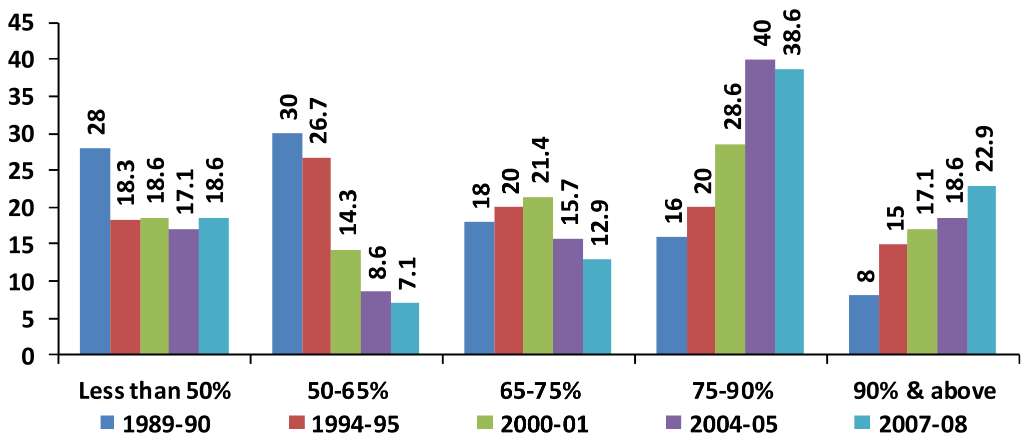

Figure 17: Proportion of districts by class of irrigated area in UP

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.

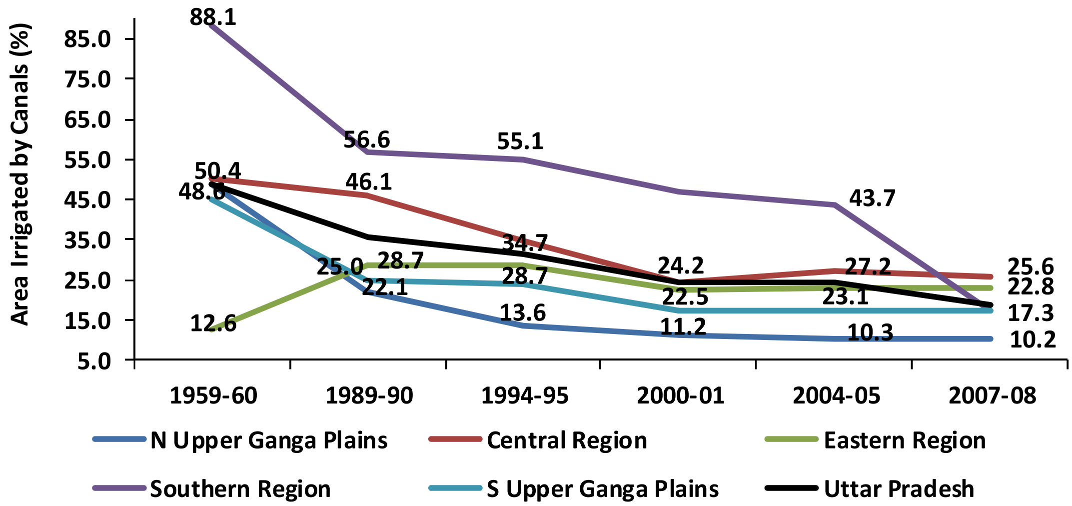

Figure 18: Region-wise trends in GIA by canals

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.

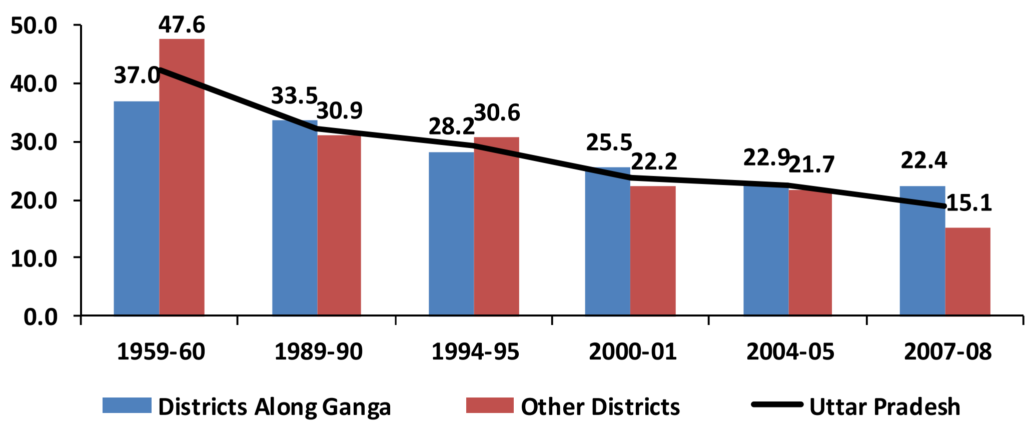

Figure 19: Trends in the share of canal irrigation in total GIA in Ganga bank districts and non-bank districts

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.

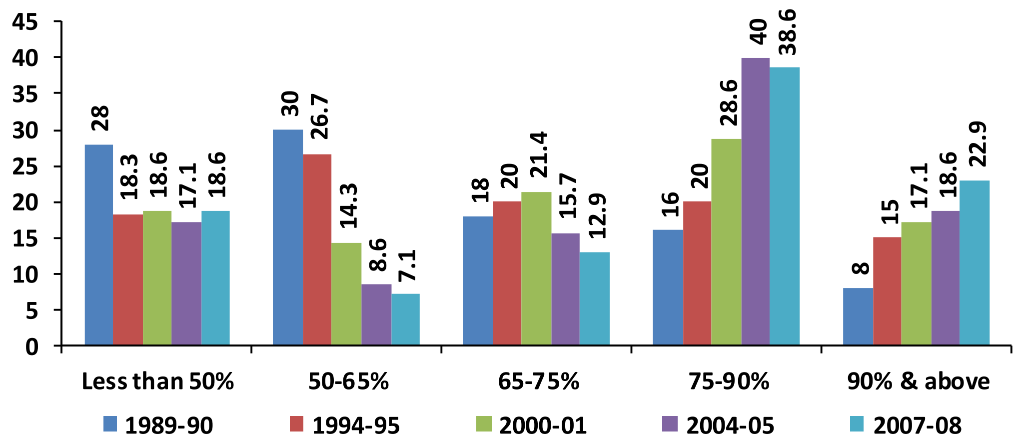

Figure 20: Trends in the percentage distribution of districts by class of canal water irrigation

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.

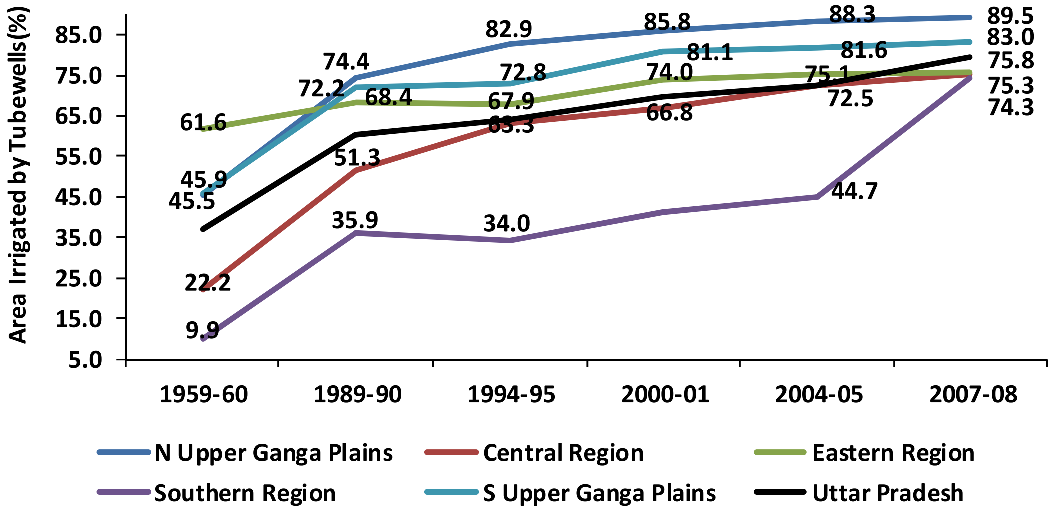

Figure 21: Region-wise share of area irrigated by tube wells/wells in total GIA

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.

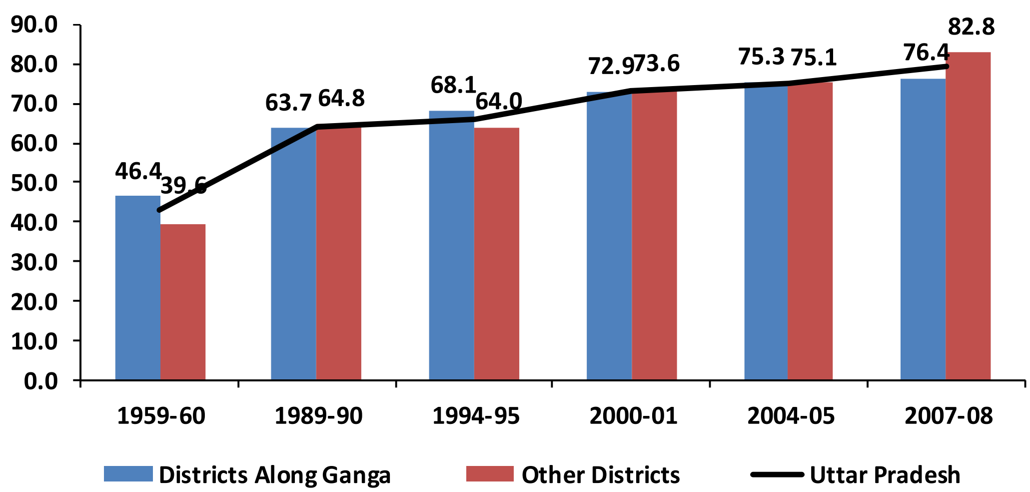

Figure 22: Trends in the share of tube-wells in total GIA in Ganga bank districts and non-bank districts

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.

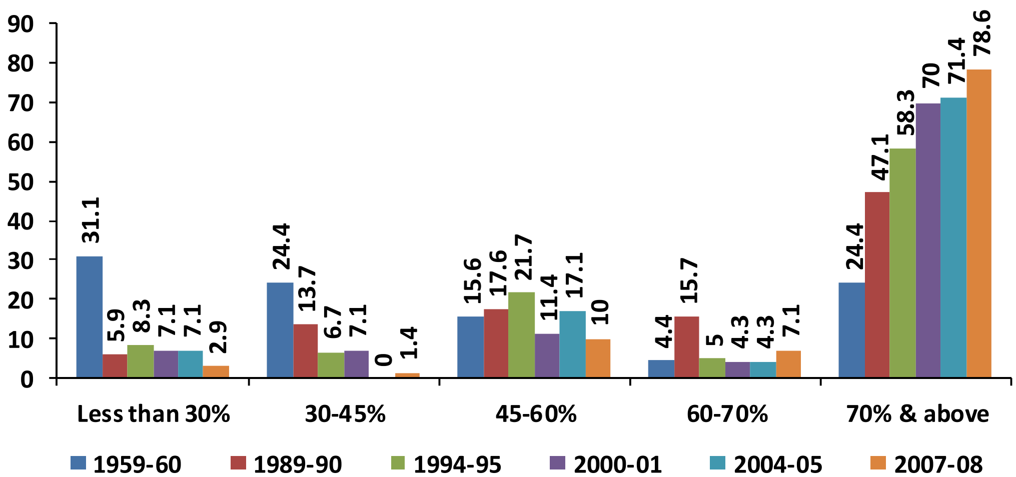

Figure 23: Proportion of districts by class of tube-well irrigated area

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.

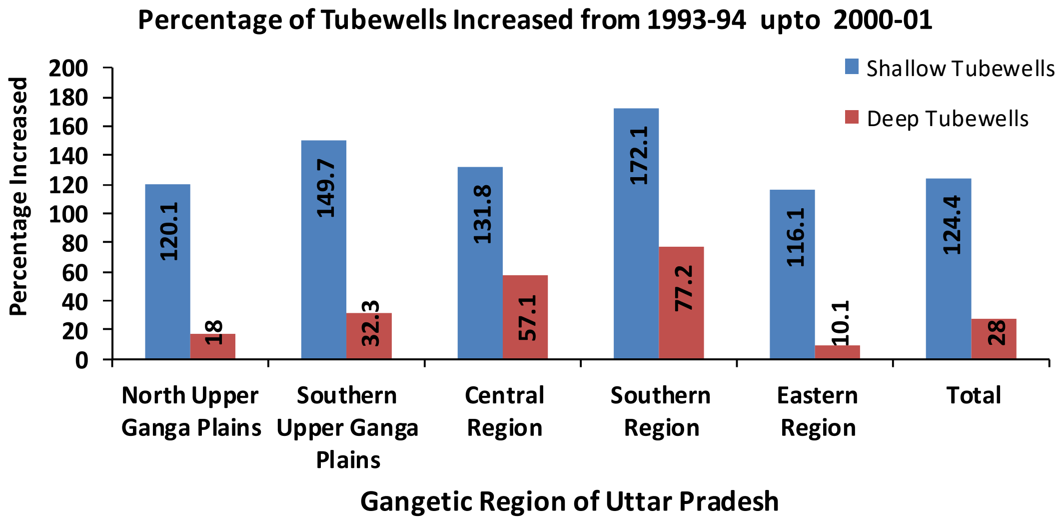

Figure 24: Region-wise percentage increase in number of shallow and deep tube-well between 1993-94 and 2000-01

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.

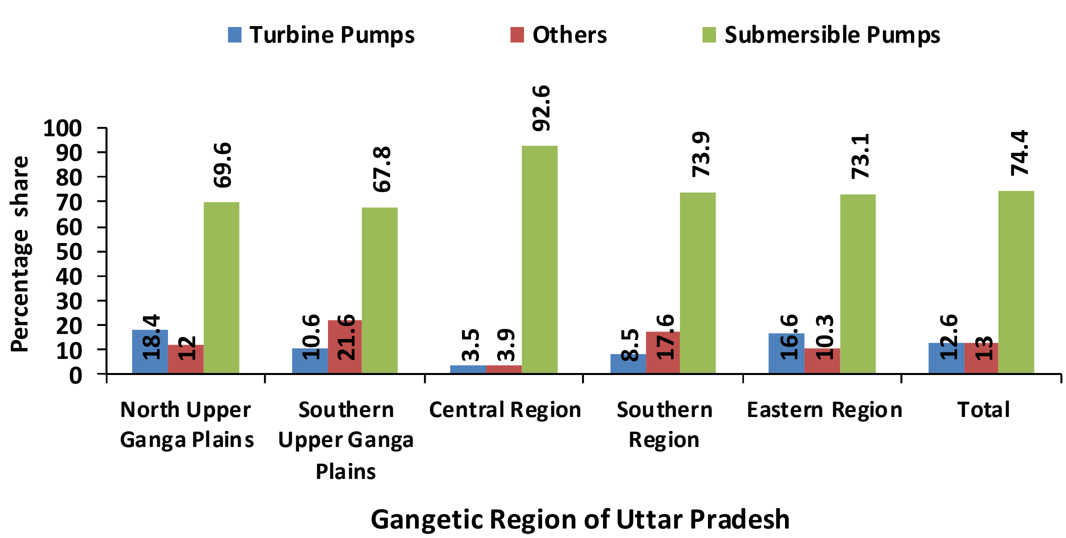

Figure 25: Distribution of deep tube-wells according to water lifting devices

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.

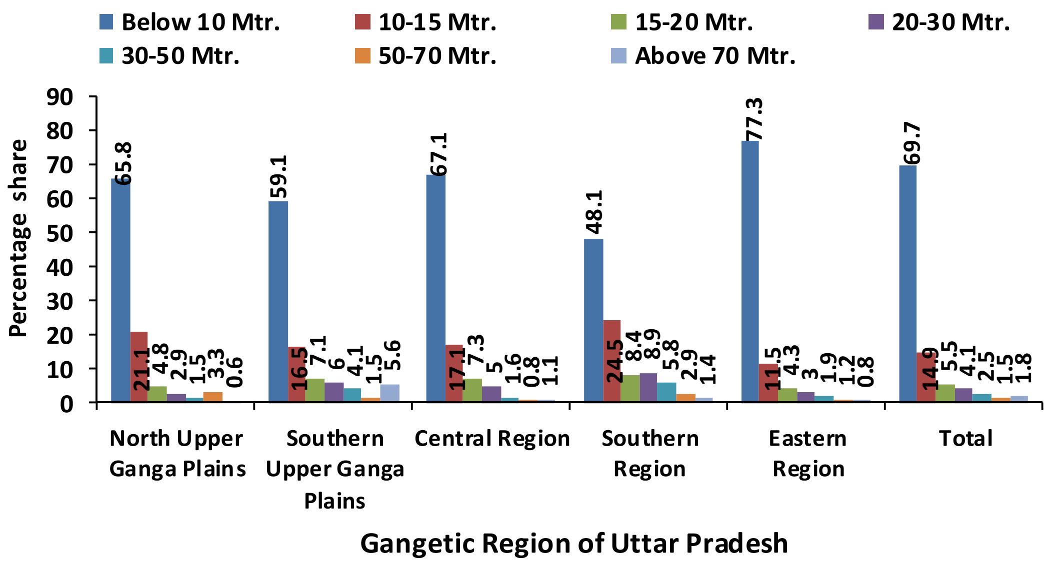

Figure 26: Region-wise percentage of number of Villages by their Groundwater Level

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.

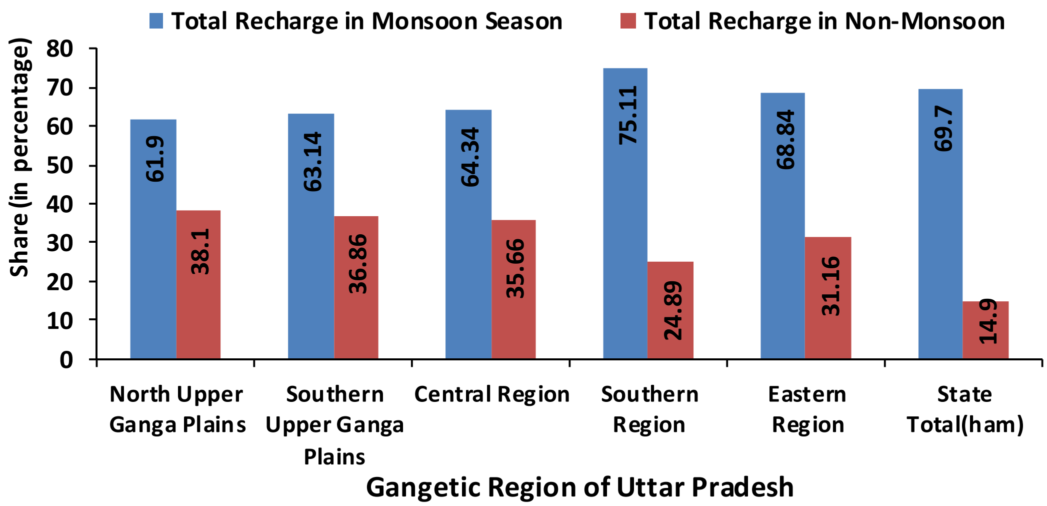

Figure 27: Region-wise Share of Groundwater Recharge in Monsoon and Non-monsoon Seasons

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.

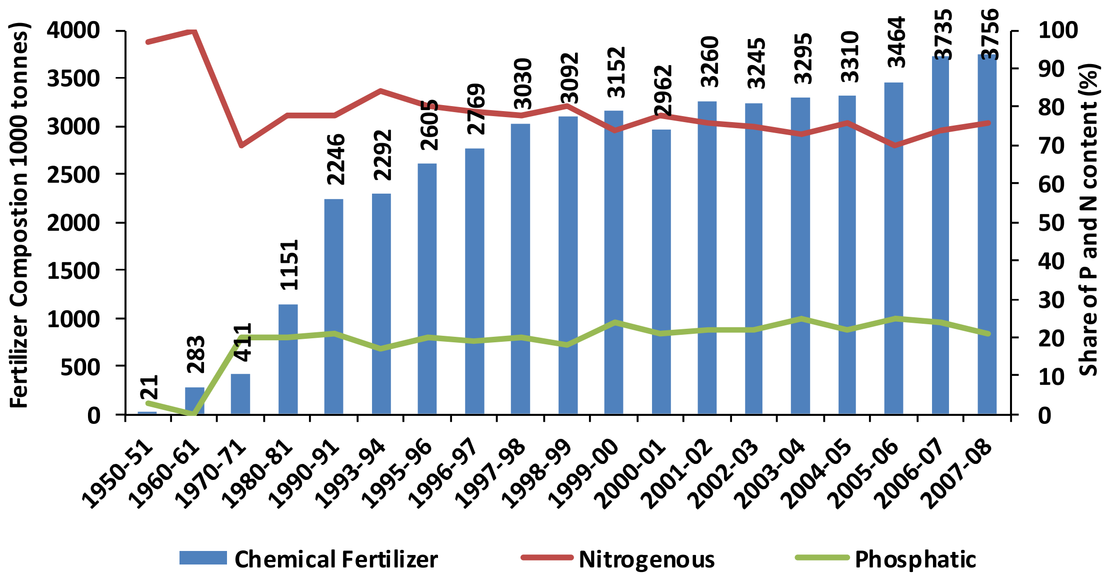

Figure 28: Trends in consumption of chemical fertilizer in Uttar Pradesh

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.

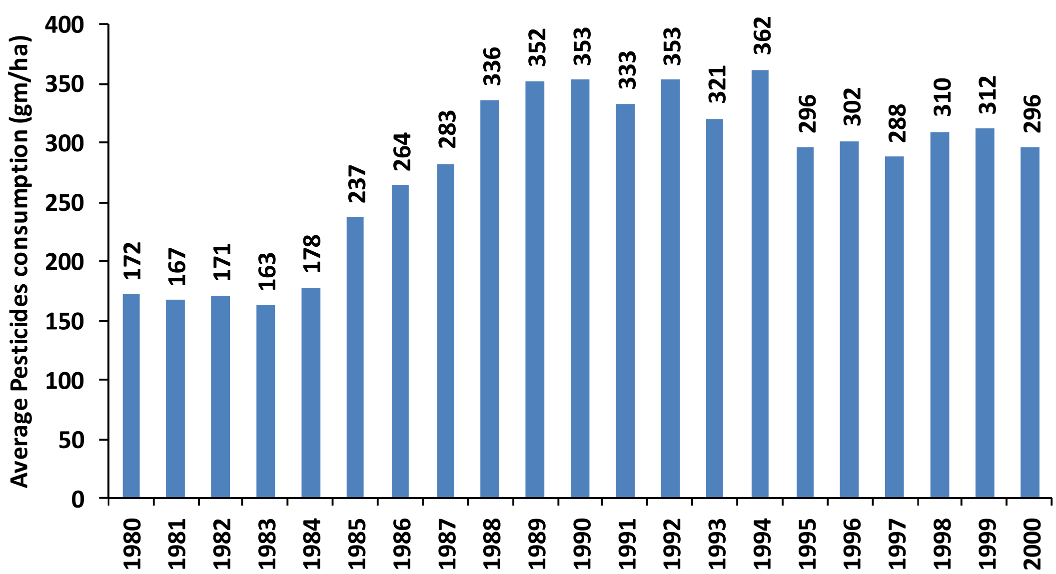

Figure 29: Trends in consumption of pesticides in Uttar Pradesh

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.

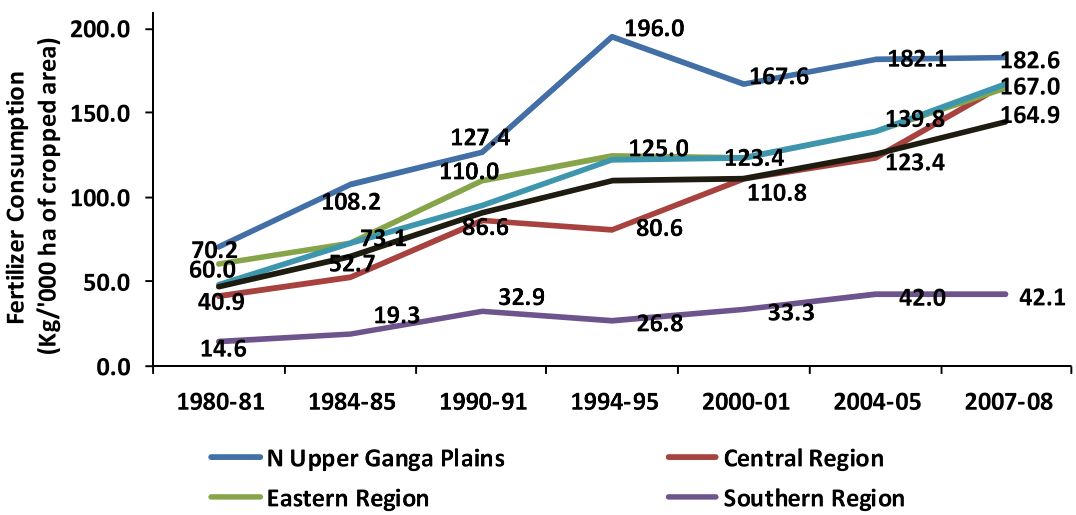

Figure 30: Region-wise trends in per hectare use of chemical fertilizer

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.

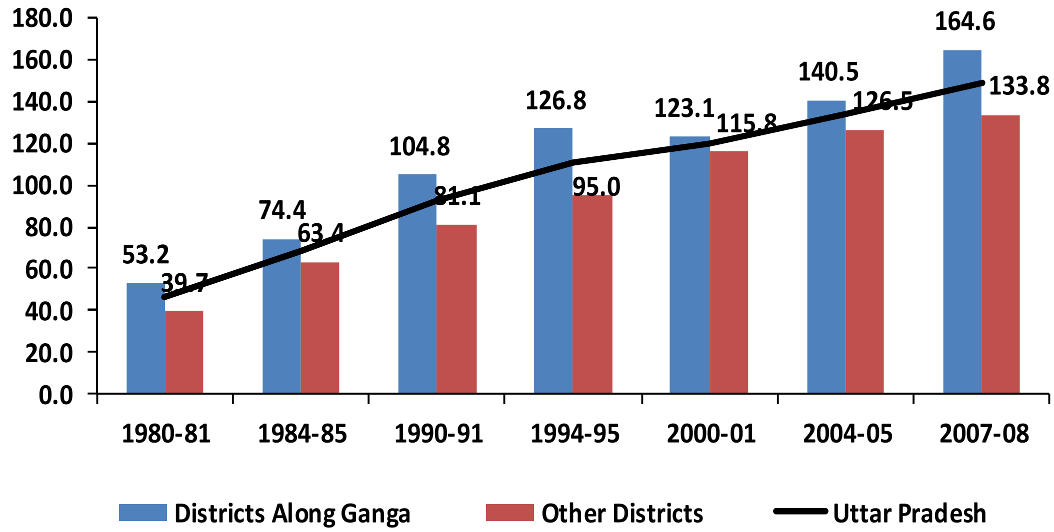

Figure 31: Trends in fertilizer consumption in the Ganga bank and non-bank districts

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.

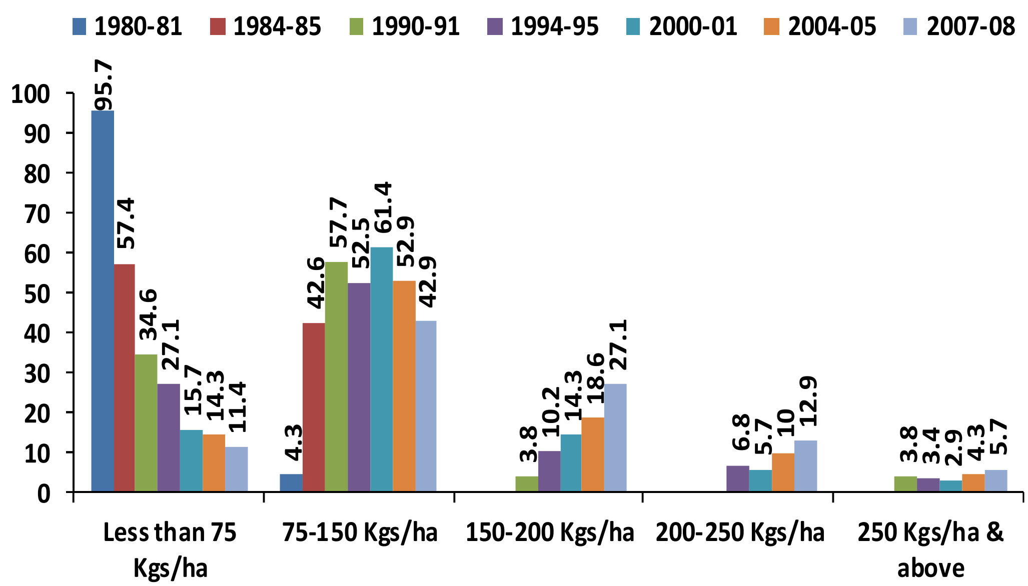

Figure 32: Percentage of number of districts using fertilizer in the stated range

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.

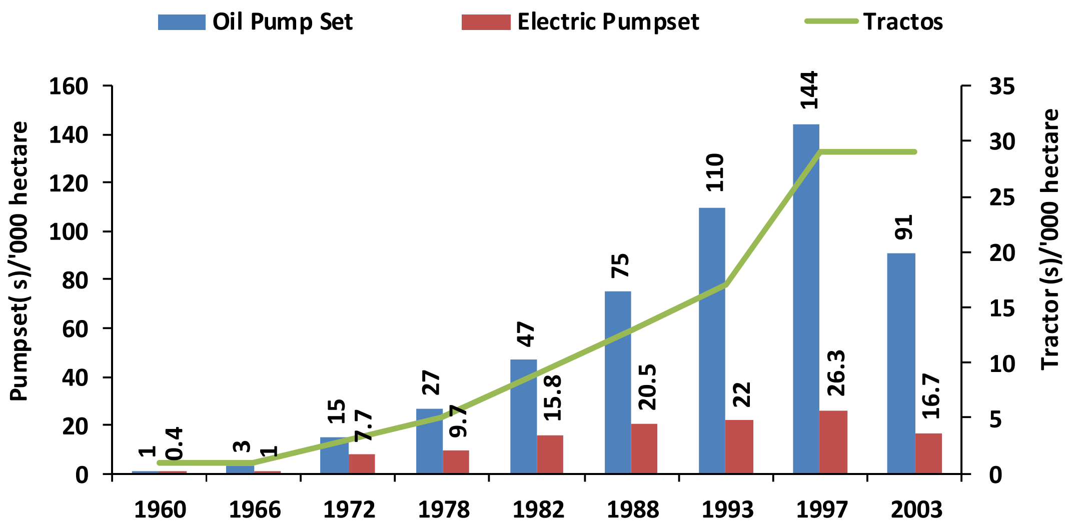

Figure 33: Trends in Farm Mechanization

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.

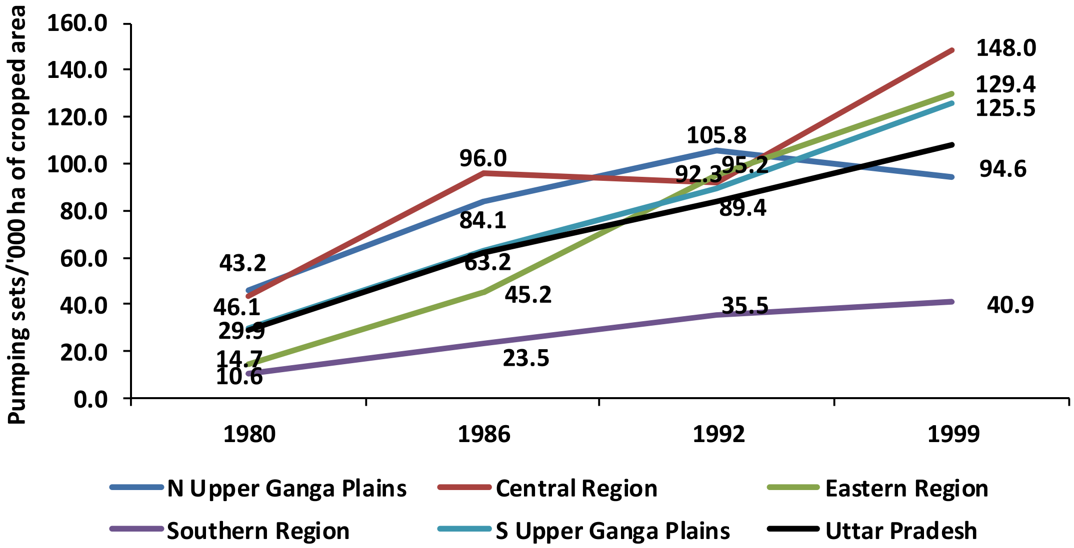

Figure 34: Region-wise total number of pump-sets in operation

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.

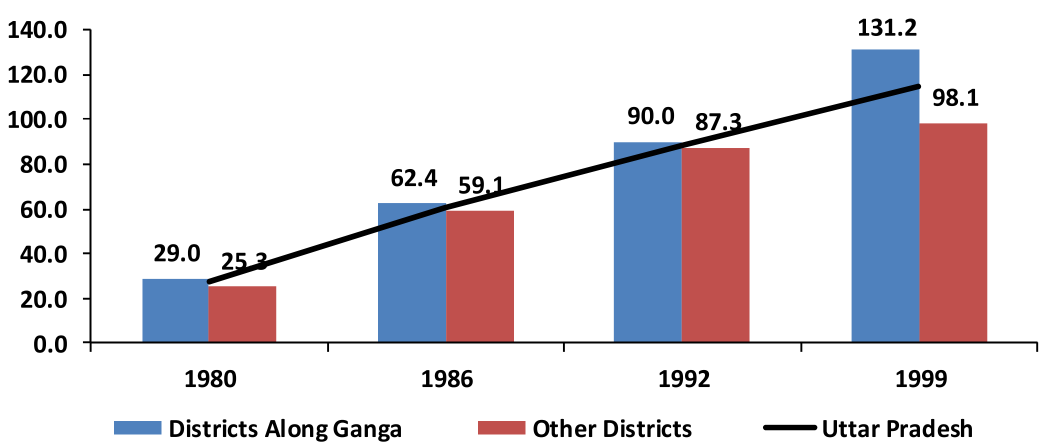

Figure 35: Trends in number of pump-sets per 1000ha of GCA in Ganga bank and non-bank districts

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.

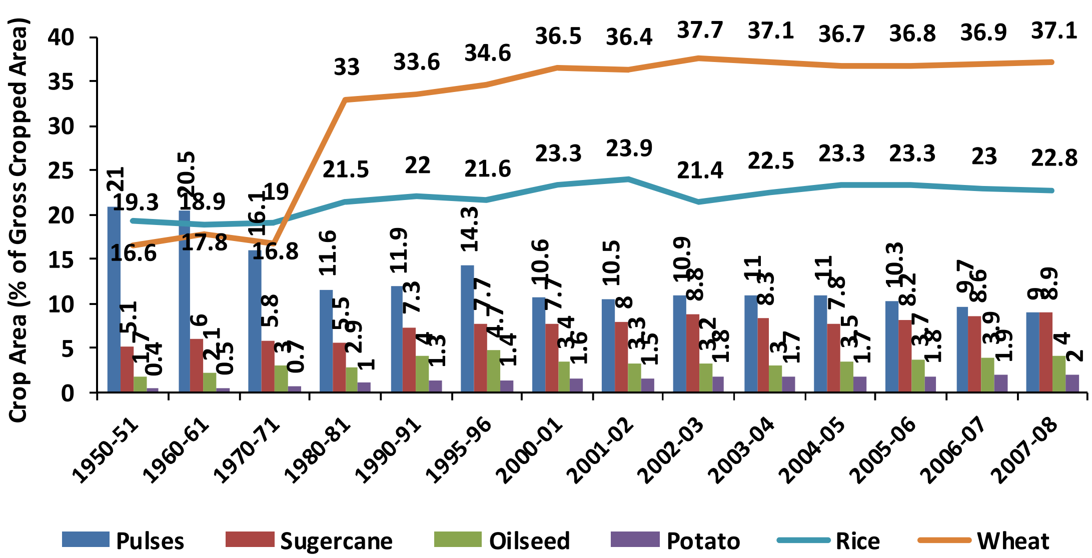

Figure 36: Trends in area under major crops in Uttar Pradesh

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.

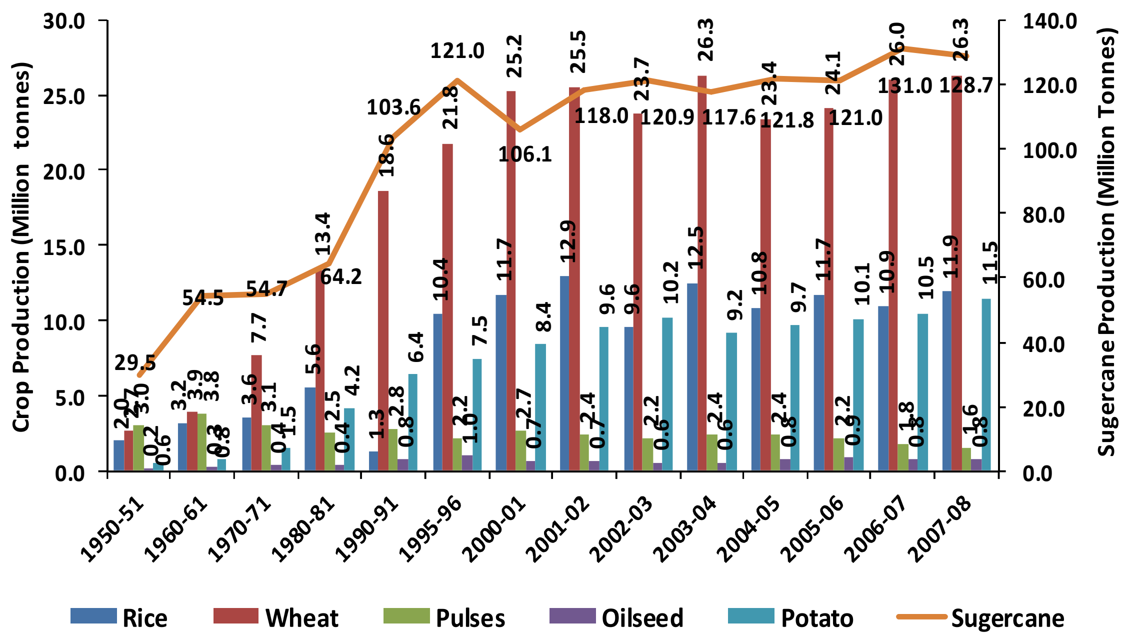

Figure 37: Trends in production of major crops, Uttar Pradesh, 1950-51 to 2007-08

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.

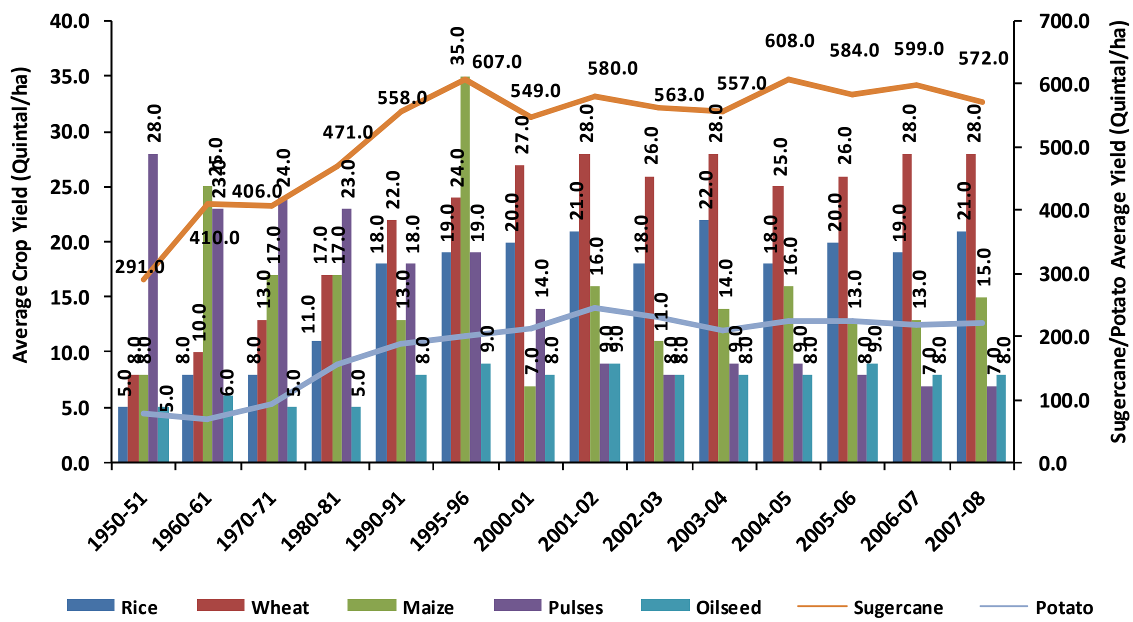

Figure 38: Average yield of major crops, Uttar Pradesh, 1950-51 to 2007-08

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.

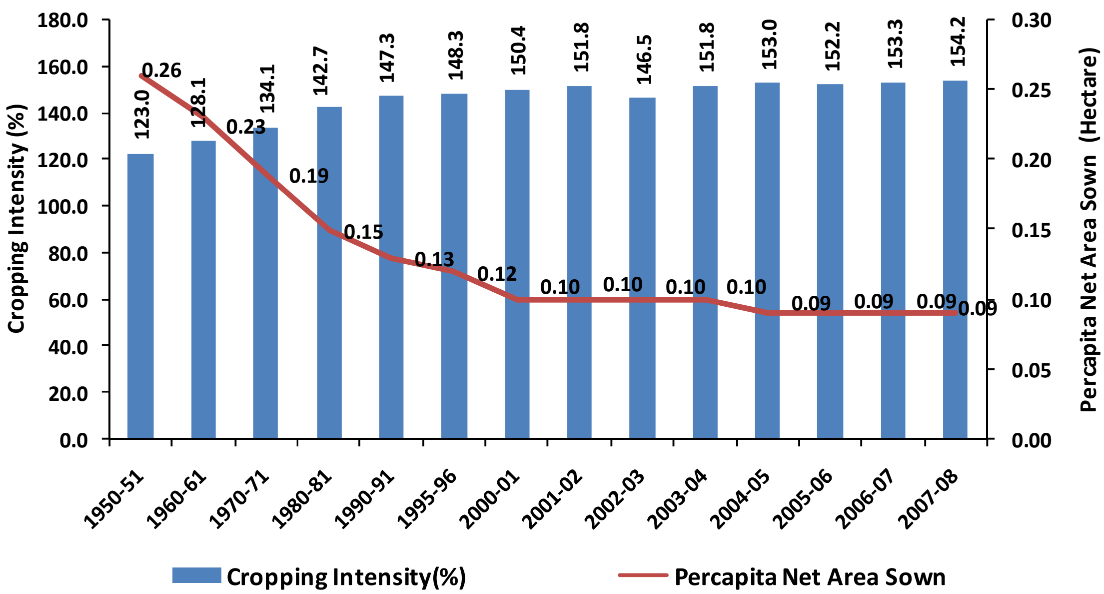

Figure 39: Trends in Cropping Intensity and Per Capita NSA in Uttar Pradesh

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.

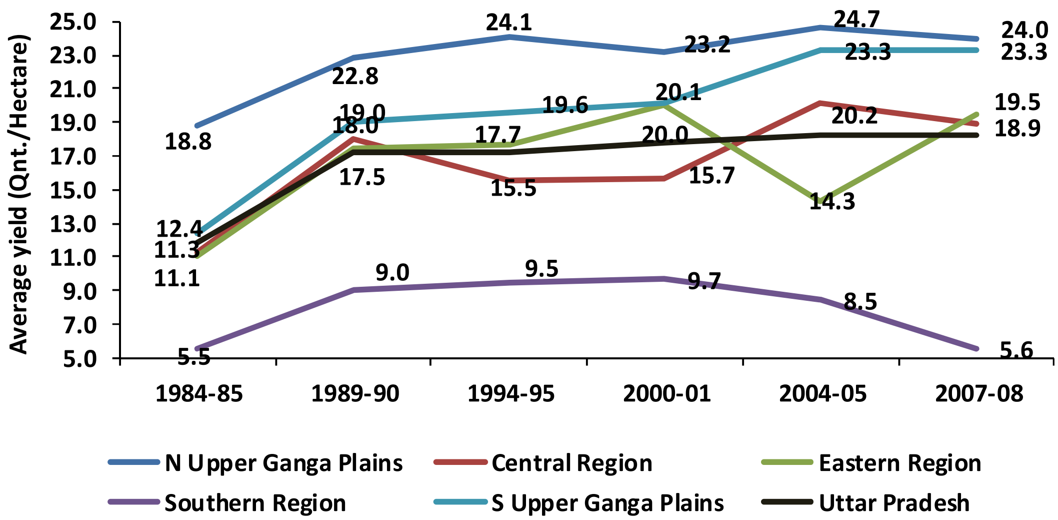

Figure 40: Region-wise trend in average yield of rice in Uttar Pradesh

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.

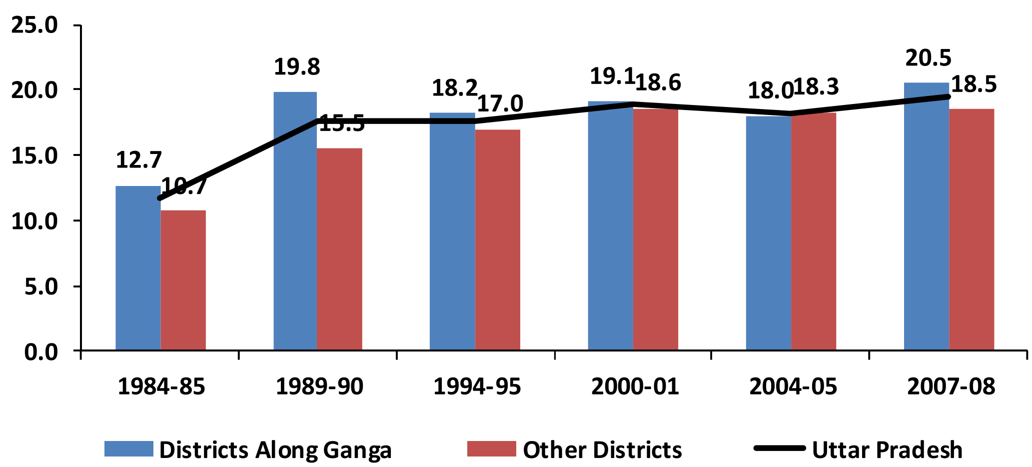

Figure 41: Average yield of rice in the Ganga bank and non-bank districts

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.

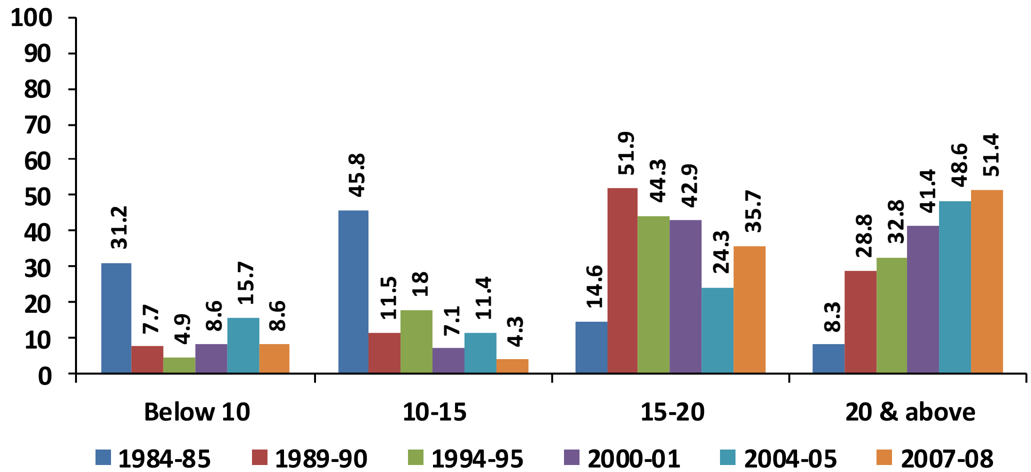

Figure 42: Proportion of districts by class of average yield of rice

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.

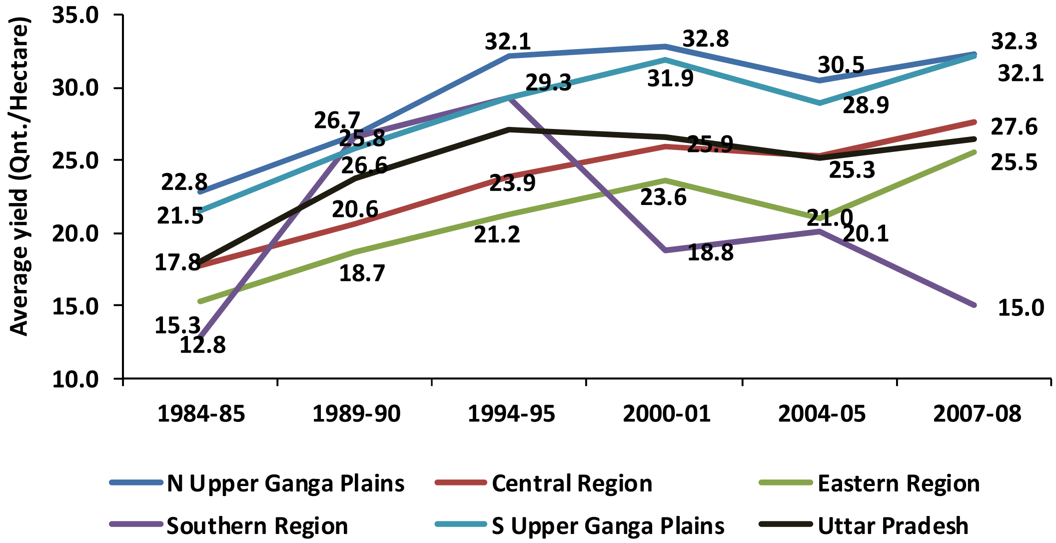

Figure 43: Region-wise average yield of wheat in Uttar Pradesh

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.

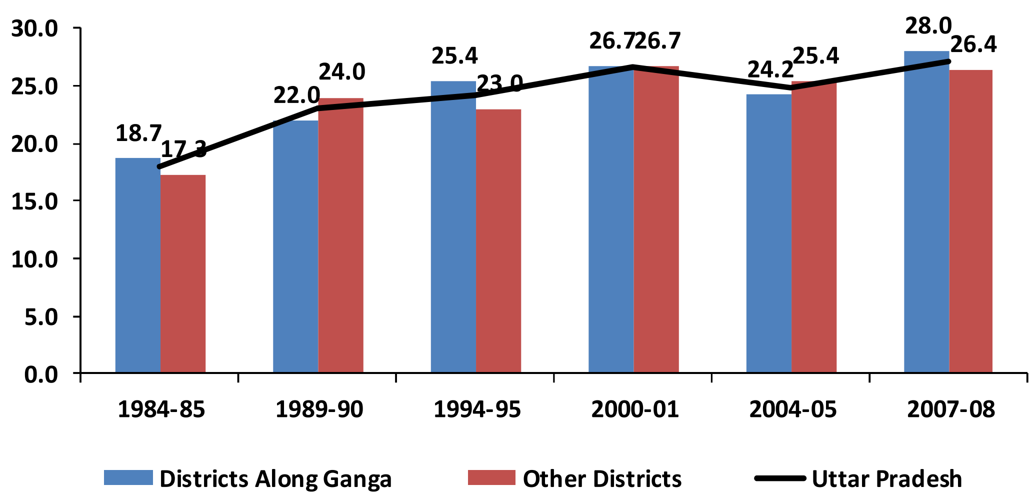

Figure 44: Trends in average yield of wheat in the bank and non-bank districts

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.

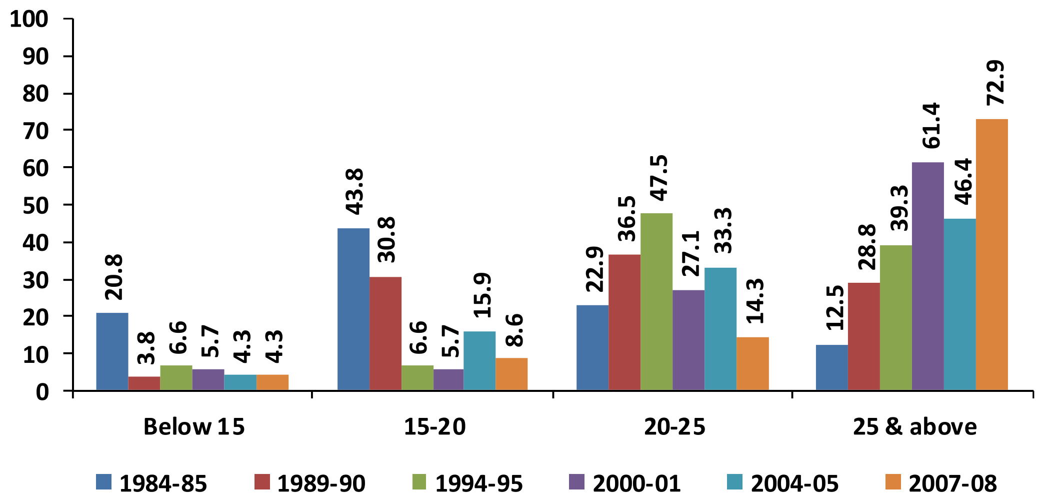

Figure 45: Proportion of districts by class of average yield of Wheat

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.

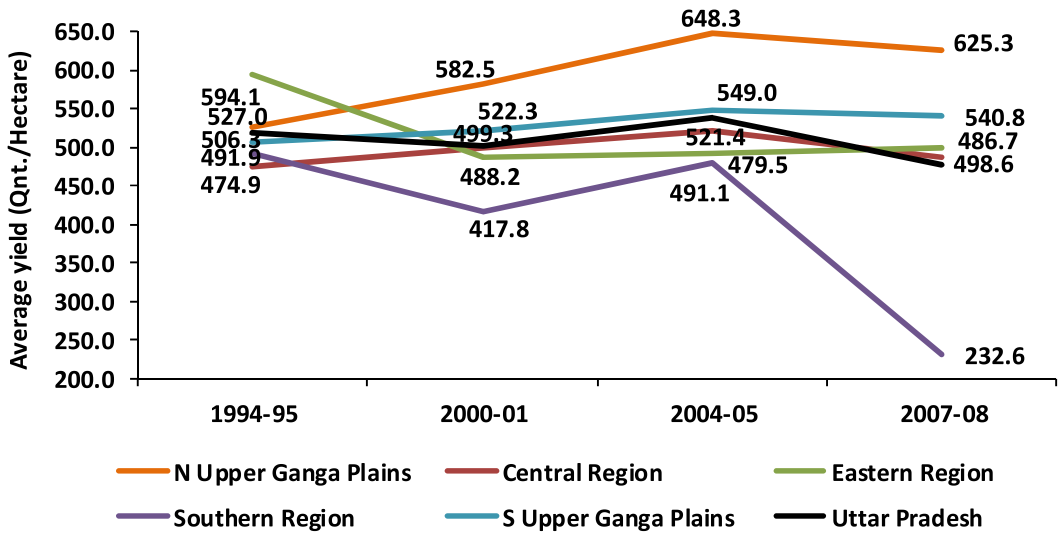

Figure 46: Average yield of Sugarcane across Regions of Uttar Pradesh

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.

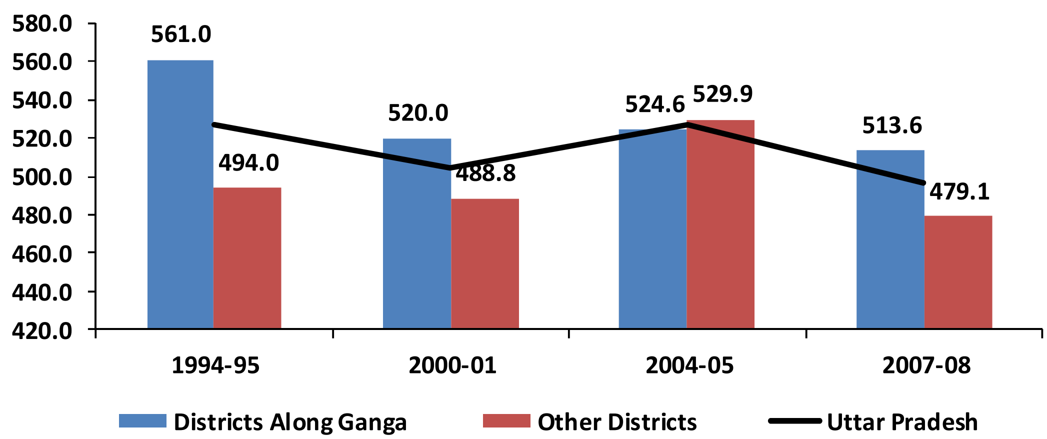

Figure 47: Average yield of sugarcane in the Ganga bank and non-bank districts

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.

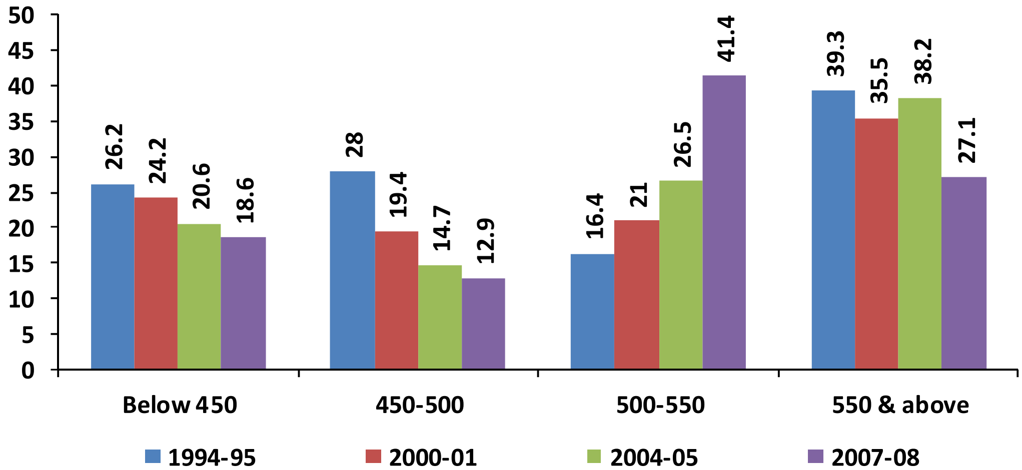

Figure 48: Proportion of districts by class of average yield of sugarcane

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.

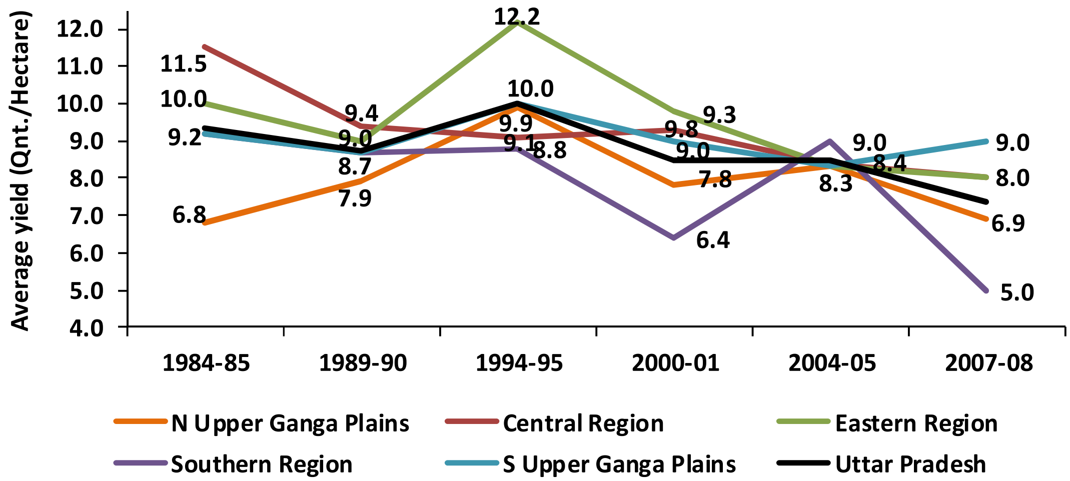

Figure 49: Region-wise trends in average yield of Pulses

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.

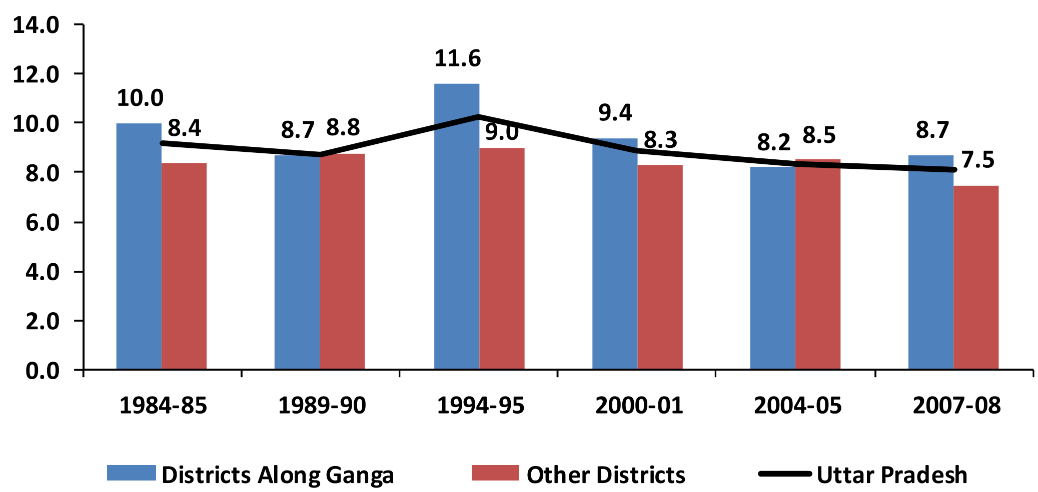

Figure 50: Trends in average yield of pulses in the Ganga bank and non-bank districts

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.

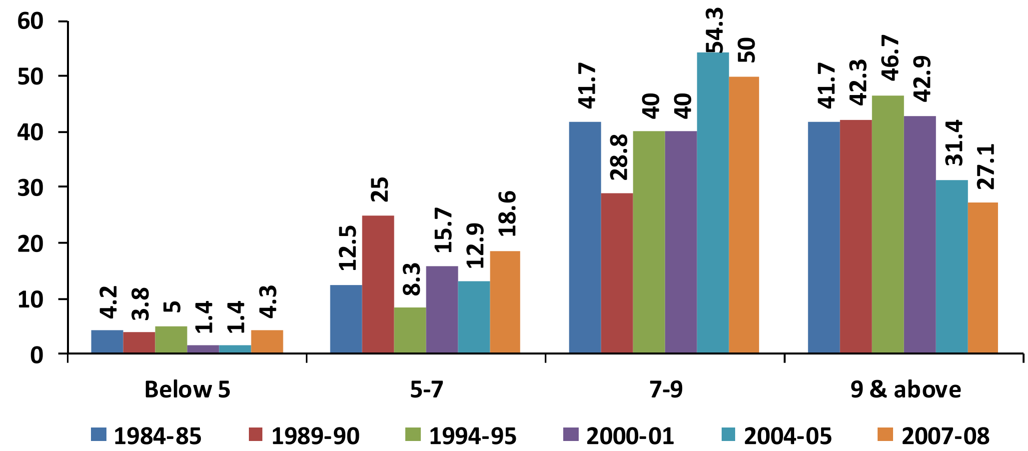

Figure 51: Proportion of districts by class of average yield of pulses

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.

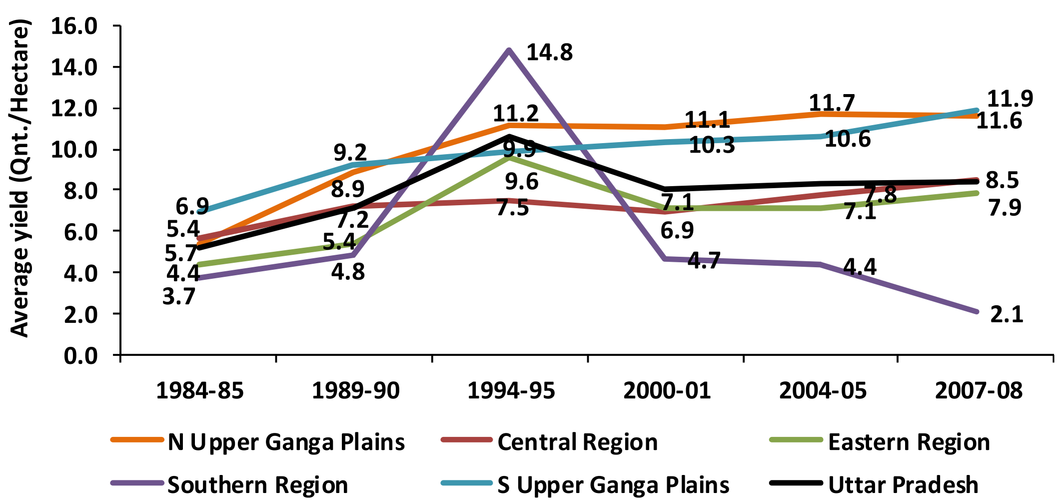

Figure 52: Region-wise trends in average yield of Oilseeds

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.

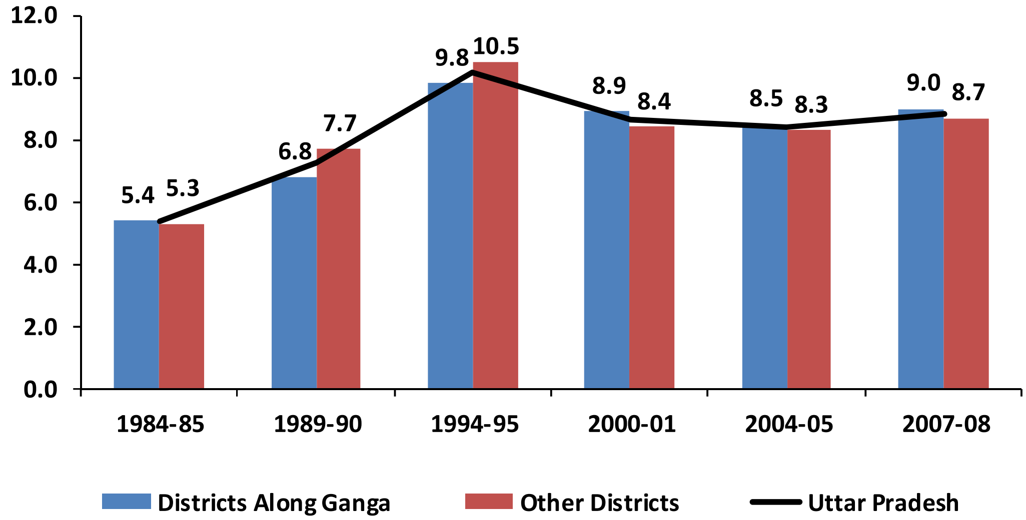

Figure 53: Trends in average yield of oilseeds in the Ganga bank and non-bank districts

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.

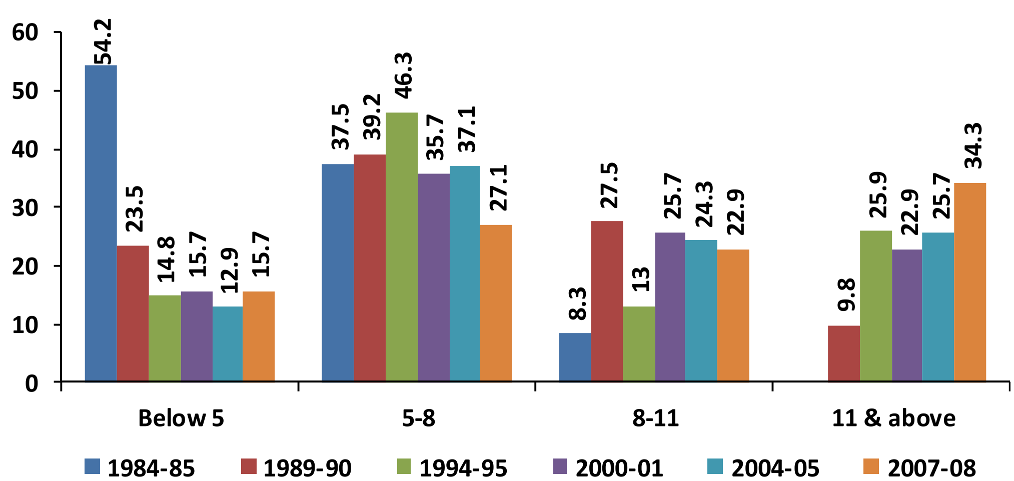

Figure 54: Proportion of districts by class of average yield of oilseeds

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.

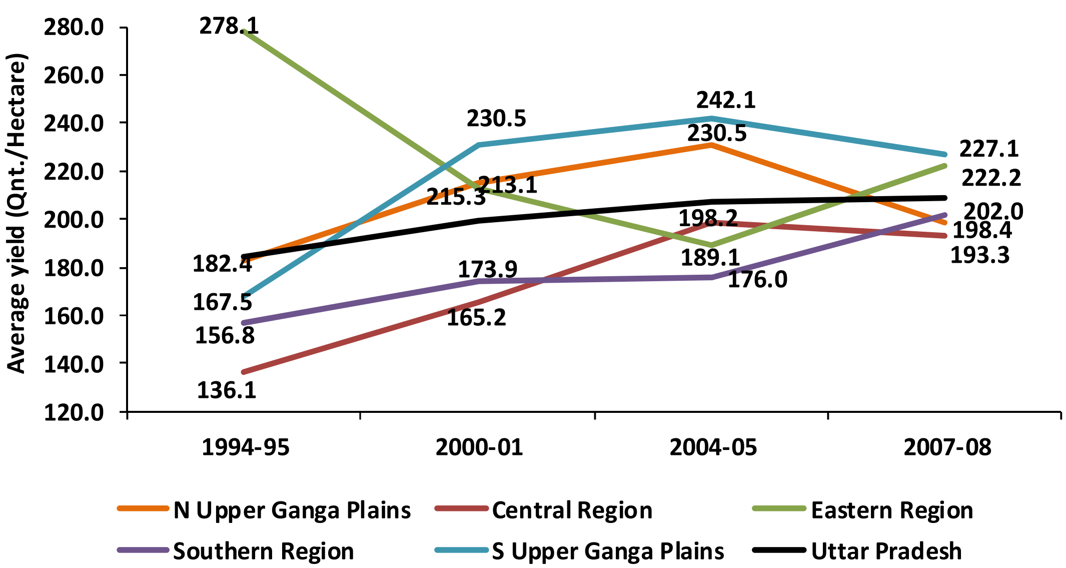

Figure 55: Average yield of Potato across Regions

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.

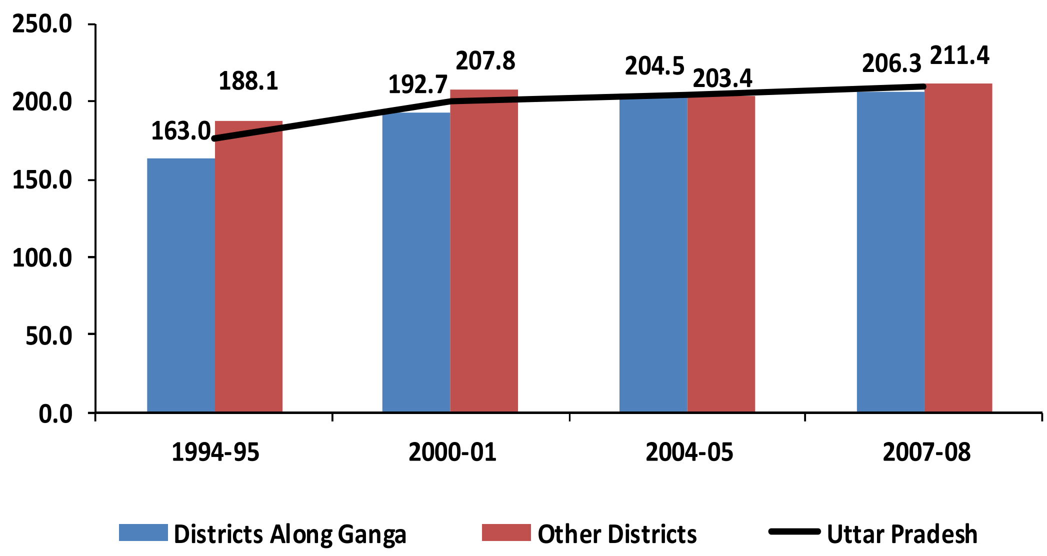

Figure 56: Average yield of Potato in the Ganga bank and non-bank districts

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.

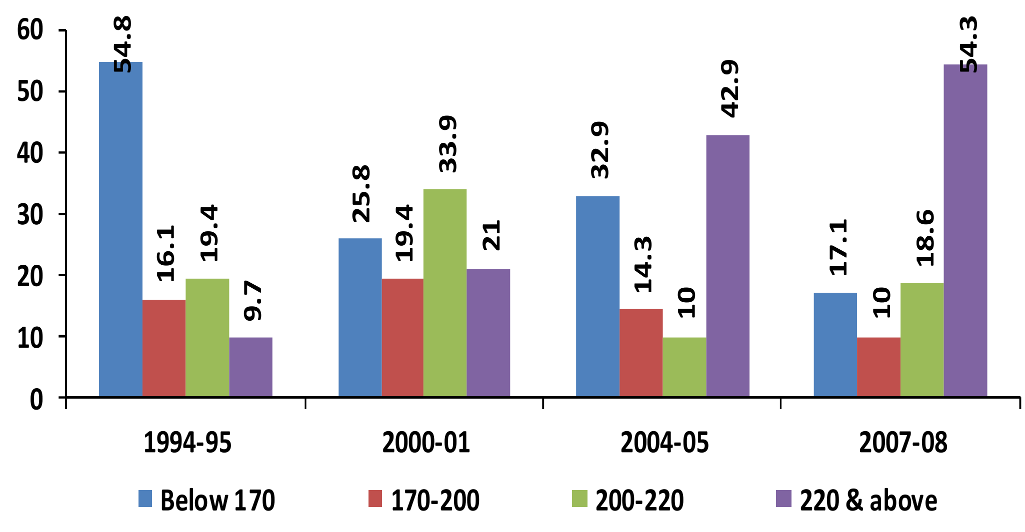

Figure 57: Proportion of districts by class of average yield of potato

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.

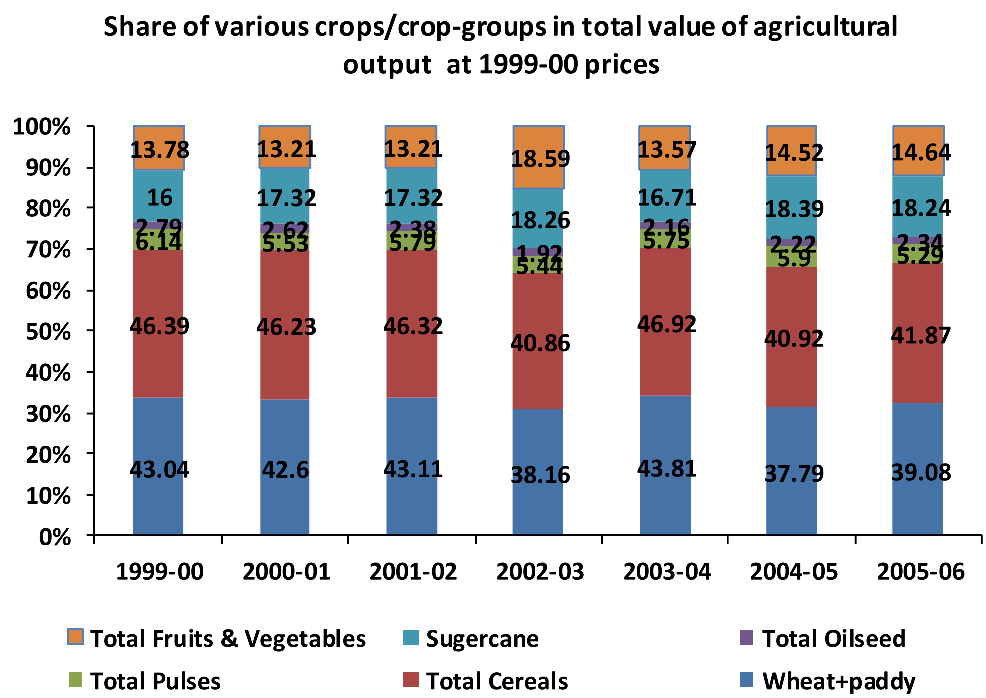

Figure 58: Share of various crops/crop-groups in total value of agricultural output

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.

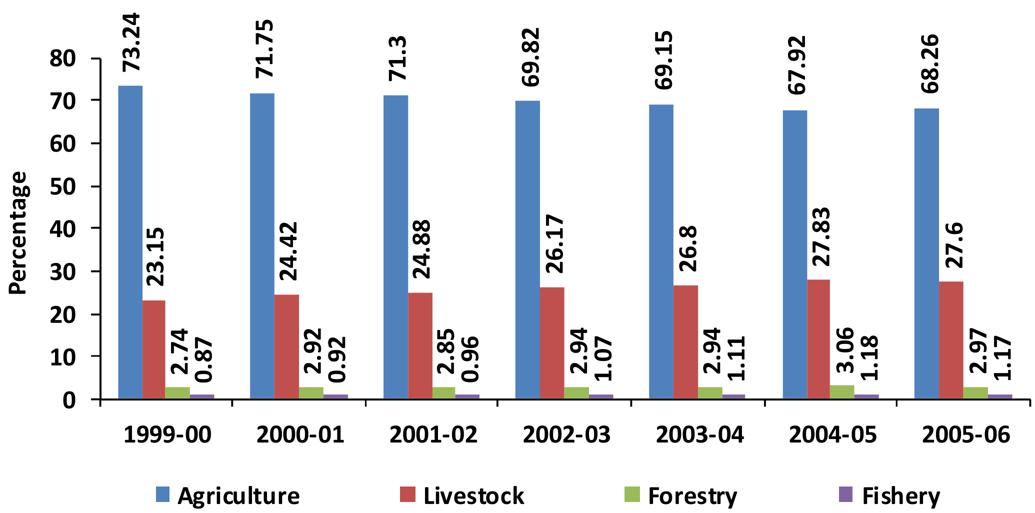

Figure 59: Share of Agriculture, Livestock, Forestry, and Fishery in Total Output of Agriculture and Allied Sector

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.

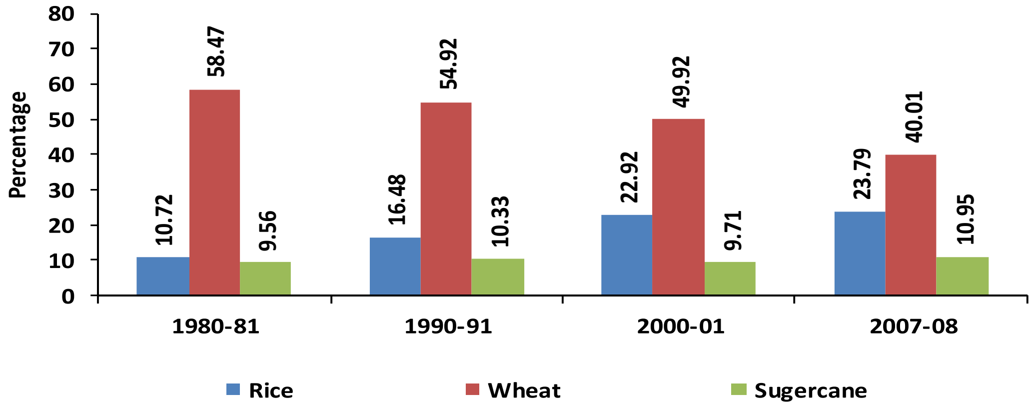

Figure 60: Share of Paddy, Wheat, and Sugarcane in Total GIA in Uttar Pradesh

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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Trends in Agriculture and Agricultural Practices in Lower Ganga Basin

Part III: Bihar

GRBMP: Ganga River Basin 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 Frame Work 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 dialog 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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Contents

1. Introduction

Bihar has been an agrarian economy and 90 percent of its population lives in rural areas (Economic Survey, 2010-11). The state is located in the fertile Gangetic Plains. Bihar is the ninth largest state of India in terms of its area and the second largest in terms of population. It is bounded by Nepal in the north, Orissa in the south, West Bengal in the east and Uttar Pradesh in the west. Bihar lies mid-way between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east. The total area covered by the state of Bihar is 94,163 $km^2$and is located between 21°58'10" N ~ 27°31'15" N latitude and 82°19'50" E ~ 88°17'40" E longitude. Bihar is mainly a vast stretch of very fertile flat land. Central parts of Bihar have some small hills, for example the Rajgir hills. The Himalayan mountainsare to the north of Bihar, in Nepal. Chota Nagpur plateau lies towards the south of Bihar**.**

In 1936, Bihar was separated from Orissa. Later in November 2000, Bihar was bifurcated and a new state Jharkhand was made by transferring 13 districts to the new state. The remaining 29 districts have been reorganized into 38 districts. Hence, currently Bihar is divided into 38 districts and 9 divisions for administrative purposes. After the bifurcation of Bihar in 2000, the industrial and mineral-rich zone has gone to Jharkhand and Bihar was left with fertile land and water resources. Bihar is richly endowed with water resources, both asthe ground water resource and the surface water resource. Bihar has substantial water from rainfall as well as the rivers which flow within the territory of the State. Bihar has a number of rivers, the most important of which is the Ganga. The river Ganga flows right across it from west to east. North Bihar is extremely fertile, the land being watered by the rivers Sarayu, Gandak and Ganga. Twelve districts of Bihar fall on the bank of river Ganga. The other rivers are the Sone, Poonpoon, Falgu, Karmanasa, Durgawati, Kosi, Ghaghara, etc.

The economy of Bihar is mainly based on agricultural and trading activities. The soil of Bihar is extremely fertile which makes it ideal for agriculture.Agriculture is the vital source of wealth in Bihar. Seventy-six percent of its population is engaged in agricultural pursuits. Paddy, wheat, maize and pulses are the principal food crops of Bihar. Main cash crops are sugarcane, potato, tobacco, oilseeds, onion, chillies and jute.Bihar is the third largest producer of vegetables and fourth largest producer of fruits in the country. It is the largest producer of litchi, makhana, guava, lady's finger and honey in the country. However, with improved methods and better management, state's contribution in food grain, fruit, vegetables, spices and flowers can be increased manifold. The major agro based industries of Bihar are rice, sugar, edible oil.

Though endowed with good soil, adequate rainfall and good ground water availability, Bihar has not yet realized its full agricultural potential. Its agricultural productivity is one of the lowest in the country, leading to rural poverty, low nutrition and migration of labour. Based on soil characterization, rainfall, temperature and terrain, three main agro-climatic zones in

Bihar have been identified. These areZoneI:North Alluvial Plain;ZoneII, north East Alluvial Plain;ZoneIII: comprising of ZoneIIIA (South East Alluvial Plain) and ZoneIIIB (South West Alluvial Plain), each with its own unique prospects.

Zone I: This zone comprises of 13districts, namelyWest and East Champaran, Gopalganj, Siwan, Saran, Sitamarhi, Muzaffarpur, Vaishali, Madhubani, Begusarai, Seohar, Darbhanga and Samastipur with an area of 32,665 km^2. The average annual rainfall in this zone is 1234.7 mm.

Zone II: This zone comprises of 8districts, namely Purnea, Katihar, Saharsa, Supaul, Arariya, Kishanganj, Madhepura and Khagaria, and covers 11.96% (20797.4 km^2) of the total geographical area of Bihar. The average annual rainfall in this Zone is 1382.2 mm.

Zone III: This zone is located in the south of the river Ganga and comprises of 17districtsof Bhagalpur, Banka, Munger, Jamui, Lakhisarai, Shekhpura, Gaya, Aurangabad, Jahanabad, Nawada, Arwal, Nalanda, Patna, Bhojpur, Buxar, Bhabhua, and Rohtash. The total geographical area is 40,875.5 km^2, which represents 25.75% of the total area of the State. The average annual rainfall in this Zone is 1102.1 mm.

Bihar is primarily an agrarian economy with largely rain-fed agriculture. Due to the poor irrigational facilities, only 50 to 60 per cent of land is covered by irrigation facilities. Its agricultural productivity is one of the lowest in the country, leading to rural poverty, low nutrition and migration of labour. In the forthcoming discussion, a detailed analysis of status of agriculture in Bihar has been presented.

2. Land Use Pattern

After division in 2000, Bihar is left with 54 percent of the total geographical area of erstwhile Bihar. It is important to note that after the formation of Jharkhand, only 21.8 percent of the previous forest cover was left with new Bihar and stands for 6.64 percent of the total area of current Bihar (Table 1 and Figure 1). Area under non agricultural use, which is 17.60 percent in 2005-06, has been almost constant in current Bihar with marginal rise in recent years (Figure 2). The barren land area in Bihar accounts for 4.66 percent of the total area. Current fallow land has been ranging between 5 to 7 percent in the post-division period (Figure 3). The net sown area has been fluctuating around 60% of the total reported area in the post-2001 period (Table 1 and Figure4). On the other hand, the area sown more than once has shown decline from 24.89% in 2000-01 to 19.52% in 2004-05 and further increased to 21.94% in 2006-07 (Figure 5).Gross sown area has shown decline resulting in decrease in cropping intensity from 1.41 in 2000-01 to 1.36 in 2006-07.The continuous decline in area sown more than once has a serious concern for the sustainability of agriculture in the state.

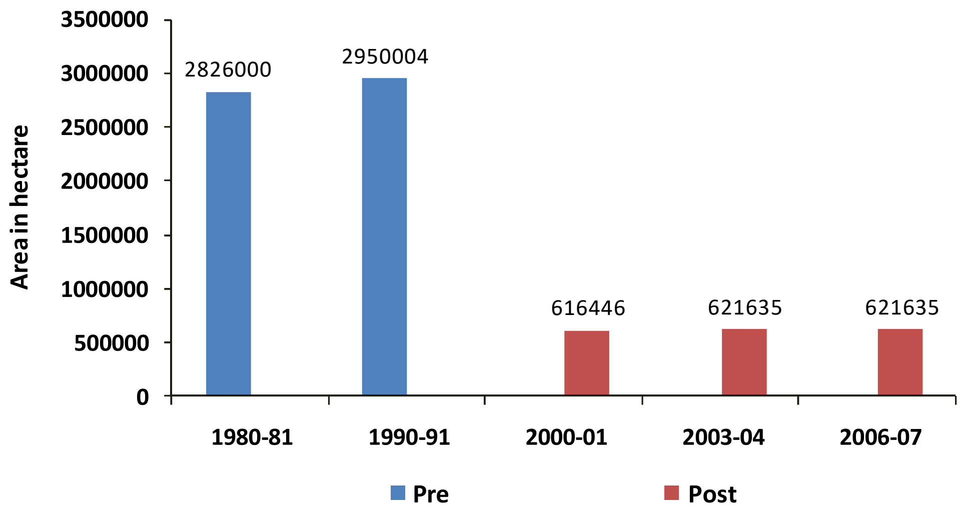

Figure 1: Forest Area of Bihar (in Hectares)

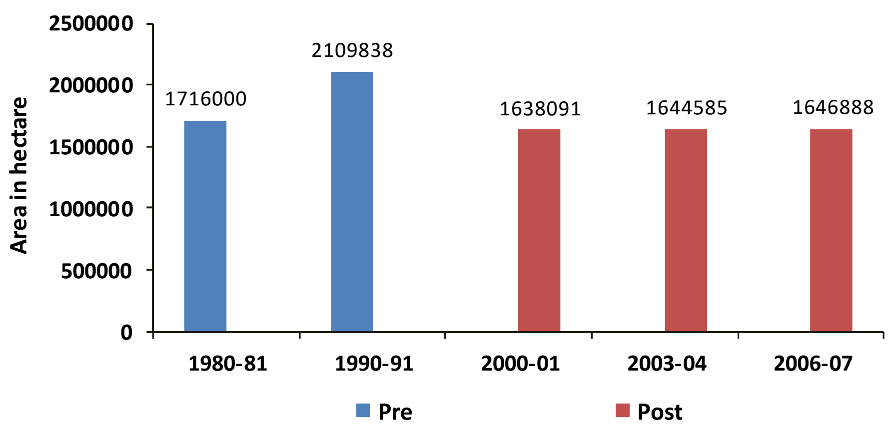

Figure 2: Area under Non Agricultural use in Bihar (in Hectares)

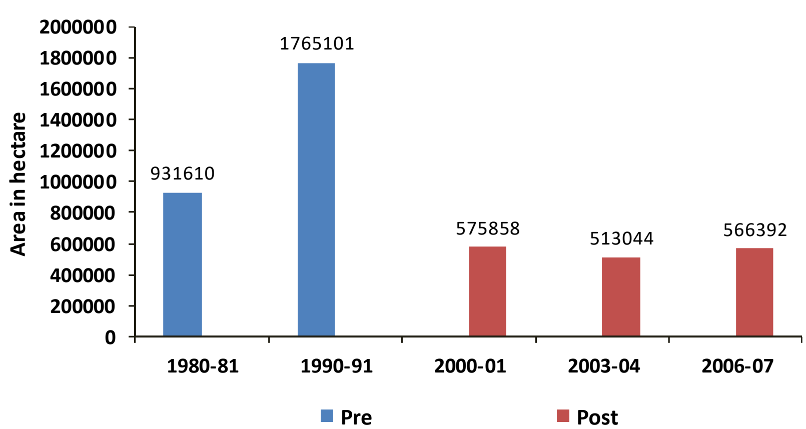

Figure 3: Current Fallow Land in Bihar (in Hectares)

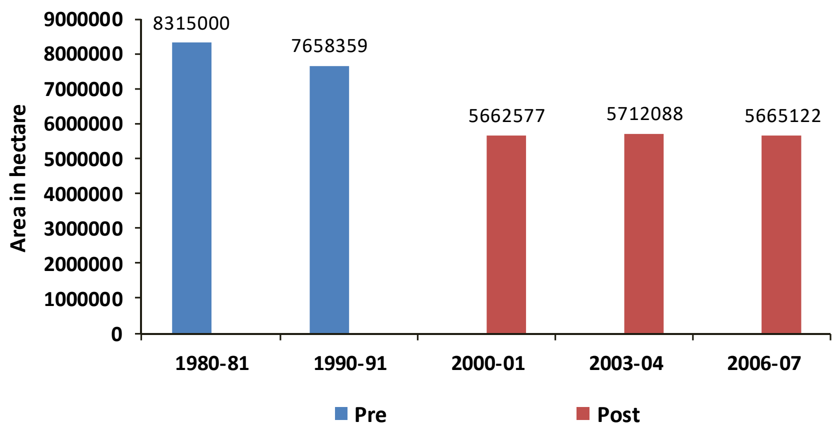

Figure 4: Net Area Sown in Bihar (in Hectares)

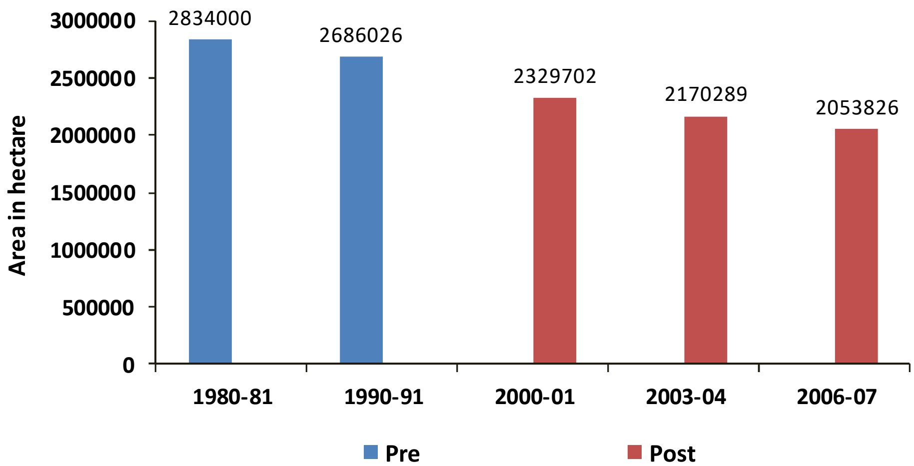

Figure 5: Area Sown more than once in Bihar (in Hectares)

The geographical area of Bihar in bank districts has remained constant after the bifurcation of Bihar and in non-bank districts, there is a marginal fall in the year 2003-04 as compared to 2000-01 but after that it has remained almost constant (see Table 2 and Figure 6).The barren land of bank districts and non-bank districts on an average has remained constant after the bifurcation (Table A.3 and Figure 7).

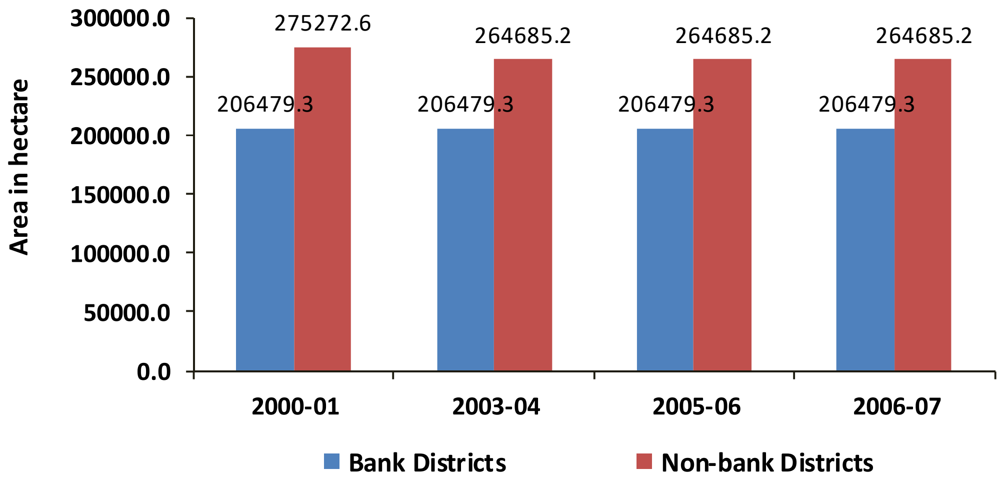

Figure 6: Geographical Area of Bank and Non-bank Districts of Bihar (Average in Hectares)

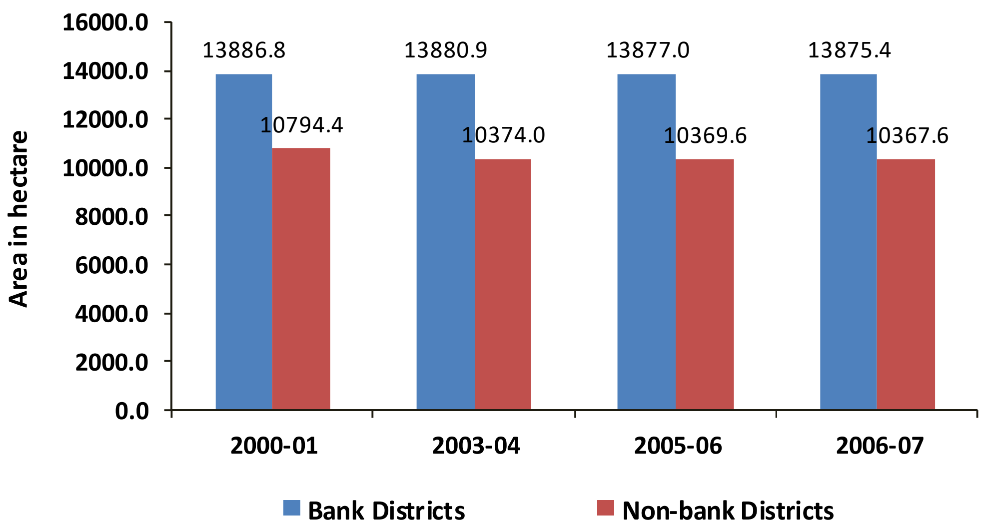

Figure 7: Barren Land of Bank and Non-bank Districts of Bihar (Average in Hectares)

The area under current fallow land shows a fluctuating pattern in case of bank and non-bank districts (Table A.4 and Figure 8). However, the increase in recent years in case of non-bank districts is significant. Net sown area has come down in case of non-bank districts (Table A.5 and Figure 9).

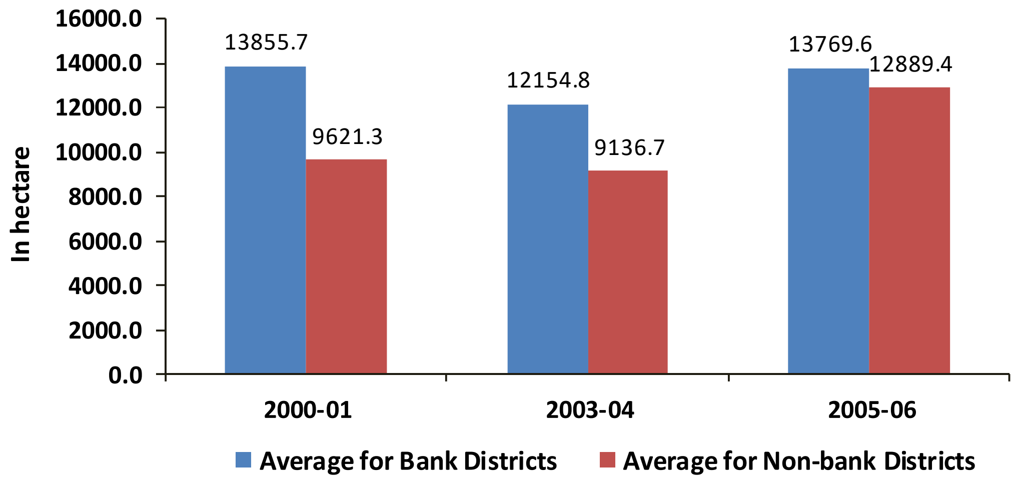

Figure 8: **Current Fallow Land of Bank and Non-bank Districts of Bihar (Average in Hectares)**

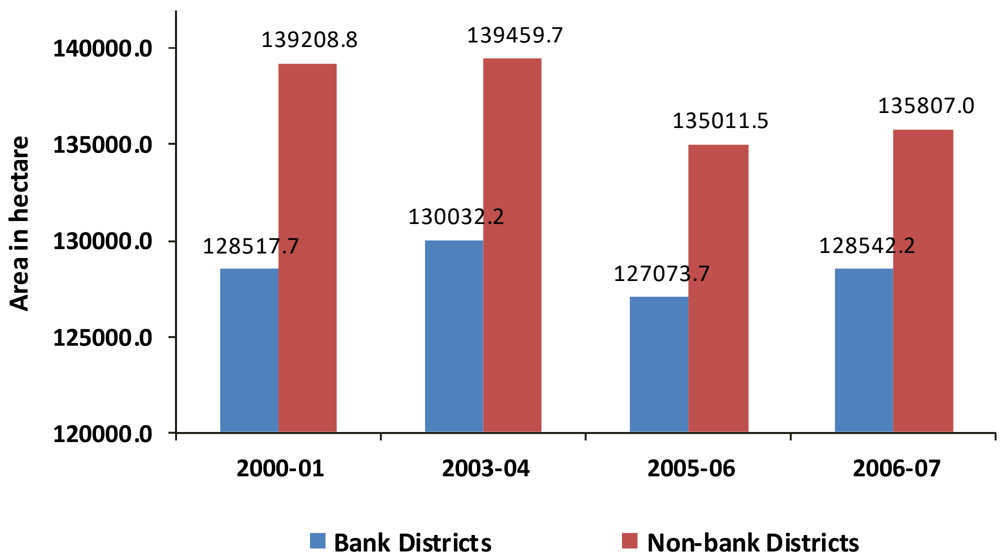

Figure 9: **Net Area Sown of Bank and Non-bank Districts in Bihar (Average in Hectares)**

The land use pattern in the post-bifurcation period has remained more or less unchanged (Figure 10). District-wise analysis also reveals similar pattern except in case of current fallow land. Fallow land has shown increase in recent years, which is more significant in case of non-bank districts. Also the net sown area has come down in case of non-bank districts.

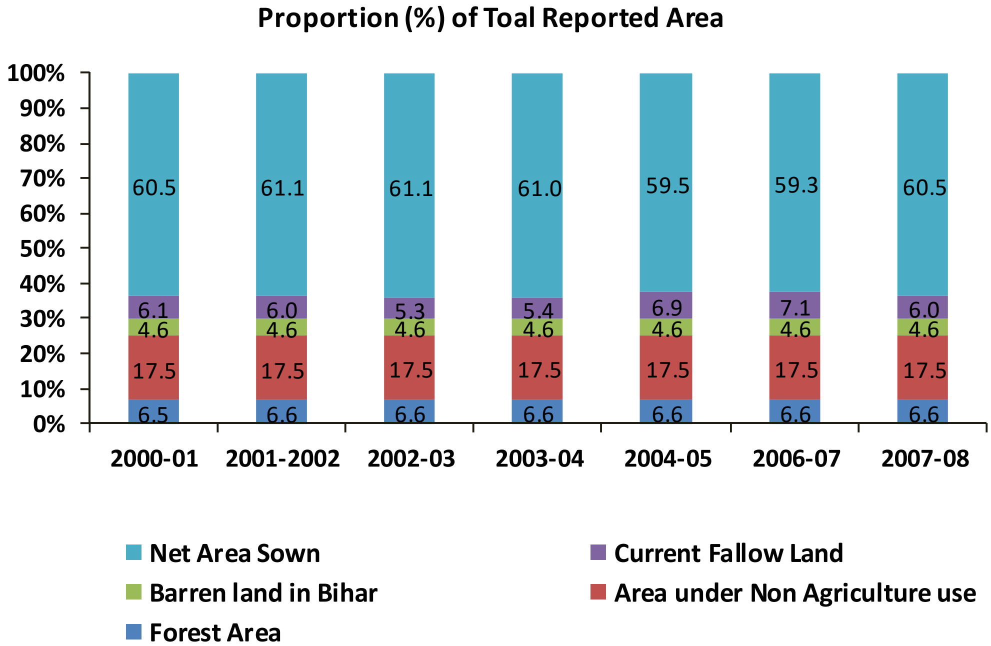

Figure 10: Trends in Land Use Pattern in Bihar

3. Land Holdings

Table A.6 reveals that there has been continuous rise in the number of marginal land holdings in Bihar from 1980-81 to 2005-06. The share of marginal holdings has increased from 75.44 percent in 1980-81 to 84.18 percent in 2000-01 and 89.54 percent in the year 2005-06. The pattern of holdings in 2005-06 is shown in Figure 11. Over the years, share of small, semi-medium, medium and large holdings has declined (Table A.6). Table A.7 presents total area under different sizes of holdings. As can be seen, area under marginal holdings has increased from 43.09 percent in 2001-01 to 52.57 percent in 2005-06. Share of other categories has shown declining trend (see Figure 12 also).This phenomenon can be linked to the rapid fragmentation of holdings in Bihar. Another finding of serious concern is that the average marginal holding in Bihar is 0.24 hectare during the year 2005-06 which has shown constant declining trend (Table A.8, Figure13). The average size of marginal holdings in Bihar was 0.24 hectare during 2005-06. This small average size is an obvious reflection of the predominance of the marginal holdings in Bihar.

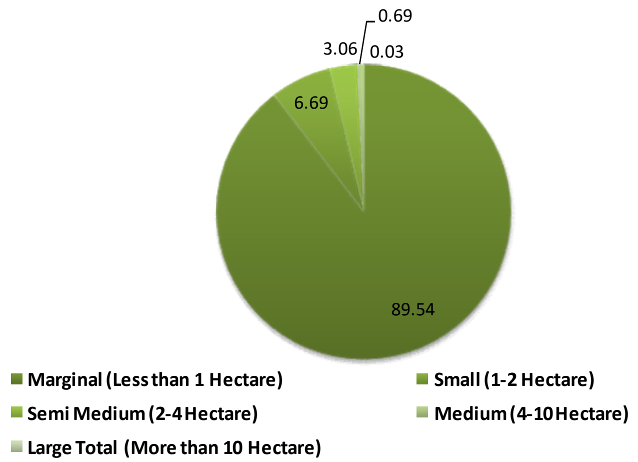

Figure 11: Share in Total Number of Land Holdings in Bihar in 2005-06 (%)

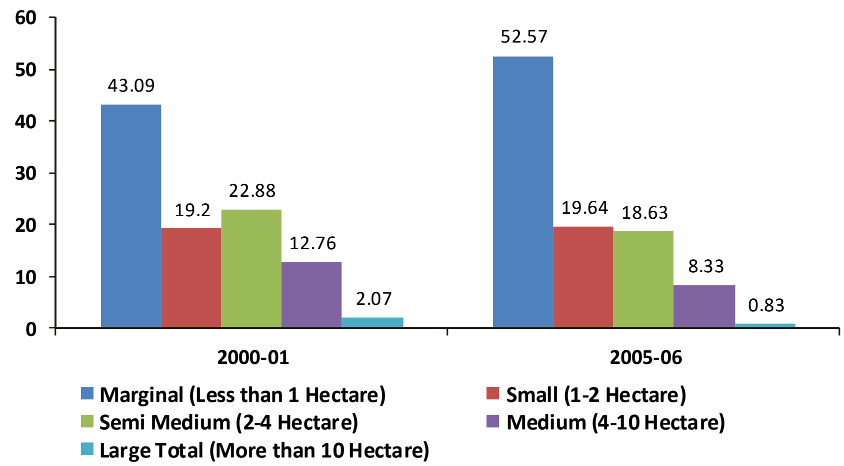

Figure 12: Share in Total Area of Land Holdings (%)

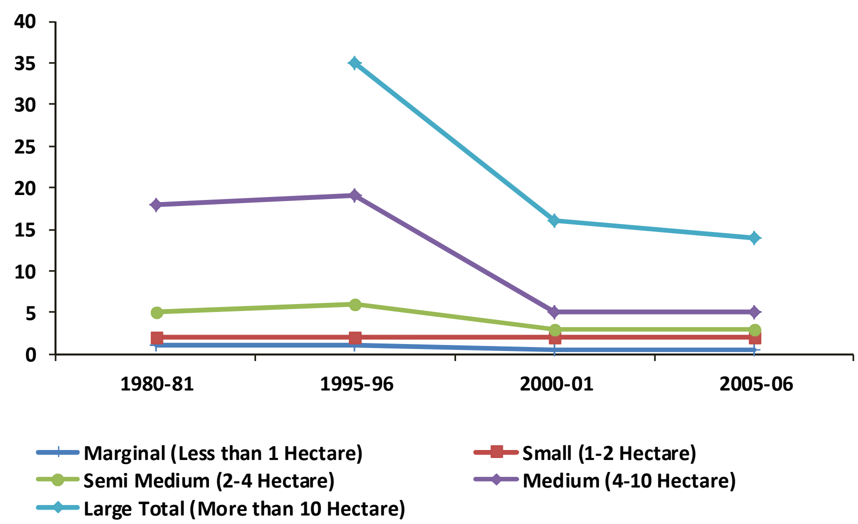

Figure 13: Average Area per Holding (in Hectares)

4. Sources of Irrigation

The ratio of net area irrigated to net sown area is declining in Bihar (Table A.9 and Figure 14). In 2005-06, 56.87 percent of net sown area was irrigated. The gross area irrigated has shown a fluctuating pattern with no clear trend (Table A.15). However, among all sources of irrigation, tubewell has been the predominant source of irrigation in Bihar. In 2005-06, 64.72 percent of net and 66.94 percent of gross irrigated area was irrigated by tubewells (TablesA.9 and A.10 and Figures15 and 16). Hence, it can be said that tube-well is the major source of irrigation in Bihar.

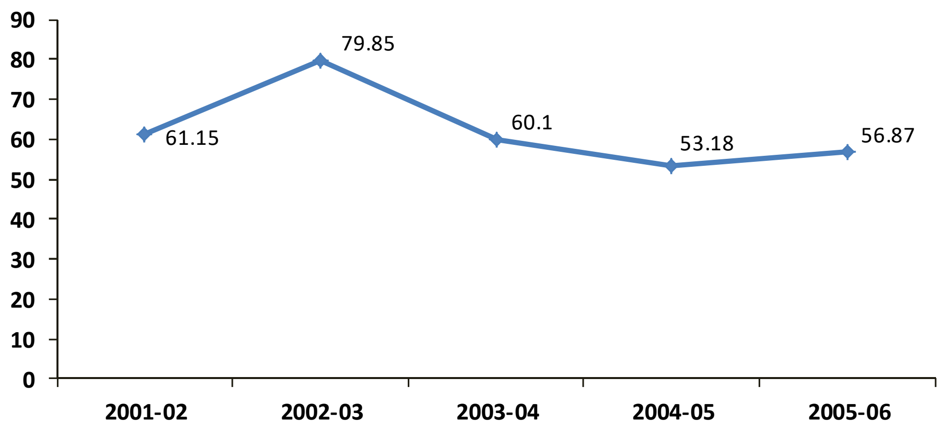

Figure 14: Net Area Irrigated as percent of Net sown Area

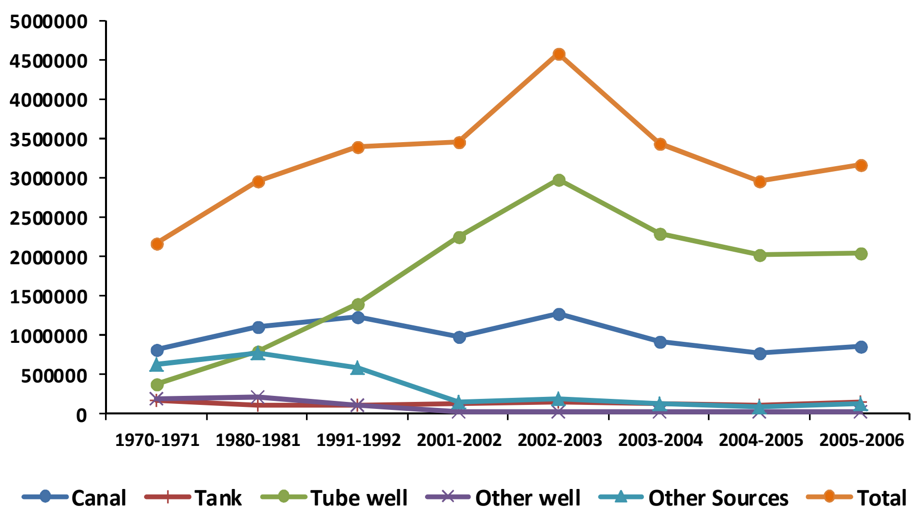

Figure 15: Sources of Net Area Irrigated (1971-2006)

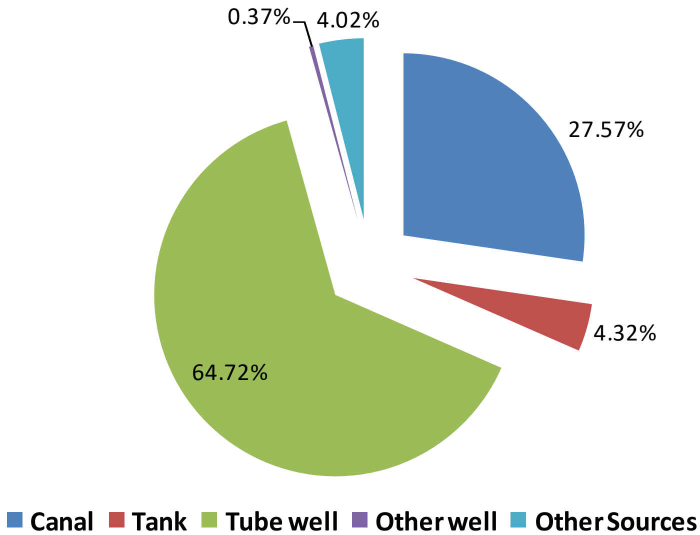

Figure 16: Sources of Net Area Irrigated (2005-2006)

At district level, non-bank districts have shown decline in net area irrigated by canals (see Table A.10). Net area irrigated from tubewell showed decline in case of both bank and non-bank districts though the decline is relatively more in case of non-bank districts (Table A.12 and Figure 17).The number of deep tube wells and dug-wells has also declined over the years in Bihar (Tables A.23 and A.25). Another important finding is that share of Govt. tubewells is insignificant to that owned by individual farmers. This has a serious implication for basin management as the private ownership leads to enormous wastage of water.

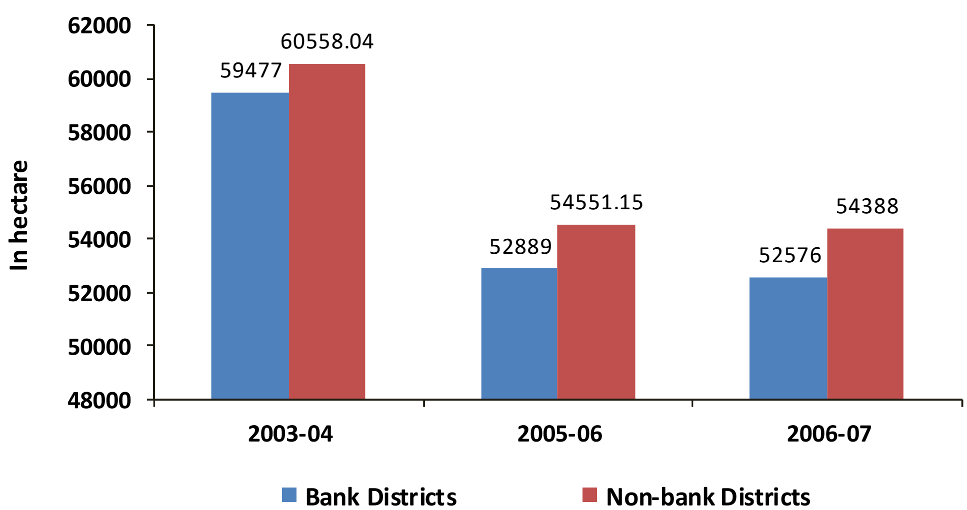

Figure 17: Net Area Irrigated from Tubewell in Bank and Non-bank Districts in Bihar (Average in Hectare)

5. Rainfall

The rainfall in Bihar has shown considerable variations over the years (Table A.21 and Figure 18).The average rainfall for the bank districts (Table A.22 and Figure 19) in Bihar during the post-bifurcation period has shown an increasing trend. In case of the non-bank districts, rainfall has been fluctuating around the average rainfall for bank districts. Vaishali witnessed highest rainfall among bank districts in the year 2007 where as Muzaffarpur recorded the maximum rainfall among non bank districts in the year 2007.

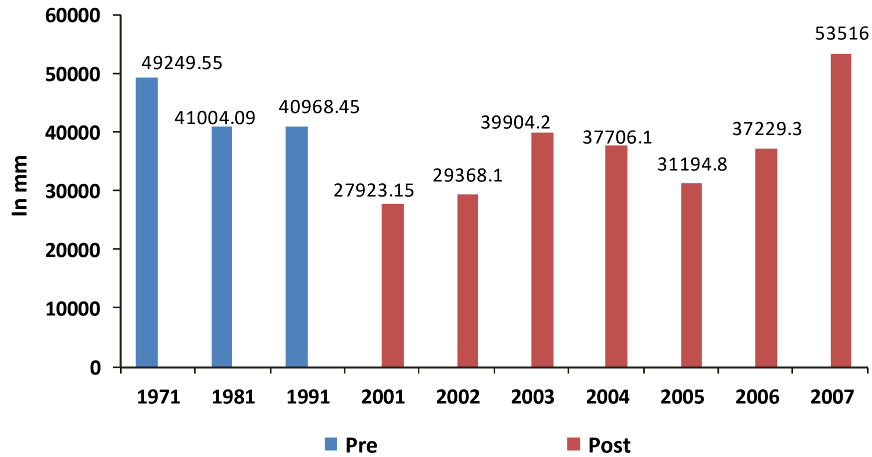

Figure 18: Rainfall in Bihar (in mm)

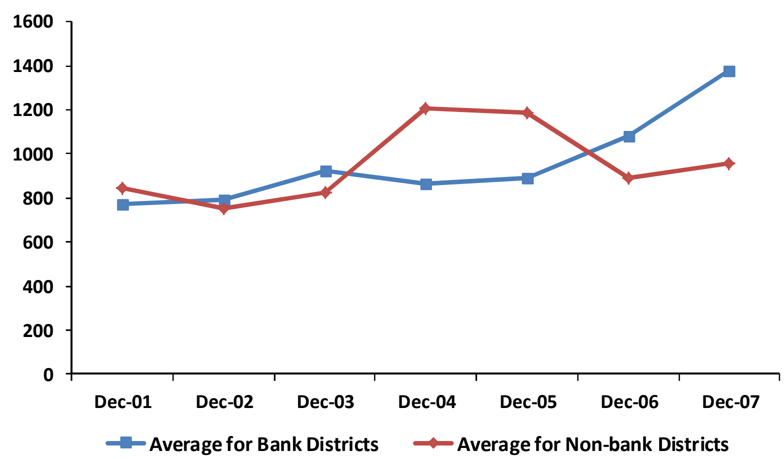

Figure 19: Rainfall in Bank and Non-bank Districts in Bihar (Average in mm)

6. Fertilizer Consumption

The consumption of all the three fertilizers viz., Nitrogen, Phosphate and Potash has increased substantially over the years. Nitrogenous fertilizers have registered maximum increase in per hectare use of fertilizer (Figure 20). This fertilizer accounted for 64.41% of the total fertilizer consumption in 2010 (Table A.29). The total consumption of chemical fertilizers in Bihar has increased from 979.94thousand tonnes in 2001 to 1309.95 thousand tonnes in 2010. The consumption of nitrogenous fertilizer has steadily been increasing from 1971 to 2010 (Figure 21 and Table A.29).The consumption of phosphate fertilizer (Table A.29 and Figure 22) has been more than the consumption of potash fertilizer (Figure 23) but less than the consumption of nitrogenous fertilizers. When compared with Bank districts, non bank districts have shown lesser consumption of all fertilizers (Table A.30, A.31, A.32 and Figures 24-26). Patna, Vaishali, Purnea, Bhojpur, Rohtas, Muzaffarpur and W. Champaran are the highest consumers of nitrogenous fertilizers (see Table A.30).Districts like Muzaffarpur, Purnea, Kartihar, Vaishali have consumed relatively more fertilizer (see Table A.31). The consumption of phosphate fertilizer has been higher in districts like Patna, Vaishali, Muzzafurpur, E. Champaran, W. Champaran, Khagaria and Samastipur (Table A.32).

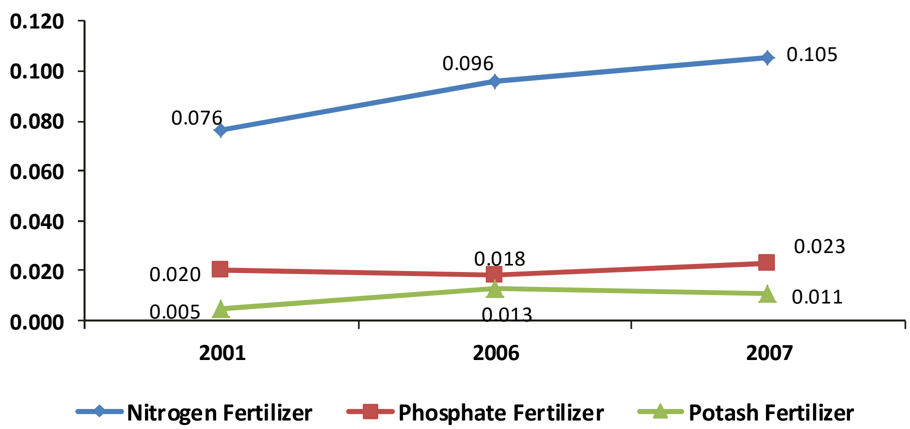

Figure 20: Per hectare Use of Fertilizers (Tonnes)

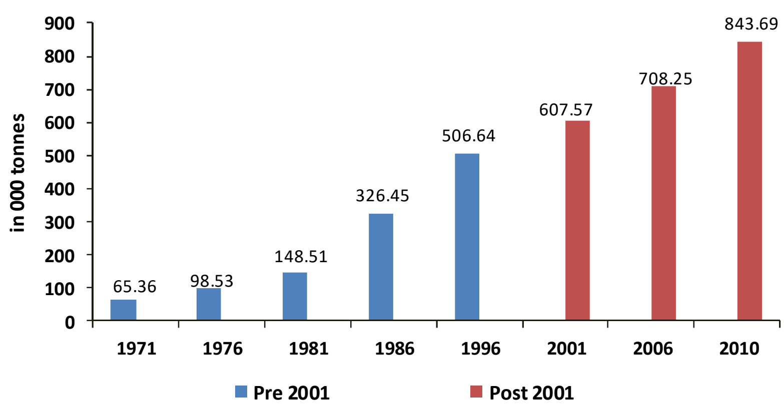

Figure 21: Consumption of Nitrogen Fertilizers in Bihar (in 000' tonnes)

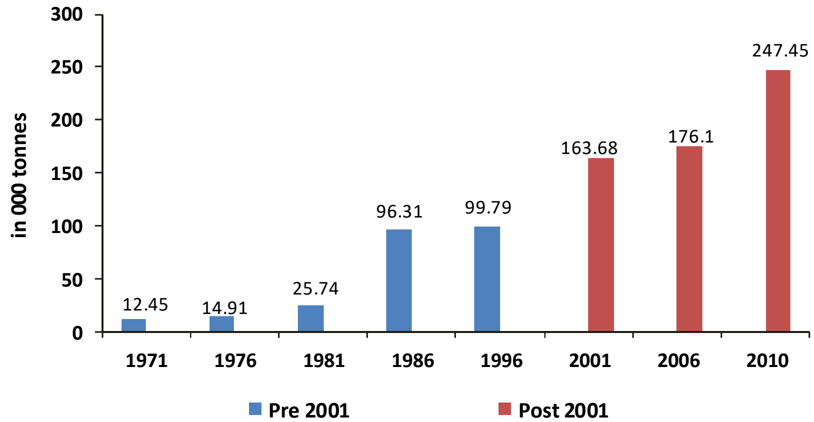

Figure 22: **Consumption of Phosphate Fertilizers in Bihar (in 000' tonnes)**

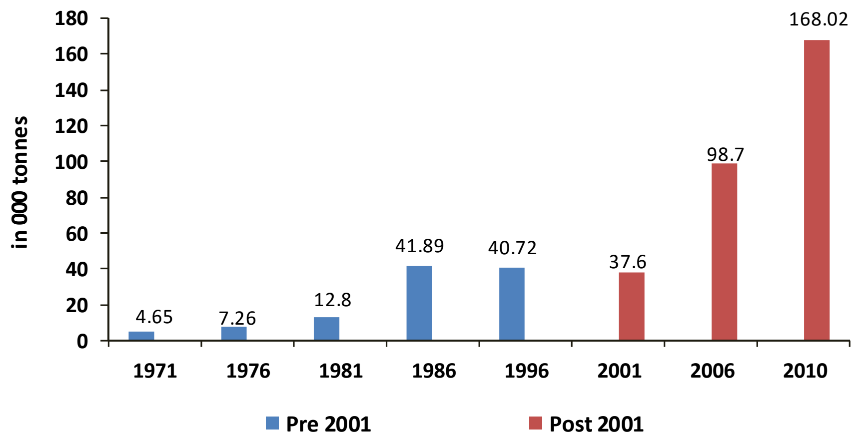

Figure 23: Consumption of Potash Fertilizers in Bihar (in 000' tonnes)

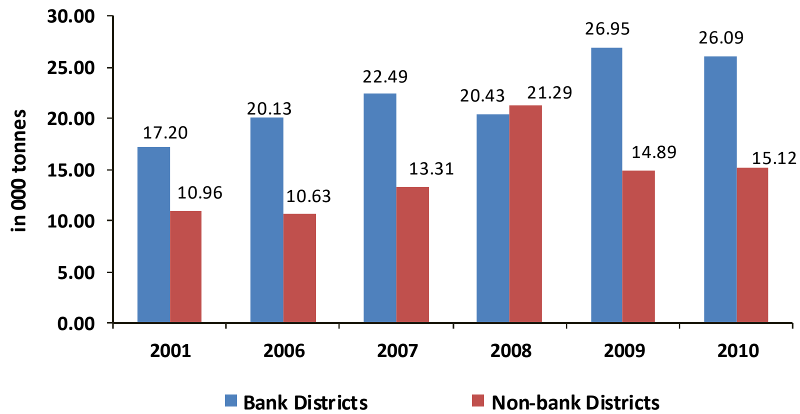

Figure 24: **Consumption of Nitrogen Fertilizer in Bank and Non-bank Districts in Bihar (Average in 000' tonnes)**

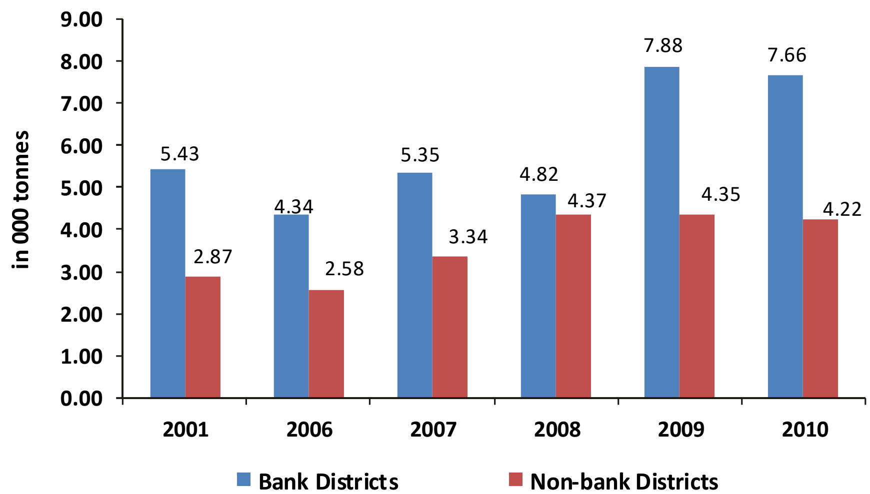

Figure 25: **Consumption of Phosphate Fertilizers on Bank and Non-bank Districts in Bihar (Average in 000' tonnes)**

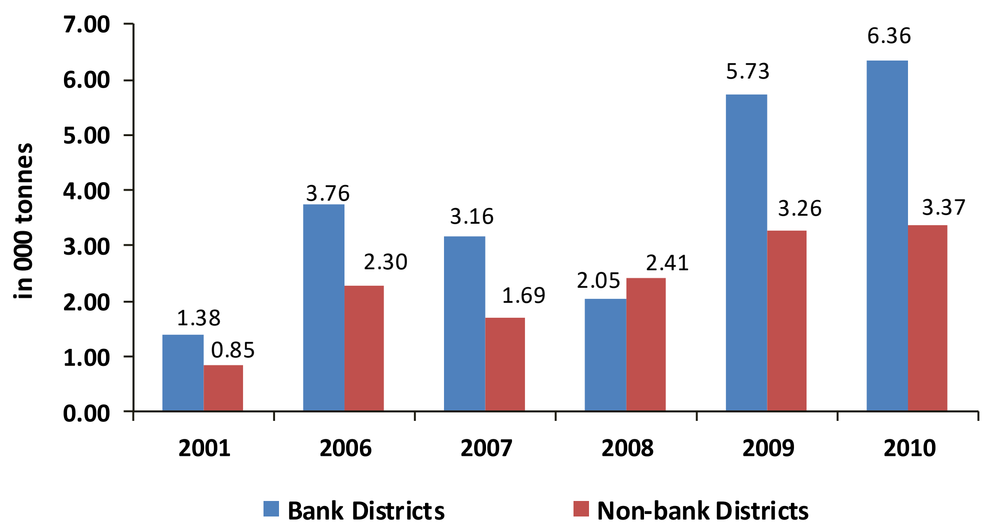

Figure 27: **Average consumption of Potash Fertilizers on Bank Districts and Non-bank Districts in Bihar (in 000' tonnes)**

7. Area, Production and Yield

Bihar is primarily an agrarian economy. Table A.33 to A.35 present performance of agriculture in Bihar in terms of area, production and productivity of major crops. Figure 28 suggest that area under rice cultivation is showing a gradual declining trend whereas area under wheat has been increasing over the years. Maize cultivation however, has been constant. This signifies that farmers are shifting away from rice which is more water consuming. The trends in production and yield for these crops are presented in Figures29 and30.

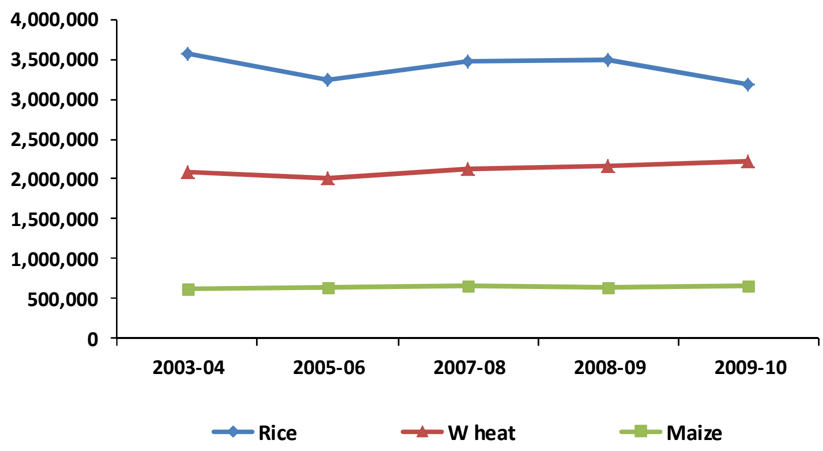

Figure 28: Area of Food Grains in Bihar (in Ha)

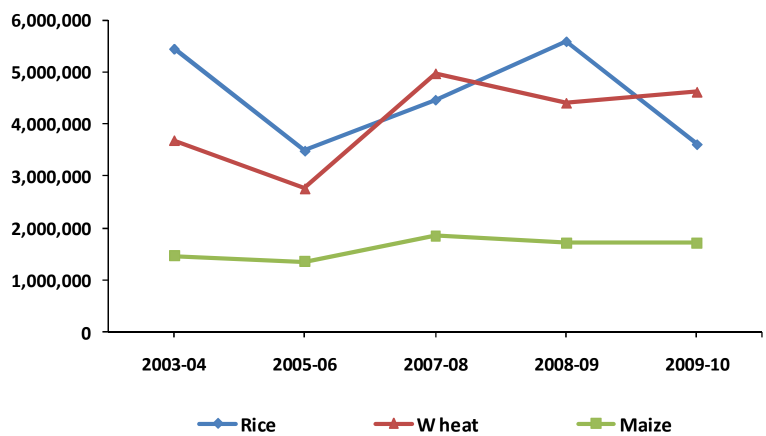

Figure 29: Production of Food grains in Bihar (in MT)

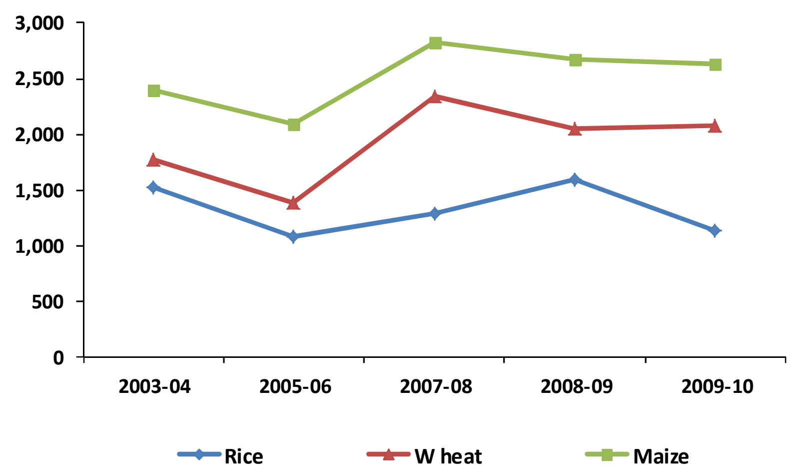

Figure 30: Yield of Food grains in Bihar (in Kg/ha)

At district level, districts like E. Champaran, Aurangabad, W. Champaran, Rohtas and Madhubaniare having the largest area in the state (Table A.35). Maximum contribution to rice production has been made by Rohtas, Aurangabad, Kaimur, Banka, Bhojpur and Nalanda (Table A.36). Highest productivity is registered by Aurangabad, Banka, Bhojpur, Nalanda, Kaimur,Sheikhpura, Patna and Lakhisaria (Table A.37). In case of area under wheat cultivation, maximum area is reported by Rohtas, E. Champaran and Siwan, w. Champaran, Mabhubani, Muzzafarpur and Madhepura (Table A.38). In case of production, the contribution of Gopalganj, Saran, E. Champaran, Siwan and Bhojpur is highest (Table A.39). Maximum productivity is seen in case of Gopalganj, Samastipur, Vaishali, Rohtas and Lakhisaria (Table A.40).

Figure 31 it can be seen that the production of oilseeds has remained constant overtime. The production of jute is also exhibiting more or less constant production. Production of sugarcane however, has shown rising trend (see Table A.35). It can be seen from Figure 32 that area under jute has declined and that of sugarcane has shown rise.

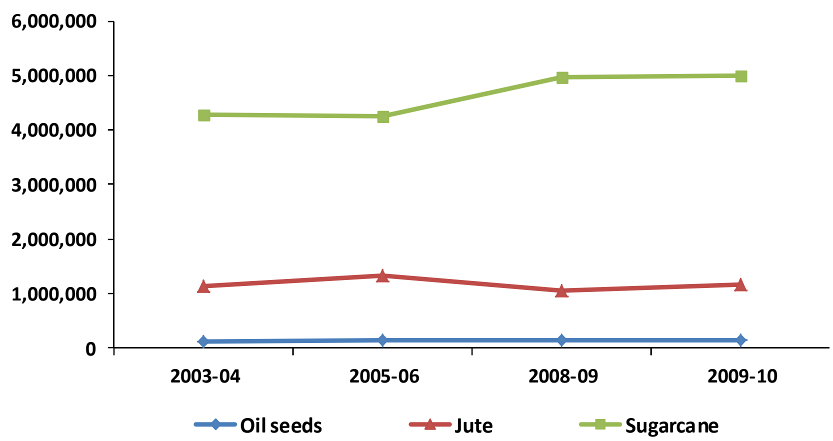

Figure 31: Production of Non Food grains in Bihar (in MT)

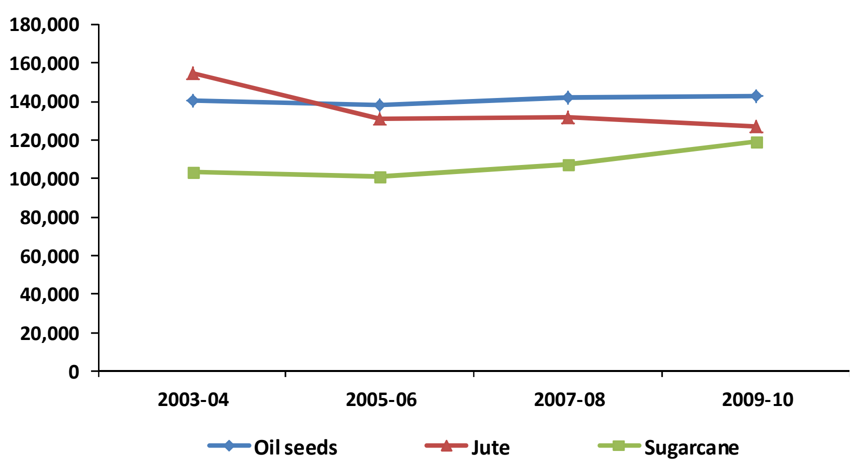

Figure 32: Area under Non Food grains in Bihar (in Hectare)

Among vegetables, the production and the area under cultivation for major vegetables have remained unchanged over the years (Figures 33 and 34). Among fruits, there is a clear bias emerging towards banana as the area has increased from 959.3 thousand hectare in 2005-06 to 1373.55 thousand hectare in 2008-09 (Table A.43 and Figures 35 and 36).

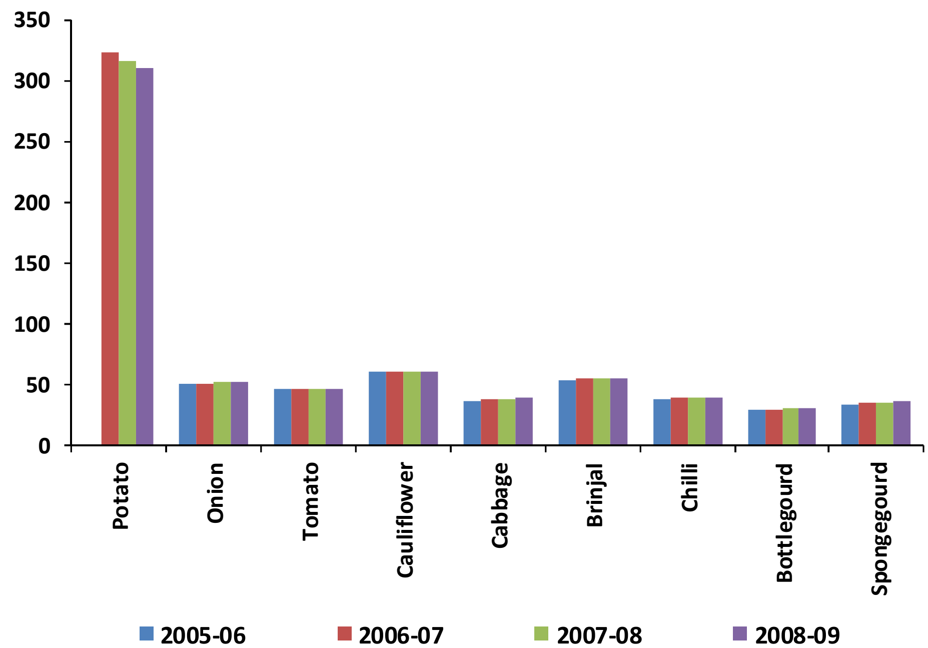

Figure 33: Production of Major Vegetables in 2008-09 ('000 tonnes)

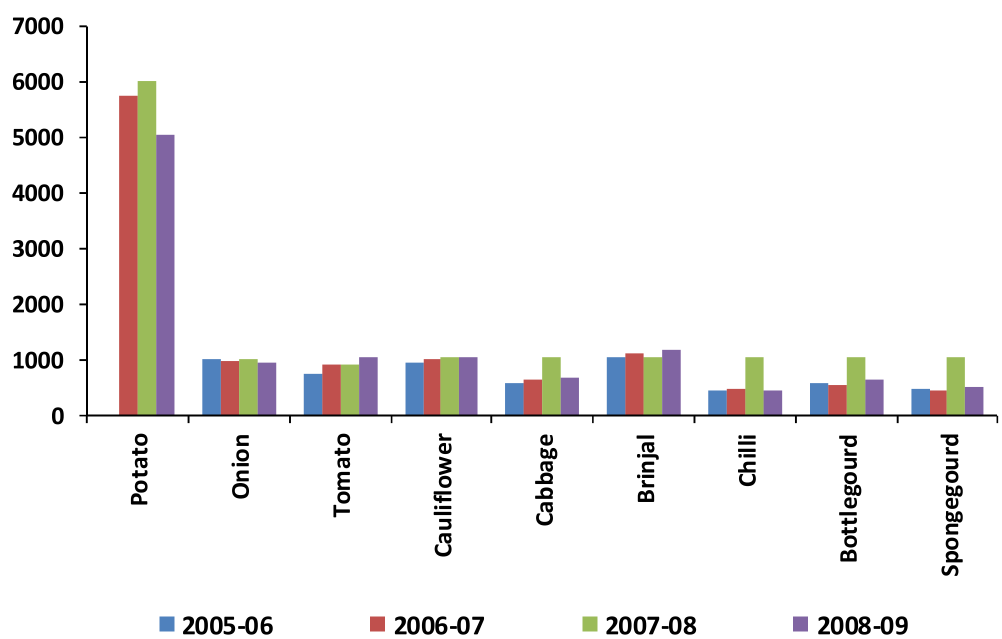

Figure 34: Area under Major Vegetables in 2008-09 ('000 hectare)

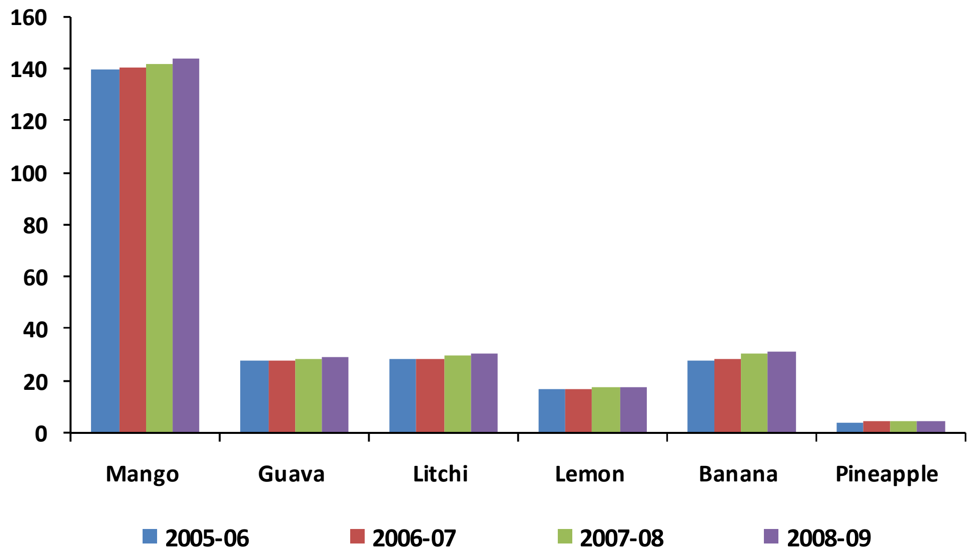

Figure 35: Production of Major Fruits in 2008-09('000 tonnes)

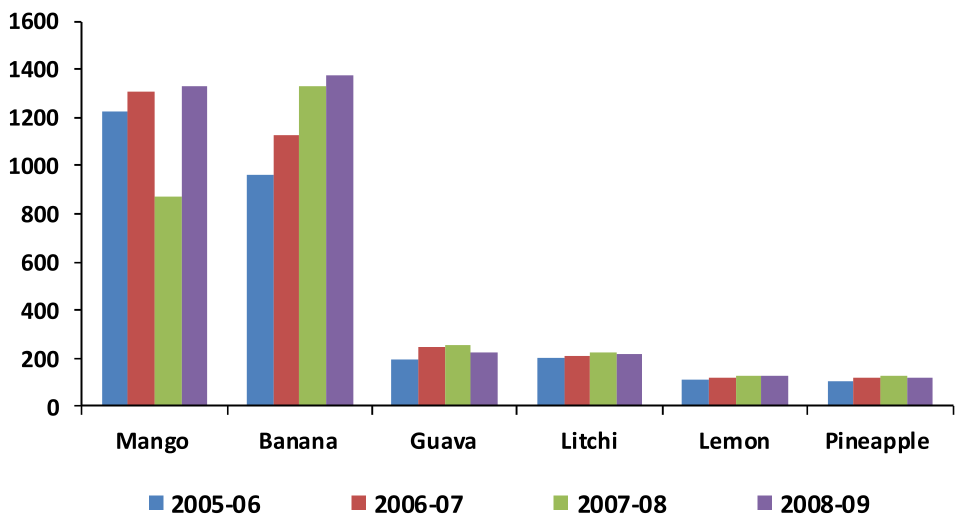

Figure 36: Area under Major Crops in 2008-09 ('000 hectare)

Table A.44 and Figure 37 present the cropping pattern of Bihar in the post-bifurcation period. The agricultural economy of Bihar exhibits a bias towards the food grains as approximately 95 percent of total cropped area has been under food grains. This indicates the orientation of Bihar agriculture towards subsistence production. Further, within the food grains, the percentage share of pulses in total cropped area has declined and cereals have shown an increase, though the changes are marginal. The oilseeds, fibers and sugarcane together account for just about 5 percent of the cropped area and their individual shares in the total cropped area have shown insignificant changes.

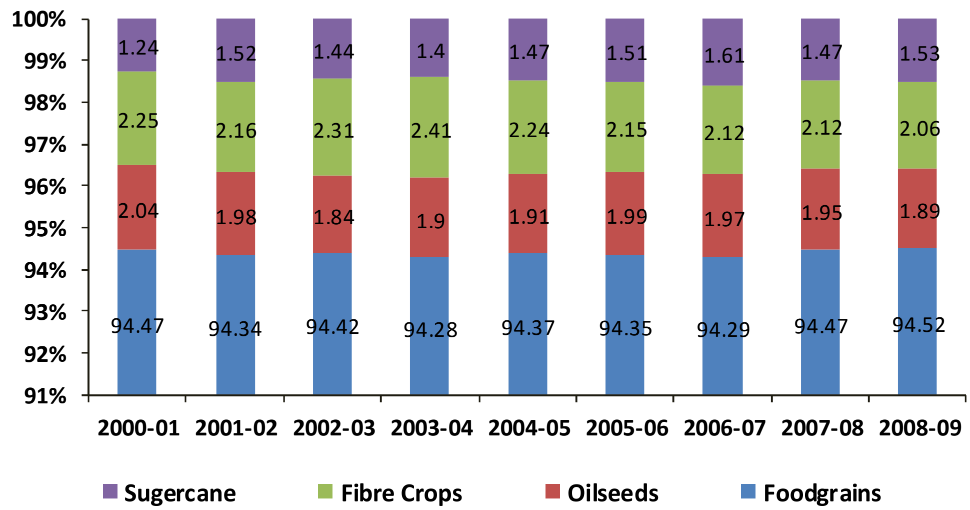

Figure 37: Cropping Pattern in Bihar (%age of Area)

8. Cost and Returns in Agriculture

Per hectare net income earned from individual crops is one of the key factors in the allocation of scarce land resources for the cultivation of various crops. In this section results of the analysis conducted on cost and returns in the major crops, use of chemical fertilizer, human labour and draught power utilization in the agriculture in Bihar has been presented. The main purpose is to determine which crop is most profitable for the farmers. Table A.44 shows the cost and returns, over the years, in paddy, wheat, maize and some other crops.

Paddy is one of the major crops in Bihar. As can be seen from the data presented in the table, net income has been fluctuating with negative trend. Return ratio has also declined during the study period. Hence paddy is not profitable for farmers. Productivity has marginally increased with CAGR as 1.91 percent. The draught power has declined drastically and fertilizer use has increased significantly with CAGR as 4.88 percent. Wheat is another important crop grown in this area. Table A.44 presents the cost and returns from the wheat cultivation. As is evident from the table, net income has been fluctuating upto 2004-05 and after that there is a remarkable increase in net income. On the other hand, the ratio of value of production (VOP) to cost of cultivation (CC) has been increasing after showing decline in 2002-03. Hence wheat is found profitable for farmers. In case of wheat, per hectare use of fertilizer has been fluctuating. Human as well as the animal labour (hrs/hec) have significantly declined during the period. It is important to note here that though the human labour has declined in both wheat and paddy cultivation the mechanical power use in wheat and paddy cultivation has significantly increased over the period. Human labour absorption in paddy cultivation is much higher than that in wheat cultivation. As can be seen from Table A.44, the rate of decline has been much higher in wheat (-5.4 percent) than paddy cultivation (-0.68 percent).

Maize cultivation is not found profitable for the farmers. As indicated in Table 7.1, net income has registered a negative compound annual growth rate of 9.26 percent. Also the return ratio has been fluctuating with negative trend. The fertilizer consumption has increased by 2.79 percent compound annually and the draught power has enormously declined by 8.25 percent.

Under pulses, masur came out to be the most profitable crop. The return ratio in case of masur has exhibited a rising trend with net income showing CAGR of 22.66 percent during the study period from 2001-02 to 2006-07. Productivity has increased by 3.14 percent compound annually. Another important feature of this crop is that the fertilizer consumption (kg/hec) has declined over the years with -5.35 percent CAGR during the study period. On the other hand, in case of gram, though the return ratio has increased but the productivity has constantly declined from 2002-03 onwards. The fertilizer use (kg/hec) has increased by 10.11 percent annually. Overall it may be stated that sugarcane, wheat and masur are the most profitable crops for farmers in Bihar.

9. Summary

The key points of the analysis performed above are enumerated below:

- Area sown more than once has shown declining trend in Bihar.
- Cropping intensity is on decline in Bihar.
- Current fallow land has increased in non-bank districts.
- Net sown area has declined in non-bank districts.
- Marginal holdings (less than one ha) account for 89.5 percent of the total land holdings in Bihar in 2005-06. Another alarming finding is that average size of marginal holding is 0.24 ha in Bihar in 2005-06.
- Tubewell has emerged as the most dominating source of irrigation in Bihar. In 2005-06, Tubewells irrigated 64.72 percent of the net irrigated area and 66.94 percent of the gross irrigated area.
- Consumption of chemical fertilizers has increased substantially in Bihar agriculture over the years. The rise in consumption has been more in case of bank districts.
- Area under rice cultivation has declined gradually.
- Area under wheat is showing rising trend.
- Among the non-food grain crops, sugarcane and banana have shown increase in area as well as production over the years.
- Looking at the cost and returns in major crops in Bihar, sugarcane, wheat and masur are found to be the profitable crops for farmers in Bihar whereas maize and paddy are not profitable for the farmers.
- The human and animal absorption in agriculture is declining which has implications for employment and use of animal waste as input in agriculture.

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Annexure

Table A.1. Land use Pattern in Bihar from 1980-81 to 2006-07 (Area in hectares)

	1980-81	1990-91	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Geographical Area	17330000	17284389	9359568	9359568	9359568	9359568	9359568	9359568	9359568
Forest Area	2826000 (16.31)	2950004 (17.07)	616446 (6.59)	621635 (6.64)	621635 (6.64)	621635 (6.64)	621635 (6.64)	621635 (6.64)	621635 (6.64)
Area under Non-agriculture Use	1716000 (9.90)	2109838 (12.21)	1638091 (17.50)	1642089 (17.54)	1642976 (17.55)	1644585 (17.57)	1645680 (17.58)	1646625 (17.59)	1646888 (17.60)
Barren Land in Bihar	1011000 (5.83)	1013701 (5.86)	436503 (4.66)	436483 (4.66)	436406 (4.66)	436295 (4.66)	436212 (4.66)	436134 (4.66)	436062 (4.66)
Current Fallow Land	931610 (5.38)	1765101 (10.21)	575858 (6.15)	562557 (6.01)	499160 (5.33)	513044 (5.48)	648003 (6.92)	666184 (7.12)	566392 (6.05)
Net Area Sown in Bihar	8315000 (47.98)	7658359 (44.31)	5662577 (60.50)	5663552 (60.51)	5725479 (61.17)	5712088 (61.03)	5572402 (59.54)	5556186 (59.36)	5665122 (60.53)
Area Sown more than once	2834000	2686026	2329702	2233336	2231923	2170289	1826916	1840306	2053826
Gross Sown Area	11149000	10344385	7992279	7896888	7957402	7882377	7399318	7396492	7718948
Cropping Intensity	134.08	135.07	141.14	139.43	138.98	137.99	132.79	133.12	136.25

Note: Figures in parentheses are share in percent

Source: (1) Ministry of Agriculture, Govt. of Bihar, Patna

(2) Directorate of Statistics and Evaluation, Govt. of Bihar

(3) Economic Survey, (Various issues), Finance Department, Govt. Of Bihar

Table A.2 Total Geographical Area (in Hectares) for Districts of Bihar

District	1980-81	1990-91	2000-01	2003-04	2005-06	2006-07
Patna	320200	317236	317236	317236	317236	317236
Vaishali	203600	201449	201449	201449	201449	201449
Saran		264827	264887	264887	264887	264887
Begusarai	191800	187828	187828	187828	187828	187828
Buxar			166999	166999	166999	166999
Munger	790800	634594	139793	139793	139793	139793
Bhagalpur	558700	559921	254300	254300	254300	254300
Khagaria		149342	149342	149342	149342	149342
Katihar	305700	291349	291349	291349	291349	291349
Lakhisarai			128602	128602	128602	128602
Purnea	794300	313883	313883	313883	313883	313883
Sheikhpura			62084	62084	62084	62084
Average for bank districts	**452157.14**	**324492.11**	**206479.33**	**206479.3**	**206479.3**	**206479.33**
Bhojpur	409800	404338	237339	237339	237339	237339
Nalanda	236700	233906	232732	232732	232732	232732
Rohtas	721300	733169	390722	390722	390722	390722
Kaimur			342447	342447	342447	342447
Gaya	654500	493774	493774	493774	493774	493774
Jehanabad		156674	156674	94043	94043	94043
Arwal				62631	62631	62631
Nawada	249400	242732	248732	248732	248732	248732
Aurangabad	330500	330011	330011	330011	330011	330011
Siwan	221900	224410	224410	224410	224410	224410
Gopalganj	203300	203774	203774	203774	203774	203774
Muzaffarpur	317200	315351	315351	315351	315351	315351
E. Champaran	396800	431715	431715	431715	431715	431715
W. Champaran	522800	484351	484351	484351	484351	484351
Sitamarhi	264300	265366	221891	221891	221891	221891
Sheohar			43475	43475	43475	43475
Darbhanga	227900	230147	254077	254077	254077	254077
Madhubani	350100	333498	353498	353498	353498	353498
Samastipur	290400	286320	262390	262390	262390	262390
Jamui			305289	305289	305289	305289
Banka			305621	305621	305621	305621
Saharsa	590000	403162	164559	164559	164559	164559
Supaul			238603	238603	238603	238603
Madhepura		179589	179589	179589	179589	179589
Kisanganj		189080	189080	189080	189080	189080
Araria		271712	271712	271712	271712	271712
Average for Non-bank Districts	**374181.25**	**320653.95**	**275272.64**	**264685.2**	**264685.2**	**264685.23**

Source: (1) Ministry of Agriculture, Govt. of Bihar, Patna
(2) Directorate of Statistics and Evaluation, Govt. of Bihar

Table A.3 Total Barren Land (in Hectares) for Districts of Bihar

District	1980-81	1990-91	2000-01	2003-04	2005-06	2006-07
Patna	13570	13475	13123	13121	13116	13118
Vaishali	22290	24265	24265	24259	24255	24253
Saran		18086	18086	18080	18074	18072
Begusarai	19220	18133	18133	18128	18124	18123
Buxar			2285	2278	2273	2270
Munger	60780	48415	11511	11503	11499	11498
Bhagalpur	69190	63810	22617	22612	22608	22606
Khagaria		15086	13694	13687	13683	13682
Katihar	21340	22289	22289	22282	22277	22274
Lakhisarai			7117	7110	7109	7107
Purnea	33070	12438	12438	12430	12426	12423
Sheikhpura			1084	1081	1080	1079
Average for Bank Districts	**34208.57**	**26221.89**	**13886.83**	**13880.92**	**13877**	**13875.42**
Bhojpur	8270	9183	6898	6886	6880	6879
Nalanda	1810	1218	1218	1216	1215	1213
Rohtas	32750	36241	16959	16951	16945	16942
Kaimur			19282	19271	19267	19264
Gaya	32480	27664	27664	27650	27643	27641
Jehanabad		5489	5489	3292	3289	3288
Arwal				2192	2190	2189
Nawada	11840	11304	11304	11299	11293	11291
Aurangabad	15250	16440	16440	16433	16429	16426
Siwan	9110	8882	8882	8875	8871	8868
Gopalganj	8830	5577	5577	5573	5570	5569
Muzaffarpur	95790	5301	5297	5290	5284	5281
E. Champaran	5660	8206	8206	8200	8196	8193
W. Champaran	3310	3025	3025	3022	3017	3015
Sitamarhi	1530	2237	1816	1811	1808	1807
Sheohar			421	417	415	415
Darbhanga	1170	1977	1393	1386	1381	1379
Madhubani	3070	2382	2336	2333	2327	2324
Samastipur	8160	4520	3940	3934	3930	3927
Jamui			28901	28899	28894	28891
Banka			43089	43084	43078	43075
Saharsa	36400	34062	10890	10885	10881	10880
Supaul			20401	20397	20391	20389
Madhepura		3953	3953	3951	3947	3946
Kisanganj		11395	11395	11388	11384	11382
Araria		5087	5085	5089	5085	5083
Average for Non-bank Districts	**17214.38**	**10207.15**	**10794.44**	**10374**	**10369.62**	**10367.58**

Source: (1) Ministry of Agriculture, Govt. of Bihar, Patna
(2) Directorate of Statistics and Evaluation, Govt. of Bihar

Table A.4. Current Fallow Land (in Hectares) for Districts of Bihar

District	1980-81	1990-91	2000-01	2003-04	2005-06	2006-07
Patna	18010	27237	16680	19190	62342	23221
Vaishali	9300	7040	1520	3686	28427	3216
Saran		19297	2328	8266	26773	8233
Begusarai	7420	4854	4018	7241	29090	6293
Buxar			8186	7686	12221	3641
Munger	80170	59897	20632	16701	19754	13861
Bhagalpur	44980	46266	5490	5115	5114	7266
Khagaria		19642	9677	9108	18679	12341
Katihar	31040	32923	30887	25921	39843	23866
Lakhisarai			18070	18121	7722	18362
Purnea	85600	38263	39270	20301	36440	32603
Sheikhpura			9510	4522	6761	12332
Average for Bank district	**39502.86**	**28379.89**	**13855.67**	**12154.83**	**24430.5**	**13769.58**
Bhojpur	24720	24042	9992	6424	28951	5133
Nalanda	8990	3103	2180	3933	30072	2512
Rohtas	35250	33896	1040	922	37689	1904
Kaimur			16830	14513	29801	8252
Gaya	80520	70968	99001	91403	61528	90722
Jehanabad		5725	16806	8703	12788	5263
Arwal				6810	8539	6875
Nawada	27400	6935	21683	22809	24622	30542
Aurangabad	57970	52234	65062	32925	50785	23842
Siwan	10880	4868	9515	10563	27436	10641
Gopalganj	11820	1031	3260	4042	29761	8817
Muzaffarpur	21240	17189	24020	21956	49446	30132
E. Champaran	12410	19439	21635	28302	49259	17316
W. Champaran	32010	18862	3111	4241	70059	4533
Sitamarhi	7380	15020	23975	20661	43784	11713
Sheohar			3835	1952	9224	2002
Darbhanga	17710	25603	6975	5203	42971	15869
Madhubani	15230	24844	12317	12561	69771	18133
Samastipur	21380	8047	612	2263	52957	3137
Jamui			38511	32012	34296	48553
Banka			2315	2401	35236	2281
Saharsa	42880	18539	2215	6221	21020	7973
Supaul			7378	6011	37862	16682
Madhepura		13936	1110	5742	25357	10133
Kisanganj		16396	2935	3001	23874	8465
Araria		23336	13277	11612	39365	9732
Average for Non-bank Districts	**20916.00**	**18215.13**	**9621.25**	**9136.67**	**36309.75**	**12889.42**

Source: (1) Ministry of Agriculture, Govt. of Bihar, Patna
(2) Directorate of Statistics and Evaluation, Govt. of Bihar

Table A.5. Net Sown Area (in Hectares) for Districts of Bihar

District	1980-81	1990-91	2000-01	2003-04	2005-06	2006-07
Patna	222530	207330	209135	206294	207288	202193
Vaishali	127050	119665	129211	126660	126944	127099
Saran		174988	199270	192938	191689	192598
Begusarai	135830	120785	120722	117193	117078	118163
Buxar			138245	138277	139661	142451
Munger	370940	263101	44436	48029	49036	51217
Bhagalpur	288960	269010	145565	145667	140869	144072
Khagaria		75211	84433	84684	82313	81429
Katihar	176920	159908	161679	167217	166372	169245
Lakhisarai			68327	68044	60300	68498
Purnea	518020	201235	201831	221166	208032	208834
Sheikhpura			39358	44217	35302	36707
Average for Bank districts	**262892.86**	**176803.67**	**128517.67**	**130032.17**	**127073.67**	**128542.17**
Bhojpur	329330	315320	182362	185364	182184	186872
Nalanda	182760	183374	183377	180872	182935	182236
Rohtas	402620	400987	254710	254360	254387	253299
Kaimur			152185	154226	156071	160937
Gaya	368510	236151	193071	200333	149611	204610
Jehanabad		115085	104485	63650	64722	67502
Arwal				41784	39889	41002
Nawada	123390	119584	112063	110565	93392	102721
Aurangabad	191040	196127	169080	197912	200714	206479
Siwan	170560	175881	164382	162889	165440	162923
Gopalganj	150100	157629	151659	150524	146439	145724
Muzaffarpur	226030	219043	205452	207145	197527	198831
E. Champaran	337740	313823	295765	288804	297095	299987
W. Champaran	262210	255996	281269	279758	280758	279809
Sitamarhi	203070	178256	118123	121048	121801	130192
Sheohar			24926	26483	26243	26469
Darbhanga	161600	139877	171263	172716	166448	162020
Madhubani	256400	212724	225686	225113	220825	219816
Samastipur	193590	201678	186719	184718	184061	183919
Jamui			74951	81117	58772	64836
Banka			154227	153818	151689	154489
Saharsa	371150	247544	113982	109633	108111	107864
Supaul			154192	155251	145788	144544
Madhepura		123818	136490	131531	125938	127105
Kisanganj		113085	130634	131105	128530	125608
Araria		185691	179312	180983	181932	182822
Average for Non-bank districts	**237162**	**175334.12**	**139208.75**	**139459.66**	**135011.5**	**135807**

Source: (1) Ministry of Agriculture, Govt. of Bihar, Patna
(2) Directorate of Statistics and Evaluation, Govt. of Bihar

Table A.6 Number of Land Holdings in Bihar

Size Class	1980-1981	1995-1996	2000-2001	2005-2006
Marginal (Less than 1 Hectare)	8320600 (75.44%)	9577000 (84.15%)	9743016 (84.18%)	11485499 (89.54%)
Small (1-2 Hectare)	1217900 (11.04%)	1051000 (9.23%)	1068785 (9.23%)	857997 (6.69%)
Semi Medium (2-4 Hectare)	951100 (8.62%)	583000 (5.12%)	589288 (5.09%)	392563 (3.06%)
Medium (4-10 Hectare)	471500 (4.28%)	161000 (1.41%)	164130 (1.42%)	88226 (0.69%)
Large Total (More than 10 Hectare)	67900 (0.62%)	9000 (0.08%)	9026 (0.08%)	3219 (0.03%)
Total	**11029000**	**11381000**	**11574245**	**12827504**

Source: (1) Bihar through Figures, 1985, Directorate of Statistics and Evaluation, Government of Bihar
(2) Agricultural Census of India, 2000-01, 2005-06

Table A.7. Area of Holdings (in Hectares)

Size Class	1980-1981	1995-1996	2000-2001	2005-2006
Marginal (Less than 1 Hectare)	2951600 (46.91%)	2934000 (43.08%)	2907256 (43.09%)	2870755 (52.57%)
Small (1-2 Hectare)	1647600 (26.19%)	1308000 (19.21%)	1295531 (19.2%)	1072378 (19.64%)
Semi Medium (2-4 Hectare)	257400 (4.09%)	1558000 (22.88%)	1543901 (22.88%)	1017067 (18.63%)
Medium (4-10 Hectare)	270900 (4.31%)	869000 (12.76%)	860761 (12.76%)	454939 (8.33%)
Large Total (More than 10 Hectare)	1164600 (18.51%)	141000 (2.07%)	139941 (2.07%)	45547 (0.83%)
Total	**6292100**	**6810000**	**6747390**	**5460686**

Source: (1) Bihar through Figures, 1985, Directorate of Statistics and Evaluation, Government of Bihar
(2) Agricultural Census of India, 2000-01, 2005-06

Table A.8. Average Area per Holdings (in Hectares)

Size Class	1980-1981	1995-1996	2000-2001	2005-2006
Marginal (Less than 1 Hectare)	0.9	0.88	0.29	0.24
Small (1-2 Hectare)	1.3	1.24	1.21	1.25
Semi Medium (2-4 Hectare)	5.6	5.78	2.62	2.59
Medium (4-10 Hectare)	18.8	19.08	5.24	5.16
Large Total (More than 10 Hectare)		34.79	15.5	14.15

Source: (1) Bihar through Figures, 1985, Directorate of Statistics and Evaluation, Government of Bihar
(2) Agricultural Census of India, 2000-01, 2005-06

Table A.9. Sources of Net Area Irrigated in Bihar (in Hectares)

Year	Canal	Tank	Tube well	Other well	Other Sources	Net Area Irrigated (NAI)	Net Sown Area (NSA)	NAI as % of NSA
1970-1971	814109 (37.71%)	169020 (7.83%)	364674 (16.89%)	185016 (8.57%)	625956 (29%)	2158775		
1980-1981	1094326 (37.05%)	96139 (3.26%)	793455 (26.87%)	202500 (6.86%)	766910 (25.97%)	2953330		
1991-1992	1233000 (36.39%)	101000 (2.98%)	1389000 (41%)	97000 (5.98%)	568000 (16.77%)	3388000		
2001-2002	965000 (27.87%)	112000 (3.23%)	2239000 (64.65%)	14000 (0.4%)	133000 (3.84%)	3463000	5663552	61.15
2002-2003	1259338 (27.55%)	149071 (3.26%)	2965410 (64.87%)	18260 (0.4%)	179503 (3.93%)	4571582	5725479	79.85
2003-2004	904028 (26.33%)	111691 (3.25%)	2288235 (66.65%)	12810 (0.37%)	116430 (3.39%)	3433194	5712088	60.10
2004-2005	774717 (26.14%)	88709 (2.99%)	2006016 (67.7%)	6614 (0.22%)	87196 (2.94%)	2963252	5572402	53.18
2005-2006	839594 (26.57%)	136576 (4.32%)	2044998 (64.72%)	11618 (0.37%)	127116 (4.02%)	3159902	5556186	56.87

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.10. District-wise Net Area Irrigated from Canals (in Hectares)

District	1970-71	1980-81	1991-92	2003-04	2004-05	2005-06
Patna	57,556	44025	34000	40806	28963	29386
Vaisali		4654	-			
saran	177	6163	-	2203	33149	19477
Begusarei		79148	0			
Buxar			-	36157	62780	60897
Monghyre	49,949		45000	12436	10211	14302
Bhagalpur	10,338	62811	62000	4297		
Khagaria						
Katihar		37592	9000		3496	10757
Lakhisarai				23951	8981	25781
Purena	49732	62139	24000	11729	10298	18135
Shekhpura				2185		809
Average for bank districts	**33,550**	**42,362**	**29,000**	**16,721**	**22,554**	**22,443**
Nalanda		7512	6000	5553	5829	14050
Gaya	115479	37345	20000		142	
Nawada		7212	1000	10178	4202	6551
Jehanabad			28000	596	3913	3648
Aurangabad		88641	111000	127368	83298	92316
Bojpur		152190	198000	40073	34138	44644
Rohtas		211239	327000	200851	215211	215073
Siwan		36388	139000	4821	3963	5478
Gopalganj		34348	31000	49766	31972	42961
Champarean west		94644	42000	72822	57979	63842
Champaran east		45013	31000	794		
Muzaffarepure	547	9345	4000			20310
Sitamarhi			-	1491		2032
Darbhanga	13,301		-			
Madubani		8861	1000			
Samastipur		463	0			
Saharsa	39,536	28364	30000	4903	6049	5664
Arwal			-			
Kaimur			-	76538	78880	22583
Jamui				1040	3752	
Banka				81686	38838	34218
Supaul				51260	33212	40207
Madhepura			43000	18124	23534	15688
Kishanganj						
Araria			12000		870	15514
Average for Non-bank Districts	**42215.75**	**54397.5**	**63250**	**43992**	**39057**	**39329.06**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. ofBihar, Patna

Table A.11. District-wise Net Area Irrigated from Tanks (in Hectares)

District	1970-71	1980-81	1991-1992	2003-04	2004-05	2005-06
Patna	3,448	9	-	40	34	
Vaisali		7051	-	162		
saran	12003	6151	-	61	7395	5965
Begusarei		123	-	1555	1452	1437
Buxar			-	143		
Monghyre	4,813	2444	6000			
Bhagalpur	3,378	9461	15000	8193	4286	3055
Khagaria			-			
Katihar		616	-			
Lakhisarai			-			
Purena	120	182	-			
Shekhpura			-	194		
Average for bank districts	**4,752**	**3,255**	**10,500**	**1,478**	**3,292**	**3,486**
Nalanda		647	9000	1116	1172	4224
Gaya	23659	3258	1000			
Nawada		1058	-			
Aurangabad		780	-	3493	3381	3460
Bojpur		6767	1000			
Rohtas		5985	1000	17994	5010	23922
Siwan		1176	1000	2446	2320	2229
Gopalganj		1401	1000			
Champarean west		1471	2000		1	
Champaran east		1189	1000	411		
Muzaffarepure	4540	1060	1000			19993
Sitamarhi		1635	3000	4570	1416	1871
Darbhanga	11,061	5238	10000	4883	20080	10883
Madubani		7797	23000	64114	30472	51225
Samastipur		2049	-			
Saharsa	208	5420	1000	311	205	207
Arwal			-			
Jamui			-	539		
Banka			-	1122	7804	8105
Supaul			-	271		
Madhepura			-	73		
Kishanganj			-			
Araria			-			
Jehanabad			1000			
Kaimur			-		3681	
Average for Non-bank Districts	**9867**	**2933.19**	**4000**	**7795.62**	**6867.45**	**12611.9**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.12 District-wise Net area irrigated from Tube Well (in Hectares)

District	1970-71	1980-81	1990-91	2003-04	2004-05	2005-06
Patna	97,992	68991	66000	83906	81259	72344
Buxar			-	42373	35986	40747
Saran	32558	17769	92000	105359	64821	73441
Vashali		16400	62000	53964	60708	62333
Munger	17,335	20959	51000	18059	18433	15142
Begusarai		45097	68000	84584	73637	73438
Shekhpura			-	35910	17314	21108
Lakhisarai			-	19214	20851	15427
Khagaria			35000	65103	67525	70472
Bhagalpur	3,034	17222	28000	39906	50729	56512
Purnea	9997	21039	51000	86288	76280	54691
Katihar		17206	52000	79060	67128	75258
Average for Bank Districts	**32183**	**28085**	**56111**	**59477**	**52889**	**52576**
Nalanda		82131	103000	94523	99547	96808
Bojpur		25179	62000	89503	65615	63814
Rohtas		42489	38000	24596	27312	22432
Kaimur			-	42366	9281	81119
Gaya	48071	529946	36000	177161	83396	81856
Jehanabad			29000	54957	29520	24701
Arwal			-	15343	8135	16010
Nawada		27978	33000	77829	49075	51376
Aurangabad		7927	11000	54019	30215	18217
Siwan		47191	16000	89041	91047	101509
Gopalganj		44455	28000	47193	64910	53320
Muzaffarpur	19617	40422	60000	106150	112168	67948
East Champaran		46940	42000	122917	124482	147660
West Champaran		13831	31000	23271	28600	36029
Sitamarhi		22503	35000	48182	47331	51586
Sheohar			-	11897	14334	13860
Darbhanga	21,687	13272	35000	74281	52585	57963
Madhubani		7686	-	26738	77222	40042
Samastipur		41305	97000	102020	97722	98067
Jamui			-	23989	17413	15970
Banka			-	16733	37397	46470
Saharsa	6,446	34242	56000	49618	46201	47453
Supaul			-	49209	46985	49479
Madhepura			19000	47170	64368	64404
Kishanganj			16000	33203	27789	26215
Araria			62000	72600	65680	39777
Average for Non-bank Districts	**23955.25**	**64218.56**	**42578.95**	**60558.04**	**54551.15**	**54387.88**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.13. District-wise Net area irrigated from Other Wells (in Hectares)

District	1970-71	1980-81	1991-92	2003-04	2004-05	2005-06
Patna	13,969	1520	-			
Buxar			-			
Saran	74578	31221	-			
Vashali		11152	1000	4772	1373	
Munger	8,837	34151	4000	12	44	63
Begusarai		436	1000			
Shekhpura			-	310		
Lakhisarai			-	6	85	
Khagaria			-			
Bhagalpur	2,182	4291	15000	1061		
Purnea	113	376	1000			
Katihar		2893	-			
Average for Bank Districts	**19936**	**10755**	**4400**	**1232**	**501**	**63**
Nalanda		18370	3000	15		7059
Bojpur		2365	4000			
Rohtas		2690	-			
Kaimur			-			
Gaya	29,760	7360	11000			
Jehanabad			2000			
Arwal			-		177	
Nawada		17254	1000			
Aurangabad		2541	1000	4688	4742	4338
Siwan		10447	1000	79	193	158
Gopalganj		809	-			
Muzaffarpur	6027	3299	-			
East Champaran		587	1000			
West Champaran		262	16000			
Sitamarhi		641	-			
Sheohar			-			
Darbhanga	1,326	14	-			
Madhubani		108	-			
Samastipur		2647	-			
Jamui			-	1700		
Banka			-	167		
Saharsa	162	4255	-			
Supaul			-			
Madhepura			2000			
Kishanganj			-			
Araria			-			
Average for Non-bank Districts	**9318.75**	**4603.06**	**4200.00**	**1329.80**	**1704.00**	**3851.67**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.14. District-wise Net area irrigated from Other Sources (in Hectares)

District	1970-71	1980-81	1991-92	2003-04	2004-05	2005-06
Patna	89020	41213	20000	5755	5851	
Buxar			-	1323	1401	1458
Saran	131816	41233	11000			365
Vashali		2465	-	5212	3456	4072
Munger	1,06,679	24205	14000	3646		
Begusarai		6143	12000			12
Shekhpura			-	6539	397	1947
Lakhisarai			-	2386	2577	1787
Khagaria			23000	4318	2006	2357
Bhagalpur	45,975	37241	18000	2865		
Purnea	64544	4569	2000			
Katihar		3053	5000			
Average for Bank Districts	**82839**	**20015**	**13125**	**4006**	**2615**	**1714**
Nalanda		68356	17000	10484	11132	17497
Bojpur		66183	46000	5818	4922	1484
Rohtas		25153	15000	6928	6366	7115
Kaimur			-	11141	8543	13779
Gaya	537009	200785	67000	2787	2363	
Jehanabad			50000	8851	8588	21845
Arwal			-	1318	2963	130
Nawada		67221	50000	2456	4869	625
Aurangabad		58009	32000	7577	1684	25862
Siwan		4283	1000	4310	1607	1098
Gopalganj		3639	26000	2799	189	203
Muzaffarpur	38701	8242	19000			
East Champaran		1407	9000			
West Champaran		3745	8000	2937	8750	11741
Sitamarhi		3012	5000	1960	264	321
Sheohar			-			
Darbhanga	63,525	6275	21000		282	5764
Madhubani		6715	7000	2944	3571	
Samastipur		10660	4000			
Jamui			-	1718	2315	1356
Banka			-	499	324	
Saharsa	49040	17630	15000	3056	2013	5979
Supaul			-	813	567	
Madhepura			7000	5924	226	
Kishanganj			3000			319
Araria			10000			
Average for Non-bank Districts	**172068.75**	**34457.19**	**20600.00**	**4437.89**	**3576.90**	**7194.88**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.15. Sources of Gross Area Irrigated (1971-2006)

Year	Canal	Tank	Tube well	Other well	Other Sources	Total
1970-1971	1118355 (41.85%)	149717 (5.6%)	515823 (19.3%)	221481 (8.29%)	667221 (24.97%)	2672597
1980-1981	1397135 (38.47%)	117925 (3.21%)	1001000 (27.26%)	242861 (6.61%)	872758 (23.77%)	3631679
1991-1992	1509000 (36.3%)	124000 (2.98%)	1702000 (40.94%)	124000 (2.98%)	698000 (16.79%)	4157000
2000-2001	1229769 (26.96%)	179637 (3.94%)	2871170 (62.95%)	15874 (0.35%)	264665 (5.8%)	4561115
2001-2002	1237156 (27.87%)	139580 (3.14%)	2864846 (64.54%)	15870 (0.36%)	181562 (4.09%)	4439014
2002-2003	1259338 (35.26%)	149071 (4.17%)	1965410 (55.03%)	18260 (0.51%)	179503 (5.03%)	3571582
2003-2004	1143361 (25.04%)	149856 (3.28%)	3103326 (67.95%)	13222 (0.29%)	157070 (3.44%)	4566835
2004-2005	1062594 (0.25%)	117531 (2.8%)	2886959 (68.78%)	6694 (0.16%)	123362 (2.94%)	4197140
2005-2006	1061478 (24.54%)	182599 (4.22%)	2894879 (66.94%)	11687 (0.27%)	174044 (4.02%)	4324687

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.16. District-wise Gross Area Irrigated from Canals (In Hectares)

Gross Area Irrigated from Canals (in Hectares)								
Districts	**1970-71**	**1980-81**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**
Patna	72716	48307	19121	28972	49992	51115	32431	34852
Vaisali		5059						
Saran	177	6537	21049	23271	27035	2414	33149	19477
Begusarai								
Buxar						44421	80760	86671
Bhagalpur	47,299	67153	5430	5256		4297		
Khagaria								
Katihar		15592	4415	4332	6558		4694	11444
Lakhisarai					15616	23951	16640	25781
Purenea	75366	70333	14434	10556	9144	11729	10298	18135
Sheikhpura			10170	1826	2428	2185		809
Average for Bank districts	**48889.5**	**35496.8**	**12436.5**	**12368.8**	**18462.2**	**20016**	**29662**	**28167**
Bojpur		188430	115152	154308	112537	50781	54713	60238
Nalanda		7678	6594	6452	7026	9442	9018	19453
Rohtas		322081	274199	262369	271928	262570	250397	266829
Kaimur			98998	75977	82126	98493	121038	28353
Gaya	131123	40356	43204	64212	57447		142	
Jehanabad						596	3913	3648
Arwal						28712	22358	20710
Nawada		8387	13685	13227	12947	13944	6033	8546
Aurangabad		101497	104471	180535	175901	140664	95416	100384
Siwan		37539	3270	2912	5938	6314	5397	6686
Gopalganj		40869	46444	46946	48103	50672	39407	46060
Muzaffarpur	735	105611	454	138				20310
Champaran West		38962	151224	130308	122192	128686	113917	109254
Champaran East		49537	32220	2345	1818	794		
Sitamarhi								
Darbhanga	15,899							
Madhubani		15371	4047					
Samastipur		463						
Jamui			5128	1316	1013	1040	3752	
Banka			51585	57268	61571	90062	50880	44654
Saharsa	61,005	68539	3908	5469	8658	5527	9309	6616
Supaul			41842	50699	53918	67352	49804	60816
Madhepura			63561	46517	53258	32795	34942	26489
Kishanganj								
Araria			2795				870	17346
Average for Non-bank districts	**52190.5**	**73237.2**	**55935.8**	**64764.59**	**67273.81**	**58143.77**	**48405.9**	**49787.77**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.17. District-wise Gross Area Irrigated from Tanks (in Hectares)

Districts	1970-71	1980-81	2000-01	2001-02	2003-04	2004-05	2005-06
Patna	3879	29	1720		40	34	
Vaisali		9480	498	960	162		
saran	12024	6161	16301	18803	61	7395	5965
Begusarei		183	1102	1143	1673	1581	1564
Buxar			2505	2555	143		
Bhagalpur	6,951	10353	7351	2234	12344	4286	5079
Khagaria				272			
Katihar		762	47				717
Lakhisarai				498			
Purena	136	182					
Shekhpura					194		
Average for Bank districts	**5747.5**	**3878.57**	**4217.71**	**3780.71**	**2088.14**	**3324**	**3331.25**
Bojpur		6980					
Nalanda		875	1712	1708	2110	1927	4815
Rohtas		7658	14002	30408	20299	7941	25928
Kaimur			10244			4371	
Gaya	24072	5722	7064	1045			
Jehanabad							
Arwal							
Nawada		1620					
Aurangabad		968	2681	2724	3493	3381	3460
siwan		1280	2307	2510	2446	2320	2229
Gopalganj		2959					
Muzaffarepure	4848	1177	999	400			19993
Champarean west		1860					
Champaran east		1282			411		
Sitamarhi		1960	3342	5835	4570	1416	2621
Sheohar			138	134			
Darbhanga	13,586	8068	21929	28521	6351	28657	19425
Madubani		9495	71546	34699	93006	43809	79428
Samastipur		2158					
Jamui			1257	1160	539		
Banka			11321	2239	1177	10065	11168
Saharsa	227	7767	599	375	493	347	207
Supaul				167	271		
Madhepura				81	73		
Kishanganj							
Araria							
Average for Non-bank districts	**10683.25**	**3864.31**	**10652.93**	**7467.07**	**10403**	**10423.4**	**16927.4**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.18. District-wise Gross Area Irrigated from Tube well (in Hectares)

Districts	1970-71	1980-81	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Patna	144651	93757	127071	128603	133043	121049	120625	129169
Vaisali		16618	66357	70612	68879	65655	80656	85669
saran	34071	18239	80236	76236	76066	115231	79108	83048
Begusarei		49577	88221	86449	88488	89416	84921	88499
Buxar			38348	44726	46851	66410	43979	58024
Bhagalpur	7,565	24306	48812	52742	62147	57797	70966	80449
Khagaria						76748	75922	79919
Katihar		28333	124990	119610	125372			
Lakhisarai						26526	30017	24090
Purena	12,123	34266	137139	158949	160387	158775	151072	151344
Shekhpura						41107	22356	33137
Average for Bank districts	**49602.5**	**37870.85**	**88896.75**	**92240.87**	**95154.12**	**81871.4**	**75962.2**	**81334.8**
Bojpur		34562	56716	25641	73897	125775	84567	83856
Nalanda		97133	201158	153824	162774	164270	158970	125608
Rohtas		76317	48198	39249	46645	36037	40935	31238
Kaimur			49367	91404	55651	54414	13845	120614
Gaya	73370	62666	137746	137446	157937	232303	124415	122484
Jehanabad			117705	125693	97515	57759	47678	44763
Arwal						18034	11102	19703
Nawada		41841	98658	99800	101334	108831	74173	76382
Aurangabad		15907	65266	28402	45854	65794	45826	18468
siwan		49928	107754	116170	120037	93353	101027	113635
Gopalganj		47156	45323	56292	58625	54027	69670	58949
Muzaffarepure	28498	44877	126359	132278	132466	130164	132654	85774
Champarean west		15702	49001	50538	47734	42971	58790	60753
Champaran east		49457	164373	184194	156111	154450	164293	165385
Sitamarhi		28189	58670	76688	69664	63661	55665	56995
Darbhanga	33,578	15874	45698	43175	56482	95736	75119	79829
Madubani		11458	40991	86726	69262	41113	91551	59216
Samastipur		55739	113158	110688	111789	112387	113436	113715
Jamui						30439	22353	20418
Banka			50371	45621	47587	23793	55025	56950
Saharsa	7969	38787	108400	93918	88633	84562	81993	78578
Supaul			79426	71548	69471	73678	88359	82398
Madhepura			61223	93073	80424	92954	94475	103481
Kishanganj			37580	47644	47664	50535	49786	44377
Araria			103066	11890	109318	110962	103199	88841
Average for Non-bank districts	**35853.75**	**42849.56**	**85487.26**	**83560.95**	**87255.39**	**84720.08**	**78356.24**	**76496.4**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.19. District-wise Gross Area Irrigated from Other Wells (in Hectares)

Districts	1970-71	1980-81	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Patna	16614	1652	1851					
Vaisali		11251	7281	8847	8402	5043	1373	
saran	77976	31279						
Begusarei		705	112	113	111			
Buxar								
Bhagalpur	6444	10784		1539	4050	1061		
Khagaria								
Katihar		3633						
Lakhisarai				25	19	10	95	
Purena	123	422						
Shekhpura			85			310		
Average for Bank districts	**25289.25**	**8532.28**	**2332.25**	**2631**	**3145.5**	**1606**	**734**	
Bojpur		3492						
Nalanda		18895	528	544	541	29		7059
Rohtas		6301						
Kaimur					3			
Gaya	41650	10868	955		2715			
Jehanabad								
Arwal							177	
Nawada		18608		9	10			
Aurangabad		3407	3527	1256	660	4811	4812	4348
siwan		13232	188	188	185	79	193	158
Gopalganj		834						
Muzaffarepure	7287	3495						
Champarean west		262						
Champaran east		730						
Sitamarhi		762						
Darbhanga	1,637	14						
Madubani		151						
Samastipur		3330						
Jamui			202	867	1164	1700		
Banka			668	245	76	167		
Saharsa	165	5874	4	324	324			
Supaul				1368				
Madhepura								
Kishanganj								
Araria								
Average for Non-bank districts	**12684.8**	**5640.93**	**867.42**	**600.12**	**630.88**	**1357.2**	**1727.33**	**3855**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.19. District-wise Gross Area Irrigated from Other Sources (in Hectares)

Districts	1970-71	1980-81	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Patna	89870	47229	26915	10522	7292	7391	6190	
Vaisali		2491	6938	9173	8866	6686	5138	6079
saran	1313	41697		875				365
Begusarei		6453	2407	2229	2246			12
Buxar			8902	18896	10644	2936	2643	1458
Bhagalpur	75148	46586	10001	14515	10520	2865		
Khagaria			1838	398	378	6645	5058	3903
Katihar		4841						
Lakhisarai			3289	6816	9187	2937	4632	2652
Purena	4966	6140	3360					
Shekhpura			6283	9455	6047	6984	397	2773
Average for Bank districts	**42824.25**	**22205.28**	**7770.33**	**8097.66**	**6897.5**	**5206.28**	**4009.66**	**2463.14**
Bojpur		75935	7597	19133	9684	11538	10650	2684
Nalanda		72835	12047	16868	15559	17437	14564	28556
Rohtas		33390	698		856	11928	6395	9556
Kaimur			3787	5377	11724	13630	14280	20800
Gaya	320169	226754	8309	251	5251	2787	2363	
Jehanabad			8494			8851	8588	21845
Arwal						1385	4516	206
Nawada		74481	10961	15088	10181	3783	6537	625
Aurangabad		62427	3598	4156	3917	9439	2355	36877
Siwan		4572	10139	1053	4901	5070	2396	1481
Gopalganj		4065	10820	2003	3366			
Muzaffarepure	10,119	9861	494					
Champarean west		4837	21446	7338	9276	5026	12257	15335
Champaran east		9955	609					
Sitamarhi		4511	1182	2390	2425	1960	264	321
Darbhanga	18,557	9145	11140	5957			282	5764
Madubani		7838	7706	4264	4542	4432	4930	
Samastipur		12173	3	46				
Jamui			12622	4279	9351	3297	3113	2667
Banka			22093	3305	7276	499	447	
Saharsa	3,087	19638	6707	4492	6292	4401	3996	9513
Supaul			2510	2117	2010	813	567	
Madhepura			19792	7203	11907	7302	446	
Kishanganj			77					319
Araria			1776					
Average (Non-bank)	**87983**	**39526.06**	**7691.95**	**5851.11**	**6971.64**	**6309.88**	**5207.68**	**10436.6**

Source: Bihar through Figures, 2005, 2007, Directorate of Economics and Statistics, Govt. of Bihar, Patna

Table A.20. Rainfall in Bihar in mm (1971-2007)

Year	1971	1981	1991	2001	2002	2003	2004	2005	2006	2007
Rainfall	49249.55	41004.09	40968.45	27923.15	29368.1	39904.2	37706.1	31194.8	37229.3	53516

Source: Indian Harvest Database, CMIE

Table A.21. District-wise Rainfall in Bihar (in mm)

District	Dec-61	Dec-71	Dec-81	Dec-86	Dec-91	Dec-96	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07
Begusarai	1007	1327	999	992	1106	773	758	762	1225	804	732	903	1592
Bhagalpur	1004	1363	1083	997	1292	970	866	853	0	0	1134	1178	1249
Buxar	1084	1272	1137	1049	1077	762	583	691	922	454	735	777	934
Katihar	1085	1426	1203	1091	1412	1157	1018	986	1802	2194	993	1146	1224
Khagaria	990	1328	1013	973	1104	842	803	793	1512	908	1007	1024	1472
Lakhisarai	1017	1331	1009	994	1207	794	760	758	1237	724	986	1526	1450
Munger	1003	1347	1030	984	1227	859	800	792	0	1006	1003	983	1109
Patna	1055	1287	1017	1054	1125	739	662	719	745	608	710	1065	1493
Purnia	1064	1397	1166	1067	1260	1082	988	951	1654	2299	1149	1155	1403
Saran	1050	1264	1059	1076	924	769	614	722	1082	837	926	941	1602
Sheikpura	1046	1326	1004	1014	1212	761	727	737	885	489	571	1093	1246
Vaishali	1048	1298	1020	1068	1000	710	671	751	0	44	714	1196	1738
Average for Bank Districts	**1038**	**1330**	**1062**	**1030**	**1162**	**852**	**771**	**793**	**922**	**864**	**888**	**1082**	**1376**
Araria	1143	1489	1250	1152	1162	1091	1080	1030	1788	1582	1111	1137	1714
Aurangbad	1128	1311	1093	1118	1401	741	622	692	1345	608	599	967	1093
Banka	1054	1432	1141	1053	1485	961	871	866	967	1449	1028	1292	1617
Bhojpur	1067	1256	1065	1068	1074	758	598	696	1046	684	852	1040	1373
Darbhanga	1024	1352	1053	1061	898	741	766	820	822	896	908	826	1611
Gaya	1132	1340	1073	1128	1464	764	674	718	1011	694	500	1074	1273
Gopalganj	1084	1342	1277	1134	845	831	646	764	860	1220	857	1105	1815
Jamui	1086	1418	1122	1082	1489	888	812	814	1072	829	510	1270	1183
Kaimur (Bhabua)	1157	1345	1233	1084	1315	767	647	719	1334	763	848	1080	1046
Kishaganj	1357	1689	1484	1449	1551	1399	1339	1258	2417	2998	1299	1034	2172
Madhepur	1002	1326	1052	992	1068	890	856	838	1363	1439	1024	1190	1358
Madubani	1052	1383	1133	1123	919	785	825	875	660	878	781	685	1805
Muzaffarpur	1052	1345	1087	1119	852	760	690	795	1051	958	835	1058	2272
Nalanda	1057	1306	1006	1036	1200	733	693	721	1080	503	496	940	1258
Nawada	1100	1381	1083	1092	1450	811	737	754	1061	654	661	1208	1179
W. Champaran	1263	1645	1828	1488	1094	1041	861	1000	1775	1270	1100	999	
E Champran	1126	1439	1337	1271	869	895	736	856	1236	1634	1071	1089	2042
Rohtas	1134	1315	1163	1093	1307	756	625	705	930	661	731	902	977
Saharsa	988	1313	1013	975	1035	836	812	800	983	965	612	864	1271
Samastpur	1013	1321	996	1017	999	728	733	766	1269	827	577	1031	1695
Sheoha	1093	1403	1200	1217	849	836	723	836	147	1748	1269	868	1605
Sitamarhi	1112	1458	1264	1269	885	833	800	896	1558	1343	976	895	1725
Siwan	1061	1296	1182	1079	821	800	611	727	1420	1015	803	811	1386
Supaul	1054	1380	1129	1069	991	894	915	904	1648	1721	1089	879	1450
Average for Non-bank Districts	**1094**	**1395**	**1120**	**1220**	**1157**	**1030**	**843**	**755**	**824**	**1203**	**1184**	**889**	**955**

Source: Indian Harvest Database, CMIE

Table A.22. Construction of Deep Tubewells and Dugwell in Bihar

	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
Deep Tubewell	202	158	132	48	36	43	43
Dug well	11380	8149	5096	3602	2467	1415	1039

Table A.23. Distribution of Deep Tube-wells According to the Farmers in Bihar

Name of District	Marginal (0 - 1 ha)	Small (1 - 2 ha)	Medium (2 - 10 ha)	Big (> 10 ha)	Total
Aurangabad	0	0	0	0	0
Banka	0	0	0	0	0
Begusarai	0	0	0	0	0
Bhagalpur	0	0	0	0	0
Bhojpur	0	0	0	0	0
Buxar	0	1	0	0	1
Darbhanga	0	0	0	0	0
East Champaran	0	0	0	0	0
Gaya	0	0	2	1	3
Gopaalganj	0	0	0	0	0
Jamui	0	0	0	0	0
Jehanabad	0	0	0	3	3
Kaimur (Bhabua)	0	0	0	1	1
Katihar	0	0	0	0	0
Khagaria	0	0	0	0	0
Kishanganj	0	0	0	0	0
Lakhisarai	0	0	0	0	0
Madhepura	0	0	0	0	0
Madhubani	24	16	12	2	54
Munger	0	0	0	0	0
Muzaffarpur	0	0	0	0	0
Nalanda	0	0	0	0	0
Nawada	0	3	13	4	20
Patna	1	1	0	0	2
Purnia	0	0	0	0	0
Rohtas(Sasaram)	0	0	0	15	15
Saharsa	0	0	0	0	0
Samastipur	0	0	0	0	0
Saran	0	0	0	0	0
Shekhpura	0	0	0	0	0

Source: Minor irrigation Census, 2001, Ministry of Water Resources, Govt. of India

Table A.24. Construction of Deep Tube-wells in Bihar

Name of District	Upto 1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	Total
Aurangabad	84	4	4	1	2	1	0	0	96
Banka	3	0	0	0	0	0	0	0	3
Begusarai	225	11	8	7	0	0	0	1	252
Bhagalpur	150	2	2	0	0	0	0	1	155
Bhojpur	121	15	1	4	0	0	0	1	142
Buxar	144	3	6	0	2	0	0	0	155
Darbhanga	203	8	1	3	0	1	0	0	216
East Champaran	195	12	7	14	3	10	25	16	282
Gaya	36	0	0	9	4	4	1	5	59
Gopaalganj	49	3	1	1	0	0	0	2	56
Jamui	3	0	0	0	0	0	0	0	3
Jehanabad	23	2	2	9	0	0	0	0	36
Kaimur (Bhabua)	127	2	0	2	3	1	9	3	147
Katihar	65	1	0	0	0	0	0	1	67
Khagaria	118	1	2	1	0	2	2	0	126
Kishanganj	10	0	0	0	0	0	0	0	10
Lakhisarai	45	0	0	0	0	0	0	0	45
Madhepura	31	0	2	2	0	0	0	0	35
Madhubani	494	52	42	26	17	6	2	3	642
Munger	2	0	0	0	0	0	0	0	2
Muzaffarpur	232	7	1	3	1	2	0	3	249
Nalanda	138	9	27	4	6	0	0	4	188
Nawada	94	25	16	13	1	1	0	0	150
Patna	288	8	6	1	0	2	2	1	308
Purnia	3	0	0	0	0	0	0	0	3
Rohtas(Sasaram)	77	1	1	6	1	0	1	1	88
Saharsa	15	0	0	0	0	0	0	0	15
Samastipur	246	8	1	2	0	0	0	0	257
Saran	103	4	8	21	8	6	1	0	151
Shekhpura	93	24	20	3	0	0	0	1	141

Source: Minor irrigation Census, 2001, Ministry of Water Resources, Govt. of India

Table A.25. Distribution of Deep Tube-wells in Bihar

Name of District	Govt.	Coop Societies.	Panchayat	Group of farmers	Individual Farmers	Others	Total
Araria	0	0	0	1	13651	0	13652
Aurangabad	10	0	0	4	8575	0	8589
Banka	10	0	0	1	5505	0	5516
Begusarai	90	0	0	2	21088	0	21180
Bhagalpur	1	0	1	2	11894	7	11905
Bhojpur	11	0	3	1	18291	0	18306
Buxar	0	0	0	0	13782	35	13817
Darbhanga	0	0	0	0	12569	0	12569
East Champaran	0	1	1	0	34902	0	34904
Gaya	130	14	23	12	24621	10	24810
Gopaalganj	3	2	0	11	21227	0	21243
Jamui	4	8	0	0	3958	0	3970
Jehanabad	7	0	1	0	19794	0	19802
Kaimur (Bhabua)	6	1	0	0	12663	0	12670
Katihar	4	1	0	0	34147	0	34152
Khagaria	1	0	0	0	14080	0	14081
Kishanganj	2	2	0	0	10432	0	10436
Lakhisarai	0	0	0	4	7131	0	7135
Madhepura	2	0	1	0	17658	0	17661
Madhubani	97	4	1	1	15323	281	15707
Munger	87	5	0	0	3280	0	3372
Muzaffarpur	3	1	0	0	34611	0	34615
Nalanda	13	2	0	6	21015	2	21038
Nawada	9	1	7	0	17460	1	17478
Patna	19	1	0	0	27906	4	27930
Purnia	2	1	0	0	22437	0	22440
Rohtas(Sasaram)	8	2	0	2	20872	1	20885
Saharsa	0	0	0	0	11784	0	11784
Samastipur	0	0	0	0	31427	3	31430
Saran	13	27	0	1	22971	0	23012

Source: Minor irrigation Census, 2001, Ministry of Water Resources, Govt. of India

Table A.26. Construction of Dugwells in Bihar

Name of District	Upto 1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	Total
Aurangabad	4797	474	404	175	171	119	44	19	6203
Banka	5481	757	504	262	315	224	150	154	7847
Bhagalpur	2045	553	749	714	418	236	85	88	4888
Bhojpur	2307	135	36	16	28	23	32	20	2597
Buxar	569	89	60	23	28	15	5	0	789
East Champaran	20	1	1	0	0	0	0	0	22
Gaya	12630	1817	1192	785	631	425	233	169	17882
Gopaalganj	4494	41	23	18	3	1	0	0	4580
Jamui	6013	812	591	398	317	270	195	99	8695
Jehanabad	2019	246	135	87	22	16	9	3	2537
Kaimur (Bhabua)	6660	845	519	217	153	97	47	58	8596
Katihar	15	0	0	0	0	0	0	0	15
Lakhisarai	548	163	95	84	110	48	23	64	1135
Madhepura	4	0	0	0	0	0	0	0	4
Madhubani	121	0	0	0	0	0	0	0	121
Munger	2892	253	137	109	42	22	1	4	3460
Muzaffarpur	104	0	3	0	1	0	0	0	108
Nalanda	12716	2499	1842	1375	934	697	366	301	20730
Nawada	2959	1181	1037	122	68	35	40	21	5463
Patna	3962	540	243	115	64	29	15	3	4971
Rohtas (Sasaram)	5361	283	276	175	225	153	134	32	6639
Saran	11246	218	114	328	14	28	32	1	11981
Shekhpura	413	70	68	45	12	9	0	2	619
Siwan	13788	323	78	29	36	17	0	1	14272
Vaishali	865	80	42	19	10	3	4	0	1023
Bihar	102029	11380	8149	5096	3602	2467	1415	1039	135177

Source: Minor irrigation Census, 2001, Ministry of Water Resources, Govt. of India

Table A.27. Distribution of Dugwells According to Farmers' Holding Size in Bihar

Name of District	Marginal (0 - 1 ha)	Small (1 - 2 ha)	Medium (2 - 10 ha)	Big (> 10 ha)	Total
Aurangabad	2211	2020	1596	191	6018
Banka	4250	2187	809	55	7301
Bhagalpur	3288	1056	461	60	4865
Bhojpur	802	1156	562	28	2548
Buxar	230	296	207	11	744
East Champaran	2	14	6	0	22
Gaya	8342	5642	3225	194	17403
Gopaalganj	2148	1688	532	39	4407
Jamui	4469	2468	668	32	7637
Jehanabad	937	954	478	35	2404
Kaimur (Bhabua)	2109	2823	3061	550	8543
Katihar	0	3	10	2	15
Lakhisarai	859	193	79	3	1134
Madhepura	0	3	0	0	3
Madhubani	45	56	15	1	117
Munger	2358	712	138	32	3240
Muzaffarpur	18	72	8	0	98
Nalanda	8798	7781	3652	318	20549
Nawada	3362	1138	448	51	4999
Patna	1946	1788	905	111	4750
Rohtas (Sasaram)	1713	2105	2526	200	6544
Saran	8090	3088	665	47	11890
Shekhpura	208	248	115	21	592
Siwan	7615	4847	1357	88	13907
Vaishali	507	368	136	7	1018
Bihar	64307	42706	21659	2076	13074

Source: Minor irrigation Census, 2001, Ministry of Water Resources, Govt. of India

Table A.28. Fertilizer Consumption in Bihar (in 000' tonnes)

Year	Nitrogenous	Phosphate	Potash	Total
1971	65.36 (79.3%)	12.45 (15.1%)	4.65 (5.6%)	82.46
1976	98.53 (81.6%)	14.91 (12.4%)	7.26 (6.0%)	120.7
1981	148.51 (79.4%)	25.74 (13.8%)	12.8 (6.8%)	187.05
1986	326.45 (70.3%)	96.31 (20.7%)	41.89 (9.0%)	464.65
1996	506.64 (78.3%)	99.79 (15.4%)	40.72 (6.3%)	647.15
2001	607.57 (75.1%)	163.68 (20.2%)	37.6 (4.6%)	808.85
2006	708.25 (75.4%)	131.98 (14.1%)	98.7 (10.5%)	938.93
2007	807.84 (75.7%)	176.1 (16.5%)	82.78 (7.8%)	1066.72
2008	892.8 (77.3%)	183.95 (15.9%)	77.95 (6.8%)	1154.7
2009	885.06 (67.9%)	252.99 (19.4%)	165.53 (12.7%)	1303.58
2010	843.69 (67.0%)	247.45 (19.7%)	168.02 (13.3%)	1259.16

Note: Figures in parentheses are the percentage share of the total.
Source: Indian Harvest Database, CMIE

Table A.29. District-wise Consumption of Nitrogen Fertilizer (in ’000 Tonnes)

District	Dec 71	Dec 76	Dec 81	Dec 86	Dec 96	Dec 01	Dec 06	Dec 07	Dec 08	Dec 09	Dec 10
Patna	10.96	7.76	11.12	23.17	34.38	30.44	39.87	42.88	45.45	46.31	40.38
Baxur						11.15	12.38	17.53	23.26	19.89	22.03
Saran	11.7	4.43	6.58	11.09	18.36	18.65	17.66	21.71	31.66	25.1	24.69
Vaishali		2.17	2.78	6.6	12.79	21.36	27.04	29.56	1.59	35.26	39.68
Begusarai		3.29	4.71	9.31	17.97	24.25	24.49	25.74	33.21	29.06	28.04
Munger	6.29	4.84	7.1	10.53	16.13	6.38	3.34	5.56	31.66	5.97	5.9
Sheikhpura						4.23	7.68	6.49	6.51	7.88	5.96
Lakhisarai						5.65	3.9	6.53	4.78	6.86	6.9
Khagaria				4.71	13.77	21.35	28.15	27.44	26.19	32.48	32.39
Bhagalpur	1.46	3.54	7.83	11.44	36.3	25.32	23.25	29.67	12.14	39.53	34.46
Purnea	1.86	2.54	4.22	18.17	21.15	22.96	31.84	35.52	16.45	45.74	44.62
Katihar		1.03	1.15	6.17	11.98	14.66	21.96	21.29	12.26	29.37	28.03
Average for Bank Districts	**6.45**	**3.7**	**5.69**	**11.24**	**20.31**	**17.2**	**20.13**	**22.49**	**20.43**	**26.95**	**26.09**
Nalanda		5.84	8.48	19.9	34.63	27.05	26.49	33.58	36.34	35.6	31.97
Bhojpur	14.4	8.57	13.99	26.71	31.89	30.05	33.7	42.37	51.79	45.35	42.83
Rohtas		10.21	15.66	38.33	37.9	36.44	33.94	40.61	48.91	45.11	40.11
Kaimur						11.4	11.38		18.11	19.13	17.94
Gaya	3.12	5.3	13.71	21.76	21.11	27.59	29.68	33.5	41.82	38.91	30.33
Jehanabad					10.96	12.63	10.96	16.23	11.58	12.73	10.24
Arwal										5.61	5.02
Nawada		2.08		8.41	16.85	16.51	10.89	13.35	4.23	14.22	12.57
Aurangabad		2.35	3	13.93		25.47	22.03	24.98	15.13	28.71	27.99
Siwan		3.19	4.04	8.37	8.87	9.12	15.44	19.32	22.42	21.64	20.96
Gopalganj		2.67	7.6	13.33	8.53	6.43	7.64	12.23	22.11	16.33	15.2
Muzaffarpur	4.89	5.77	8.44	10.87	20.24	29.25	39.8	42.45	13.2	51.03	46.76
E. Champaran	2.77	6.59	8.13	14.36	34.01		50.64	53.39	50.8		
W. Champaran		3.11	4.81	10.67	22.3	37.73	46.53	46.23	55.69	48.57	47.26
Sitamarh		2.11	3.42	6.9	9.9	18.69	10.74	18.03	46.42	22.15	24.28
Seohar						0.72	0.52	2.16	20.12	2.57	2.39
Darbhanga	5.64	1.93	1.96	4.62	12.35	20.55	21.06	17.18	31.28	22.68	19.74
Madhubani		1.28	1.71	3.89	4.14	9.19	7.61	11.13	20.37	13.17	13.54
Samastipur		3.38	4.79	10.01	16.14	26.42	32.12	32.79	10.25	35.33	36.69
Jamui						3.23	10.79	10.84	7.43	14.6	13.13
Banka						7.19	4.15	10.28	37.35	11.62	12.03
Saharsa	2.27	1.75	3.28	5.9	13.93	10.58	8.23	12.86	8.19	13.1	16.39
Supaul						5.66	3.08	6.92	12.94	6.52	7.69
Madhepura		2.8		7.3	9.07	14.48	12.26	15.26	5.56	14.94	15.19
Kisanganj					4.47	4.21	4.6	7.19	50.23	6.59	4.97
Araria					6.52	10.58	12.41	15.04	5.37	15.4	15.39
Average for Non-bank Districts	**3.96**	**2.21**	**3.03**	**6.44**	**9.57**	**10.96**	**10.63**	**13.31**	**21.29**	**14.89**	**15.12**

Source: Indian Harvest Database, CMIE

Table A.30. District-wise Consumption of Potash Fertilizer (in ’000 Tonnes)

District	Dec 71	Dec 76	Dec 81	Dec 86	Dec 96	Dec 01	Dec 06	Dec 07	Dec 08	Dec 09	Dec 10
Patna	0.31	0.19	0.25	1.36	0.98	1.24	3.4	3.04	3.59	5.03	6.29
Baxur						0.34	0.38	0.51	1.07	1.88	1.67
Saran	0.32	0.48	0.89	1.39	1.85	1.86	0.95	0.85	1.14	4.38	4.45
Vaishali		0.24	0.21	0.55	0.87	1.8	2.56	1.36	0.3	7.69	9.28
Begusarai		0.32	0.51	1.75	2.48	2.98	6.66	5.2	3.86	8.02	9.16
Munger	1.08	0.44	0.66	1.22	0.63	0.07	0.06	0.35	4.65	1	1.31
Sheikhpura						0.02	0.11	0.27	0.69	0.52	0.49
Lakhisarai						0.01	0.56	0.83	0.77	1.4	1.14
Khagaria				1.23	1.26	2.17	6.26	6.88	3.98	11.32	13.1
Bhagalpur	0.07	0.31	0.84	1.5	5.8	1.78	7.91	5.98	0.92	6.35	6.92
Purnea	0.57	0.31	0.63	3.02	4.19	3.49	10.85	8.7	1.97	12.15	12.94
Katihar		0.12	0.2	1.22	3.48	0.78	5.36	3.96	1.65	9.05	9.59
Average for Bank Districts	**0.47**	**0.3**	**0.52**	**1.47**	**2.39**	**1.38**	**3.76**	**3.16**	**2.05**	**5.73**	**6.36**
Nalanda		0.2	0.41	2.52	0.48	0.69	1.83	2.27	2.94	5.04	4.84
Bhojpur	0.94	0.36	0.58	2.61	0.69	0.63	1.15	2.7	3.12	5.32	4.17
Rohtas		0.54	0.88	5.59	0.82	0.91	1.04	1.15	2.01	4.54	3.59
Kaimur						0.53	0.29		1.06	1.87	1.69
Gaya	0.18	0.25	0.78	1.76	1.09	0.27	2.25	1.83	1.94	5.16	3.25
Jehanabad					0.18	0.08	0.27	0.69	0.86	1.6	0.91
Arwal										0.73	0.35
Nawada		0.17		1.2	0.19	0.17	0.29	0.33	0.16	1.17	0.9
Aurangabad		0.19	0.17	1.7		0.55	0.69	0.69	0.4	3.05	2.03
Siwan		0.29	0.79	0.61	0.43	0.32	1	0.93	1.45	2.79	2.7
Gopalganj		0.24	1.04	2.04	0.29	0.1	0.38	0.54	1.69	1.78	1.32
Muzaffarpur	0.59	0.43	0.67	1.55	2.02	3.48	7.93	6.09	0.7	9.46	10.53
E. Champaran		0.48	0.87	2.12	2.39	1.3	4.2	3.35	4.2	7.67	7.09
W. Champaran		0.5	0.8	1.12	1.64	1.86	7.04	4.02	3.91	7.42	7.89
Sitamarhi		0.23	0.29	0.62	0.17	0.72	1.29	1.25	4.29	2.81	3.29
Seohar						0.04	N.A.	0.2	0.98	1.16	0.46
Darbhanga	0.21	0.18	0.26	0.64	0.53	1.6	3.29	1.76	3.88	4.04	4.12
Madhubani		0.1	0.24	0.45	0.48	0.51	0.36	0.74	1.85	2.07	2.63
Samastipur		0.26	0.59	1.51	2.73	2.29	6.06	4.91	0.91	7.41	9.55
Jamui						0.01	1.04	1	0.47	1.31	1.74
Banka						0.12	0.46	0.57	4.75	2.14	2.05
Saharsa	0.38	0.27	0.24	1.22	1.06	1.36	1.43	2.15	1.03	4.78	3.91
Supaul						0.69	1	1.1	2.84	1.71	2.06
Madhepura		0.16		1.39	1.17	1.46	3.9	2.71	1.08	3.67	3.99
Kisanganj					0.77	0.18	1.06	0.43	6.53	1.37	1.37
Araria					2.05	1.19	5.39	3.44	0.31	6.67	5.25
Average for Non-bank Districts	**0.3**	**0.2**	**0.32**	**0.97**	**1.12**	**0.85**	**2.3**	**1.69**	**2.41**	**3.26**	**3.37**

Source: Indian Harvest Database, CMIE

Table A.31. District-wise Consumption of Phosphate Fertilizer (in '000 Tonnes)

District	Dec 71	Dec 76	Dec 81	Dec 86	Dec 96	Dec 01	Dec 06	Dec 07	Dec 08	Dec 09	Dec 10
Patna	1.36	0.6	0.8	3.32	5.08	10.26	11.3	10.06	9.69	12.56	12.47
Baxur						1.15	1.13	3.15	3.84	4.51	5.07
Saran	0.06	0.88	1.6	2.51	6.44	7.11	2.74	3.68	5.93	8.33	7.26
Vaishali		0.41	0.66	2.26	3.84	5.13	3.69	5.45	0.55	15.01	13.47
Begusarai		0.44	0.96	3.43	4.52	10.19	7.04	9.06	7.88	11.66	10.33
Munger	2.44	0.72	1.1	3.08	1.59	0.55	0.16	1.01	8.92	1.78	2.33
Sheikhpura						0.59	0.43	1.34	2.29	1.21	1.33
Lakhisarai						0.69	0.82	1.36	1.42	3.02	2.5
Khagaria				1.53	3.45	5.92	3.33	6.88	6.24	10.4	10.31
Bhagalpur	0.15	0.39	1.47	2.5	8.12	10.42	6.39	6.76	2.9	6.89	8.24
Purnea	1.32	0.86	1.08	6.95	5.87	5.59	9.22	9.85	3.99	10.22	9.62
Katihar		0.24	0.25	3.02	2.08	7.52	5.78	5.58	4.21	8.99	8.93
Average for Bank Districts	**1.07**	**0.57**	**0.99**	**3.18**	**4.55**	**5.43**	**4.34**	**5.35**	**4.82**	**7.88**	**7.66**
Nalanda		0.45	0.78	4.83	3.02	5.73	4.35	6.99	7.09	9	9.07
Bhojpur	5.18	1.15	1.71	6.04	3.18	4.69	4.8	7.79	10.3	9.47	10.24
Rohtas		1.48	2.58	12.76	6.38	10.21	3.53	6.8	8.85	9.54	9.6
Kaimur						2.48	0.99		3.49	4.68	4.94
Gaya	0.47	0.6	1.57	4.62	6.72	5.18	6.91	6.14	7.74	8.91	8.28
Jehanabad					0.94	1.82	1.13	2.28	2.63	3.26	3.75
Arwal										2.5	2.25
Nawada		0.34		2.53	3.09	2.17	1.16	1.75	0.92	3.1	2.48
Aurangabad		0.35	0.48	4.03		4.08	2.54	4.43	1.54	6.5	6.83
Siwan		0.74	1.1	2.68	1.53	2.05	2.27	3.85	5.22	7.37	6.95
Gopalganj		0.82	1.7	4.78	0.74	0.81	0.64	2.21	5.53	4.58	4.73
Muzaffarpur	0.16	0.73	1.3	4.39	6.45	8.3	8.17	8.92	3.2	13.97	12.68
E. Champaran		0.65	1.52	4.31	5.46	7.43	6.33	9.3	9.01	11.28	11.97
W. Champaran		0.78	1.43	3.22	2.71	9.16	8.73	11.39	8.09	12.08	11.15
Sitamarhi		0.27	0.45	1.32	0.44	2.71	1.92	2.99	10.56	5.6	6.05
Seohar						0.06	N.A.	0.37	3.97	1.05	0.89
Darbhanga	0.29	0.29	0.41	1.38	4.52	6.92	4.75	5.04	9.1	8.25	6.79
Madhubani		0.32	0.47	1.78	0.59	2.62	0.92	2.36	5.15	5.3	4.47
Samastipur		0.39	1.6	3.66	6.02	9.44	6.29	7.67	2.55	10.54	10.79
Jamui						0.47	2.81	2.96	1.01	2.69	2.88
Banka						0.98	0.92	1.61	4.79	1.89	2.34
Saharsa	1.02	0.42	0.72	2.27	2.06	2.47	1.35	3.1	1.83	3.81	4.42
Supaul						2.11	1.07	2.05	2.76	2.14	2.32
Madhepura		0.59		3.11	2.48	3.73	2.42	4.72	1.42	3.81	3.87
Kisanganj					0.39	0.13	1.23	1.23	8.4	1.53	1.21
Araria					2.08	2.81	4.72	5.97	0.94	5.56	4.64
Average for Non-bank Districts	**0.66**	**0.38**	**0.73**	**2.25**	**2.32**	**2.87**	**2.58**	**3.34**	**4.37**	**4.35**	**4.22**

Source: Indian Harvest Database, CMIE

Table A.32. Area, Production & Yield of Different Crops in Bihar

Area in ha., Prod. in MT, Yield in kg/ha.										
		2003-2004			2004-2005			2005-2006		
Sl. No.	Crops	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
1	Rice	3,577,988 (48.24%)	5,447,795	1,523	3,188,246 (45.95%)	2,625,135	823	3,252,357 (46.91%)	3,495,932	1,075
2	W heat	2,076,839 (28%)	3,688,941	1,776	2,022,347 (29.16%)	3,279,946	1,622	2,003,728 (28.90%)	2,763,324	1,379
3	Maize	616,430 (8.31%)	1,473,569	2,390	626,853 (9.04%)	1,491,183	2,379	648,822 (9.36%)	1,361,110	2,098
4	Jowar	1,513 (0.02%)	1,527	1,009	2,006 (0.03%)	2,034	1,014	4,112 (0.06%)	4,203	1,022
5	Bajra	1,568 (0.02%)	1,638	1,045	1,193 (0.02%)	1,309	1,097	4,338 (0.06%)	4,591	1,058
6	Ragi	15,187 (0.2%)	10,375	683	15,424 (0.22%)	10,900	707	14,506 (0.21%)	11,277	777
7	Barley	21,446 (0.29%)	24,007	1,119	18,379 (0.27%)	20,306	1,105	16,302 (0.24%)	18,813	1,154
8	Small Millets	7,010 (0.09%)	5,325	760	5,457 (0.08%)	4,156	762	7,369 (0.11%)	5,506	747
9	**Total Coarse Cereals** (3 to 8)	663154	1,516,441	2,287	669,312	1,529,888	2,286	695,449	1,405,500	2,021
10	**Total Cereals** (1 to 8)	6,317,981	10,653,177	1,686	5,879,905	7,434,969	1,264	5,951,534	7,664,756	1,288
11	Gram	80,322 (1.08%)	78,585	978	73,278 (1.06%)	60,960	832	62,238 (0.90%)	56,061	901
12	Lentil	171,037 (2.31%)	159,754	934	179,358 (2.59%)	131,190	731	162,545 (2.34%)	114,525	705
13	Khesari	133,064 (1.79%)	122,574	921	117,982 (1.7%)	84,948	720	92,079 (1.33%)	78,635	854
14	Pea	23740 (0.32%)	22,172	934	23,104 (0.33%)	20,908	905	24,116 (0.35%)	21,488	891
15	Summer Moong	181,373 (2.45%)	88,908	490	171,178 (2.47%)	87,539	511	174,123 (2.51%)	96,218	553
16	Other Rabi Pulses	3,298 (0.04%)	2,450	743	2,322 (0.03%)	1,777	765	2,408 (0.03%)	1,929	801
17	Tur	38,855 (0.52%)	48,100	1,238	35,276 (0.51%)	49,189	1,394	33,311 (0.00%)	43,040	1,292
18	Moong	8,398 (0.11%)	4,231	504	6,835 (0.1%)	3,854	564	8,247 (0.12%)	4,898	594
19	Urad	24,199 (0.33%)	18,009	744	24,412 (0.35%)	18,068	740	25,197 (0.36%)	19,443	772
20	Ghaghra	421 (0.01%)	232	551	502 (0.01%)	248	494	477 (0.01%)	236	495
21	Kulthi	15,425 (0.21%)	11,399	739	14,296 (0.21%)	12,367	865	11,744 (0.17%)	10,101	860
22	Other kharif Pulses	740 (0.01%)	397	536	681 (0.01%)	354	520	903 (0.01%)	520	576
23	**Total Pulses**	680,872	556811	818	649,224	471,402	726	597,388	447,094	748
24	**Total Foodgrain**	6,998,853	11,209,988	1,602	6,529,129	7,906,371	1,211	6,548,922	8,111,850	1,239
25	Carstor seed	155 (0%)	154	994	150 (0%)	141	940	911 (0.01%)	450	494

Area in ha., Prod. in MT, Yield in kg/ha.										
		2003-2004			2004-2005			2005-2006		
Sl. No.	**Crops**	**Area**	**Prod.**	**Yield**	**Area**	**Prod.**	**Yield**	**Area**	**Prod.**	**Yield**
26	Groundnut	468 (0.01%)	231	494	769 (0.01%)	381	495	164 (0.00%)	154	939
27	Sesamum	3,795 (0.05%)	2,840	748	3,497 (0.05%)	2,741	784	3,188 (0.05%)	2,554	801
28	Sunflower	17,531 (0.24%)	24,159	1,378	21,183 (0.31%)	29,122	1,375	22,713 (0.33%)	30,473	1,342
29	Rapeseed and Mustard	83,666 (1.13%)	68,966	824	83,339 (1.2%)	59,802	718	83,622 (1.21%)	77,365	925
30	Linseed	34,696 (0.47%)	27,202	784	27,768 (0.4%)	23,958	863	27,135 (0.39%)	23,227	856
31	Safflower				214 (0%)	17	799	173 (0.00%)	138	798
32	**Total oil seeds**	140,311	123,552	881	136,920	116,316	850	137,906	134,361	974
33	Jute	154,588 (2.08%)	1,147,358	1,336	148,876 (2.15%)	1,223,691	1,564	131,049 (1.89%)	1,329,256	41,884
34	Mesta	20,011 (0.27%)	138,908	1,249	16,057 (0.23%)	147,292	1,691	14,532 (0.21%)	143,039	1,772
35	Sugarcane	103,599 (1.4%)	4,285,888	41,370	104,457 (1.51%)	3,769,207	36,084	101,243 (1.46%)	4,240,413	41, 884

Note: Production of Jute & Mesta in 000' Bales(1 bales = 180 kg) ; Yield of Potato & Onion in MT/ha

Source: Department of Agriculture, Govt. of Bihar

Table A.33. Area, Production & Yield of Different Crops in Bihar

Area in ha., Prod. In MT, Yield in kg/ha.							
Sl. No.	Crops	2006-2007			2007-2008		
		Area	Prod.	Yield	Area	Prod.	Yield
1	**Rice**	3,463,463 (48%)	5,131,179	1,482	3,473,015 (48%)	4,472,679	1,288
2	**W heat**	2,069,444 (29%)	4,149,019	2,005	2,131,232 (29%)	4,974,663	2,334
3	**Maize**	646,703 (9%)	1,754,410	2,713	657,884 (9%)	1,857,009	2,823
4	Jowar	3,688 (0%)	3,804	1,031	3,426 (0%)	3,762	1,098
5	Bajra	4,708 (0%)	5,005	1,063	3,497 (0%)	3,858	1,103
6	Ragi	14,142 (0%)	13,335	943	13,222 (0%)	7,998	605
7	Barley	16,961 (0%)	18,708	1,103	15,402 (0%)	18,513	1,202
8	Small Millets	4,526 (0%)	3,391	749	7,000 (0%)	5,169	738
9	**Total Coarse Cereals** (3 to 8)	690,728	1,798,653	2,604	700,431	1,896,309	2,707
	Total Cereals (1 to 8)	**6,223,635**	**11,078,851**	**1,780**	**6,304,678**	**11,343,651**	**1,799**
13	Gram	70,397 (1%)	59,609	847	64,105 (1%)	63,473	990
14	Lentil	166,785 (2%)	121,098	726	158,487 (2%)	126,134	796
15	Khesari	102,872 (1%)	81,156	789	98,114 (1%)	82,348	839
16	Pea	23,934 (0%)	22,255	930	23,288 (0%)	25,083	1,077
17	Summer Moong	155,887 (2%)	79,888	512	156,044 (2%)	93,579	600
18	Other Rabi Pulses	3,287 (0%)	2,386	726	3,052 (0%)	2,261	0
19	Tur	37,508 (1%)	46,504	1,240	30,860 (0%)	42,667	1,383
20	Moong	9,184 (0%)	6,023	656	8,834 (0%)	5,358	607
21	Urad	24,891 (0%)	19,348	777	22,366 (0%)	17,497	782
22	Ghaghra	883 (0%)	637	721	994 (0%) (0%)	885	890
23	Kulthi	13,926 (0%)	12,016	863	13,711 (0%)	12,739	929
24	Other kharifPuls	868 (0%)	503	579	1,403 (0%)	917	654
26	**Total Pulses**	**610,422**	**451,423**	**740**	**581,258**	**472,941**	**814**
27	**Total Foodgrain**	**6,834,057**	**11,530,274**	**1,687**	**6,885,936**	**11,816,592**	**1,716**
28	Carstor seed	115 (0%)	109	948	203 (0%)	194	956
29	Groundnut	1,006 (0%)	497	494	1,207 (0%)	868	719
30	Sesamum	3,227	2,497	774	2,832	2,245	793

Area in ha., Prod. In MT, Yield in kg/ha.							
Sl. No.	**Crops**	**2006-2007**			**2007-2008**		
		Area	**Prod.**	**Yield**	**Area**	**Prod.**	**Yield**
		(0%)			(0%)		
31	Sunflower	21,513 (0%)	28,590	1,329	22,052 (0%)	30,646	1,390
32	Rapeseed and Mustard	86,101 (1%)	83,856	974	88,126 (1%)	87,464	992
33	Linseed	29,638 (0%)	25,162	849	27,507 (0%)	22,691 (0%)	825
34	Safflower	80 (0%)	64	800	115 (0%)	92	800
35	**Total oil seeds**	141,680	140,775	994	142,042	144,200	1,015
37	Jute	132,644 (2%)	1,353,967	1,837	131,627 (2%)	1,242,822	1,700
38	Mesta	17,646 (0%)	151,245	1,543	22,626 (0%)	209,564	1,667
40	Sugarcane	117,494 (2%)	5,416,400	46,092	107,039 (1%)	4,027,229	37,624

Source: Department of Agriculture, Govt. of Bihar

Table A.34. Area, Production & Yield of Different Crops in Bihar

Sl. No.	Crops	Area in ha, Prod. In MT, Yield in kg/ha.					
		2008-2009 (Last Est.)			2009-2010 (Forth Adv. Est.)		
		Area	Prod.	Yield	Area	Prod.	Yield
1	Rice	3,495,734 (47.76%)	5,590,352	1,599	3,180,280 (44.77%)	3,620,690	1,138
2	W heat	2,158,327 (29.49%)	4,410,017	2,043	2,226,680 (31.34%)	4,623,000	2,076
3	Maize	640,455 (8.75%)	1,714,001	2,676	652,170 (9.18%)	1,713,930	2,628
4	Jowar	2,399 (0.03%)	2,540	1,059	3,930 (0.06%)	4,310	1,097
5	Bajra	2,969 (0.04%)	3,599	1,212	4,170 (0.06%)	4,990	1,197
6	Ragi	11,435 (0.16%)	9,296	813	10,680 (0.15%)	8,760	820
7	Barley	14,592 (0.20%)	15,898	1,090	12,730 (0.18%)	14,140	1,111
8	Small Millets	7,832 (0.11%)	5,993	765	5,080 (0.07%)	3,930	774
9	**Total Coarse Cereals (3 to 8)**	**679,682**	**1,751,327**	**2,577**	**688,760**	**1,750,060**	**2,541**
	Total Cereals (1 to 8)	**6,333,743**	**11,751,696**	**1,855**	**6,095,720**	**9,993,750**	**1,639**
13	Gram	61,214 (0.84%)	56,637	925	60,330 (0.85%)	60,660	1,005
14	Lentil	163,773 (2.24%)	128,599	785	171,730 (2.42%)	147,800	861
15	Khesari	97,195 (1.33%)	79,791	821	92,960 (1.31%)	94,790	1,020
16	Pea	23,768 (0.32%)	22,865	962	23,290 (0.33%)	22,850	981
17	Summer Moong	162,666 (2.22%)	108,935	670	160,690 (2.26%)	94,650	589
18	Other Rabi Pulses	4,159 (0.06%)	3,082	741	3,670 (0.05%)	2,700	736
19	Tur	28,139 (0.38%)	33,119	1,177	35,980 (0.51%)	49,910	1,387
20	Moong	8,587 (0.12%)	5,609	653	8,980 (0.13%)	5,880	655
21	Urad	21,444 (0.29%)	17,980	838	26,370 (0.37%)	22,460	852
22	Ghaghra				2,060 (0.03%)	1,360	660
23	Kulthi	11,308 (0.15%)	10,404	920	12,840 (0.18%)	10,750	837

Sl. No.	Crops	Area in ha, Prod. In MT, Yield in kg/ha.					
		2008-2009 (Last Est.)			2009-2010 (Forth Adv. Est.)		
		Area	Prod.	Yield	Area	Prod.	Yield
24	Other kharifPuls	2,116 (0.03%)	1,414	668			
26	**Total Pulses**	584,369	468,435	802	598,900	513,810	858
27	**Total Foodgrain**	6,918,112	12,220,131	1,766	6,694,620	10,507,560	1,570
28	Carstor seed	185 (0.00%)	177	957	180 (0.00%)	180	1,000
29	Groundnut	1,734 (0.02%)	857	494	1,650 (0.02%)	820	497
30	Sesamum	2,298 (0.03%)	1,842	802	3,230 (0.05%)	2,600	805
31	Sunflower	22,419 (0.31%)	31,062	1,386	23,760 (0.33%)	31,050	1,307
32	Rapeseed and Mustard	85,265 (1.16%)	81,811	959	87,220 (1.23%)	90,800	1,041
33	Linseed	25,957 (0.35%)	21,959	846	27,100 (0.38%)	22,930	846
34	Safflower	215 (0.00%)	172	800	220 (0.00%)	170	773
35	**Total oil seeds**	138,073	137,880	999	143,360	148,550	1,036
37	Jute	131,949 (1.80%)	1,054,798	1,439	127,340 (1.79%)	1,161,090	1,641
38	Mesta	19,019 (0.26%)	165,323	1,618	19,420 (0.27%)	144,310	1,338
40	Sugarcane	111,902 (1.53%)	4,959,918	44,324	119,420 (1.68%)	4,999,620	41,866

Source: Department of Agriculture, Govt. of Bihar

Table A.35. Area used for Production of Rice in the Districts of Bihar (in hectares)

District	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	46448	46041	45960	45055	41693	48200
Begusarai	23103	28367	29297	26902	24898	24451
Buxar	84153	73347	67949	67878	58545	82536
Katihar	125197	125811	130849	126839	116604	106491
Khagaria	24885	28290	26283	23568	20276	22217
Lakhisaria	31295	29093	33473	30314	28204	24520
Patna	99926	104738	108394	100978	76258	88480
Purnia	114767	120395	127367	120397	113594	123851
Saran	92523	80174	87310	78924	81437	86752
Sheikhpura	23987	13046	30373	29386	27218.8	39302
Vaishali	62874	61511	62183	62188	60592	59596
Monghyr	46774	38525	27926	38981	38474	59693
Average For Bank Districts	**64661**	**62445**	**64780**	**62618**	**57316.57**	**63841**
Araria						138639
Arwal				31856	24656	
Aurangabad	131316	164109	176397	173050	105259	171133
Banka			103299	100564	71841	99429
Kaimur	99500	108673	94093	109947	95307	133136
Bhojpur	108849	111618	111685	106433	96763	85454
Champaran (East)	192009	201290	189667	170981	187580	212875
Champaran (West)	186268	158125	160977	157932	169039	168920
Darbhanga	92701	72738	94065	100718	93695	74855
Gaya	143648	152985	147435	160989	72404	54595
Gopalganj	92265	94283	94197	91125	89838	75801
Jahanabad	86295	84043	61340	44571	34334	84720
Kishanganj	112975	95883	87376	102693	102598	82768
Madhubani	191082	179854	182561	176482	169632	158929
Madhepura	85070	89465	86669	79125	76801	78281
Muzaffarpur	130230	134716	146674	154116	151329	139377
Nalanda	123926	87819	93295	99066	94061	95385
Nawadha	82483	80834	81106	78474	37552	73308
Rohtas	213648	197725	193291	195726	178297	166681
Saharsa	102816	94029	94686	88143	79329	87740
Samastipur	87852	84598	84977	83803	63697	70238
Sheohar	16141	26960	23524	25310	24164	23671
Sitamarhi	91557	123360	106844	103388	71973	92512
Siwan	105977	109711	105913	105036	113061	106790
Supaul			116838	124978	116429	102061
Jamui	47597	37981	53386	52784	48284	
Average For Non-Bank Districts	**114737**	**113218**	**112096**	**108692**	**94717**	**107387**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Govt. of Bihar

Table A.36. Production of Rice in the Districts of Bihar (in tonnes)

District	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	51776	57017	51558	57045	20412	114228
Begusarai	23521	32663	28473	36330	12592	33919
Buxar	225068	183073	170384	154420	22366	187071
Katihar	160312	176206	168475	155497	105673	138899
Khagaria	14715	14819	5977	22168	5156	19132
Lakhisaria	47188	41233	48097	42299	15913	56289
Monghyr	46774	38525	27926	38981	38474	59693
Patna	202790	203542	218176	230566	43374	145350
Purnia	165399	145730	145758	188409	90812	118237
Saran	131329	97972	99238	141486	58822	97669
Sheikhpura	31950	20193	57047	38431	2844	94300
Vaishali	97965	88866	80475	44254	18675	46071
Average (Bank Districts)	**99899**	**91653**	**91799**	**95824**	**36259**	**92572**
Araria						142541
Arwal				54084	19357	
Aurangabad	257326	345060	334134	312702	120193	444650
Banka			145882	150537	97758	258065
Kaimur	193229	271478	246883	341878	137845	310928
Bhojpur	252862	243841	207493	224770	31775	226802
Champaran (East)	237240	275936	264547	242179	117723	166100
Champaran (West)	388842	270832	296371	227115	127864	167909
Darbhanga	89287	65161	70097	102002	41056	65429
Gaya	229902	257723	244069	246468	13502	80617
Gopalganj	112602	124793	110118	134432	122631	89959
Jahanabad	134133	163476	100679	80925	13230	156043
Kishanganj	130584	98342	93800	146778	71253	75595
Madhubani	216912	173059	141280	176318	46846	141393
Madhepura	110802	95687	115228	117017	86041	89689
Muzaffarpur	164967	144543	158660	165258	43067	95559
Nalanda	116419	132648	83225	96891	17099	227246
Nawadha	91166	131561	123596	127430	13022	147689
Rohtas	544066	492175	465583	517411	465646	468067
Saharsa	153859	92994	94089	107515	70393	86432
Samastipur	94341	90791	66881	67996	12112	41689
Sheohar	21644	32885	29540	12071	10866	12351
Sitamarhi	102317	146387	111241	130879	33271	64415
Siwan	133368	131447	130564	122387	109707	148459
Supaul			142709	164591	119930	120735
Jamui	50893	27598	70195	60080	20970	88727
Average (Non-Bank Districts)	**173944**	**173110**	**160286**	**165189**	**78526**	**156684**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Govt. of Bihar

Table A.37. Yield of Rice in the Districts of Bihar (in tonnes/hectare)

District	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	1.11	1.24	1.12	1.27	0.49	2.37
Begusarai	1.02	1.15	0.97	1.35	0.51	1.39
Buxar	2.67	2.5	2.51	2.27	0.38	2.27
Katihar	1.28	1.4	1.29	1.23	0.91	1.3
Khagaria	0.59	0.52	0.23	0.94	0.25	0.86
Lakhisaria	1.51	1.42	1.44	1.4	0.56	2.3
Monghyr	1.5	1.44	1.19	1.5	1.5	1.99
Patna	2.03	1.94	2.01	2.28	0.57	1.64
Purnia	1.44	1.21	1.14	1.56	0.8	0.95
Saran	1.42	1.22	1.14	1.79	0.72	1.13
Sheikhpura	1.33	1.55	1.88	1.31	0.33	2.4
Vaishali	1.56	1.44	1.29	0.71	0.31	0.77
Average (Bank Districts)	**1.46**	**1.42**	**1.35**	**1.47**	**0.61**	**1.61**
Araria						1.03
Arwal				1.7	0.79	
Aurangabad	1.96	2.1	1.89	1.81	1.14	2.6
Banka			1.41	1.5	1.36	2.6
Kaimur	1.94	2.5	2.62	3.11	1.45	2.34
Bhojpur	2.32	2.18	1.86	2.11	0.33	2.65
Champaran(East)	1.24	1.37	1.39	1.42	0.63	0.78
Champaran(West)	2.09	1.71	1.84	1.44	0.76	0.99
Darbhanga	0.96	0.9	0.75	1.01	0.44	0.87
Gaya	1.6	1.68	1.66	1.53	0.19	1.48
Gopalganj	1.22	1.32	1.17	1.48	1.37	1.19
Jahanabad	1.55	1.95	1.64	1.82	0.39	1.84
Kishanganj	1.16	1.03	1.07	1.43	0.69	0.91
Madhubani	1.14	0.96	0.77	1	0.28	0.89
Madhepura	1.3	1.07	1.33	1.48	1.12	1.15
Muzaffarpur	1.27	1.07	1.08	1.07	0.28	0.69
Nalanda	0.94	1.51	0.89	0.98	0.18	2.38
Nawadha	1.11	1.63	1.52	1.62	0.35	2.01
Rohtas	2.55	2.49	2.41	2.64	2.61	2.81
Saharsa	1.5	0.99	0.99	1.22	0.89	0.99
Samastipur	1.07	1.07	0.79	0.81	0.19	0.59
Sheohar	1.34	1.22	1.26	0.48	0.45	0.52
Sitamarhi	1.12	1.19	1.04	1.27	0.46	0.7
Siwan	1.26	1.2	1.23	1.17	0.97	1.39
Supaul			1.22	1.32	1.03	1.18
Jamui	1.07	0.73	1.31	1.14	0.43	1.76
Average (Non-Bank Districts)	**1.44**	**1.45**	**1.38**	**1.46**	**0.75**	**1.45**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Govt. of Bihar

Table A.38. Area Used for the Production of Wheat in the Districts of Bihar (in hectares)

District	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	42251	42781	42187	43502	56392	44159
Begusarai	60737	56277	56065	55379	52639	52751
Buxar	45742	46633	46647	45684	65969	60699
Katihar	43144	47809	43461	46803	36216	35316
Khagaria	35783	41772	41069	40787	41286	32229
Patna	61360	61484	63403	61820	59857	57643
Purnia	52485	58812	57017	58778	51855	46296
Lakhisaria	23133	20020	25035	23938	21137	30061
Saran	91452	90027	98192	94593	94074	88112
Sheikhpura	20234	19323	17486	22287	15893	20530
Vaishali						47880
Monghyr	22802	21320	19350	22780	18418	18205
Average (Bank Districts)	**45375**	**46023**	**46356**	**46941**	**46703**	**44490**
Araria						57551
Arwal				14770	11622	
Aurangabad	55516	55528	57409	53655	52479	61320
Banka			26260		21538	28781
Kaimur	66012	69409	60977	63927	64511	61071
Bhojpur	67312	82212	82037	76500	49786	75252
Champaran (East)	113956	114857	81431	91390	98001	98681
Champaran (West)	83236	84041	80092	79151	80131	83627
Darbhanga	60446	59395	66303	73492	69647	67181
Gaya	51685	51878	71524	63367	48810	73663
Gopalganj	78256	86361	87218	85212	84361	83202
Jahanabad			34230	19220	22710	32803
Kishanganj	25552	28459	29190	27750	28121	21676
Madhubani	69182	72068	87324	82822	92281	82150
Madhepura	51512	51601	50082	38948	38450	36629
Muzaffarpur	85586	85827	86840	90699	92891	85448
Nalanda	88154	101255	83416	83849	81480	82238
Nawadha	45237	45680	49407	49812	43423	45191
Rohtas	119690	150461	132763	128102	119130	135644
Saharsa	54469	49963	50013	43708	44093	42621
Samastipur	55149	54766	52095	52112	52126	51367
Sheohar	11962	10936	10944	10838	10942	14075
Sitamarhi	52744	70696	70712	52930	49806	68215
Siwan	97531	93941	98714	84459	85638	91888
Supaul	43299	47414	43369	39075	44743	50795
Jamui	20851	20490	17278	16972	15177	11777
Average (Non-bank districts)	**63515.32**	**67601.73**	**62901.17**	**59281.67**	**56075.88**	**61713.84**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Govt. of Bihar,

Table 3.39. **Production of Wheat in the Districts of Bihar (in tonnes)**

District	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	87814	69488	63061	76853	72898	73965
Begusarai	145269	107892	103343	107492	88559	114505
Buxar	131621	113817	127040	126276	123090	123162
Katihar	94508	83436	69677	56043	42603	44389
Khagaria	63733	60395	52928	61432	70979	47665
Patna	162834	145488	163022	158649	111277	123775
Purnia	94510	91884	84862	71463	59646	62224
Lakhisaria	50877	30104	56500	51182	27249	74091
Saran	219828	212755	188654	208739	200718	206367
Sheikhpura	38098	30904	31902	39392	23427	41845
Vaishali						120298
Monghyr	38970	31234	22678	41423	34678	33736
Average (Bank Districts)	**102551**	**88854**	**87606**	**90813**	**77739**	**88835**
Araria						40153
Arwal				40533	21265	
Aurangabad	113367	110171	121475	111218	74460	124774
Banka			36958		27735	53142
Kaimur	162507	175141	162476	144491	105395	131927
Bhojpur	171824	205799	164475	185606	91356	190165
Champaran (East)	255835	233874	143375	143031	208865	199138
Champaran (West)	246107	212254	170399	141538	177609	159715
Darbhanga	99524	65825	99172	97345	120068	126518
Gaya	95283	147132	143891	127641	54608	156981
Gopalganj	193138	283784	163081	199739	115719	208168
Jahanabad			80656	47494	43974	72142
Kishanganj	40741	44737	47913	22669	37283	27904
Madhubani	106501	94980	114682	65802	74322	131494
Madhepura	120800	98516	81820	40681	70831	53177
Muzaffarpur	185053	179819	162133	129362	144180	163884
Nalanda	177138	189805	157880	124225	67059	157209
Nawadha	75350	82304	99484	95080	40440	97142
Rohtas	253865	326907	322003	322248	245078	330444
Saharsa	149817	94601	93821	79240	71703	82012
Samastipur	122104	122758	87958	59571	96491	143248
Sheohar	22211	25480	19140	18893	16571	19128
Sitamarhi	91912	152426	119007	84738	80475	118146
Siwan	201281	208778	193517	181132	179321	191136
Supaul	109076	108088	91786	34720	96752	94125
Jamui	23128	27920	19868	22120	17409	17647
Average For Non Bank Districts	**137116.5**	**145050**	**120707.1**	**104963.2**	**91158.76**	**123580.76**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Bihar, Patna

Table A.40. Yield of Wheat in the districts of Bihar (in tonnes/hectare)

Districts	2000-01	2001-02	2002-03	2003-04	2004-05	2006-07
Baghalpur	2.08	1.62	1.49	1.77	1.29	1.67
Begusarai	2.39	1.92	1.84	1.94	1.68	2.17
Buxar	2.88	2.44	2.72	2.76	1.87	2.03
Katihar	2.19	1.75	1.60	1.20	1.18	1.26
Khagaria	1.78	1.45	1.29	1.51	1.72	1.48
Patna	2.65	2.37	2.57	2.57	1.86	2.15
Purnia	1.80	1.56	1.49	1.22	1.15	1.34
Lakhisaria	2.20	1.50	2.26	2.14	1.29	2.46
Saran	2.40	2.36	1.92	2.21	2.13	2.34
Sheikhpura	1.88	1.60	1.82	1.77	1.47	2.04
Vaishali						2.51
Monghyr	1.71	1.47	1.17	1.82	1.88	1.85
Average For Bank Districts	**2**	**2**	**2**	**2**	**2**	**2**
Araria						0.70
Arwal				2.74	1.83	
Aurangabad	2.04	1.98	2.12	2.07	1.42	2.03
Banka			1.41		1.29	1.85
Kaimur	2.46	2.52	2.66	2.26	1.63	2.16
Bhojpur	2.55	2.50	2.00	2.43	1.83	2.53
Champaran (East)	2.25	2.04	1.76	1.57	2.13	2.02
Champaran (West)	2.96	2.53	2.13	1.79	2.22	1.91
Darbhanga	1.65	1.11	1.50	1.32	1.72	1.88
Gaya	1.84	2.84	2.01	2.01	1.12	2.13
Gopalganj	2.47	3.29	1.87	2.34	1.37	2.50
Jahanabad	1.87	2.15	2.36	2.47	1.94	2.20
Kishanganj	1.59	1.57	1.64	0.82	1.33	1.29
Madhubani	1.54	1.32	1.31	0.79	0.81	1.60
Madhepura	2.35	1.91	1.63	1.04	1.84	1.45
Muzaffarpur	2.16	2.10	1.87	1.43	1.55	1.92
Nalanda	2.01	1.87	1.89	1.48	0.82	1.91
Nawadha	1.67	1.80	2.01	1.91	0.93	2.15
Rohtas	2.12	2.17	2.43	2.52	2.06	2.44
Saharsa	2.75	1.89	1.88	1.81	1.63	1.92
Samastipur	2.21	2.24	1.69	1.14	1.85	2.79
Sheohar	1.86	2.33	1.75	1.74	1.51	1.36
Sitamarhi	1.74	2.16	1.68	1.60	1.62	1.73
Siwan	2.06	2.22	1.96	2.14	2.09	2.08
Supaul	2.52	2.28	2.12	0.89	2.16	1.85
Jamui	1.11	1.36	1.15	1.30	1.15	1.50
Average For Non Bank Districts	**2.08**	**2.09**	**1.87**	**1.73**	**1.59**	**1.92**

Source: Bihar through Figures, 2007, Directorate of Economics and Statistics, Bihar, Patna

Table A.41. Area and Production of Vegetables in Bihar

Area in '000 ha/Production in '000 tonnes								
Crops	**2005-06**		**2006-07**		**2007-08**		**2008-09**	
Area	**Prodn.**	**Area**	**Prodn.**	**Area**	**Prodn.**	**Area**	**Prodn.**	**Area**
Potato	-	-	322.84 (39.17%)	5741.29 (42.19%)	315.46 (38.30%)	6019.65 (42.79%)	310.33 (37.53%)	5033.58 (37.60%)
Onion	49.80 (10.04%)	1011.70 (13.93%)	50.47 (6.12%)	962.71 (7.07%)	51.29 (6.23%)	1019.61 (7.25%)	51.61 (6.24%)	946.60 (7.07%)
Tomato	46.00 (9.27%)	727.20 (10.01%)	46.46 (5.64%)	916.77 (6.74%)	46.23 (5.61%)	921.87 (6.55%)	46.39 (5.61%)	1037.19 (7.75%)
Cauliflower	59.80 (12.5%)	938.50 (12.92%)	60.14 (7.30%)	1008.98 (7.41%)	60.66 (7.36%)	1023.89 (7.28%)	60.97 (7.37%)	1043.84 (7.80%)
Cabbage	36.60 (7.38%)	578.30 (7.96%)	37.00 (4.49%)	623.46 (4.58%)	37.45 (4.55%)	638.11 (4.54%)	38.33 (4.64%)	676.98 (5.06%)
Brinjal	53.70 (10.82%)	1031.00 (14.20%)	54.07 (6.56%)	1120.58 (8.23%)	54.55 (6.62%)	1158.16 (8.23%)	55.12 (6.67%)	1186.12 (8.86%)
Chilli	38.13 (7.69%)	442.35 (6.09%)	38.51 (4.67%)	459.73 (3.38%)	38.96 (4.73%)	439.42 (3.12%)	39.42 (4.77%)	450.61 (3.37%)
Bottlegourd	29.21 (5.89%)	566.73 (7.80%)	29.37 (3.56%)	542.46 (3.99%)	29.86 (3.63%)	574.29 (4.08%)	30.62 (3.70%)	625.22 (4.67%)
Spongegourd	33.68 (6.79%)	458.10 (6.31%)	33.88 (4.11%)	455.56 (3.35%)	34.34 (4.17%)	467.68 (3.32%)	36.07 (4.36%)	497.10 (3.71%)
Cucumber	1.25 (0.25%)	14.52 (0.20%)	1.47 (0.18%)	15.68 (0.12%)	1.60 (0.19%)	17.21 (0.12%)	1.72 (0.21%)	18.74 (0.14%)
Ridgegourd	8.10 (1.63%)	46.96 (0.65%)	8.27 (1.00%)	47.80 (0.35%)	8.42 (1.02%)	49.50 (0.35%)	8.49 (1.03%)	50.45 (0.38%)
Bittergourd	8.51 (5.89%)	49.35 (0.68%)	8.73 (1.06%)	59.38 (0.44%)	8.93 (1.08%)	61.82 (0.44%)	9.01 (1.09%)	63.44 (0.47%)
Ashgourd	0.30 (0.06%)	7.03 (0.10%)	0.31 (0.04%)	7.06 (0.05%)	0.34 (0.04%)	7.88 (0.06%)	0.37 (0.04%)	8.64 (0.06%)
Water melon	0.89 (0.18%)	19.12 (0.26%)	0.98 (0.12%)	19.93 (0.15%)	1.08 (0.13%)	21.97 (0.16%)	1.11 (0.13%)	23.54 (0.18%)
Muskmelon	0.63 (0.13%)	7.25 (0.10%)	0.71 (0.09%)	8.45 (0.06%)	0.80 (0.10%)	9.77 (0.07%)	0.85 (0.10%)	10.49 (0.08%)
Pointedgourd	4.64 (0.94%)	47.81 (0.66%)	4.86 (0.59%)	46.02 (0.34%)	5.63 (0.68%)	57.80 (0.41%)	5.76 (0.70%)	60.17 (0.45%)
Cowpea	11.64 (2.35%)	86.11 (1.19%)	12.17 (1.48%)	88.25 (0.65%)	12.40 (1.51%)	92.72 (0.66%)	12.72 (1.54%)	97.85 (0.73%)
Pea	8.10 (1.63%)	50.50 (0.70%)	8.74 (1.06%)	53.07 (0.39%)	8.97 (1.09%)	57.58 (0.41%)	9.09 (1.10%)	61.28 (0.46%)
Radish	14.43 (2.91%)	221.02 (3.04%)	14.93 (1.81%)	226.57 (1.66%)	15.15 (1.84%)	230.93 (1.64%)	15.54 (1.88%)	241.12 (1.80%)
Carraot	4.06 (0.82%)	45.32 (0.62%)	4.16 (0.50%)	46.33 (0.34%)	4.23 (0.51%)	48.03 (0.34%)	4.47 (0.54%)	52.21 (0.39%)
Sweet Potato	0.22 (0.04%)	4.24 (0.06%)	0.23 (0.03%)	4.44 (0.03%)	0.26 (0.03%)	5.24 (0.04%)	0.33 (0.04%)	6.62 (0.05%)
Colocasia	0.59 (0.12%)	6.15 (0.08%)	0.60 (0.07%)	6.44 (0.05%)	0.69 (0.08%)	7.56 (0.05%)	0.77 (0.09%)	8.60 (0.06%)
Yam (Oal)	0.33 (0.07%)	14.05 (0.19%)	0.35 (0.04%)	15.38 (0.11%)	0.41 (0.05%)	17.88 (0.13%)	0.47 (0.06%)	21.40 (0.16%)
Others	85.51 (17.24%)	888.70 (12.24%)	84.92 (10.30%)	1132.16 (8.32%)	85.99 (10.44%)	1119.18 (7.96%)	87.29 (10.56%)	1163.95 (8.70%)
Total	**496.11**	**7262.01**	**824.16**	**13608.50**	**823.70**	**14067.74**	**826.87**	**13385.75**

Source: Economic Survey 2010-11, Govt. of Bihar

Table A.42. Area and Production of Fruits in Bihar

Area in '000 ha/Production in '000 tonne								
Fruits	**2005-06**		**2006-07**		**2007-08**		**2008-09**	
Area	**Prodn.**	**Area**	**Prodn.**	**Area**	**Prodn.**	**Area**	**Prodn.**	**Area**
Mango	140.20 (50.72%)	1222.70 (39.85%)	140.80 (50.39%)	1306.90 (38.15%)	142.21 (49.68%)	870.35 (26.76%)	144.07 (49.56%)	1329.80 (35.72%)
Guava	27.70 (10.02%)	199.00 (6.49%)	28.00 (10.02%)	248.00 (7.24%)	28.67 (10.02%)	255.72 (7.86%)	29.09 (10.01%)	229.19 (6.16%)
Litchi	28.40 (10.27%)	200.10 (6.52%)	28.80 (10.31%)	211.90 (6.19%)	29.84 (10.42%)	223.23 (6.86%)	30.47 (10.48%)	216.92 (5.83%)
Lemon	16.80 (6.08%)	112.30 (3.66%)	17.10 (6.12%)	121.20 (3.54%)	17.58 (6.14%)	125.84 (3.87%)	17.74 (6.10%)	128.09 (3.44%)
Banana	28.00 (10.13%)	959.30 (31.26%)	29.00 (10.38%)	1125.10 (32.84%)	30.46 (10.64%)	1329.36 (40.87%)	31.27 (10.76%)	1373.55 (36.90%)
Pineapple	4.20 (1.52%)	108.00 (3.52%)	4.50 (1.61%)	121.10 (3.53%)	4.64 (1.62%)	126.77 (3.90%)	4.69 (1.61%)	119.48 (3.21%)
Papaya	1.00 (0.36%)	22.50 (0.73%)	1.10 (0.39%)	25.30 (0.74%)	1.27 (0.44%)	30.36 (0.93%)	1.43 (0.49%)	33.61 (0.90%)
Aonla	1.10 (0.40%)	8.60 (0.28%)	1.20 (0.43%)	10.70 (0.31%)	1.31 (0.46%)	12.09 (0.37%)	1.38 (0.47%)	12.83 (0.34%)
Others	28.90 (10.46%)	235.90 (7.69%)	29.00 (10.38%)	255.90 (7.47%)	30.26 (10.57%)	278.66 (8.57%)	30.56 (10.51%)	279.34 (7.50%)
Bihar	**276.40**	**3068.40**	**279.40**	**3426.00**	**286.24**	**3252.38**	**290.71**	**3722.82**

Source: Economic Survey 2010-11, Govt. of Bihar

Table A.43. Cropping Pattern in Bihar

	Percentage of Area								
Crops	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**
Foodgrains	94.47	94.34	94.42	94.28	94.37	94.35	94.29	94.47	94.52
Cereals*	90	90.15	90.15	90.27	89.91	91.31	91.01	91.56	91.55
Pulses*	10	9.85	9.85	9.73	10.09	8.69	8.91	8.44	8.45
Oilseeds	2.04	1.98	1.84	1.9	1.91	1.99	1.97	1.95	1.89
Fibre Crops	2.25	2.16	2.31	2.41	2.24	2.15	2.12	2.12	2.06
Sugarcane	1.24	1.52	1.44	1.4	1.47	1.51	1.61	1.47	1.53
Total Area	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

* Share (%) in total area under foodgrains

Source: Economic Survey 2010-11, Govt. of Bihar

Table A.44. Cost and Returns in Major Crops in Bihar (Rs./ha)

	Total Value of Production (VOP)	Cost of Cultivation (CC)	Net Income	Ratio of VOP to CC	yield qntl. per ha	Fertilizer Kg per ha	Human labor Hrs/ha	Animal Labour hrs/ha
				Paddy				
1990-91	5819.69	5501.61	318.08	1.06	20.95	49.3	893.3	177.54
1996-97	10313.51	9395.03	918.48	1.1	21.43	72.37	885.08	107.43
1997-98	10918.55	9827.74	1090.81	1.11	22.61	80.07	845.13	99.62
1998-99	12310.7	10461.54	1849.16	1.18	23.79	76.57	870.14	103.49
1999-00	12964.07	12251.94	712.13	1.06	23.52	76.56	888.25	76.25
2000-01	10846.29	12796.84	-1950.55	0.85	23.38	75.36	900.6	63.55
2001-02	11427.77	12304.27	-876.5	0.93	24.56	67.62	808.46	60.86
2002-03	11906.13	13292.84	-1386.71	0.9	22.91	82.06	873.85	56.16
2003-04	12293.84	13557.33	-1263.49	0.91	24.84	75.68	840.23	55.82
CAGR	**8.66**	**10.54**	**-216.56**		**1.91**	**4.88**	**-0.68**	**-12.06**
				Wheat				
2001-02	14804.97	14525.2	279.77	1.02	23.52	129.86	536.66	51.11
2002-03	15033.67	15310.28	-276.61	0.98	22.53	130.24	485.68	45.45
2003-04	15368.95	15460.31	-91.36	0.99	21.9	118.01	454.78	44.76
2004-05	16441.16	15456.25	984.91	1.06	22.7	116.74	404.06	36.83
2005-06	16982.02	15642.09	1339.93	1.09	18.78	121.16	399.93	29.98
2006-07	21306.57	16104.6	5201.97	1.32	20.5	122.31	384.73	32.3
CAGR	**6.26**	**1.74**	**62.77**		**-2.26**	**-0.99**	**-5.4**	**-7.36**
				Maize				
1996-97	11308.2	8790.11	2518.09	1.29	22.61	92.65	782.96	77.91
1997-98	10395.82	8711.07	1684.75	1.19	18.4	98.27	750.2	77.4
1998-99	11949.28	10187.71	1761.57	1.17	20.76	126.28	755.14	80.1
1999-00	10582.93	13031.85	-2448.92	0.81	22.22	142.39	785.64	37.5
2000-01	12864.58	14419.19	-1554.61	0.89	24.88	157.07	776.36	83.49
2001-02	10904.7	13850.29	-2945.59	0.79	21.7	120.98	823.15	60.17
2002-03	17099.66	13200.49	3899.17	1.3	31.91	106.31	758.24	38.45
2003-04	17029.71	15872.44	1157.27	1.07	34.94	115.45	799.2	39.11
CAGR	**5.25**	**7.67**	**-9.26**		**5.59**	**2.79**	**0.26**	**-8.25**
				Masur				
2001-02	11253.95	8809.59	2444.36	1.28	7.8	35.85	308.59	34.61
2002-03	15338.48	10374.5	4963.98	1.48	10.39	29.04	300.04	28.83
2003-04	17099.1	10512.76	6586.34	1.63	10.64	22.36	315.3	38.23
2004-05	15658.27	9931.47	5726.8	1.58	10.42	28.62	302.89	48.61
2005-06	16502.42	11218.16	5284.26	1.47	8.98	38.33	321.13	34.56
2006-07	19757.99	11432.6	8325.39	1.73	9.39	25.78	297.22	36.7
CAGR	**9.83**	**4.44**	**22.66**		**3.14**	**-5.35**	**-0.62**	**0.98**
				Gram				
2001-02	14409.95	9216.35	5193.6	1.56	8.59	32.69	244.94	19.38
2002-03	17367.25	11494.93	5872.32	1.51	10.14	13.54	279.81	7.67
2003-04	16367.01	10430.55	5936.46	1.57	9.21	18.73	267.53	9.5
2004-05	14765.54	9974.3	4791.24	1.48	8.71	44.31	213.74	12.99
2005-06	19387.53	11860.32	7527.21	1.63	8.75	47.48	286.42	7.01

	Total Value of Production (VOP)	Cost of Cultivation (CC)	Net Income	Ratio of VOP to CC	yield qntl. per ha	Fertilizer Kg per ha	Human labor Hrs/ha	Animal Labour hrs/ha
2006-07	21747.37	12552.23	9195.14	1.73	7.75	58.27	273.24	6.87
CAGR	**7.1**	**5.28**	**9.99**		**-1.7**	**10.11**	**1.84**	**-15.87**
				Potato				
2005-06	59922.77	39765.17	20157.6	1.51	183.92	215.99	1198.3	58.67
2006-07	70796.29	45305.61	25490.68	1.56	180.14	210.68	1111.84	84.8
				Sugarcane				
1990-91	18229.41	9026.91	9202.5	2.02	436.3	35.57	652.8	1.55
1991-92	19503.52	8299.04	11204.48	2.35	425.05	38.54	569.39	6.07
				Jute				
1997-98	9208.16	6995.69	2212.47	1.32	16.87	50.92	560.61	37.13
1998-99	9233.98	7145.05	2088.93	1.29	16.69	49.35	481.95	37.07

Source: Based on data from www.indiastat.com

Trends in Agriculture and Agricultural Practices in Lower Ganga Basin

Part IV: West Bengal

GRBMP: Ganga River Basin 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 Frame Work 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 dialog 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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Contents

1. Introduction

In West Bengal, agriculture continues to play a predominant role both in terms of its contribution to the state's GDP as well as its share in total employment. Amongst the 16 major states, West Bengal ranks 10th according to the share of agriculture in the state's GDP. Although the state is said to have witnessed a structural transformation in recent years, as many as 45.6 percent of the total employed are absorbed in agriculture, thus positing the significance of agriculture in the State as a major source of livelihood (NSSO, 2006). West Bengal has a predominantly rural economy, where about 72 percent of the people live in rural areas (Table A2). The most disturbing feature of the State pertains to its high density of population, which stands at 903 per km2 against an all India average of 325 (Table A1). With increasing demand for food in the State, attainment of higher agricultural growth remains an unaccomplished target.

While there is no denying the fact that agricultural growth must rise to feed the increasing population, the former brings in numerous challenges towards environmental sustainability including the sustainability of river water. River Ganga, which flows through the State, is said to have been the life line of the State. It supports varieties of gainful economic activities in the basin area including agriculture. As many as 10 districts (8 erstwhile undivided) out of 19 (15 erstwhile undivided) are located on the banks of Ganga river. Needless to say, river and agriculture are mutually interdependent in many different ways. While any unsustainable agricultural practices may create serious harm to river water, both in quantity and quality, lack of flow of water in the river may lead to water shortage in agriculture. It is thus pertinent to carry out agricultural practices that would be sustainable through time.

This report thus attempts to present the trends in agriculture and agricultural practices in West Bengal and its possible implications on the Ganga river basin. Accordingly, the objectives of the study are as follows. First, the study intends to examine the agricultural land use and land holding patterns in the state. Second, the trend of growth of agricultural output according to major crops is analyzed. Third, it tries to find out the sources of inputs used in agriculture with special reference to water and fertilizers. On the basis of the above studies, implications for Ganga river basin are assessed. Before the state of agriculture is presented, a brief profile of West Bengal is presented as follows.

2. Brief Profile

West Bengal, one of the major states in the eastern part of the country, has predominantly an agrarian economy. It is endowed with rich natural resources and climatic conditions favourable for agriculture. These include large areas of good alluvial soil, abundant surface water and groundwater resources, and good rainfall. The climate of the region (other than in the hill regions) is tropical, hot and humid. Annual rainfall is between 1,300 mm and 1,750 mm. Despite these favourable conditions, the State has witnessed wide fluctuations in the growth of agricultural production (Rawal and Swaminathan, 1998). In line with the changing trend across the country, West Bengal has experienced a structural shift in output front as the share of agriculture in the State's GDP is recorded to have come down from about 33 percent in 1999-00 to about 25 percent in 2007-08 (Table A3).

The river Ganga is considered the life line of West Bengal. It is a perennial source of water to the plains of West Bengal for irrigation as well as human and industry consumptions. The river is navigable and it acts as a major transport system in the State with heavy traffic flow. The entire State of West Bengal, except four districts namely Darjeeling, Cooch Behar, Jalpaiguri and Purulia fall under the lower Gangetic Plains region. The Ganges and its numerous distributaries have resulted in highly fertile soils in this region. Accordingly, agriculture has become the key to the economy of the State. A large section of the population derives their livelihood from agriculture. This region also covers many major tributaries of the Ganga.

The agro-climatic zone in West Bengal can be divided into four sub-zones, viz., Barind Plains, Central Alluvial Plains, Alluvial Coastal Saline Plains, and Rarh Plains. The zone of barind plains, that covers two districts namely West Dinajpur and Malda, has a relatively high rainfall. It has high Net Sown Area (NSA) but the irrigation facilities are not developed. The Central Alluvial Plains, on the other hand, is the largest sub-zone in the lower Gangetic plains covering around 3.5 million hectares i.e. about 40 percent of the total land. It covers the districts of Murshidabad, Nadia, Burdwan, Hooghly, Howrah and Medinipur. About 68 percent of the land of this zone is cultivated and over 60 percent of the cultivated land is irrigated resulting in a reasonably high cropping intensity. The alluvial coastal saline plains cover the districts of North and South 24-Parganas along with the metropolitan city of Calcutta. Only about 26 percent of the NSA of this is irrigated. The rarh plains that include Birbhum and Bankura districts are mostly rural and poorly developed. About two-thirds of the land in this zone is cultivated with 23 percent falling under forest cover. Poor irrigation facilities in this zone have resulted in a very low cropping intensity. Given this variations in agro-climatic zone in the lower Ganga Region that constitutes a large part of the State of West Bengal, what follows next is an attempt to examine state of agriculture in the State and its constituent districts.

3. Land Use and Patterns of Land Holding

The total geographical area of West Bengal is 8875.2 thousand hectares of which NSA constitutes approximately 5332 thousand hectares in 2007-08. As against this, GCA is recorded to be 9799 thousand hectares, indicating thereby that the State witnesses very high cropping intensity (Table 1). In West Bengal, the cropping intensity stands at 184 percent (Table 16). With increasing demand for food and other agricultural demands of the State's rising population, high cropping intensity appears to have been the only viable option. It indicates that over the years, NSA has come down, while GCA has recorded an increase (Figure 1). This indicates that with the passage of time, greater portions of the land have been brought under multiple cropping in the State.

It is further important to note that the districts falling in close proximity to the river Ganga have by and large experienced higher cropping intensity as compared to their counterparts. While this may be considered as a welcome phenomenon from the point of view of attaining food security in the State, it may lead to serious environmental consequences. Rise in cropping intensity without proper crop diversification may lead to unsustainable use of agricultural land indicating greater demand for fertilizers, pesticides and insecticides, water, etc (Table 16).

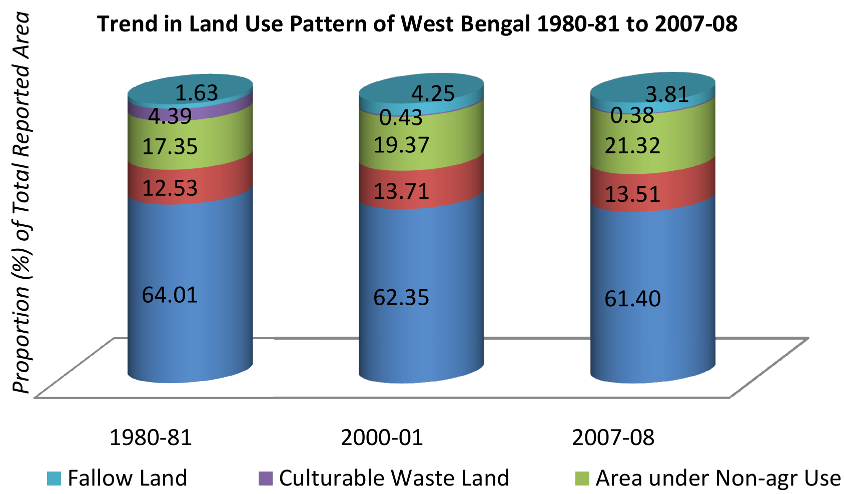


Figure 2: Trends in Land Use Pattern of West Bengal

A comparison of the land use pattern across districts according to the proximity from the Ganga River reveals some interesting aspects. Some such aspects are presented below. For paucity of data for the earlier years, the data for the currently divided districts are presented against the undivided ones.

- NSA as a percentage of the total reported area is, on an average, found to be little higher in the river bank districts (62 percent) as compared to their counterparts (60 percent). However, for the entire State, the share of NSA of the total area reported is about 61.4 percent (Table 1).
- As compared to the NSA, GCA is quite large in districts closer to the river than their counterparts. Consequently, average cropping intensity of river bank districts stands at 194 percent, while that for the other districts stands at 168.47 percent (Table 16).
- It is noteworthy to mention that four categories of land use, namely, fallow other than current fallows, culturable waste land, permanent pasture and other grazing land, and barren and unculturable land are significantly low in the river basin districts in the State of West Bengal. Much of the barren and uncultivable land, culturable waste land and

fallows other than current fallow, whatsoever in existence, is concentrated in six districts, Birbhum, Bankura, Darjeeling, Paschim Medinipur, Purulia and Burdwan. The areas under forests are also limited in the State and are concentrated in a few regions namely Bankura, West Medinipur, Purulia, South 24 Parganas, Darjiling and Jalpaiguri. Of the total forested area of 11.73 lakh hectares, undivided 24 Parganas alone has a share of 4.26 lakh hectares. It is in this part of the State where the Sundarban delta is located.

It is further found that in West Bengal, the average size of operational holdings have declined significantly over the years. In 1980-81, the State had recorded average land holding size of 0.94 hectare, which has come down to 0.79 hectares in 2005-06. By and large, similar trend is noticed across the districts of West Bengal. Comparing across districts for the latter period, the average holding is the least in Howrah (0.45 hectare) followed by Midnapore-E (0.53 hectare), South 24 Parganas (0.59 hectare), Hoogly (0.63 hectare) and North 24 Parganas (0.66 hectare). Interestingly, all these districts fall in the close proximity of the Ganga River (Table 2).

A further analysis according to the size of holdings indicates that as many as 92.06 percent of the farming households in West Bengal are marginal farmers having land holding size less than 1 hectare. As against this, only about 5.7 percent of the households are small farmers having land holding size between 1-2 hectares, 1.4 percent are semi-medium farmers with 2 to 4 hectares of land holdings and meager 0.2 percent are medium farmers having land holding size between 4-10 hectares (Table 3). The skewed distribution of agricultural land holdings in the State is further evident from the estimates of the areas under different sizes of holdings. While as much as 58.23 percent of the operational areas are under marginal land holdings, only 25.71 percent are under small holdings and meager 1.88 percent and 4.02 percent are under semi-medium and medium land holdings respectively.

It is important to note that land reforms measures like *Operation Barga*, which was introduced in West Bengal leading to the distribution of surplus land and Panchayati Raj which diversified the rural activities (Chandrasekhar, 1993) is said to have brought about a significant change in the land distribution and land holding patterns in West Bengal. Interestingly, the number of operational land holdings has increased significantly (18.95 percent) over the period 1980/81 to 2005/06, whereas the area of operational land holdings has declined (-0.52 percent) irrespective of classes (Table 4). According to the size of the land holdings, there is phenomenal increase of the marginal land owners both in terms of number (38.54 percent) and area (72.82 percent) of holdings over the above said period. There is a decline in all size-classes of land holdings except marginal holdings. However, the percentage change is more for semi-medium and medium size-classes.

Table 1: Land use Pattern of West Bengal across the River and Non-River Bank Districts (Area in '000 ha)

Particulars	Total Reported Area			Net Sown Area			Gross Cropped Area			Forest Area			Area under Non-agr use			Culturable Waste land			Fallow land		
	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008
River Basin Districts																					
24-Parganas*	1460	1346	1335	693.4	638.2	631.5	880.3	1052	1052	426.3	426.3	426.3	329.0	244.1	267.0	8.0	1.6	0.2	3.5	33.7	10.2
Burdwan	700.6	698.5	698.8	471.1	477.5	452.0	683.7	788.7	832.2	31.0	28.8	21.2	131.2	170.7	208.6	51.9	7.5	7.6	15.4	15.1	9.4
Hoogly	314.5	312.2	313.4	234.4	230.5	219.9	371.5	396.4	540.6	0.3	0.7	0.5	70.5	77.2	91.2	7.5	2.6	1.3	1.8	1.3	0.4
Howrah	145.1	136.0	138.7	96.7	87.0	80.7	129.2	165.3	162.9	N.A	N.A	N.A	43.3	44.2	53.4	3.4	0.3	0.2	1.6	5.6	4.3
Malda	360.5	371.1	370.9	283.9	222.2	210.3	396.2	459.6	391.1	1.4	1.7	1.7	67.1	87.9	92.8	7.1	0.1	0.1	1.1	58.5	66.0
Midnapore**	1360.6	1323.9	1325.2	862.0	874.3	887.7	1074.9	1438.6	1508.6	172.1	170.8	172.8	238.1	253.3	269.8	55.5	4.1	6.2	32.0	21.3	25.8
Murshidabad	536.7	532.5	532.5	426.8	393.0	398.8	677.2	754.9	976.3	0.8	0.8	0.8	94.2	147.3	131.8	7.9	0.7	0.8	4.2	2.7	0.3
Nadia	390.9	390.7	390.7	320.3	298.5	289.2	535.3	721.6	697.7	1.3	1.2	1.2	63.9	80.8	93.3	2.6	1.0	0.8	2.8	8.6	6.1
Total	5269	5111	5105	3389	3221	3170	4748	5778	6161	633.0	630.2	624.5	1037	1106	1208	144	17.9	17.2	62.5	147	122
Non-River Basin Districts																					
Bankura	685.6	688.1	688.0	379.5	344.1	345.4	447.0	499.2	565.8	139.6	148.4	148.9	83.4	124.5	153.1	63.9	6.7	2.1	19.3	64.5	38.5
Birbhum	451.4	451.1	451.1	341.9	337.5	318.5	450.0	458.7	560.8	15.7	16.0	15.9	50.8	85.1	98.1	31.9	3.4	3.9	6.8	9.1	14.7
Cooch Behar	341.4	331.4	331.6	264.4	264.9	248.1	417.8	508.4	547.1	5.7	3.8	4.3	58.9	56.9	76.7	11.8	0.8	1.0	0.5	5.8	1.5
Darjeeling	83.9	325.5	325.5	45.8	136.9	140.7	141.6	186.3	195.8	22.6	124.6	124.6	10.5	50.1	42.4	4.0	1.7	1.8	1.2	12.8	16.0
Dinajpur***	534.0	534.4	534.4	468.4	463.9	461.5	709.2	800.2	819.0	1.3	1.5	1.5	53.5	63.4	68.6	8.4	0.2	0.1	2.4	6.1	2.8
Jalpaiguri	616.1	622.7	622.7	317.7	336.5	334.6	435.7	560.7	564.4	172.6	179.0	179.0	89.9	100.2	94.1	32.5	0.2	0.1	3.5	3.5	14.9
Purulia	623.4	623.3	625.6	301.9	311.7	312.9	312.0	325.4	385.2	87.6	87.6	75.1	108.5	97.0	110.2	81.7	6.4	7.3	43.7	120.6	120.2
Total	**3336**	**3576**	**3570**	**2119**	**2196**	**2162**	**2913**	**3339**	**3638**	**445.0**	**560.8**	**549.2**	**455.4**	**577.2**	**643.2**	**234**	**19.3**	**16.2**	**77.4**	**222.3**	**209**
West Bengal Total	**8605**	**8688**	**8684**	**5508**	**5417**	**5332**	**7662**	**9117**	**9799**	**107**	**1191**	**1174**	**1493**	**1683**	**1851**	**378**	**37.1**	**33.4**	**140**	**369.0**	**331.0**

Source: Directorate of Agriculture (Evaluation), Government of West Bengal. Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinajpur; NA: Data Not Available

Table 2: Average Area of Holdings (in Hectares)

District	1980-81	1990-91	2000-01	2005-06
Burdwan	1.24	1.15	1.04	1.00
Birbhum	1.23	1.12	1.05	1.01
Bankura	1.13	1.12	1.05	1.00
Midnapore (E)	0.61	0.57	0.53	0.53
Midnapore (W)	1.03	1.02	0.75	0.73
Howrah	0.47	0.43	0.43	0.45
Hooghly	0.75	0.71	0.65	0.63
24 Parganas (N)	0.75	0.69	0.66	0.66
24 Parganas (S)	0.66	0.71	0.60	0.59
Nadia	0.97	0.96	0.87	0.84
Murshidabad	0.90	0.75	0.74	0.74
Dinajpur (U & D)	1.07	1.08	0.95	1.8
Malda	0.89	0.87	0.82	0.79
Jalpaiguri	1.67	1.62	1.24	1.20
Darjeeling	2.35	2.08	1.65	1.47
Cooch Behar	1.01	0.97	0.88	0.85
Purulia	1.18	1.05	0.86	0.82
West Bengal	0.94	0.90	0.82	0.79

Source: Agricultural Census, Directorate of Agriculture, Govt. of West Bengal.

Table 3: Percentage Distributions of Operational Holdings, Ownership of Households, Area Owned over Five Broad Classes of Holding in India and West Bengal in 2006

Particulars	Marginal (Below 1.0 ha)	Small (1.0-2 ha)	Semi medium (2.0 - 4 ha)	Medium (4.0 - 10.0 ha)	Large (Above 10 ha)
All India					
Operational Holdings (%)	69.8	16.2	2.0	4.2	0.8
Ownership of Holdings (%)	79.6	10.8	6.00	3.00	0.60
Area owned (%)	23.05	20.38	21.98	23.08	0
West Bengal					
Operational Holdings (%)	88.8	8.9	2.10	0.20	0.00
Ownership of Households (%)	92.06	5.70	1.40	0.2	0.00
Area owned (%)	58.23	25.71	1.88	4.02	0.00

Source: Bureau of Applied Economics & Statistics, Government of West Bengal, 2007

Table 4: Estimated Number and Areas of Operational Holdings according to Size Class in West Bengal

Size	Class	1980-81	2000-01	2005-06	Percentage Change over the Periods 1980/81-2000/01	2000/01-2005/06	1980/81-2005/06
Marginal (Below 1.0 ha)	No. of Holdings	4096001	5462089	5674788	33.35	3.89	38.54
	Area of Holdings (Ha)	1619657	2758843	2799071	70.34	1.46	72.82
Small (1.0 - 2 ha)	No. of Holdings	1148936	1009328	1005594	-12.15	-0.37	-12.48
	Area of Holdings (Ha)	1733512	1606686	1595340	-7.32	-0.71	-7.97
Semi-medium (2.0-4 ha)	No. of Holdings	519445	282992	282767	-45.52	-0.08	-45.56
	Area of Holdings (Ha)	1403246	783773	772428	-44.15	-1.45	-44.95
Medium (4.0- 10.ha)	No. of Holdings	111859	34797	27862	-68.89	-19.93	-75.09
	Area of Holdings (Ha)	594883	178298	137672	-70.03	-22.79	-76.86
Large (10.0 ha or above)	No. of Holdings	1408	785	652	-44.25	-16.94	-53.69
	Area of Holdings (Ha)	203484	218976	221303	7.61	1.06	8.76
All Size	No. of Holdings	5877649	6789991	6991663	15.52	2.97	18.95
	Area of Holdings (Ha)	5554782	5546576	5525814	-0.15	-0.37	-0.52
Average Size of Holdings		0.94	0.82	0.79	-12.77	-3.66	-15.96

Source: Agricultural Census, Directorate of Agriculture, Government of West Bengal

Table 5: Distribution of Number and Area of Operational Holdings according to Size Class in West Bengal across River and Non-River Basin Districts

		River Bank Districts	Non-River Bank Districts	West Bengal	River Bank Districts	Non-River Bank Districts	West Bengal
		Area of Holdings (in hectors)			No. of Holdings (in numbers)		
Large (more than 10 hec.)	1980-81	8551	194933	203484	520	888	1408
	2000-01	3287	215689	218976	174	611	785
	2005-06	2596	218707	221303	142	510	652
Medium (4-10 hec.)	1980-81	246159	348724	594883	46487	65372	111859
	2000-01	81675	96623	178298	326854	456919	783773
	2005-06	59392	78280	137672	11883	15979	27862
Semi Mdium (2-4 hec)	1980-81	632154	771092	1403246	234219	285226	519445
	2000-01	326854	456919	783773	118063	164929	282992
	2005-06	309516	462912	772428	112845	169922	282767
Small (1-2 hec.)	1980-81	844939	888573	1733512	556181	592755	1148936
	2000-01	780917	825769	1606686	496414	512914	1009328
	2005-06	765656	829684	1595340	477751	527843	1005594
Marginal (Below 1.0)	1980-81	857750	761907	1619657	2250235	1845766	4096001
	2000-01	1343344	1415499	2758843	2781458	2680631	5462089
	2005-06	1389134	1409937	2799071	2879521	2795267	5674788

Source: Bureau of Applied Economics & Statistics, Government of West Bengal, 2007

4. Growth of Agriculture in West Bengal

The growth of agricultural production in West Bengal in the 1980s and early 1990s was very impressive particularly when that is compared with the earlier decades[1]. This high rate of growth of production was combined with a reasonably high rate growth in productivity[2], especially during 1984-85 to 1995-96 that enabled the State to maintain a growth rate higher than the national average in the subsequent years. But, what is more important perhaps is that the State experienced a lower rate of growth of the sector in terms of its NSDP during 1994-95 to 2004-05 (Chand, *et al*., 2007). This slowdown, as Chand *et al*. (2007) suggested, was largely due to stagnation in NSA, decline in power supply to the sector, lower rate of growth in fertilizer and slowdown in expansion of area under irrigation.

Bhattacharya and Bhattacharya (2007) attempted to examine growth of some important parameters of agriculture sector viz. area, production, yield, input use, credit and land reforms in a long-term perspective of 23 years from 1980-81 to 2002-03 by considering 1992-93 as the year of trend break[3]. Such a trend break is expected to capture the impact of the liberal policies such as reduction in subsidies in fertilizers, credit, etc. on the agriculture sector of the State during 1992-93 to 2002-03. Referring to their findings, it is observed that rate of growth of area under agriculture, production of the sector and its yield in the State as a whole was lower during 1992-2003 as compared to that during 1980-1992. The same can be said in case of input use viz. fertilizer, HYV seeds, etc. in the sector. This coupled with slowdown in the pace of land reforms as well as inadequate supply of institutional credit to the sector has resulted in lower rate of increase in cropping intensity in the State (Table 6).

Table 6 Growth of Agriculture in West Bengal, 1980-81 to 2002-03

Variables	Simple Exponential Growth Rates			Kinked Exponential Growth Rates	
	1980-81 to 1991-92	1992-93 to 2002-03	1980-81 to 2002-03	1980-81 to 1991-92	1992-93 to 2002-03
Area	0.80	0.29	0.52	0.75	0.22
Production	5.64	2.33	3.61	5.05	1.73
Yield	5.08	1.98	3.18	4.52	1.43
Fertilizer	10.9	5.63	6.93	9.23	4.01
HYV Area	5.36	2.84	4.52	5.61	3.09
Cropping Intensity	1.83	1.29	1.20	1.43	0.89
Credit	15.9	9.24	11.10	14.00	7.28
Land Reform	0.96	0.90	0.80	0.83	0.77

Sources: Bhattacharyya and Bhattacharyya (2007).

[1]The rate of growth of agricultural production between 1949 and 1980 was only 1.74 per cent per annum (Boyce, 1987). This growth rate of agriculture production was even less than the rates of growth of the rural population as well as total population of the state forcing a significant portion of the rural population living in abject poverty (Chattopadhyay, 2005).

[2] Per hectare production in West Bengal was the second highest in the country during the mid-1980s after Kerala (Chand *et al*., 2007).

[3] It is assumed that, although process of economic reforms was initiated in July 1991, its effects were realised in 1992-93.

However, the growth experience of the agriculture in West Bengal varies across crops (Table 7). It is observed that area under aus rice has declined over the years and the rate of decline is quite substantial during 1992-2005. This has resulted in decline in total area under rice during 1970-81 as well as during 1992-2005. Although the total area under rice increased during 1981-92, this was largely on account of substantial increase in area under boro rice. Interestingly, area under wheat has increased in recent years resulting in increase in area under foodgrains in general and cereals in particular, though the rate of increase is marginal. On the other hand, the rate of growth of area under oilseeds and potato was positive, but it declined over time.

Table7: Rate of Growth of Area under Major Crops in West Bengal, 1970-71 to 2004-05

Crop	Growth Rate (%)		
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2004-05
Aus rice	-2.63	-1.57	-4.25
Aman rice	0.07	0.51	-0.58
Boro rice	3.18	9.65	3.46
Total rice	-0.20	1.23	-0.16
Wheat	-2.07	-1.42	3.66
Total cereals	-0.31	0.97	0.31
Total pulses	-3.11	-6.04	-0.63
Total foodgrains	-0.51	0.57	0.27
Jute	2.84	-0.36	2.75
Mustard	3.73	9.81	-0.33
Total oilseeds	6.85	5.19	0.32
Potato	5.74	5.02	3.36

Source: Ghosh (2010)

The growth experience differs across crops in terms of production as well (Table 8). Production of most of the crops fluctuated over the years. But, while the rate of growth of potato and oilseeds produce continued to decline, that of boro rice increased during 1981-82 to 1991-92 and declined thereafter. Interestingly, production of aus rice and total pulses continued to decline. Further, although production of aman rice and mustard grew at a higher rate during 1981-82 to 1991-92, the rate of growth of production of these crops was negative during 1992-93 to 2004-05 indicating a decline in their total production.

As regards yield, it is observed that except mustard and potato, the rate of growth of yield of all the major crops increased in the 1980s and declined thereafter (Table 9). For most of the crops, the decline in the rate of growth of yield in the post-reforms era was quite high. For the crops like aus rice and jute, the increase in the rate of growth of yield in the 1980s was quite sharp. It should, however, be noted that although the area under boro rice and its production increased significantly in the 1980s, the growth of yield was marginal. The rate of growth of yield of mustard and potato, on the other hand, continued to decline over the years. The decline in the rate of growth of yield in the post-reforms era is likely to have implications on growth and sustainability of agriculture sector in West Bengal.

Table 8: Rate of Growth of Production of Major Crops in West Bengal

Crop	Growth Rate (%)		
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2004-05
Aus rice	-4.37	4.47	-2.38
Aman rice	0.52	4.45	1.09
Boro rice	2.53	11.07	3.55
Total rice	0.51	5.31	1.77
Wheat	-3.18	-0.43	4.44
Total cereals	-3.23	7.18	2.15
Total pulses	-3.16	-4.31	0.35
Total foodgrains	0.35	4.52	1.94
Jute	-1.74	6.77	3.94
Mustard	9.76	12.18	0.86
Total oilseeds	10.72	9.79	0.21
Potato	8.84	7.37	3.35

Source: Ghosh (2010)

Table 9: Rate of Growth of Yield of Major Crops in West Bengal, 1970-71 to 2004-05

Crop	Growth Rate (%)		
	1970-71 to 1980-81	1981-82 to 1991-92	1992-93 to 2004-05
Aus rice	1.74	6.05	1.89
Aman rice	0.45	3.94	0.43
Boro rice	-0.65	1.42	0.08
Total rice	0.72	4.07	1.61
Wheat	-1.11	0.98	0.77
Total cereals	-2.92	6.21	1.84
Total pulses	-0.05	1.80	1.07
Total foodgrains	0.86	3.93	1.66
Jute	-4.58	7.23	1.03
Mustard	6.03	2.37	1.19
Total oilseeds	3.87	4.60	-0.11
Potato	3.10	2.35	-0.01

Source: Ghosh (2010)

It is, in this context, important to cite the findings of Ghosh (2010), who attempts to examine whether there has been acceleration or deceleration in the production of the major crops by fitting quadratic trend equation for each of the sub-periods. It is observed that the rate of growth of production of all the major crops except jute, mustard and potato decelerated in the 1970s (Table 10). Interestingly, although all types of rice show deceleration in growth of production in the 1970s, total production of rice shows acceleration. On the other hand, while production of majority of the crops accelerated in the 1980s, that of some important cash crops like pulses, mustard, and potato decelerated during this period. What is more important perhaps is that although the annual average rate of growth of production of boro rice was higher in the 1980s as compared to that in the 1970s, the deceleration continued. This means that production of boro rice increased at a declining rate during the period under consideration. However, production of all the crops, except jute and wheat continued accelerating in the post-reforms era. Besides, although production of mustard and pulses decelerated in the 1980s, the post-reform era experienced acceleration in their production.

Table 10: Acceleration/Deceleration of production of Major Crops in West Bengal

Crop	1970-71 to 1979-80	1980-81 to 1991-92	1992-93 to 2004-05
Aman Rice	Deceleration	Acceleration	Acceleration
Boro Rice	Deceleration	Deceleration	Deceleration
Aus Rice	Deceleration	Acceleration	Acceleration
Total Rice	Acceleration	Acceleration	Acceleration
Wheat	Deceleration	Acceleration	Deceleration
Total Cereals	Deceleration	Acceleration	Acceleration
Total Pulses	Deceleration	Deceleration	Acceleration
Total Foodgrain	Deceleration	Acceleration	Acceleration
Jute	Acceleration	Acceleration	Deceleration
Mustard	Acceleration	Deceleration	Acceleration
Potato	Acceleration	Deceleration	Deceleration

Source: Source: Ghosh (2010)

4.1. Growth of Agriculture across Districts of West Bengal

Tables 11, 12 and 13 present growth rates of area under major crops, their production and yield across the districts of West Bengal as computed by Sanyal *et al*. (1998). The growth rates are computed by fitting the exponential function $Y_t = e^{\beta_0 + \beta_1 t}$. It is observed that in most of the districts, the area under boro rice has increased at a significantly high rate during 1977-78 to 1993-94 (Table 11). The districts like Birbhum, Bankura and Howrah recorded a reasonable high rate of growth of area under aus rice, whereas it declined in many of the districts like Nadia, Murshidabad, West Dinajpur, Malda, Jalpaiguri and Coochbehar during this period and the decline was quite sharp in Malda and West Dinajpur. In most of the districts, area under the traditional crop of the State i.e. aman rice increased only marginally. More importantly, while majority of the districts recorded a very high rate of growth of area under rapeseed, possibly due to its low base, that under pulses and wheat declined significantly. This has largely undermined the rate of growth of area under non-food grains. Although the area under non-food grains increased at reasonably high rate in the districts like Burdwan, Hooghly, Birbhum, Midnapur, Bankura, Purulia, this was largely on account of sharp increase in area under potato or jute.

However, despite decline or marginal increase in area, production of rice in general and boro rice in particular has increased at a significantly high rate in most of the districts during 1977-78 to 1993-94 (Table 12). Further, like area, in majority of the districts, production of rapeseed also recorded a very high rate of growth, possibly due to its low base, whereas that of pulses and wheat declined quite sharply affecting the rate of growth of production of non-foodgrains. However, many of the districts like Burdwan, Hooghly, Malda, Midnapur, Nadia, Bankura, Birbhum and Purulia recorded reasonably high rate of growth of production largely due to increase in production of potato at a high rate therein.

Table 11: Rate of Growth of Area of Crops by Districts, 1977-78 to 1993-94

District	Growth Rate (%)											
	Rice				Wheat	Pulses	Food grains	Jute	Rapeseed	Potato	Non-Food Grains	All Crops
	Aus	Aman	Boro	Total								
River Bank Districts												
Burdwan	1.9	0.2	6.2	1.2	-14.4	-16.9	0.3	3	12	2.5	3.4	1
Hooghly	1.3	0.5	2.7	1	-18	-20	0.4	-1.6	11.1	5.3	3.5	1.2
Howrah	3.4	0.1	12.5	2.8	-21.6	-12.8	1.8	-5.3	21.3	0.2	-0.2	1.6
Malda	-4.3	1.1	7.2	1	3.1	-0.4	0.5	-1.8	7.8	2	0.8	0.6
Midnapore*	1.7	-0.2	9.3	1	6.3	-6.9	0.6	0	17.5	8.6	6.8	1.2
Murshidabad	-1.9	2	8.9	1.7	-2.6	-7.4	-0.3	1.8	10.7	-0.7	2.2	0.3
Nadia	-1.8	1.4	10.3	2.3	0	-2.9	0.9	1	11.2	-0.6	2.2	1.3
24-Parganas*	0.5	-0.5	8.8	0.9	-3	-4.9	0.5	-3.8	11.7	0.2	1.4	0.7
Average	0.1	0.6	8.2	1.5	-6.3	-9	0.6	-0.8	12.9	2.2	2.5	1
Non-River Bank Districts												
Bankura	2.3	0.3	16.6	1.1	-6.7	-7.9	0.8	6.6	12.8	7.6	3.9	1.1
Birbhum	4.8	-0.3	6.2	0.3	-8.6	-9.1	-0.8	5.6	15.2	1.4	5.2	1.2
Coochbehar	-1.3	1.6		0.9	-3.6	0.4	0.5		-1.7	7.1	1.1	0.6
Jalpaiguri	-1.6	0.5		0	-1.8	-8.7	-0.4		1.1	6.6	0.7	-0.1
Purulia	3.8	1.3		1.3	-6.6	1.7	0.9		2.7	4.2	4.2	1.5
West Dinajpur *	-9.2	1.3	17.8	0.5	-3.2	-5.5	-0.3	-2.8	6.8	-0.6	-1	-0.4
Average	-0.2	0.8	13.5	0.7	-5.1	-4.9	0.1	3.1	6.2	4.4	2.4	0.7
West Bengal	-1.6	0.4	8.4	1	-2.5	-5	0.4	0	10.1	4.5	3.3	0.5

Table 12: Rate of Growth of Production of Major Crops by Districts

District	Growth Rate (%)											
	Rice				Wheat	Pulses	Food grains	Jute	Rapeseed	Potato	Non-Food Grains	All Crops
	Aus	Aman	Boro	Total								
River Bank Districts												
Burdwan	5	3.2	7.5	4.4	-15.2	-15.4	3.8	0.3	13.1	4.3	4.2	3.9
Hooghly	4	4.2	3.1	3.9	-16.2	-20.5	3.3	1.1	15.5	6.7	6.2	4.5
Howrah	8.4	4.3	13	6.8	-23.1	11.8	6	-3	17.8	3.4	2.4	5.4
Malda	-1.7	3.5	9.9	4.9	4.2	2.4	4	1	9.9	3.9	4.5	4.1
Midnapore*	6.7	3.6	9.7	5.1	-6.3	-2.3	4.8	0.3	24.7	11.8	10.5	5.9
Murshidabad	0.7	5.1	10.1	5.3	0	-6.3	3.1	5.8	12.5	2.4	4.3	3.8
Nadia	3	6.7	11.3	7.5	-0.1	-1.7	5.5	5.1	16.2	1	5.1	5.7
24-Parganas*	5.4	2.9	10.2	4.3	-1.8	-4.4	3.9	-1.1	18.6	1.9	2.9	3.8
Average	3.3	3.8	9.2	4.9	-7.5	-4.6	3.9	0.9	15.2	4.2	4.8	4.3
Non-River Bank Districts												
Bankura	8.1	3.9	19.7	5.2	-2.7	-5.9	4.8	-4.9	14.4	11.2	9.8	5.7
Birbhum	8.9	2.6	7.2	3.2	-7.3	-6.2	2.3	0.4	17.6	6.7	6.7	2.9
Coochbehar	4.5	3.5		4.2	-4.8	1.5	2.9		4.3	12	2.8	3
Jalpaiguri	2.4	2		2.2	-2.6	-6.8	1.5		6	11.5	1.5	1.5
Purulia	9.8	4.1		4.3	-7.8	3.9	4.2		8.7	7.2	5.2	4.2
West Dinajpur *	-3.5	4.2	20.9	4.9	-1.7	-4.2	3.8	1.4	13.3	1.1	1.5	3.6
Average	5	3.4	15.9	4	-4.5	-3	3.3	-1	10.7	8.3	4.6	3.5
West Bengal	3.2	3.6	9.4	4.6	-3.2	-3.2	3.6	2.6	13.9	6.8	4.7	4.1

Note: * Data stands for undivided district; Source: Sanyal *et al.* (1998)

It is important to note that despite marginal increase or decline in area under many of the crops in majority of the districts, their production recorded a high rate of growth largely due to increase in yield at a very high rate. As it is seen in Table 13, yield of rice in general, and aus rice and aman rice in particular, as well as that of potato increased at reasonably high rate in majority of the districts. However, yield of wheat declined in some of the districts like Burdwan, Howrah, Midnapur, Nadia, Coochbehar, Jalpaiguri and Purulia. Further, although area under production of rapeseed increased at a very high rate in most of the district, the rate of growth of yield of this crop was very low in many of the districts.

Table 13: Rate of Growth of Yield of Major Crops by Districts, 1977-78 to 1993-94

District	Growth Rate (%)											
	Rice				Wheat	Pulses	Food grains	Jute	Rapeseed	Potato	Non-Food Grains	All Crops
	Aus	Aman	Boro	Total								
River Bank Districts												
Burdwan	6.3	6.3	3.7	6.8	-1.6	1.9	7.6	3.3	0.7	4	1.1	4.5
Hooghly	5.1	5.8	1.2	5.5	4.6	0	5.7	8.4	2.9	3.1	4.1	5.3
Howrah	7.3	3.4	1.6	6.2	-2.7	1.2	6.5	2.8	2.2	6.9	3.5	4.4
Malda	2.2	3.5	7.2	6	2.1	1.9	5	0.4	1.2	1.5	3.8	5.8
Midnapore*	6.3	5.2	1.1	6.1	-0.3	5.3	6.2	2.3	3.8	6	5.7	6.4
Murshidabad	3.2	5.4	3.4	6.3	13.2	1.1	5.6	2.5	1.3	4.8	3.1	5.2
Nadia	6.4	8.2	6.2	9.4	-0.2	1.2	7.3	4.1	3.3	3	4.4	7.2
24-Parganas*	9.3	4.8	4.6	5.4	2.3	0.6	5.2	4.2	4.4	3.1	1.8	4.5
Average	5.8	5.3	3.6	6.5	2.2	1.7	6.1	3.5	2.5	4.1	3.4	5.4
Non-River Bank Districts												
Bankura	9.4	5.7	7.5	6.6	4.7	2.2	6.5	3.4	1	7.5	7.6	5.6
Birbhum	8.3	5.3	2.5	5.5	2.5	3.8	5.6	4.7	1.7	8.3	1.3	2.1
Coochbehar	5	2.1		3.5	-2.3	1.3	2.8		2.7	4	2	2.5
Jalpaiguri	3.5	1.7		2.3	-1.3	2	2		2.5	4	1	1.9
Purulia	4.3	3.1		3.4	-8.5	2.2	3.3		3.2	1.2	1	2.9
West Dinajpur *	6.4	3.7	7.6	5.7	2.5	1.6	5.3	2.7	3.5	1.2	3	5
Average	6.2	3.6	5.9	4.5	-0.4	2.2	4.3	3.6	2.4	4.4	2.7	3.3
West Bengal	5.9	4.6	2.9	5.7	-2.4	1.9	5.1	3.1	2.4	4.5	3.6	5

Note: * Data stands for undivided district; Source: Sanyal *et al*. (1998)

4.2. Crop Diversification in West Bengal

Sustainable growth of the agricultural sector depends considerably on the process of agricultural transformation, which in turn is well connected with shifts in production patterns i.e. on the extent of crop diversification[4]. A greater degree of diversification from the traditional wheat-paddy system helps in overcoming various ecological problems

[4] By crop diversification we generally refer to a gradual process of moving out of monoculture system of subsistence food crop production to a diversified production system with technological change in production.

including decline in soil fertility[5]. The importance of crop diversification becomes more pertinent particularly as a strategy to reduce variability in agriculture production and yield (Rahman, 2009). A diversified cropping pattern can be seen as a strategy to cope with production risks and uncertainties associated with climatic and biological vagaries (Shiyani and Pandya 1998)[6] and a correct crop mix can help the farmers to cope with the risks of crop loss due to climatic variations[7]. Farmers living in fragile ecosystem such as semi-arid and arid regions and those who are in subsistence economy more often than not adopt diversified cropping strategy because of the fear of crop failures due to pest attack or lack of sufficient water, etc. In essence, crop diversification helps the farmers in reducing variability in income (Guvele, 2001), sustaining a reasonable income level (Van den Berg *et al*., 2007), and mitigating drought and enhancing water use efficiency (Kar *et al.*, 2004).

Contrary to this, in recent years, the growing demands for agricultural production has forced the farmers to adopt intensification of agriculture practices along with the increasing use of high yielding crop varieties for maintaining higher levels of production (Weinberger and Lumpkin, 2007). This has restricted the scope for crop diversification and hence efficient water use in agriculture.

Given this backdrop, attempts are made to examine the extent of crop diversification in West Bengal and its possible implications for the river basin. Two indices viz. Herfindahl Index (DI_H) based on Berry (1971) and Entropy Index (DI_E) as suggested by Hart (14) are computed. Berry's Index of crop diversification is computed by using the formula,

$$DI_H = \sum_{i=1}^{n} (s_{it})^2 \text{ with } s_{it} = \frac{A_{it}}{\sum_{i=1}^{n} A_{it}}$$

Here, A_{it} stands for area under the i^{th} crop in year t and n for total number of crops cultivated in the State in that year. We consider 40 crops cultivated in the State to compute these Indices in different years. Higher the value of the index, lower is the extent of crop diversification. When the entire GCA is confined to a single crop, value of the index DI_H is zero implying no crop diversification. As the GCA is distributed across more number of crops, value of the index DI_H declines indicating greater extent of crop diversification.

[5]For example, a non-rice crop in sequence with rice that allows the soil to dry out, enhances soil nutrient supply and arrests pest build up can improve the productivity of the subsequent rice crop (Pingali and Rosegrant, 1995).

[6] Such production risks and uncertainties generally arise from various diseases of crops and pests along with variations in weather condition and irregular rainfall (Mandal, 2010).

[7] For example, the farmers in drought-hit Rajasthan areas adopt a mixed cropping system with a flexible production schedule as a response to varying rainfalls (Rathore, 2004). A large number of crops and their combinations are used to take care of climatic risks in such areas (Mandal, 2010).

On the other hand, the Entropy Index of crop diversification is computed by using the formula,

$$DI_E = \sum_{i=1}^{n} s_{it} * \ln\left(\frac{1}{s_{it}}\right)$$

However, unlike the Herfindahl index, a higher value of the entropy index indicates greater extent of crop diversification and vice versa.

Table 14 shows changing distribution of land in West Bengal across crops during 1970-71 to 2004-05. It is observed that, though declining over the years, around 80 percent of the GCA in the State is still under foodgrains and, more specifically, around 50 percent of this GCA is under aman rice. Further, the proportion of GCA under boro rice has increased significantly during this period. Although proportion of GCA under some of the major crops like oilseeds, potato, chilies, ginger, etc. has increased, that under the pulses and sugarcane has declined quite sharply over the years.

Table 14: Changing Distribution of Land across Crops, 1970-71 to 2004-05

Crops	1970-71	1980-81	1990-91	2004-05
Aus	11.45	8.37	7.73	4.06
Aman	56.88	57.38	54.55	49.26
Boro	2.67	4.72	11.35	16.59
Rice	71	70.48	73.63	69.91
Wheat	5.16	3.85	3.41	5.08
Other cereals	2	1.58	1.26	0.18
Total cereals	78.14	75.91	78.3	75.17
Gram	2.22	1.31	0.32	0.55
Arhar	0.37	0.31	0.07	0.04
Other pulses	7	5.52	3.57	2.3
Total pulses	9.59	7.14	3.98	2.9
Food grain	87.74	83.05	82.28	78.07
Rapeseed and mustard	1.55	1.78	4.79	5.4
Linseed	0.62	0.92	0.11	0.11
Til	0.15	1.47	1.26	1.34
Total oilseeds	2.41	4.32	6.5	8.18
Jute	5.83	8.31	6.34	7.41
Mesta	0.95	0.6	0	0.12
Cotton	0.02	0	0	0.01
Total fibre	6.83	8.94	6.48	7.57
Tea	1.27	1.28	1.28	1.31
Sugarcane	0.55	0.19	0.15	0.2
Tobacco	0.14	0.26	0.16	0.16
Potato	0.93	1.57	2.46	3.68
Chillies	0.11	0.34	0.62	0.72
Ginger	0.02	0.04	0.07	0.11
Total cropped area	100	100	100	100

Source: Ghosh (2010)

This highly skewed distribution of land towards the foodgrains is reflected in low extent of crop diversification in the State. Table 15 presents the Herfindahl index and entropy index of crop diversification in the districts of West Bengal. It is observed that three of the river-bank districts namely Malda, Nadia and Murshidabad have always been among the top five districts in respect of crop diversification. What is more interesting is that although increasing over the years, the extent of crop diversification is still low in some of the river basin districts like Burdwan, Howrah, Midnapur and 24-Parganas, particularly when compared with some of the non-river basin districts like Coochbehar, Darjeeling, Jalpaiguri and West Dinapur. The extent of crop diversification has increased in most of the districts over the years. However, the pace of increase is not very encouraging.

Table 15: Extent of crop diversification across districts, 1970-73 to 2002-05

District	Herfindahl-Hirschman Index				Entropy Index			
	1970 - 1973	1979 - 1982	1989 - 1992	2002 - 2005	1970 - 1973	1979 - 1982	1989 - 1992	2002 - 2005
River Bank Districts								
Burdwan	0.53	0.48	0.40	0.37	1.14	1.27	1.32	1.31
Hooghly	0.31	0.33	0.29	0.28	1.53	1.55	1.59	1.51
Howrah	0.45	0.49	0.33	0.38	1.30	1.18	1.16	1.22
Malda	0.18	0.18	0.22	0.21	1.95	1.89	2.02	1.84
Midnapore	0.58	0.62	0.48	0.40	0.99	0.95	1.18	1.31
Murshidabad	0.18	0.18	0.18	0.17	1.94	1.96	1.95	1.95
Nadia	0.17	0.16	0.15	0.15	1.97	1.97	2.02	2.02
24 Paraganas	0.58	0.56	0.48	0.42	1.02	1.07	1.19	1.31
Average	0.37	0.38	0.32	0.30	1.48	1.48	1.55	1.56
Non-River Bank Districts								
Bankura	0.63	0.64	0.52	0.49	0.87	0.91	1.15	1.18
Birbhum	0.40	0.56	0.50	0.44	1.31	1.08	1.17	1.24
Cooch Behar	0.33	0.30	0.33	0.33	1.39	1.50	1.49	1.56
Darjeeling	0.35	0.33	0.28	0.33	1.30	1.44	1.52	1.57
Jalpaiguri	0.42	0.36	0.40	0.37	1.20	1.40	1.35	1.65
Purulia	0.70	0.77	0.69	0.78	0.73	0.58	0.72	0.57
West Dinajpur	0.31	0.30	0.37	0.28	1.61	1.65	1.50	1.75
Average	0.44	0.45	0.43	0.42	1.25	1.26	1.31	1.40
West Bengal	0.36	0.37	0.34	0.30	1.55	1.54	1.59	1.67

Source: De and Chattopadhyay (2010)

In the face of the poor crop diversification in the State, a rise in cropping intensity (Table 16) may amount to suggest the following. The crops whose production has gone up in recent years are the ones which may have been more water and fertilizer intensive in nature. While a higher cropping intensity is desirable for the State, as the NSA is on the decline or stagnant, in the absence of a pattern of crop diversification, which would be ecologically sustainable, high cropping intensity may pose a serious threat to the river Ganga both in terms of water use and fertilizer consumption. The declining rate of growth of cropping intensity in recent years may have been attributed to the paucity of water and other complementary inputs.

Table 16: Changing Cropping Intensity by Districts, 1980-81 to 2007-08

District	Cropping Intensity							Average	Coeff. of Variation	Growth Rate (%)
	1980-81	1985-86	1990-91	1995-96	1999-00	2005-06	2007-08			
River-Bank Districts										
Burdwan	145.1	147.1	161.9	165.7	191.1	181.4	184	176.2	0.1	0.8
Hooghly	158.5	171.5	203	215.8	219.7	241.6	246	216.3	0.1	1.3
Howrah	133.6	161.5	202.9	183.8	206.2	209.4	202	199.5	0.1	1
Malda	139.6	136.2	191.9	162.7	156.5	198.5	186	175.8	0.1	1.3
Medinipur	124.7	133.5	150.3	164.9	166.1	172.1	173	161.6	0.1	1
Murshidabad	158.7	168.8	183.3	190	210.3	233.7	245	209.7	0.1	1.4
Nadia	167.1	183.8	229.7	235.8	248.6	250.2	241	240.7	0.1	1.2
North 24 Parganas	127	180	163.1	179.8	209.2	190.3	201	186.8	0.1	1
South 24 Parganas	119.1	129.1	127.5	127.7	147.5	137.1	143	137.4	0.1	0.6
Average	141.5	156.8	179.3	180.7	195	201.6	202.3	189.3	0.1	1.1
Non-River Bank Districts										
Bankura	117.8	124.5	138.6	147.6	149.7	147.2	164	142	0.1	0.6
Birbhum	131.6	132.3	144	157.4	155.9	160.8	176	154.8	0.1	0.9
Coochbihar	158	176.3	183.8	190.9	202.6	207.5	220	192.8	0.1	0.6
Darjeeling	309.6	365.5	125	119.8	117.4	169.1	139	155	0.5	-3.9
Jalpaiguri	137.2	203.1	135.7	143.7	153.4	166.9	169	159.4	0.1	0.3
Purulia	103.4	120.5	106.1	109.3	110.1	106.8	123	108.2	0.1	0.3
West Dinajpur	151.4	157	160.7	159.4	170.9	171.8	177	167.9	0	0.5
Average	158.4	182.7	142	146.9	151.4	161.4	166.9	154.3	0.1	-0.1
West Bengal	139.1	147	158.6	164.3	174.4	180	184	169.9	0.1	0.9

Source: Computed by the authors

5. Agricultural Inputs

In the backdrop of the agricultural growth scenario in the State, it is important to present the nature and state of agricultural inputs that are in use in the State of West Bengal and their implications. Irrigation and fertilizer use are the two major inputs that have significant importance as far as their effects on the Ganga river basin in West Bengal are concerned. Agriculture is the dominant sector in West Bengal that put tremendous pressure on Ganga River in terms of the use of her water for irrigation and receiving run-offs from the cultivation. Hence, it is imperative to examine the trends of use of irrigation practices in the State for better understanding of implications of changing dynamics of irrigation practices and their further implications on the Ganga river basin.

5.1. Sources of Irrigation

With regard to the sources of irrigation system in West Bengal, there seems to be a significant difference between West Bengal and the rest of the country. A comparison of increase in net area irrigated (NIA) by different sources of irrigation between West Bengal and India from 1976-77 to 1985-86 presents striking differences. For instance, in groundwater irrigation, tube wells showed a whopping 575 percent increase in NIA as compared to 60 percent in the country at large. As far as all the sources of irrigation are concerned, interestingly, the State witnessed an increase by about 74 percent during the above-said period as compared to only 20 percent increase at the all India level (Table 17). This clearly indicates the enormity of demand for water in the State.

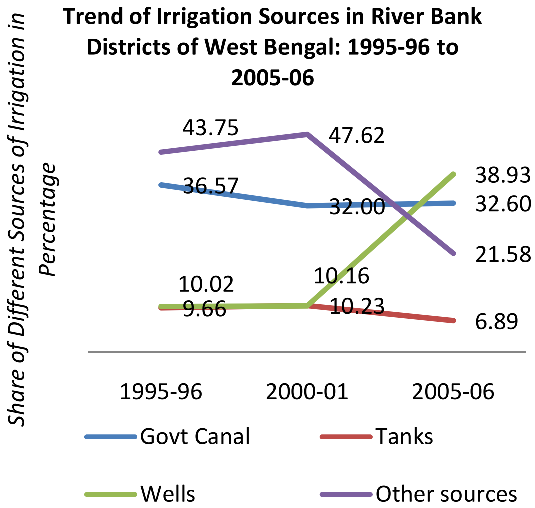
Table 17: Increase in NIA by Sources of Irrigation in West Bengal and India

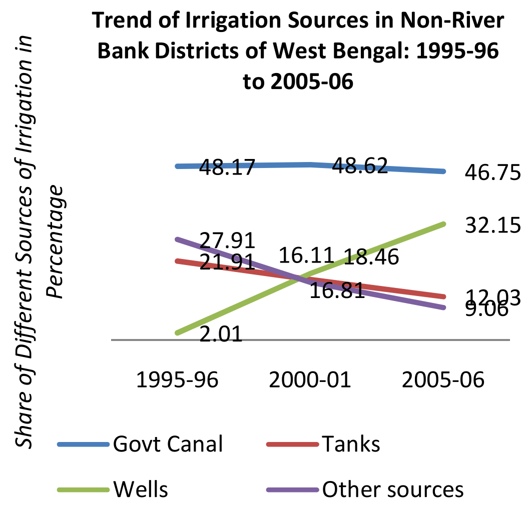
Source of Irrigation	Percentage Increase (1976-77 to 1985-86)	
	West Bengal	All-India
Canals	12.9	14.4
Tubewells	575.4	59.7
Tanks/ponds	44	(-) 22.0
Wells	(-) 34.0	13.7
Other sources	201	13.6
All sources	74	19.7

Source: Ray and Ghosh (2007)

The trends in irrigation sources in river bank districts clearly reveal that while the traditional irrigation systems such as tanks and ponds have shown sharply declining trend, the sources of irrigation by wells have registered substantial increase over the period 1995-96 to 2005-06. A slightly similar trend can also be observed in non-river bank districts as well. In the entire State, the share of tanks in the total irrigation has declined from 33 percent in 1960-61 to 11 percent in 1999-2000 (Table 18).This has serious implications on the flow of river Ganga because of overexploitation of groundwater in the basin area, as groundwater table and river flow are intricately connected.

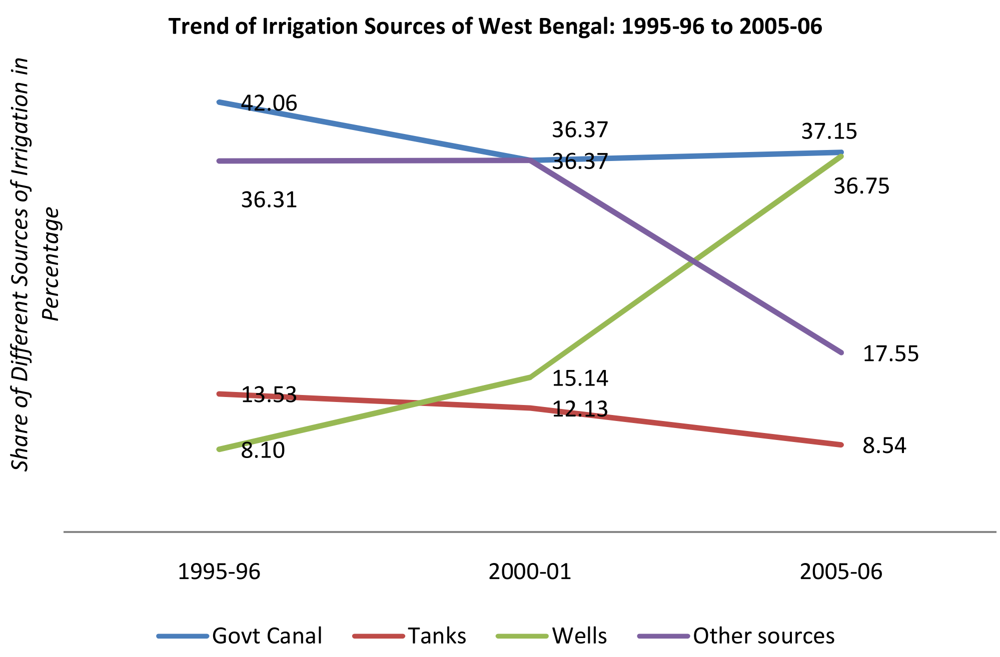
During the pre-colonial period, irrigation in West Bengal was based on ponds, bunds, shallow wells and other kinds of storage works (Rawal, 2001). However, extensive canal irrigation system was constructed during colonial period to irrigate land in dry season and also to supplement in monsoon. Today it constitutes one of the major sources of irrigation in West Bengal. In1990-91, canal as a source of irrigation constituted about 54 percent of the GCA of the State, which however, has registered decline to 42 percent in 1999-2000. However, the distribution of canal irrigation in the State is highly skewed, as it is concentrated only in a few districts like Burdwan, Bankura, Birbhum, Midinapur, and Hoogly. The growth of area under canal irrigation has occurred in a few districts like Jalpaiguri, Darjeeling and Howrah. The growth of area irrigated by canals has slowed down in West Bengal over the years (Tables 18 and 19).





Source: Statistical Abstract of West Bengal, 2005.

Figure 3: Trends in Sources of Irrigation in River and Non-River Bank Districts of West Bengal



Source: Statistical Abstract of West Bengal, 2005.

Figure 4: Trends in Sources of Irrigation in West Bengal

Table 18: Irrigation Sources as a Percentage of Gross Irrigated Area

District	1960-61			1990-91			1999-2000		
	Canal	Tank	Ground water Structure	Canal	Tank	Ground water Structure	Canal	Tank	Ground water Structure
Burdwan	77.4	14.2	8.38	95.41	na	4.58	91.54	na	8.45
Birbhum	59.82	25.23	14.93	74.62	16.37	9	65.74	14.73	19.52
Bankura	16.89	78.03	5.07	69.13	21.13	9.73	52.35	11.37	36.27
Medinipur	29.1	26.62	44.26	55.13	13.85	31	37.51	11.44	51.03
Howarh	11.76	7.35	80.88	9.59	0	90.4	42.55	22.17	35.27
Hooghly	56.14	13.75	30.09	51.32	6.48	42.19	49.8	9.15	41.04
24 Parganas	na	88.57	11.42	43.3	50.78	5.91	9.64	1.09	89.26
Nadia	na	na	na	Na	na	Na	na	na	Na
Murshidabad	49.94	30.36	19.69	86.85	0	13.14	36.95	7.87	55.16
Dinajpur	na	90.12	9.87	Na	37.59	62.4	9.76	24.13	66.1
Malda	na	98.92	1.07	0	14.46	85.53	0	10.55	89.44
Jalpaiguri	61.44	10.84	27.71	60.24	7.46	32.28	71.2	2.99	25.8
Darjeeling	4.8	na	95.19	4.95	0	95.04	100	0	0
Coochbehar	na	na	na	2.7	8.6	88.69	1.24	9.53	89.21
Purulia	0.39	98.68	0.91	Na	na	Na	35.9	35.29	28.8
West Bengal	46.57	33.46	19.96	54.21	13.7	32.07	42.22	10.64	47.13

Source: Ray and Ghosh (2007)

Table 19: Growth in Irrigated Area according to Sources

District	1960-1967			1990-2000		
	Canal	Tank	Groundwater Structure	Canal	Tank	Groundwater Structure
West Bengal	4	-1.42	1.19	1.35	1.74	6.6
Burdwan	2.55	-1.19	1.61	0.73	Na	6.88
Birbhum	2.64	-2.19	0.1	-0.09	-2.52	12.92
Bankura	18.44	-1.94	0.8	-0.16	-2.76	16.51
Medinipur	6.32	-0.09	0.1	-12.7	5.98	13.33
Howarh	18.18	-4.9	-3.62	17.38	10.27	-24.65
Hooghly	3.76	-1.41	2.11	0.68	6.62	-2.32
24 Parganas	na	-0.82	33.09	4.39	1.3	28.28
Nadia	18.34	-4.1	10.73	Na	Na	2.12
Murshidabad	1.35	-0.55	2.49	0.13	-12.77	6.69
Dinajpur	na	2.38	8.9	0.09	-21.4	2.7
Malda	na	0.58	22.42	Na	1.72	8.72
Jalpaiguri	8.39	-9.46	1.86	35.23	15.3	23.11
Darjeeling	-0.34	na	-1.54	29.69	Na	27.7
Coochbehar	na	na	-1.55	0.43	11.28	11.16
Purulia	9.18	-1.65	5.59	3.41	12.96	-0.88

Source: Ray and Ghosh (2007)

In West Bengal, river water is also pumped out to irrigate agricultural field which constitutes one of the major sources of irrigation in some districts. According to the second census on minor Irrigation, there were 3,167 river lift irrigation schemes in West Bengal in 1995-96. The growth of river lift irrigation has been quite phenomenal since the late 1980s, and this growth has been registered mainly in Medinipur, Birbhum, Bankura, Bardhaman, Nadia, and Murshidabad and Hoogli district (Rawal, 2001)

Table 20: Compound Annual Rate of Growth of Electrified Pumps, Various States, 1977 to 1993

State	Growth of Electrified Pumps	State	Growth of Electrified Pumps
Orissa	12.98	Gujarat	7.42
West Bengal	11.28	Assam	7.28
Madhya Pradesh	10.04	Rajasthan	7
Andhra Pradesh	9.81	Himachal Pradesh	6.49
Kerala	9.51	Haryana	5.27
Maharashtra	8.75	Uttar Pradesh	5.26
Karnataka	8.36	Bihar	4.33
Jammu & Kashmir	8.2	Tamil Nadu	3.66
Punjab	7.44	All-India	7.2

Source: Rawal (2001)

Groundwater irrigation in the State is mainly from tube wells, which are owned privately as well as by the government. According to the data from the Censuses of Minor Irrigation, the GIA was about 993 thousand hectares in 1987-88 and about 1332 thousand hectares in 1994-95 (Rawal, 2001). It is also observed that the growth in the 1980s and 1990s was highest in the case of tube well irrigation, and it was also high in comparison with other states as well. West Bengal stands at the second place after Orissa in terms of rate of growth of electrified pumps (Table 20). The high growth in irrigation from tube well was primarily a result of the increase in the number of private shallow tube wells. It was estimated that between 1981 and 1987-88, the number of shallow tube wells increased by an average of 23.5 percent every year. According to data from West Bengal State Electricity Board, the number of electrified tube wells increased by an average of 18.3 percent every year between 1981 and 1987. According to Rawal (2001), there was a deceleration in the expansion of groundwater irrigation after the mid-1980s. The deceleration was higher for tube wells operated by diesel pumps than the tube wells operated by electric pumps.

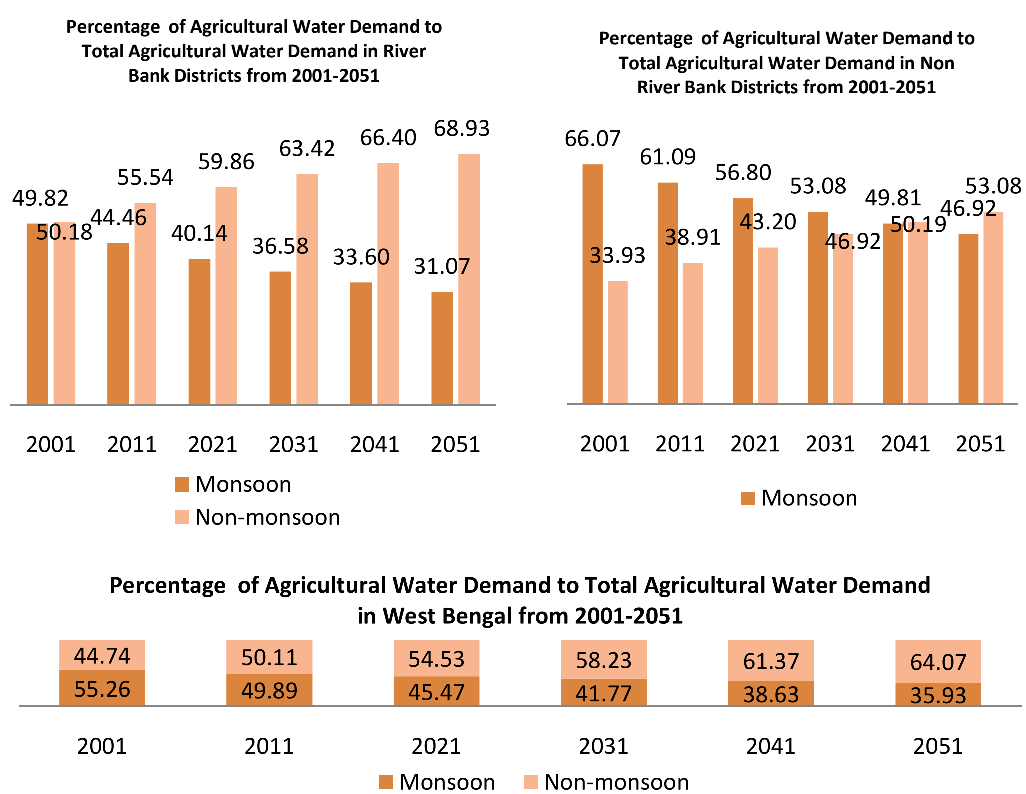
According to some empirical studies on the agriculture practices in West Bengal, boro (a summer crop) paddy cultivation is absolutely dependent on irrigation and groundwater contributes the major share (77.11 percent) of the total supply (Ray and Ghosh, 2007). It is also found that the districts with boro area having registered greater average than the State average have irrigation systems that are essentially dependent on groundwater and receive minimum contribution from surface water schemes. Often summer rice production has been held responsible for widespread arsenic contamination in ground water sources (Zaman *et al.*, 2004). According to Ray and Ghosh (2007), around 69 blocks in the State are affected by arsenic problem and the cause of this problem is stated to be excessive exploitation of groundwater. Districts such as Murshidabad, Nadia and North 24 Parganas are worst affected. It is also observed that excessive withdrawals have resulted in declining groundwater levels in the state (Table 21).

As the state embarks on the path of economic development, there are ever increasing agricultural and other economic activities, which are likely to demand more water in near future. This may result in water stress in the state. Demand for water for agriculture activities is projected for the period 2001 to 2051 for both river and non-river basin districts of West Bengal. As can be observed from the projection, in the river basin districts the percentage of agricultural water demand during non-monsoon periods is likely to increase by 69 percent by 2051 (figure 5). This may lead to overexploitation of both ground and river water indicating continued pressure on the river in the State.

Table 21: Arsenic Content Blocks in West Bengal

Arsenic Affected Blocks	
District	**Blocks**
Burdwan	1
Hooghly	1
Howarh	3
Malda	5
Murshidabad	15
Nadia	15
North 24 Paraganas	19
South 24 Paraganas	10
Total	**69**

Source: Adapted from Ray and Ghosh (2007)



Source: Water Resource and its Quality in West Bengal, West Bengal Pollution Control Board, 2009.

Figure 5: Projection of Agricultural Water Demand (Monsoon and Non-monsoon) in West Bengal across the River and Non-River Basin Districts from 2001-2051

5.2. Use of Chemical Fertilizers

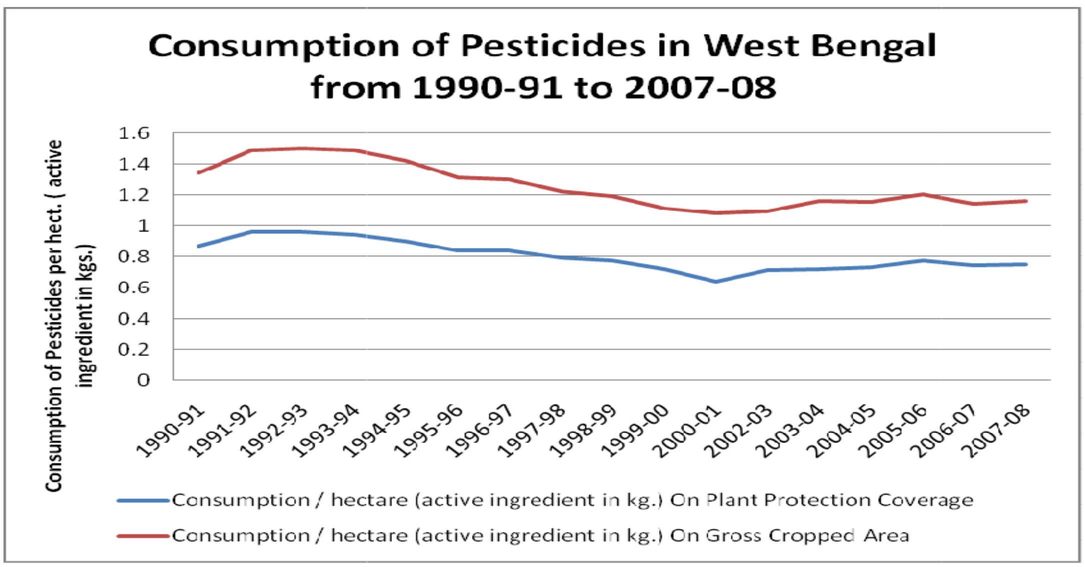
While water demand and its sources remain a critical challenge for the State in general and the river basin in particular, fertilizer consumption remains yet another area of concern for the river basin. Use of chemical fertilizer has significantly increased over time in West Bengal in general and in river basin districts in particular (Table 22). Fertilizer consumption per unit of gross cropped area is higher in river bank districts as compared to their counterparts. Among the traditional crops, paddy consumes greater amount of fertilizer. Fertilizer consumption in potato is also very high and has increased at a very faster rate in the 1990s. However, it is also observed that fertilizer consumption is relatively lower in jute crops. By and large, all the major crops are found to have recorded increasing consumption of fertilizer per hectare of GCA. The consumption of pesticides per hectare of land had registered a declining trend during 1990-91 to 2000-01 (Figure 6). However, since 2001-02, there has again been an increase in the use of pesticides in the State.

Table 22: Consumption of Fertilizer per unit of GCA (in kg/ha)

District	1990-91	2000-01	2002-03	2003-04	2004-05	2005-06	2006-07 (P)	2007-08 (P)
River Bank Districts								
Burdwan	115.15	149.73	144.27	138.19	154.16	153.45	205.43	219.41
Hooghly	170.13	258.12	205.59	199.85	219.21	197.85	271.76	265.08
Howrah	241.96	350.20	374.64	328.81	362.87	372.51	123.17	107.04
Malda	90.56	94.19	111.54	105.65	131.72	140.28	237.28	201.30
Midnapore	69.62	113.27	131.32	120.12	129.97	128.61	146.65	149.59
Murshidabad	74.36	68.38	63.90	57.87	66.52	71.23	145.24	135.15
Nadia	79.58	70.80	69.29	68.73	86.99	94.05	129.60	123.59
24-Parganas	85.03	120.60	135.86	129.82	160.05	152.01	96.35	113.77
Average	115.80	153.16	154.55	143.63	163.94	163.75	169.44	164.37
Non-River Bank Districts								
Bankura	63.72	109.28	125.74	117.42	123.44	111.16	137.40	142.96
Birbhum	110.00	140.85	126.14	125.94	127.10	124.19	147.68	159.57
Dinajpur	57.68	72.47	88.12	81.57	114.98	116.45	122.91	121.63
Jalpaiguri	51.20	95.89	102.47	103.18	118.02	119.44	79.70	76.03
Darjeeling	88.09	172.93	201.04	184.68	215.58	153.48	220.49	249.80
Cooch Behar	72.52	114.14	137.28	129.83	146.93	142.86	72.28	70.15
Purulia	77.19	144.27	159.51	118.64	128.82	131.05	37.98	33.71
Average	**74.34**	**121.40**	**134.33**	**123.04**	**139.27**	**128.38**	**116.92**	**121.98**
West Bengal (Average)	**86.93**	**119.02**	**122.77**	**115.54**	**132.47**	**130.05**	**141.69**	**140.98**

(P): Provisional ; Sources: (1) Agricultural (Inputs) Department, (2) Directorate of Agriculture, Evaluation Wing, GOWB.

A high correlation between irrigation and consumption of fertilizer per hectare has been observed in the State. For instance, an analysis of data by Ray and Ghosh (2007) for 1980-2002 for boro paddy shows that consumption of fertilizer per hectare has increased considerably. Interestingly, output elasticity of fertilizer for one of the important paddy crops in the State, Boro, has declined considerably (Table 23), forcing farmers to use more fertilizers. According to Rassel (1973), crops commonly use 30 to 70 per cent of added nitrogen, 10 to 30 per cent of added phosphorous and 50 to 80 per cent of added potassium in a moderate to good soil exchange capacity status. The residual amount gets deposited in the soil, passes on with the irrigated water as agriculture run-offs to surface water and reaches river, and even reaches groundwater underneath. The increased use of chemical fertilizer has several serious implications. First, it pollutes both ground and surface water sources, which causes serious human and animal health hazards. Second, the polluted water finally finds ways to river that damages flora and fauna in river ecosystem. Third, agriculture wastewater is considered one of the major sources of river pollution that is hard to track as it is a non-point source of pollution. The obvious policy implication is that if crops that require less use of chemical fertilizer can be identified and grown in the river basin areas, it will help reduce pollution load in the river.



Source: Directorate of Agriculture, Government of West Bengal Bureau of Applied Economics & Statistics, Government of West Bengal - Statistical Abstract.

Figure 6: Consumption Pesticides in West Bengal across the River and Non-river Bank Districts

Table 23: Output Elasticity of Fertilizer for Boro Paddy in West Bengal

Time-Period	Coefficient
1983-1986	0.22 (1.75)
1994-1998	0.26 (1.01)
1999-2002	0.13 (0.97)

Source: Ray and Ghosh (2007)

6. Implications

From the preceding analysis, the following important observations can be made, which may have significant bearing on the Ganga river basin.

- Average land holding is very low in the state and a significant proportion of farmers are marginal farmers. This may hinder agricultural productivity to rise and the production of crops highly uneconomical.
- There has been a significant increase in agriculture production in the State largely due to introduction of high-yielding boro rice cultivation that enabled the farmers to grow more than one crop in a year[8]. The area under boro rice and its production have increased over the years. Sourcing water for boro is made mainly through minor irrigation and hence amounting to high extraction of ground water, which poses a challenge. It may be worthwhile to mention here that the declining phase since the 1990s in agricultural growth may be largely attributed to the depletion of ground water level in the State. In such a situation, effective crop diversification may be considered to be the key to attain higher agricultural growth without, however, jeopardizing the ecological health of the region.
- It is also found that amongst the traditional crops, the fertilizer consumption in rice and potato cultivation is very high, while that in jute is relatively lower. There is thus a need to introduce crop diversification, which would economize the use of all resources including chemical fertilizers.
- Cropping intensity is substantially higher in river bank districts as compared to their counterparts indicating thereby possibility of unsustainable use of land and water as the current cropping pattern is more water and fertilizer intensive. It is thus important to promote traditional agricultural practices that economize the use of water and land. It is, in this context, pertinent to provide extension services that promote sustainable agricultural practices in the river basin districts.
- Turning to sources of irrigation, it is quite evident from the above findings that the number of tube wells has increased significantly over time in the river basin, which might have contributed to the depletion of groundwater and thereby river flow and river ecosystem at large. Therefore, it is imperative on the part of the government to bring law that promotes the use of tube wells in the basin area more judiciously.
- While the restrictions on the number of tube wells in the river basin may improve groundwater table, this may be implemented along with policy that creates incentive to encourage recharge of groundwater through percolation tanks/ponds in the region.
- In addition, constant monitoring of groundwater tables in the river basin districts is necessary for evaluating its status from time to time.

[8] High rate of growth of agriculture in the 1980s was also attributed to land reforms (Sarkar, 2006).

- In order to utilize the groundwater resources for agricultural use and other development activities in the Ganga river basin on a sustainable fashion, it is necessary to ensure that extraction of groundwater is less than or equal to the rate of recharge. This will ensure that the groundwater resources are not overexploited.

- Before the advent of modern irrigation practices viz. the use of tube wells and canals, agricultural practices in West Bengal were completely based on traditional irrigation practices like tanks and ponds. Over the last couple of decades, these traditional sources of irrigation system in the state have declined dramatically and it is now imperative to revert back to the old system in order to restore the agricultural ecosystem.
- Another important implication is concerning the use of chemical fertilizer which has not only damaged the top soil but also polluted both surface (including river) water and groundwater with serious human and animal health hazards. This has serious negative impacts on river as well as agriculture ecosystem. It is also important to understand that growth of agricultural production is absolutely essential for livelihoods and food security of local communities in particular and nation as whole in general. However, efforts should be made to transit from inorganic farming practice to that of organic one for sustainable agricultural development as the current practices of chemical fertilizer may result in severe reduction in production in agriculture.

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Appendix

Relevant Data on Agricultural and Agricultural Practices

Table A.1: Population Growth, Density and Literacy in West Bengal and India

Particulars	1981		1991		2001	
	India	West Bengal	India	West Bengal	India	West Bengal
Population (in lakhs)	6833.29	545.81	8463.03	680.78	1028.37	801.76
Decennial percentage variation of population	24.66 (1971-81)	23.17 (1971-81)	23.85 (1981-91)	24.73 (1981-91)	21.56 (1991-01)	17.77 (1991-01)
Density of population (per sq km.)	216	615	273	767	325	903
Percentage of urban population to total population	23.34	26.47	26.13	27.48	27.81	27.97
Literacy (per cent)	43.56	48.64	52.19	57.7	64.82	68.64
Sex Ratio	933	911	927	917	933	934

Source: Census Reports; Economic Review 2008-09 Government of West Bengal

Table A.2: Some Important Demographic Features of West Bengal

Particulars	1971	1981	1991	2001
Total population (in lakhs)	443.12	545.81	680.78	801.76
Number of male population (in lakhs)	234.36	285.61	355.11	414.66
Percentage of male population to total population	52.89	52.33	52.16	51.72
Number of female population (in lakhs)	208.76	260.2	325.67	387.1
Percentage of female population to total population	47.11	47.67	47.84	48.28
Urban population (in lakhs)	109.67	144.47	187.08	224.27
Percentage of Urban population to total population	24.75	26.47	27.48	27.97
Rural population (in lakhs)	333.45	401.34	493.7	577.49
Percentage of Rural population to total population	75.25	73.53	72.52	72.03
Population of Kolkata Urban Agglomerations (in lakhs)	70.31	91.94	110.22	132.06
Percentage of population of Kolkata Urban Agglomerations to total urban population	64.11	63.64	58.92	58.88
Number of main workers (in lakhs)	123.69	154.24	205.81	230.24
Number of cultivators (in lakhs)	39.55	45.91	58.45	N.A
Number of agricultural labourers (in lakhs)	32.72	38.92	50.55	N.A
Percentage of cultivators to main workers	31.97	29.76	28.4	N.A
Percentage of agricultural labourers to main workers	26.45	25.23	24.56	N.A

Source: Census of India; Economic Review 2008-09, Government of West Bengal;NA-Data Not Available

Table A.3: Percentage Share of Different Sectors in Total NSDP (at 1999 - 2000 Prices)

Sectors	1999-00	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Primary	32.77	30.17	29.47	28.22	27.2	25.69	24.9
Secondary	14.64	15.59	15.99	16.57	16.46	17.18	17.26
Tertiary	52.59	54.24	54.54	55.21	56.74	57.13	57.76
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Sources: Bureau of Applied Economics & Statistics, Government of West Bengal Economic Review 2008-09

Table A.4: Land use Pattern of West Bengal across the River and Non-River Bank Districts (Area in '000 ha)

Particulars	Total Reported Area			Net Sown Area			Gross Cropped Area			Forest Area			Area under Non-agr use			Culturable Waste land			Fallow land		
	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008	1980-1981	2000-2001	2007-2008
River Basin Districts																					
24-Parganas*	1460.2	1346.5	1335.2	693.4	638.2	631.5	880.3	1052.5	1051.7	426.3	426.3	426.3	329.0	244.1	267.0	8.0	1.6	0.2	3.5	33.7	10.2
Burdwan	700.6	698.5	698.8	471.1	477.5	452.0	683.7	788.7	832.2	31.0	28.8	21.2	131.2	170.7	208.6	51.9	7.5	7.6	15.4	15.1	9.4
Hoogly	314.5	312.2	313.4	234.4	230.5	219.9	371.5	396.4	540.6	0.3	0.7	0.5	70.5	77.2	91.2	7.5	2.6	1.3	1.8	1.3	0.4
Howrah	145.1	136.0	138.7	96.7	87.0	80.7	129.2	165.3	162.9	NA	NA	NA	43.3	44.2	53.4	3.4	0.3	0.2	1.6	5.6	4.3
Malda	360.5	371.1	370.9	283.9	222.2	210.3	396.2	459.6	391.1	1.4	1.7	1.7	67.1	87.9	92.8	7.1	0.1	0.1	1.1	58.5	66.0
Midnapore**	1360.6	1323.9	1325.2	862.0	874.3	887.7	1074.9	1438.6	1508.6	172.1	170.8	172.8	238.1	253.3	269.8	55.5	4.1	6.2	32.0	21.3	25.8
Murshidabad	536.7	532.5	532.5	426.8	393.0	398.8	677.2	754.9	976.3	0.8	0.8	0.8	94.2	147.3	131.8	7.9	0.7	0.8	4.2	2.7	0.3
Nadia	390.9	390.7	390.7	320.3	298.5	289.2	535.3	721.6	697.7	1.3	1.2	1.2	63.9	80.8	93.3	2.6	1.0	0.8	2.8	8.6	6.1
Total	**5269.0**	**5111.3**	**5105.2**	**3388.7**	**3221.2**	**3170.2**	**4748.3**	**5777.6**	**6161.0**	**633.0**	**630.2**	**624.5**	**1037.2**	**1105.5**	**1208.0**	**144.0**	**17.9**	**17.2**	**62.5**	**146.7**	**122.4**
Non-River Basin Districts																					
Bankura	685.6	688.1	688.0	379.5	344.1	345.4	447.0	499.2	565.8	139.6	148.4	148.9	83.4	124.5	153.1	63.9	6.7	2.1	19.3	64.5	38.5
Birbhum	451.4	451.1	451.1	341.9	337.5	318.5	450.0	458.7	560.8	15.7	16.0	15.9	50.8	85.1	98.1	31.9	3.4	3.9	6.8	9.1	14.7
Cooch Behar	341.4	331.4	331.6	264.4	264.9	248.1	417.8	508.4	547.1	5.7	3.8	4.3	58.9	56.9	76.7	11.8	0.8	1.0	0.5	5.8	1.5
Darjeeling	83.9	325.5	325.5	45.8	136.9	140.7	141.6	186.3	195.8	22.6	124.6	124.6	10.5	50.1	42.4	4.0	1.7	1.8	1.2	12.8	16.0
Dinajpur***	534.0	534.4	534.4	468.4	463.9	461.5	709.2	800.2	819.0	1.3	1.5	1.5	53.5	63.4	68.6	8.4	0.2	0.1	2.4	6.1	2.8
Jalpaiguri	616.1	622.7	622.7	317.7	336.5	334.6	435.7	560.7	564.4	172.6	179.0	179.0	89.9	100.2	94.1	32.5	0.2	0.1	3.5	3.5	14.9
Purulia	623.4	623.3	625.6	301.9	311.7	312.9	312.0	325.4	385.2	87.6	87.6	75.1	108.5	97.0	110.2	81.7	6.4	7.3	43.7	120.6	120.2
Total	**3335.8**	**3576.4**	**3578.9**	**2119.5**	**2195.5**	**2161.8**	**2913.3**	**3339.0**	**3638.0**	**445.0**	**560.8**	**549.2**	**455.4**	**577.2**	**643.2**	**234.1**	**19.3**	**16.2**	**77.4**	**222.3**	**208.5**
West Bengal Total	**8604.9**	**8687.7**	**8684.1**	**5508.2**	**5416.7**	**5332.0**	**7661.6**	**9116.6**	**9799.0**	**1078.0**	**1191.0**	**1173.7**	**1492.6**	**1682.7**	**1851.1**	**378.1**	**37.1**	**33.4**	**139.9**	**369.0**	**331.0**

Source: Directorate of Agriculture (Evaluation), Government of West Bengal. Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinajpur; NA - Data Not Available

Table A.5: Estimated Number of Operational Holdings According to Size Class in West Bengal Across Various Districts

District	Large (more than 10 ha.)			Medium (4-10 ha.)			Semi Medium (2-4 ha)			Small (1-2 ha.)			Marginal (Below 1.0 ha)		
	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06
River Bank Districts															
24 Parganas*	94	22	31	10437	63927	1271	58419	23465	20151	149600	127861	115431	783791	887078	917729
Burdwan	216	60	81	12822	92627	5377	55125	32015	31761	101530	88410	89543	211236	325565	343359
Hooghly	11	15	NA	2037	24778	1169	18499	8377	7464	51607	38309	40363	241432	284330	293535
Howrah	_N.A	21	11	355	6472	95	4541	2768	888	17680	14550	12496	184260	218281	211654
Malda	164	22	1	6687	37859	991	27364	13224	15012	60545	52988	49860	240162	295805	310706
Midnapore**	163	37	24	14490	64246	1545	69250	23411	25337	168302	108853	121184	788298	1127637	1139415
Murshidabad	35	15	5	6916	67032	2100	38767	25556	25126	101125	97910	94306	352750	460025	473388
Nadia	_N.A	19	13	7233	34159	880	31504	12658	12443	74094	76386	75752	236604	310374	329150
Total	683	211	166	60977	391100	13428	303469	141474	138182	724483	605267	598935	3038533	3909095	4018936
Non-River Bank Districts															
Bankura	82	20	7	8481	101521	7423	39463	36870	36895	84938	84960	85292	204248	239365	258414
Birbhum	71	54	1	7329	65671	1891	34723	23114	26494	62480	63374	59972	135264	200265	213304
Cooch Behar	2	14	40	5219	57423	432	30686	20200	20789	65548	51459	50748	157838	235934	249437
Darjeeling	226	156	151	3006	8156	411	9059	2902	3807	17583	13876	13044	35217	74719	86284
Dinajpur ***	41	84	80	13454	73861	1622	50636	25849	29995	80574	83141	90096	235778	358855	376390
Jalpaiguri	185	219	196	4812	27455	1104	23289	10128	9854	49230	43501	47175	127236	230771	237307
Purulia	118	27	11	8581	58586	1551	28120	22455	16751	64100	63750	60332	161887	213085	234716
Total	725	574	486	50882	392673	14434	215976	141518	144585	424453	404061	406659	1057468	1552994	1655852
West Bengal	1408	785	652	111859	783773	27862	519445	282992	282767	1148936	1009328	1005594	4096001	5462089	5674788

Source: Agricultural Census, Directorate of Agriculture, Govt. of West Bengal. Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore Dinajpur *** includes Uttar and Dakshin Dinajpur; NA - Data Not Available

Table A.6: Estimated Area of Operational Holdings According to Size (Class) in West Bengal Across Various Districts (Area in hectares)

District	Large (more than 10 ha)			Medium (4-10 ha)			Semi Medium (2-4 ha)			Small (1-2 ha.)			Marginal (Below 1.0 ha)		
	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06	1980-81	2000-01	2005-06
River Bank Districts															
24-Parganas*	1889	246	401	54970	8490	6321	155396	63927	52371	212213	185631	176239	275262	395433	415134
Burdwan	3508	992	1500	67042	36993	27152	151281	92627	92275	153533	149896	154220	95610	191611	196271
Hooghly	194	304	NA	10749	5380	5476	49491	24778	20379	81157	61856	61311	93740	125391	128989
Howrah	_NA	393	220	1833	587	505	12129	6472	2105	26711	17910	16849	55814	77256	81177
Malda	2282	324	10	36855	8792	4864	75549	37859	40121	95176	90938	81798	88264	160936	171105
Midnapore**	2898	900	1226	78198	8479	7373	188180	64246	71013	254931	180648	194106	293892	569488	547622
Murshidabad	678	158	50	35823	15575	10252	107956	67032	68355	159666	144139	146560	145039	212183	213695
Nadia	_N.A	870	415	38887	5858	4822	80352	34159	33910	116483	130547	128679	104021	180534	182763
Total	8551	3287	2596	246159	81675	59392	632154	326854	309516	844939	780917	765656	857750	1343344	1389134
Non-River Bank Districts															
Bankura	1243	304	84	46625	30375	36707	105740	101521	97059	136826	133229	125064	91560	123280	128494
Birbhum	1411	707	173	39337	14788	8887	93359	65671	74614	96914	107247	100338	63884	118018	121202
Cooch Behar	85	259	2042	24828	8806	2094	77944	57423	57528	90139	79937	79525	68393	128277	132758
Darjeeling	66433	82829	82752	16968	2106	2250	25820	8156	9546	26266	20681	19400	17466	38604	38009
Dinajpur ***	648	5257	8799	69368	13802	7811	133541	73861	81753	110066	143840	145554	91771	212359	202470
Jalpaiguri	120418	124745	123478	24690	7111	5535	65458	27455	27158	70987	70640	74995	60106	125159	124369
Purulia	1797	688	153	48710	11156	7623	81050	58586	44241	102444	89547	90702	74835	100314	115013
Total	192035	214789	217481	270526	88144	70907	582912	392673	391899	633642	645121	635578	468015	846011	862315
West Bengal	203484	218976	221303	594883	178298	137672	1403246	783773	772428	1733512	1606686	1595340	1619657	2758843	2799071

Source: Agricultural Census, Directorate of Agriculture, Govt. of West Bengal. Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinajpur; NA - Data Not Available

Table A.7: Gross Area Irrigated (Area in '000 ha)

District	1995-96	2000-01	2005-06
River Bank Districts			
24-Pgs*	225.21	232.75	265.24
Burdwan	350.00	320.32	317.99
Hooghly	195.39	199.15	335.11
Howrah	25.10	27.36	51.57
Malda	94.29	112.89	125.38
Midnapur**	638.29	512.11	513.62
Murshidabad	115.41	227.85	204.66
Nadia	165.50	211.67	213.03
Total	1809.19	1844.10	2026.60
Non-River Bank Districts			
Bankura	407.60	332.76	273.56
Birbhum	282.40	273.60	291.80
Cooch Behar	25.93	64.78	106.50
Darjeeling	19.10	19.50	8.94
Dinajpur***	124.90	110.27	175.94
Jalpaiguri	44.05	84.22	93.58
Purulia	117.00	70.26	72.13
Total	1020.98	955.39	1022.45
West Bengal	2830.17	2799.49	3049.05

Source: District Statistical Handbook, Government of West Bengal (Various issues). Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinajpur

Table A.8: Distribution of Irrigated Land of West Bengal across Districts by Different Sources (Area In '000 ha)

District	Tank		HCDT		MCDT		LCDT		Shallow Tube well		River Lift Irrigation		Open Dug Well	
	2002-03	2006-07	2002-03	2006-07	2002-03	2006-07	2002-03	2006-07	2002-03	2006-07	2002-03	2006-07	2002-03	2006-07
River Bank Districts														
24-Parganas*	52.333	30.09	8.176	7.76	0.83	1.259	1.57	11.25	131.201	129.016	7.888	46.078	N.A	N.A
Bardwan	40.5	25.28	20.96	19.75	0.56	2.25	1.9	1.74		0.12	12.08	11.79	N.A	N.A
Hoogly	33.341	37.45	12.834	13.162	1.215	1.011	0.203	0.236	129.546	139.512	39.99	42.88	N.A	N.A
Howrah	8.39	8.39	3.57	0.941	1.16	1.226	N.A	N.A	1.8	2.04	2.5	2.1	N.A	N.A
Malda	1.308	1.316	6.15	6.498	0.242	0.269	0.641	0.7	78.499	82.647	8.8	9.247	N.A	N.A
Midnapore**	48.34	51.56	14.48	14.63	38.85	52.23	0.52	0.59	174	182.18	19.18	19.59	9.64	10.57
Murshidabad	7.87	7.84	13.98	10.46	2.47	0.29	0.2	0.47	3.61	0.53	11.44	10.57	N.A	N.A
Nadia			22.07	24.21	0.64	0.56	1.28	0.96	165.11	171.32	10.32	10.98	N.A	N.A
Total	192.082	161.926	102.22	97.411	45.967	59.095	6.314	15.946	683.766	707.365	112.198	153.235	9.64	10.57
Non-River Bank Districts														
Bankura	24.86	33.47	1.06	0.53	1.5	1.49	6.58	1.35	37.84	45.91	3.31	5.08	2.7	2.49
Birbhum	NA	NA	NA	NA	0.9	3.71	0.88	NA	NA	45.68	2.15	2.07	2	0.62
Cooch Behar	5.85	5.87	17.7	15.84	4.32	3.3	NA	NA	15.68	51.01	14.19	11.26	4.47	6.56
Darjeeling	NA	NA	NA	NA	NA	NA	NA	NA	0.32	2.23	2.48	4.16	0.24	0.17
Dinajpur***	25.19	15.63	9.61	14.65	0.3	3.05	0.04	1.61	134.94	131.43	9.5	20.75	0	0
Jalpaiguri	2.25	2.1	6.12	1.76	NA	NA	NA	NA	3.15	8.84	13.15	11.14	0.54	3.68
Purulia	22.8	28.83	NA	NA	NA	NA	NA	NA	NA	NA	1.43	0.97	1.02	0.97
Total	80.95	85.9	34.49	32.78	7.02	11.55	7.5	2.96	232.68	285.1	46.21	55.43	10.97	14.49
West Bengal (Total)	273.032	247.826	136.71	130.191	52.987	70.645	13.814	18.906	916.446	992.465	158.408	208.665	20.61	25.06

Source: (1) Principal Agricultural Officer (2) Irrigation and Waterways Directorate, Govt. of West Bengal. Note: 24 Parganas* includes North-24 Parganas and South-24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinajpur; NA - Data Not Available

Table A.9: Distribution of Area Irrigated by Government Canals in West Bengal Across Various Districts (Area in '000 ha)

District	1980-81	1990-91	2000-01	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
River Bank Districts									
24-Parganas*	NA	23.8	16.1	10.4	9	NA	52.4	52.4	52.4
Bardwan	319.4	312.4	292.7	307	300.9	287.8	283.7	296	308.5
Hoogly	1001.1	95	79	96.4	101.9	104	99.8	90.6	111.6
Howrah	4	5	10.1*	9.5	9.8	36.0**	30	29.3	30.6
Malda	NA	NA	NA	NA	NA	NA	NA	NA	NA
Midnapore**	158.2	177.4	0	149.5	132	0	217.4	224.3	226.4
Murshidabad	58.4	48.9	50.2	52.7	45.5	34.5	32.9	50.1	44.7
Nadia	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	1541.1	662.5	438	625.5	599.1	426.3	716.2	742.7	774.2
Non-River Bank Districts									
Bankura	163.9	207.4	151.0*	182.3	180.7	177.2	176.3	180.4	195.9
Birbhum	191.6	196	185.7	169.2	192.6	184	159.9	184.7	196.6
Cooch Behar	NA	0.6	1.6	0.8	0.8	0.5	NA	NA	NA
Darjeeling	0.8	0.6	9.0+	4.3	4.7	3.3	2.4	4.9	7.7
Dinajpur***	NA	NA	6	7.6	6.5	1.8	2.6	4.6	11
Jalpaiguri	6.2	5	57.7+	61.8	58.4	48.6	81	62.5	NA
Purulia	14.6	24	27.3	23.8	29.1	24.1	22.2	28.8	28.9
Total	377.1	433.6	220.6	449.8	472.8	439.5	444.4	465.9	440.1
West Bengal (Total)	1918.2	1096.1	658.6	1075.3	1071.9	865.8	1160.6	1208.6	1214.3

Source: Directorate of Irrigation and Waterways, Govt. of West Bengal. Note: Figures include area irrigated under Kharif, Rabi & Boro Cultivation.* Area reduced due to less Storage of the Kangsabati Reservoir; + The sharp increase in the figures for Jalpaiguri and Darjeeling in 2000-01; ** There is an additional actual coverage in area under irrigation through back water flow; 24 Parganas* includes North-24 Parganas and South-24 Parganas ; Midnapore** includes East & West Midnapore; Dinajpur *** includes Uttar and Dakshin Dinapur; NA - Data Not Available

Table A.10: Average Annual Rainfall in West Bengal across Districts (in Millimeter)

District	1980	1990	2000	2007
River Bank Districts				
24-Parganas*	1573	2208	N.A	3648
Bardwan	1427	1557	1830	1813
Hoogly	1582	1571	1530	1606
Howrah	1291	1953	1465	2025
Malda	1558	1526	1500	1716
Midnapore**	1391	2152	1381	4282
Murshidabad	1823	1538	1753	1722
Nadia	1521	1685	1571	1612
Total	**12166**	**14190**	**11030**	**18424**
Non-River Bank Districts				
Bankura	1344	1640	1235	1803
Birbhum	1924	1542	2015	1711
Cooch Behar	3454	1357	3123	2537
Darjeeling	2510	3810	3733	3806
Dinajpur***	N.A	N.A	N.A	3029
Jalpaiguri	3025	3434	1033	3488
Purulia	1448	1811	3961	1614
Total	**13705**	**13594**	**15100**	**17988**
West Bengal	**25871**	**27784**	**26130**	**36412**

Source: (1) Agricultural Meteorologist, (2) Directorate of Agriculture Government of West Bengal. Note: NA-Data Not Available; 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.11: Creation and Utilization of Irrigation Potential in West Bengal

Year	Potential created upto the year ('000 ha)	Potential utilized during the year ('000 ha)	Percentage utilization over creation
1996-97	4424.54	3559.41	80.45
2001-02	5096.95	3985.22	78.19
2006-07	5430.14	4375.62	80.58
2007-08	5501.12	4492.49	81.66

Sources: (1) Water Investigation and Development Department, Government of West Bengal; (2) Irrigation & Waterways Directorate, Government of West Bengal; (3) Economic survey, 2008-09, Government of West Bengal

Table A.12: Agricultural Water Demand of West Bengal across Districts in the Next Few Decades (in Million Cubic Meters)

Districts	2001		2011		2021		2031		2041		2051	
	Monsoon	Non-monsoon	Monsoon	Non-Monsoon	Monsoon	Non-Monsoon	Monsoon	Non-Monsoon	Monsoon	Non-Monsoon	Monsoon	Non-Monsoon
River Bank Districts												
24-Parganas*	5404.20	3762.10	5404.20	4667.00	5404.20	5571.80	5404.20	6476.80	5404.20	7381.60	5404.20	8286.40
Bardwan	4006.80	4232.20	4006.80	5250.10	4006.80	6268.00	4006.80	7286.00	4006.80	8303.90	4006.80	9321.80
Hoogly	1827.00	2293.40	1827.00	2845.00	1827.00	3396.60	1827.00	3948.20	1827.00	4499.80	1827.00	5051.40
Howrah	713.50	943.30	713.50	1170.20	713.50	1397.00	713.50	1623.90	713.50	1850.80	713.50	2077.70
Malda	1556.90	1824.10	1556.90	2262.80	1556.90	2701.60	1556.90	3140.30	1556.90	3579.10	1556.90	4017.80
Midnapore**	7458.50	5714.00	7458.50	7088.30	7458.50	8462.60	7458.50	9837.00	7458.50	11211.30	7458.50	12585.70
Murshidabad	2528.60	3185.50	2528.60	3951.70	2528.60	4717.90	2528.60	5484.10	2528.60	6250.30	2528.60	7016.50
Nadia	1609.30	3329.00	1609.30	4129.70	1609.30	4930.40	1609.30	5731.10	1609.30	6531.80	1609.30	7332.50
Total (RBD)	25104.80	25283.60	25104.80	31364.80	25104.80	37445.90	25104.80	43527.40	25104.80	49608.60	25104.80	55689.80
Non-River Bank Districts												
Bankura	NA	1397.70	3170.40	1733.90	3170.40	2070.10	3170.40	2406.20	3170.40	2742.40	3170.40	3078.60
Birbhum	2944.90	1648.80	2944.90	2045.40	2944.90	2442.00	2944.90	2838.60	2944.90	3235.20	2944.90	3631.80
Cooch Behar	1878.00	960.10	1878.00	1191.00	1878.00	1421.90	1878.00	1652.80	1878.00	1883.70	1878.00	2114.60
Darjeeling	330.40	288.20	330.40	357.50	330.40	426.90	330.40	496.20	330.40	565.50	330.40	634.80
Dinajpur***	3649.60	2880.30	3649.60	3573.00	3649.60	4265.80	3649.60	4958.60	3649.60	5651.30	3649.60	6344.10
Jalpaiguri	2077.40	931.70	2077.40	1155.70	2077.40	1379.80	2077.40	1603.90	2077.40	1828.00	2077.40	2052.10
Purulia	2678.10	484.30	2678.10	600.80	2678.10	717.30	2678.10	833.80	2678.10	950.30	2678.10	1066.80
Total (NRBD)	13558.40	8591.10	16728.80	10657.30	16728.80	12723.80	16728.80	14790.10	16728.80	16856.40	16728.80	18922.80
Total West Bengal	38663.20	33874.70	41833.60	42022.10	41833.60	50169.70	41833.60	58317.50	41833.60	66465.00	41833.60	74612.60

Source: State of Environment Report on Water Resource and its Quality in West Bengal 2009; Note: NA - Data Not Available; 24-Parganas* includes North and South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.13: Agricultural Demand of Water and Supply of Water and Supply of Rainwater in West Bengal Across Various Districts (Average over 1994-95 to 2003-04) (in Million Cubic Meters)

Particulars	Area	Cultivable area 2004-05 (sqkm)	Water demand for agriculture (mcm)	75% assured rainfall (mcm)	Average rainfall (mcm)	Water for agriculture (mcm)	75% assured rainfall (mcm)	Average rainfall (mcm)	Water for agriculture (mcm)	75% assured rainfall (mcm)	Average rainfall (mcm)
River Bank Districts											
24-Parganas*	14054	6691	5405	7577	8380	3536	2339	3065	8940	10404	11444
Burdwan	7024	4915	4007	4995	5770	3978	1689	2092	7984	7216	7862
Hoogly	3149	2302	1827	2500	2781	2155	785	1016	3983	3481	3797
Howrah	1467	941	713	1051	1168	887	314	425	1600	1433	1593
Malda	3733	2853	1557	3119	3731	1714	898	1161	3271	4431	4893
Midnapore**	14081	9127	7464	10315	11189	5370	3001	4080	12829	13578	15268
Murshidabad	5324	4089	2529	4055	4773	2994	1244	1577	5523	5726	6350
Nadia	3927	3145	1609	3159	3697	3129	1044	1359	4738	4602	5056
Total (RBD)	52759	34063	25111	36771	41489	23763	11314	14775	48868	50871	56263
Non-River Bank Districts											
Bankura	6882	3958	3170	4077	4591	1314	1222	1534	4484	5795	6125
Birbhum	4545	3441	2945	3423	3933	1550	1061	1322	4495	4853	5255
Cooch Bihar	3387	2694	1878	6287	7014	902	1492	1798	2780	8413	8812
Darjeeling	3149	1622	330	3273	3607	271	701	856	601	4186	4463
Dinajpur***	5359	4763	3650	7431	8217	2707	1838	2313	6356	9540	10529
Jalpaiguri	6227	3648	2207	8282	9016	876	1693	2207	2953	10674	11222
Puruliya	6259	4614	2678	4539	5366	455	1278	1588	3133	6180	6954
Total (NRBD)	35808	24740	16858	37312	41744	8075	9285	11618	24802	49641	53360
Total (West Bengal)	88567	58803	41969	74083	83233	31838	20599	26393	73670	100512	109623

Source: State of Environment Report on Water Resource and its Quality in West Bengal 2009 and Statistical Abstracts 1995-2004, West Bengal; Note: NA - Data Not Available; 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.14: Deficit of Water for Agriculture in the Districts of West Bengal

District	Total area (sq. km)	Cultivable area (sq. km)	Culturable command area of minor irrigation, 2000-01 ha			Culturable command area of major non-monsoon irrigation (ha)	% of cultivable area covered by minor irrigation (2000-01)			% of cultivable area covered by major non-monsoon irrigation (2004-05)	Sum of %'s cultivable area covered by minor & major non-monsoon irrigation	Deficit in non-monsoon rainfall as % of annual rainfall	Replenishable groundwater as percentage of average annual rainfall
			Ground water	Surface water	Total		Ground water	Surface water	Total				
River Bank Districts													
24-Parganas	14054	6691	118993	86316	205309	NA	42	23	23	NA	65	13	43
Burdwan	7024	4915	168363	36410	204773	61747	34	7	61754	13	54	24	27
Hoogly	3149	2302	93718	29581	123299	14984	41	13	14997	7	60	30	29
Howrah	1467	941	8184	58326	66511	257	9	62	319	NA	71	29	13
Malda	3733	2853	97477	24352	121829	NA	34	9	43	N.A	43	11	20
Midnapore	14081	9127	211479	89601	3011089	24291	46	20	24311	4	70	24	31
Murshidabad	5324	4089	170701	24834	195535	4033	42	6	4039	1	49	22	28
Nadia	3927	3145	119775	18797	138572	NA	38	6	6	NA	44	35	31
Total (RBD)	52759	34063	988690	368217	4066917	105312	287	145	105491	24	456	189	223
Non-River Bank Districts													
Bankura	6882	3958	50966	102289	153255	28329	13	26	28355	7	46	-4	18
Birbhum	4545	3441	50169	54946	105115	17423	15	16	17439	5	36	4	22
Cooch Bihar	3387	2694	62944	8826	71770	NA	23	3	27	NA	27	-10	19
Darjeeling	3149	1622	8144	14632	22776	NA	5	9	14	NA	14	-13	5
Dinajpur	5359	4763	169369	31264	200633	NA	68	15	83	NA	83	5	41
Jalpaiguri	6227	3648	45734	32280	78014	NA	13	9	21	NA	21	-12	12
Puruliya	6259	4614	5003	102366	107369	7840	1	22	7862	2	25	-16	7
Total (NRBD)	35808	24740	392329	346603	738932	53592	138	100	53801	14	251	-46	125
West Bengal(Total)	88567	58803	1381019	714820	4805849	158904	424	245	159292	38	707	143	347

Source: State of Environment Report on Water Resource and its Quality in West Bengal 2009; Note: NA - Data Not Available

Table A.15: Agricultural Machinery and Implements in Numbers

District	Animal operated implements	Plant protection equipments	Hand operated implements	Tractor and other power operated implements
River Bank Districts				
24-Parganas*	134306	484059	245649	30878
Burdwan	260505	208108	322668	41905
Hoogly	78221	39173	184315	23793
Howrah	2745	30	35211	3962
Malda	120695	232802	138057	3611
Midnapore**	501813	158813	540862	23184
Murshidabad	205696	115415	210734	22068
Nadia	NA	336550	110051	5364
Total (RBD)	**1303981**	**1574950**	**1787547**	**154765**
Non-River Bank Districts				
Bankura	422754	249172	330542	6008
Birbhum	344279	90435	244563	4609
Cooch Bihar	116024	105848	89308	1127
Darjeeling	25963	126457	95172	1036
Dinajpur***	280130	3323633	223810	3638
Jalpaiguri	129802	564046	124883	1574
Puruliya	368423	121600	155903	2910
Total (NRBD)	**1687375**	**4581191**	**1264181**	**20902**
West Bengal(Total)	**2991356**	**6156141**	**3051728**	**175667**

Source: Directorate of Animal Resources & Animal Health, Government of West Bengal. Note: The figures for 2003 are projected; NA - Data Not Available; 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.16: Consumption of Fertilizers and Pesticides in West Bengal

Year	Total Fertilizer Consumption in tones			Fertilizer	Pesticide Consumption		Ingredient Active
	N	P	K	Consumption (in kg) per unit of Gross Cropped Area (kg/ha)	Quantity consumed in MT	Coverage (lakh hectares)	Per ha in kg
1980-81	167321	70844	44669	_	_	_	_
1990-91	411896	206782	134330	86.93	4040	46.48	0.47
2000-01	561880	296959	226252	119.02	3180	49.00	0.44
2001-02	586841	329785	261556	120.48	3170	52.00	0.42
2002-03	562998	341244	263377	122.77	3780	53.00	0.38
2003-04	581565	304177	230080	115.54	4000	51.00	0.44
2004-05	630995	339615	290894	132.47	4100	51.23	0.42
2005-06	611000	358000	271000	_	_	_	_
2006-07	678000	386000	301000	_	_	_	_
2007-08	685000	386000	304000	150	_	_	_

Source: Directorate of Agriculture, Government of West Bengal Bureau of Applied Economics & Statistics, Government of West Bengal - Statistical Abstract 2005

Table A.17: Use of Chemical Fertilizers in West Bengal Across Various Districts (in '000 tones)

District	1980-81	1990-91	2000-01	2007-08
River Bank Districts				
24-Pgs	28174	73563	126840	119336
Burdwan	41778	85790	118086	182587
Hooghly	36590	76600	102312	143300
Howrah	13929	41627	57902	17433
Malda	13424	44240	43284	78734
Midnapur	32337	87734	162946	210550
Murshidabad	24003	55143	51623	131943
Nadia	24235	52510	51091	86237
Total	214470	517207	714084	970120
Non-River Bank Districts				
Bankura	13202	34549	54555	80884
Birbhum	19473	54411	64603	89480
CoochBehar	6805	32984	58034	38378
Darjeeling	3349	15146	32223	48919
Dinajpur	14949	39323	60871	91064
Jalpaiguri	4832	23709	53768	42910
Purulia	6114	27579	46948	12983
Total	68724	227701	371002	404618
West Bengal	283194	744908	1085086	1374738

Source: Directorate of Agriculture, Govt of WB.

Table A.18: Total Main Workers and Its Percentage Distribution in West Bengal and India

Category	Rural			Urban			Total		
	Person	Male	Female	Person	Male	Female	Person	Male	Female
Main workers	**16106580**	**13551865**	**2554715**	**6217003**	**5943106**	**973897**	**23023583**	**19494971**	**3528612**
Percentage distribution of Main Workers									
I. Cultivators	19.53	17.95	1.58	0.25	0.21	0.09	19.79	18.17	1.62
II. Agricultural labourers	19.3	15.48	3.32	0.34	0.29	0.05	19.64	16.26	3.38
III. Household industries	4.72	2.42	2.30	1.52	0.96	0.56	6.24	3.38	2.86
IV. Other workers	26.40	22.51	3.09	27.92	24.35	3.52	54.32	46.95	7.47

Source: Census Reports: Economic Review 2008-09 Government of West Bengal

Table A.19: Number of Workers in West Bengal Across Various Districts

District	Cultivators	Agricultural labours	Main workers	Marginal workers
River Bank Districts				
24-Parganas*	300930	406931	2623352	364808
Burdwan	361687	734022	1902334	548907
Hoogly	277901	452114	1528040	331447
Kolkata	6376	4378	1623779	93955
Howrah	74935	146492	1224972	213902
Malda	279276	411862	967143	373563
Midnapore**	1054924	1192363	2530112	1220945
Murshidabad	375172	561874	1672311	332863
Nadia	320464	375541	1405724	209981
Total (RBD)	3051665	4285577	15477767	3690371
Non-River Bank Districts				
Bankura	439957	503214	944216	483056
Birbhum	260955	416949	831699	296798
Cooch Bihar	361840	285426	754311	212394
Darjeeling	88194	58350	478851	90591
Dinajpur***	466545	593039	1187670	360582
Jalpaiguri	269944	230163	1025433	277703
Puruliya	352712	406223	645506	481982
Total (NRBD)	**2240147**	**2493364**	**5867686**	**2203106**
West Bengal (Total)	**5291812**	**6778941**	**21345453**	**5893477**

Source: Census of India, 2001 Government of India. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A. 20: Area under Principal Crops (Food Grains) in West Bengal (Area in '000 ha; Production in 000 tones)

Sl. No.	Crops	1980-81	1990-91	2000-01	2004-05	2005-06	2006-07	2007-08
Food grains : Cereals -								
1.	Rice	5176.2	5812.9	5435.3	5783.6	5782.9	5687.0	5719.8
	(i) Aus	615.1	610.3	394.0	320.8	288.1	283.9	281.6
	(ii) Aman	4214.6	4306.5	3639.5	4086.4	4112.9	4001.9	3926.6
	(iii) Boro	346.5	896.1	1401.8	1376.4	1381.9	1401.2	1511.6
2.	Wheat	283.0	269.1	426.0	400.1	366.7	350.6	352.6
3.	Barley	35.4	10.3	3.5	2.4	2.4	2.9	2.0
4.	Maize	52.6	64.6	35.3	64.6	71.8	85.4	77.2
5.	Other Cereals	27.8	24.9	18.3	17.7	17.4	17.9	17.9
Total Cereals		**5575.0**	**6181.8**	**5918.4**	**6268.4**	**6241.2**	**6143.8**	**6169.5**
Pulses -								
6.	Gram	96.2	25.6	54.7	38.0	40.0	31.2	25.1
7.	Tur (Arhar)	22.6	5.8	8.9	1.5	1.8	2.0	1.1
8.	Mung	29.2	15.5	1.2	11.7	11.5	12.6	16.5
9.	Masur	94.6	73.8	76.0	62.7	61.5	64.2	58.7
10.	Khesari	134.7	44.8	40.4	35.0	33.3	32.2	33.5
11.	Other Pulses	147.0	148.5	83.3	77.5	74.5	77.4	66.0
Total Pulses		**524.3**	**314.0**	**274.5**	**226.4**	**222.6**	**219.6**	**200.9**
Total Food grains (Total Cereals+ Total Pulses)		**6099.3**	**6495.8**	**6192.9**	**6494.8**	**6463.8**	**6363.4**	**6370.4**

Sources: (1) Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2) Tea Board. (P) Provisional; (a) '000 bales of 180 kg each; (c) '000 kg; (b) Figure related to calendar year

Table A. 21: Area under Principal Crops (Non-Food Grains) in West Bengal (A in '000 ha; P in 000 tones)

Sl. No.	Crops	1980-81	1990-91	2000-01	2004-05	2005-06	2006-07	2007-08
Non - Food Grains : Oilseeds								
1	Rapeseed and Mustard	131.1	378.1	436.0	457.5	421.5	421.5	407.5
2	Linseed	67.8	8.5	11.9	5.3	6.7	5.0	5.9
3	Sesame (Til)	108.1	99.3	107.2	148.3	148.6	200.4	203.1
4	Sunflower	2.2	0.6	0.2	8.5	12.5	13.7	16.0
5	Other Oilseeds	8.2	26.7	43.3	53.5	54.2	62.8	74.9
	Total Oilseeds	317.4	513.2	598.6	673.1	643.5	703.4	707.4
Fibers								
6	Jute	610.4	500.2	613	569.2	558.9	594.9	609.8
7	Mesta	44.4	9.1	10.9	8.6	10.4	9.6	7.4
8	Other Fibers	2.1	2.0	2.7	2.5	2.8	7.0	9.3
Total Fibers		**656.9**	**511.3**	**626.6**	**580.3**	**572.1**	**611.5**	**626.5**
Miscellaneous Crops :								
9	Sugarcane	14.3	12.2	21.6	15.6	15.0	16.6	16.9
10	Potato	115.6	194.5	299.7	320.6	354.5	407.9	400.8
11	Tobacco	18.9	12.7	10.5	15.1	13.9	12.0	11.7
12	Tea	93.5	101.2	107.5	114	114.5	114.8 (P)	114.8 (P)

Sources: (1) Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal (2) Tea Board; (P) Provisional; (a) '000 bales of 180 kg each; (c) '000 kg; (b) Figure related to calendar year

Table A.22: Yield Rates of Some Selected Crops in West Bengal and India

Crops	1980-81		1990-91		2000-01		2005-06		2006-07		2007-08	
	WB	India	WB	India	WB	India	WB	India	WB	India	WB	India
Rice	1442	1336	1795	1740	2287	1901	2509	2102	2593	2131 (R)	2573	2203
Wheat	1672	1630	1970	2281	2485	2778	2109	2619	2281	2708 (R)	2602	2785
Gram	578	657	584	712	917	744	1024	815	768	845 (R)	983	780
Jute	1310	1245	1978	1833	2182	2026	2572	2362	2545	2342 (R)	2425	2246
Rapeseed & Mustard	605	560	889	904	956	935	909	1117	803	1099 (R)	888	1009
Potato	17	13	23	16	26	18	21	17	12	15	25	_
Tea	1424 (b)	1491 (b)	1480 (b)	1794 (b)	1689 (b)	1682 (b)	1899 (R)	1708 (R)	2091 (P)	1716 (P)	1983 (P)	1664 (P)

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal

Table A.23: Agricultural Production in West Bengal Across Various Districts (Production in thousand tones)

District	1980-81	1990-91	2000-01	2006-07	2007-08	2008-09
River Bank Districts						
24-Parganas*	1927	2376	3129	3344	3164	3382
Burdwan	2057	2855	3186	3950	3733	3767
Hoogly	1049	1225	1017	1703	1694	1762
Howrah	319	470	453	490	522	416
Malda	773	1266	1377	1271	1335	1643
Midnapore**	2578	3117	5278	5758	5382	5496
Murshidabad	1200	1990	1960	2745	3036	2861
Nadia	797	1660	1687	1639	1747	1837
Total (RBD)	**10700**	**14959**	**18087**	**20900**	**20613**	**21164**
Non-River Bank Districts						
Bankura	1228	1733	2033	2307	2366	2069
Birbhum	1270	1688	1784	2599	2669	2654
Cooch Bihar	608	865	1149	1023	1220	1142
Darjeeling	198	242	229	217	246	259
Dinajpur***	1205	1694	2432	2427	2739	2860
Jalpaiguri	639	550	883	955	879	912
Puruliya	716	807	1032	1521	1568	1531
Total (NRBD)	**5864**	**7579**	**9542**	**11049**	**11687**	**11427**
West Bengal(Total)	**16564**	**22538**	**27629**	**31949**	**32300**	**32591**

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.24: Area of Production under Rice and Wheat in West Bengal Across Various Districts (in thousand hectares)

District	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09
River Bank Districts								
24-Pgs*	639.80	705.30	699.80	690.50	9.00	9.50	16.80	9.00
Burdwan	549.40	560.00	582.60	666.50	10.40	2.70	6.30	2.00
Hooghly	253.20	275.30	199.30	305.70	6.40	0.80	1.60	1.60
Howrah	90.30	133.00	113.30	115.30	0.80	0.10	1.00	0.10
Malda	202.90	263.80	221.70	221.70	24.60	37.60	49.40	44.40
Midnapur**	903.30	1024.90	1108.50	1125.70	8.80	5.60	30.10	5.00
Murshidabad	302.60	353.90	224.10	398.40	86.70	92.20	135.50	101.80
Nadia	208.40	285.00	229.20	277.20	44.00	41.50	60.40	35.90
Total	**3149.90**	**3601.20**	**3378.50**	**3801.00**	**190.70**	**190.00**	**301.10**	**199.80**
Non-River Bank Districts								
Bankura	380.90	434.80	395.60	371.10	10.20	7.80	8.80	3.90
Birbhum	356.60	376.70	318.20	394.00	20.50	14.20	26.90	34.90
Cooch Behar	272.70	305.70	291.90	309.80	12.60	13.60	49.80	16.60
Darjeeling	43.10	55.30	34.20	32.20	1.50	3.70	3.30	2.00
Dinajpur***	457.30	477.80	493.90	489.80	37.00	28.00	47.70	41.50
Jalpaiguri	264.70	275.40	260.80	235.50	8.80	10.60	26.60	15.90
Purulia	251.00	285.00	262.20	301.00	1.70	1.20	2.90	0.90
Total	**2026.30**	**2210.70**	**2056.80**	**2133.40**	**92.30**	**79.10**	**166.00**	**115.70**
West Bengal	**5176.20**	**5811.90**	**5435.30**	**5934.40**	**283.00**	**269.10**	**467.10**	**315.50**

Source: Agriculture Evaluation Wing, Government of India; Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.25: Area, Production and Yield rate of Food grains in West Bengal AcrossVarious Districts

District	Food grains											
	Area (in thousand ha.)				Production (in thousand tons)				Yield rate (in kgs. per ha.)			
	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09
River Bank Districts												
24-Parganas*	700	743	738	699	964	1188	1566	1693	2800	3355	4290	4774
Burdwan	578	566	595	669	1028	1428	1593	1884	1780	2522	2679	2804
Hoogly	268	277	202	308	525	613	508	881	1958	2212	2512	2859
Howrah	107	138	115	115	160	235	227	208	1496	1705	1977	1786
Malda	309	374	314	277	NA	NA	NA	NA	NA	NA	NA	NA
Midnapore**	969	1054	1923	1129	1609	1834	1695	1338	2445	2410	3817	3827
Murshidabad	513	504	421	507	386	633	689	821	1249	1693	2195	2762
Nadia	356	405	347	316	600	995	980	1430	1169	1974	2328	2628
Average (RBD)	**475**	**508**	**582**	**503**	**659**	**866**	**907**	**1032**	**1612**	**1984**	**2475**	**2680**

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District	Food grains											
	Area (in thousand ha.)				Production (in thousand tons)				Yield rate (in kgs. per ha.)			
	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09
Non-River Bank Districts												
Bankura	402	449	407	376	523	727	795	988	1493	1923	2283	2516
Birbhum	408	400	366	429	614	867	1017	1034	1528	1932	2499	2753
Cooch Bihar	295	332	328	329	635	844	892	1327	1557	2108	2438	2977
Darjeeling	86	105	64	62	99	121	115	129	1148	1151	1790	2048
Dinajpur***	542	529	556	561	662	836	1091	1337	2310	2548	3478	4043
Jalpaiguri	287	296	297	263	N.A	N.A	495	536	N.A	N.A	2199	2458
Puruliya	280	324	299	310	N.A	N.A	1385	1819	N.A	N.A	2285	2569
Average (NRBD)	**329**	**348**	**331**	**333**	**362**	**485**	**827**	**1024**	**1148**	**1380**	**2425**	**2766**
Average West Bengal	**407**	**433**	**465**	**423**	**520**	**688**	**870**	**1028**	**1396**	**1702**	**2451**	**2720**

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.26: Area, Production and Yield Rate of Cereals in West Bengal AcrossVarious Districts

District	Cereals											
	Area in thousand ha				Production in thousand tons				Yield rate in kg per ha.			
	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09	1980-81	1990-91	2000-01	2008-09
River Bank Districts												
24-Parganas*	649	714	717	699	940	1177	1548	1677	2957	3466	4381	4882
Burdwan	561	563	589	669	1021	1426	1587	188	1820	2532	2694	2813
Hoogly	260	276	201	308	521	612	507	880	2008	2217	2526	2863
Howrah	91	133	114	115	153	233	226	207	1678	1746	1981	1794
Malda	253	315	278	277	349	595	659	803	1374	1889	2374	2904
Midnapore**	914	1032	1124	1129	1273	1540	2616	2745	1394	1492	4662	4744
Murshidabad	404	451	362	507	554	965	924	1407	1371	N.A	N.A	N.A
Nadia	255	332	290	316	355	780	799	891	2141	2553	2754	2162
Average (RBD)	423	477	459	503	646	916	1108	1100	1843	1987	2672	2770
Non-River Bank Districts												
Bankura	394	446	406	376	610	856	1051	1034	1549	1940	2504	2754
Birbhum	379	392	346	429	621	839	875	1312	1638	2140	2536	3055
Cooch Bihar	287	323	318	329	299	427	568	566	1041	1323	1786	1720
Darjeeling	85	104	62	62	N.A	N.A	493	535	N.A	N.A	2229	2416
Dinajpur***	502	506	543	561	681	957	830	1020	2317	2808	4051	4663
Jalpaiguri	279	290	290	263	315	272	437	454	1131	937	1507	1722
Puruliya	262	303	280	310	351	390	509	759	1337	1285	1817	2445
Average (NRBD)	**313**	**338**	**321**	**333**	**411**	**534**	**680**	**811**	**1288**	**1490**	**2347**	**2682**
Average West Bengal	**372**	**412**	**395**	**423**	**536**	**738**	**909**	**965**	**1584**	**1755**	**2520**	**2729**

Source: Directorate of Agriculture, Evaluation Wing, Govt. of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur; NA - Stands for Data Not Available

Table A.27: Area, Production and Yield rate of Pulses in West Bengal Across Various Districts

	Pulses											
	Area in thousand ha				Production in thousand tons				Yield rate in kgs. per ha			
District	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**
River Bank Districts												
24-Parganas*	50	38	22	22	24	12	17	15	940	815	1597	1383
Burdwan	17	3	5	3	8	1	6	2	447	497	1110	552
Hoogly	268	277	202	308	3	1	1	1	393	539	662	773
Howrah	16	5	0	1	7	2	0	1	429	494	952	795
Malda	56	59	36	21	37	39	30	18	665	650	820	868
Midnapore**	56	22	21	13	16	19	20	4	286	860	1980	819
Murshidabad	109	53	59	37	46	30	56	29	420	558	591	785
Nadia	101	74	57	36	44	50	44	27	432	673	774	760
Average (RBD)	84	66	50	55	23	19	22	12	502	636	1061	842
Non-River Bank Districts												
Bankura	8	3	1	0	4	1	1	0	468	516	705	787
Birbhum	29	9	20	16	14	5	17	15	498	626	832	937
Cooch Bihar	295	332	328	336	5	6	7	4	580	607	663	618
Darjeeling	1	1	2	1			2	1			598	577
Dinajpur***	40	23	13	6	21	12	6	4	1133	1035	1152	1280
Jalpaiguri	8	5	7	4	5	3	4	2	570	603	672	527
Puruliya	17	21	19	16	7	14	7	7	415	66	660	388
Average (NRBD)	**57**	**56**	**56**	**54**	**8**	**6**	**6**	**5**	**523**	**493**	**755**	**731**
Average West Bengal	**71**	**62**	**53**	**55**	**16**	**13**	**15**	**9**	**512**	**569**	**918**	**790**

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.28: Area, Production and Yield rate of Rice in West Bengal Across Various Districts

	Rice											
	Area in thousand ha				Production in thousand tons				Yield rate in kgs. per ha			
District	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**
River Basin Districts												
24-Parganas*	640	714	700	667	923	1157	1508	1657	2954	3470	4376	4896
Burdwan	549	560	583	636	1003	1420	1571	1876	1825	2534	2697	2815
Hoogly	253	275	119	302	509	611	504	876	2011	2218	2527	2866
Howrah	90	133	113	118	1514	233	224	207	1677	1747	1979	1795
Malda	203	264	222	147	287	492	523	657	1416	1866	2360	2962
Midnapore**	903	1025	1108	1046	1256	1529	2584	2737	1390	1492	4665	4746
Murshidabad	303	354	224	398	422	785	548	1124	87	92	136	258
Nadia	208	285	229	241	281	695	650	800	1347	2439	2836	2884
Average (RBD)	**394**	**451**	**412**	**444**	**774**	**865**	**1014**	**1242**	**1588**	**1982**	**2697**	**2903**

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	Rice											
	Area in thousand ha				Production in thousand tons				Yield rate in kgs. per ha			
District	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**	**1980-81**	**1990-91**	**2000-01**	**2008-09**
Non-River Bank Districts												
Bankura	381	435	396	417	593	844	993	1026	1556	1941	2511	2764
Birbhum	357	377	318	394	586	813	797	1212	1643	2158	2503	3078
Cooch Bihar	273	306	292	294	278	402	517	500	1018	1315	1772	1615
Darjeeling	43	55	34	32			467	502			2218	2412
Dinajpur***	0	0	494	479	539	833	682	729	2289	2776	3769	4435
Jalpaiguri	265	275	261	236	295	250	384	391	1113	907	1473	1662
Puruliya	251	285	262	314	343	373	475	744	1368	1307	1812	2472
Average (NRBD)	**224**	**248**	**294**	**309**	**376**	**502**	**616**	**729**	**1284**	**1486**	**2294**	**2634**
Average West Bengal	**315**	**356**	**357**	**381**	**589**	**696**	**828**	**1003**	**1446**	**1751**	**2509**	**2777**

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.29: Total Number of Livestock and Poultry in West Bengal Across Various Districts

District	Total Livestock				Total Poultry			
	1972	**1982**	**2003**	**2007**	**1972**	**1982**	**2003**	**2007**
River Bank Districts								
24-Pgs*	2599209	4706037	3897836	4492983	3083379	5755087	9146957	12961961
Burdwan	1705819	2673286	3329912	3701702	1481503	2073583	5004744	6429429
Hooghly	675709	1438240	1842076	1865685	376790	1663017	2516338	3116070
Howrah	463730	718565	581734	596230	720409	1245768	1063795	1392115
Malda	936300	1583622	1547269	1933732	701594	1303043	2412470	3282042
Midnapore**	2717180	4410886	5491896	6159861	1651222	3433780	6064881	9638942
Murshidabad	1253943	2019267	3024300	3658709	1411196	2222829	5471013	5167809
Nadia	893380	1713203	1612653	2002652	743097	1882813	2807473	2844168
Total	**11245270**	**19263106**	**21327676**	**24411554**	**10169190**	**19579920**	**34487671**	**44832536**
Non-River Bank Districts								
Bankura	1623240	2237600	2548281	2779169	915888	1429777	2964836	3880710
Birbhum	1285956	1641428	2125056	2502876	1005849	1844844	3580657	4223131
CoochBehar	946797	1285343	1614689	1830308	438370	783720	1667453	1655786
Darjeeling	306404	4331709	599168	695064	303883	559270	673026	953032
Dinajpur***	1287641	1868491	2579421	2738961	997000	2035746	3604328	3574542
Jalpaiguri	1037154	1230318	1726436	1892418	704639	1136091	1996697	2143252
Purulia	1316184	1736790	1949082	2250647	900447	1268566	2074056	2601303
Total	**7803376**	**14331679**	**13142133**	**14689443**	**5266076**	**9058014**	**16561053**	**19031756**
West Bengal	**19048646**	**33594785**	**34469809**	**39100997**	**15435266**	**28637934**	**51048724**	**63864292**

Source: Directorate of Agriculture, Evaluation Wing, Government of West Bengal. Note: 24-Parganas* includes North & South 24 Parganas; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur

Table A.30: Revenue and Expenditure of Forest of West Bengal (in Lakh)

Year	Revenue	Expenditure	Profit	Growth
1980-81	1576.05	1805.02	-228.97	-
1990-91	3394.09	7252.00	-3857.91	-1.5849
2000-01®	6577.36	17915.42	-11338.1	-0.19389
2007-08	15215.35	26612.24	-11396.9	-0.00052

Sources: (1) The Principal Chief Conservator of Forest, Government of West Bengal; (2) Forest Development Corporation Ltd., Govt. of West Bengal

Table A.31: Out-turn of Forest Produce in West Bengal Across Various Districts ('000 cubic meters)

State/District	Item	1980-81	1990-91	2000-01	2003-04	2004-05	2005-06	2006-07	2007-08
River Bank Districts									
24-Pgs*	Timber	2.2	11.5	0.1	-	0.1	0.2	-	0.87
	Firewood	11.2	7.5	0.3	0.4	0.1	0.1	-	0.02
Burdwan	Timber	4.3	4	2.9	2.8	1.3	1.6	1.1	12.15
	Firewood	16.3	5.5	6.3	18.4	10.9	10.6	9.7	9.5
Hooghly	Timber	(a)	(a)	(a)	0.1	-	-	-	-
	Firewood	(a)	(a)	(a)	-	-	-	-	-
Howrah	Timber			2.3	-	0.1	-	-	0.04
	Firewood	(a)		0.2	-	-	-	-	-
Malda	Timber	0.2	0.8	0.5	-	0.5	-	0.4	0.85
	Firewood	0.2	0.1	-	0.1	-	-	0.1	0.11
Midnapur**	Timber	41.7	0.2	17.8	13.6	28	3.1	4.3	156.51
	Firewood	149	2.4	97.1	116.4	165.4	67.2	47.8	85.99
Murshidabad	Timber	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
	Firewood	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Nadia	Timber	1.6	0.5	0.1	-	0.5	0.7	0.3	0.97
	Firewood	1.4	1	-	0.1	0.1	0.6	0.6	0.47
Total	**Timber**	**50.00**	**17.00**	**23.70**	**16.50**	**30.50**	**5.60**	**6.10**	**171.39**
	Firewood	**178.10**	**16.50**	**103.90**	**135.40**	**176.50**	**78.50**	**58.20**	**96.09**
Non-River Bank Districts									
Bankura	Timber	13.5	1	22.1	29.3	21.9	6	5.7	17.85
	Firewood	40.4	3	68.9	112.9	135.5	53.5	16	143.52
Birbhum	Timber	1	0.3	2.1	1.3	8.6	0.2	1.3	0.81
	Firewood	2.5	-	6	5	3.7	1.4	2.2	0.01
Cooch Behar	Timber		11.7	3.4	5.8	0.2	2.9	0.6	0.24
	Firewood		15.1	31.7	1.2	-	0.9	-	-
Darjeeling	Timber	10.5	21.1	12.3	12.7	14.3	10.7	8.3	6.72
	Firewood	14.7	33.6	8.4	22.1	17.4	7.5	4.3	4.27
Dinajpur***	Timber	(c)	(c)	2.3	0.6	0.9	0.3	0.4	-
	Firewood	(c)	(c)	-	0.1	-	-	-	-
Jalpaiguri	Timber	112.8	37.2	19.3	59.6	22.3	27.8	38.1	10.96
	Firewood	165.8	130.7	14.6	14.6	20.6	14.8	23.7	4.37
Purulia	Timber	1.2	-	3	4.8	15.2	0.9	0.5	23.61
	Firewood	3.8	11.7	16.9	15.4	12.9	10.7	19.1	13.76
Total	**Timber**	**139.00**	**71.30**	**64.50**	**114.10**	**83.40**	**48.80**	**54.90**	**60.19**
	Firewood	**227.20**	**194.10**	**146.50**	**171.30**	**190.10**	**88.80**	**65.30**	**165.93**
West Bengal	**Timber**	**189.00**	**189.00**	**88.30**	**88.20**	**130.60**	**113.90**	**54.40**	**61**
	Firewood	**405.30**	**210.60**	**250.40**	**306.70**	**366.60**	**167.30**	**123.50**	**262.02**

Source: Principal Chief Conservator of Forests, Government of West Bengal. Notes: 24-Parganas* includes North & South 24 Parganas ; Midnapore** includes East & West Midnapore; Dinajpur*** includes Uttar and Dakshin Dinajpur; (a) The forest area of Hooghly, Murshidabad, and Uttar & Dakshin Dinajpur district are included in Burdwan, Nadia, and Malda districts respectively.; (1) "Timber" includes plywood, match wood, other timber and poles, upto 2004-05. (2) "Firewood" includes quantity of firewood required for production of charcoals, other firewood and pulp wood upto 2004-05. (3) For 2005-06 and 2006-07 Timber does not include any other wood. Firewood does not include pulpwood.

Reform Imperatives for Agricultural Sustainability in Ganga Basin

GRBMP: Ganga River Basin 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 Frame Work 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 dialog 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.

Dr Vinod Tare
Professor and Coordinator
Development of GRBMP
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Contents

1. Preamble

Agriculture is the main source of livelihood of a majority of rural population in the Ganga River Basin. As per the National Sample Survey (NSS) 68th Round (2011-12), 62.37% of total workforce in Bihar, 52.41% in Uttar Pradesh, 48.96% in Uttarakhand and 39.23% in West Bengal directly depend on agriculture. The Ganga river, being a perennial source of water, facilitates both surface and groundwater irrigation in the basin. Since, the scope of bringing more area under cultivation is limited due to rising land demand for non-agricultural uses, such as, urbanization and industrialization, future requirement of agricultural commodities, including food, may be met by intensive use of land, water and other resources which would have some implications in terms of degradation of soil and water resources. Green revolution technology, though has made significant contribution to transform agriculture from the food-deficit economy to food-surplus one and substantially raised farm production, productivity and income, it has no longer remained 'green' and its environmental and ecological consequences have now become quite obvious. The high input-intensive farm practices followed by farmers in the basin have caused depletion in the groundwater table, increase in input cost, deterioration in the quality of soil and water and increased credit requirement and consequently rising indebtedness among farmers. Therefore, basic issue for the GRBMP is how to achieve ever-green and sustainable agricultural development without adversely affecting soil, water, ecology and environment. Keeping these aspects in view, there is strong need to introduce changes in the existing agricultural practices and encourage farmers to adopt sustainable agricultural practices. The proposed sustainable agriculture mission, synergized with other missions, intends to reduce the water resource consumption and pollution and improve rural livelihood by way of promoting sustainable agricultural practices in the basin.

2. Objectives of the Mission

- Develop farming systems that widen livelihood opportunities; conserve soil, water, and other natural resources; protect environment, ecology and biodiversity; reduce farmers' dependence on external inputs; ensure food security; and improve human health and safety.
- Enhance water-use efficiency and reduce non-point sources of water pollution.

3. Emerging Issues

The adverse effects of on-going agricultural practices in the basin on soil fertility and quality of water have already been considerably documented in the literature. For instance, excessive use of chemical fertilizers and pesticides was found to have polluted both surface and groundwater and became the major non-point source of pollution of river water resources, thus adversely affecting the aquatic lives and livelihood of people directly depending upon the river resources. Further, the intensive use of fertilizers, pesticides, and weedicides not only caused degradation of natural resources but also adversely affected human and animal health. Exponential growth of tube-wells in the basin has caused serious depletion in the ground water table and consequently the quality of water[1]. Groundwater irrigation is preferred on the grounds of equity, efficiency, productivity and private investment. But due to the government policies related to agricultural credit, subsidy, inputs, and energy and absence of effective regulation, its sustainability has become one of the major concerns in the basin. Availability of subsidized electricity and flat rate system of power encouraged farmers to over-exploit the groundwater, as the marginal cost of drawing water from electrified tube-wells is almost zero.

As per the Working Group Report on “Natural Resource Management” (Government of India, 2007a), cost of soil degradation in India during 1980s and 1990s ranged from 11 to 26 percent of gross domestic product (GDP). The land has become addicted to high doses of chemical fertilizers. Absence of the network of reliable advice and soil-testing facilities has also contributed to the indiscriminate, overdose and unsafe use of chemicals. Use of farm yard manure and green manure has declined due to various reasons, such as decline in draught animals and change in the cropping pattern from legume crops to rice, wheat, sugarcane and other commercial crops[2]. The key issues are how to reduce water consumption and water pollution in agriculture and protect livelihood of small and marginal farmers who constitute more than 90% of total farmers in the basin. Can alternative agricultural practices (such as organic farming) generate more income and employment opportunities in agriculture on sustainable basis and improve river health and consequently health of human, animals, and plants in the basin? What kinds of institutional, technological, market and financial support related interventions are required for sustainable agriculture? Can organic farming ensure food security and sustain farmers’ livelihood? What are the key factors that would determine the shift of farmers towards sustainable agriculture? What are the demand and supply side constraints to the promotion of organic farming? How to estimate positive externality of organic farming in terms of environment and health and compensate farmers accordingly? What types of changes are needed in the supply chain management for organic products? How to remove the knowledge-deficit in agriculture? And, of course, what could be the action plan to accomplish the desired results? These are some of the important issues that need to be addressed through the mission interventions. The proposed sustainable agriculture mission should address the following issues:

3.1. Reduction in Water Consumption and Increase in Water Use Efficiency in Agriculture

Water is the most precious resource which has competing uses in agriculture, domestic sector, industry and ecological services. Traditionally, agriculture is main consumer of water (more than 80% of total water consumption). How to reduce water consumption per unit of output produced and improve the water use efficiency in agriculture is the key policy concern. Saving in irrigation water implies saving of energy and reduction in the environmental pollution. Due to fast growth of tube-wells, groundwater has become the major source of irrigation. For example, groundwater constituted 80% of total gross area irrigated (GIA) in the Middle Ganga

[1] See IIT Consortium’s GRBMP reports on agriculture for more details.

[2] For example, three crops—sugarcane, wheat and paddy together constituted 68.8% of GCA, and 83% of GIA in Uttar Pradesh in 2007-08.

Basin in 2007-08. Figure 1 also highlights that the share of canal irrigation in the total GIA has significantly declined over the period, while share of tube-wells/wells has tremendously increased. Number of pump-sets per 1000 ha of gross cropped area (GCA) in the basin has risen from mere 30 in 1980-81 to 125 by 2007-08 and this fourfold increase has serious medium- and long-term implications for sustainability of groundwater[3].

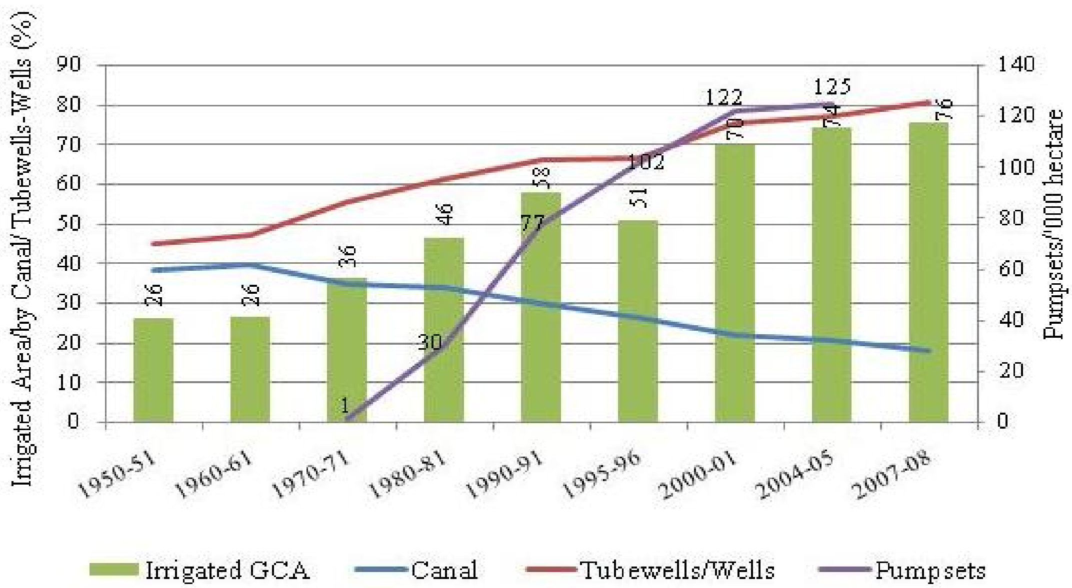

Figure 1: Trends in Gross Irrigated Area by Sources of Irrigation and Number of Pump Sets in Operation in Uttar Pradesh

As is evident from Figure 2, since 1950-51 till 2007-08, cropping pattern has shifted towards water intensive crops viz. paddy, sugarcane and wheat which jointly shared 83 percent of GIA, implying that vast quantity of water could be saved through diversification of cropping pattern towards less water intensive crops.

3. 2. Chemicalization of Agriculture and Non-point Source of Water Pollution

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 transformed agriculture to the extent that India moved away from a food deficient to food surplus country. However, as indicated earlier, it has also led to the overuse of the ground and surface water, along with avoidable gross wastage of energy through the installation of an ever increasing number of power inefficient agricultural pump-sets[4]. The increasing doses of chemical fertilizers and other inputs have also become non-point sources of water pollution. Consumption of chemical fertilizer has increased over time. Figure 3 displays trends in chemical fertilizer consumption in the Middle Ganga Basin wherefrom it is evident that there has been

[3] Data given for the Middle Ganga Basin is only for the purpose of illustration. For more details, state-wise reports on agriculture may be consulted.

[4] See GRBMP reports on agriculture for more details.

tremendous increase in its use during the post-green revolution period with Nitrogen constituting more than 75% of the total fertilizer use.

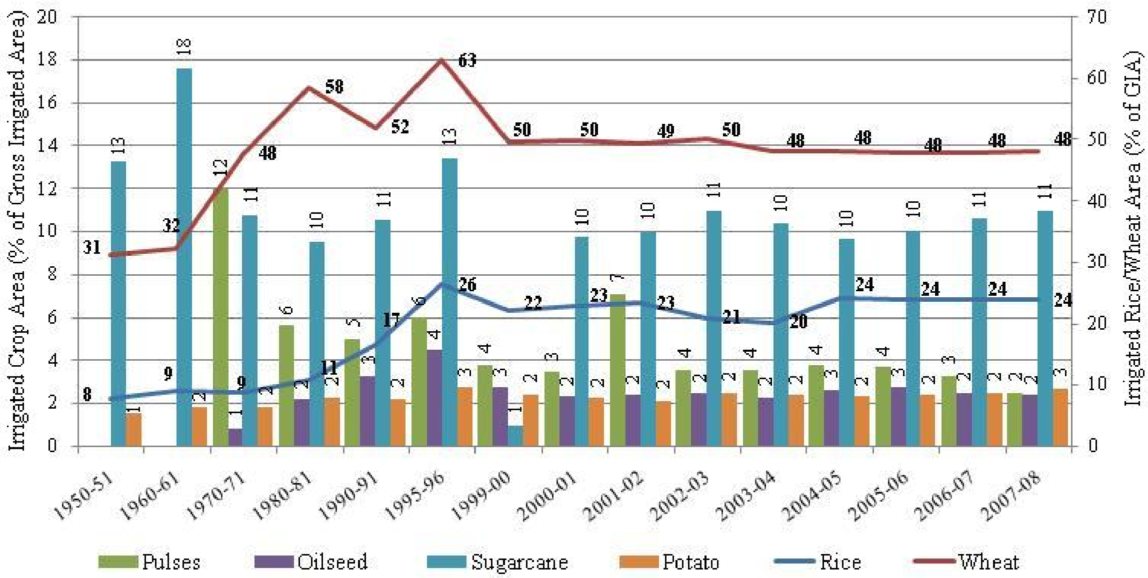

Figure 2: Percentage Share of major crops in the total GIA in Uttar Pradesh

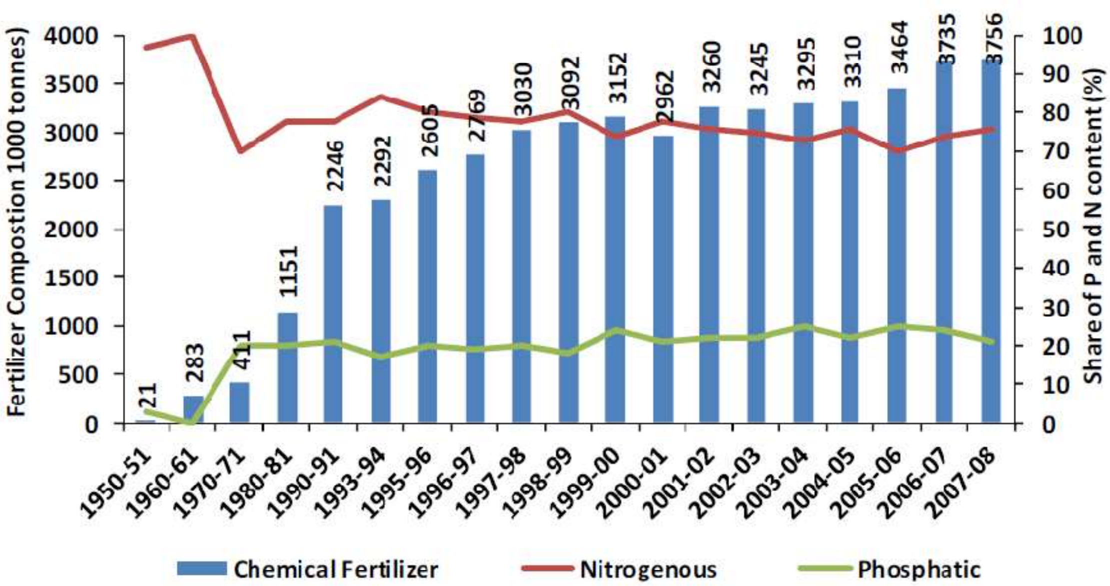

Figure 3: Trends in Chemical Fertilizer Consumption in the Middle Ganga Basin (Uttar Pradesh)

Within the Middle Ganga Basin, the North Upper Ganga Plains region has demonstrated highest intensity of fertilizer consumption, followed by South Upper Ganga Plains and the Eastern

Region (Figure 4). This implies that chemicalization of agriculture varies significantly across regions of the Gang Basin.

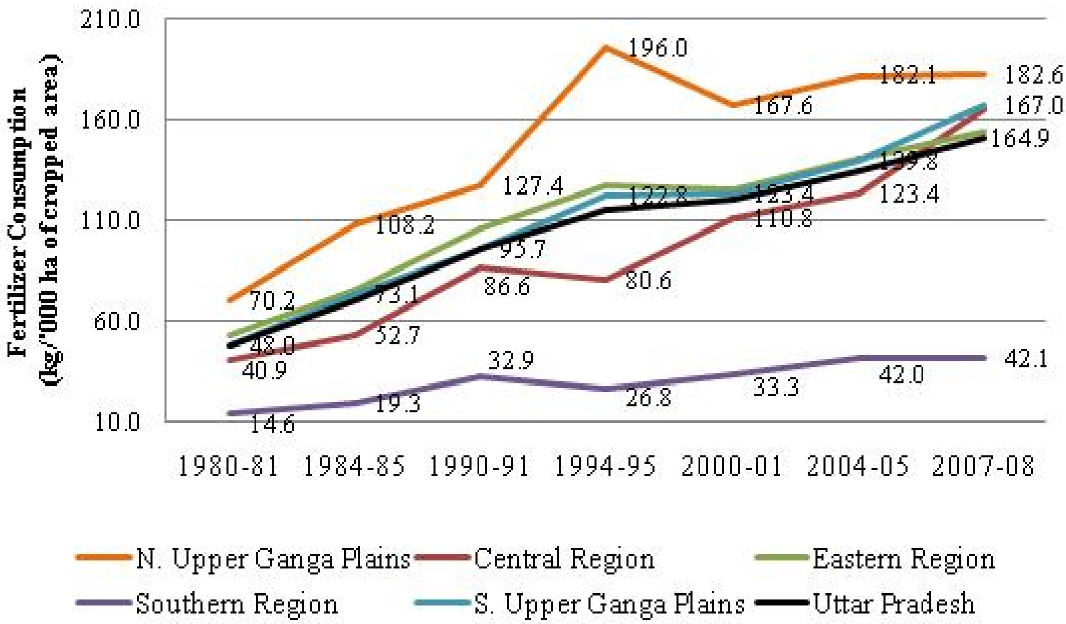

Figure 4: Region-wise Trends in per hectare use of Chemical Fertilizer

Three important crops of the Middle Ganga Basin, namely wheat, paddy and sugarcane consume more than 75% of total chemical fertilizer used in agriculture in the basin. Pesticide use in agriculture varies across years recorded highest at 362 g/ha in 1994 and lowest at 163 g/ha in 1983.

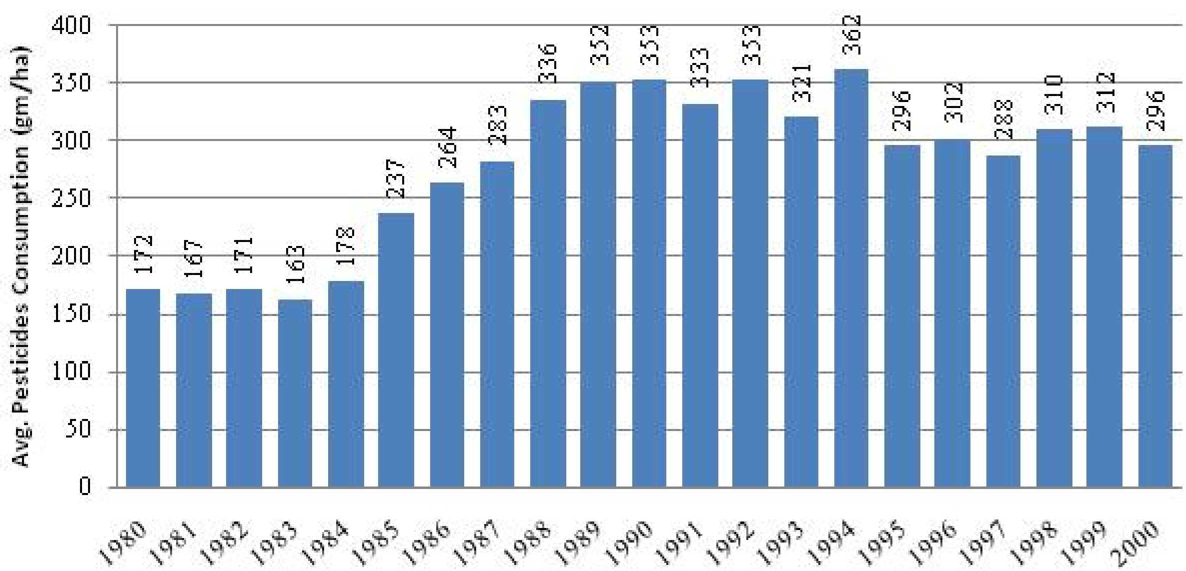

Figure 5: Trends in Consumption of Pesticides in Uttar Pradesh

Increasing use of chemicals for raising production and productivity has not only started backfiring in terms of increasing salinity and degradation of land, it may further necessitate more use of chemicals in order to maintain production and productivity of the land. This may seriously jeopardize health and safety of human beings and other living creatures directly or indirectly dependent on agriculture and may further vitiate quality of the ground and surface water as a consequence of run-off. Indiscriminate use of these chemical nutrients has adverse effects on the physical, biological and chemical properties of the soil and water resources (Greenpeace, 2011).

3.3. Slow Pace of Diversification

Slow pace of crop diversification is a critical issue as far as sustainability of agriculture is concerned. For instance, area under wheat, paddy and sugarcane has significantly increased, jointly accounting about 69% of GCA. Wheat alone constitutes about 37% of the GCA (Figure 6). There is need to diversify the agriculture in favour of other remunerative and water saving crops as the rice-wheat system of farming prevalent in the basin would not be economically and environmentally sustainable for a longer period. Further given the low possibility of horizontal expansion of area under cultivation, the most plausible options to augment farm income and employment are diversification of agriculture and intensive use of scarce land and water resources. Towards this end, price signals and market conditions could be influenced through some interventions viz., agricultural price policy.

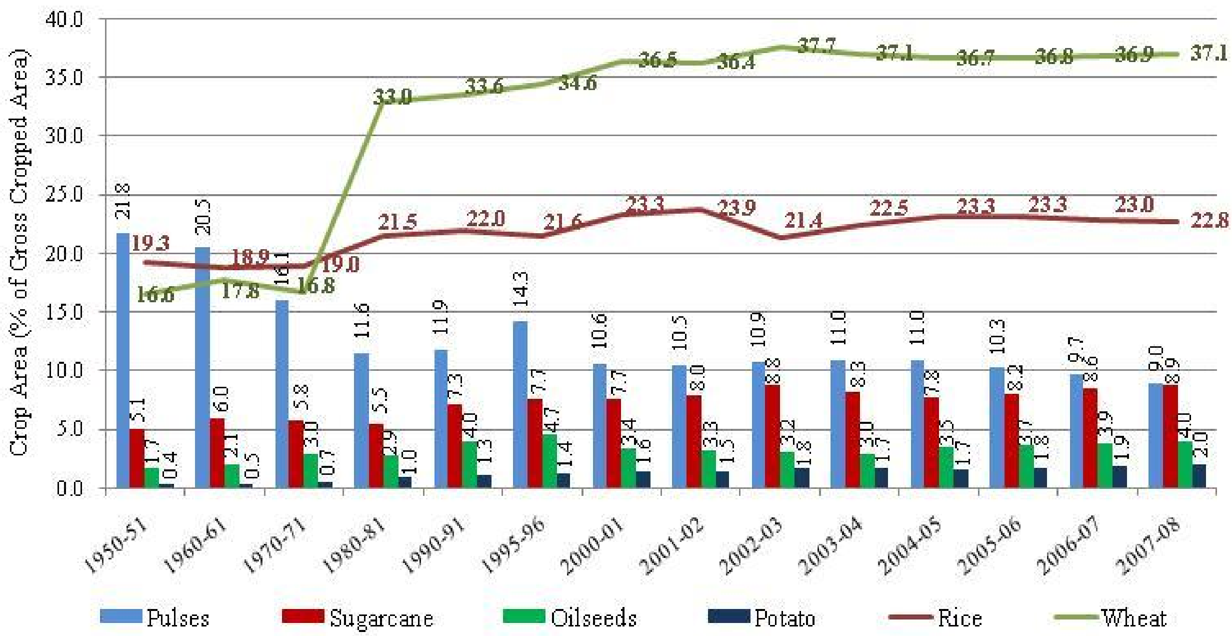

Figure 6: Trends in Area Under Major Crops in Uttar Pradesh

Horticulture and livestock are two emerging sectors within agriculture which have enormous potential for raising 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 higher availability of family labour per unit of land.

3.4. Marginalization of Agricultural Holdings

Marginalization of agricultural holdings is one of the key concerns for sustaining the livelihood of farmers. Table 1 shows that number of small and marginal holdings (below two hectares) has increased from 42.23 thousand in 2005-06 to 44.92 thousand in 2010-11, thus recording a net increase of 6.37 percent. Highest increase in number of small and marginal holdings is observed in Bihar (11.16%), followed by Uttar Pradesh (4.64%) and West Bengal (2.28%). In 2010-11, about 96.92% of operational holdings in Bihar, 95.93% in West Bengal, 92.46% in Uttar Pradesh and 90.80% in Uttarakhand were small and marginal. Making agriculture as a profitable activity for these 94.47% small and marginal farmers of the Ganga River Basin is also one of the key challenges.

Table 1: Number and Area of Operational Holdings in the Ganga River Basin

States	Size	2010-11		2005-06		% Variation	
		Number ('000)	Area ('000 ha)	Number ('000)	Area ('000 ha)	Number	Area
Bihar	**All Sizes**	16191	6388	14657	6251	10.47	2.19
	Small & Marginal	15692 (96.92)	4855 (76.00)	14117 (96.32)	4537 (72.58)	11.16	7.00
UP	**All Sizes**	23325	17622	22458	17906	3.86	-1.59
	Small & Marginal	21567 (92.46)	11414 (64.77)	20610 (91.77)	11313 (63.18)	4.64	0.89
UK	**All Sizes**	913	816	922	847	-0.97	-3.70
	Small & Marginal	829 (90.80)	521 (63.85)	821 (89.04)	486 (57.38)	0.97	7.20
WB	**All Sizes**	7123	5510	6992	5526	1.88	-0.29
	Small & Marginal	6833 (95.93)	4448 (80.73)	6681 (95.55)	4394 (79.52)	2.28	1.23
Basin	**All Sizes**	47552	30336	45029	30530	5.60	-0.63
	Small & Marginal	44921 (94.47)	21238 (70.00)	42229 (93.78)	20730 (67.90)	6.37	2.45

Note: Figures in parentheses are percentages to the total operation holdings and operated areas.

Source: Agricultural Census 2010-11, Ministry of Agriculture, Government of India

For economic growth to be at all inclusive and sustainable, livelihood needs of small and marginal farmers are required to be met. While some of them may exit farming due to non-viability, a majority of them would remain in agriculture and the objective of inclusiveness requires that their concerns are properly addressed (GOI, 2012). Although, most of the new farm technologies are scale-neutral and can be used by any category of farmers, but these technologies are not resource-neutral and therefore, their access to the marginal and small farmers is extremely limited.

3. 5. Knowledge-Deficit in Agriculture

One of the major problems is the knowledge-deficit in agriculture. As per the NSS survey, about 60 percent farmers did not have access to any source of information for advanced agricultural technologies. Due to lack of education, skills, and timely availability of resources, technology transferred to farmers' fields fails to provide the desired yield (GOI, 2005). Educated young farmers are better able to respond to new technology, market opportunities, and risks, while uneducated ones usually copy their agricultural practices with a time lag that too with their own modifications which make replication a redundant exercise. Foster and Rosenzweig (1995) observe that technical change in agriculture is likely to have a greater effect on profits in an educated population than an uneducated one; and policies resulting in greater technical change are complementary to those increasing investment in schooling. Farmers requires not only the skills to grow cost-effective products but also the strategic skills that help them to select the farming system that gives the highest possible returns while maintaining sustainability of soil and water and also skills to deal effectively with agri-business companies, input dealers and extension workers.

4. Mission Interventions

Sustainability has three intertwined dimensions: ecological, economic and social. National Mission for Sustainable Agriculture (GOI, 2010) emphasizes that sustainable agricultural practices have to balance environmental health and economic profitability in order to promote social and economic equity. While there is no denying the fact that agricultural growth must rise to feed the increasing population, the former brings in numerous challenges towards environmental sustainability including the sustainability of surface and ground water. Any unsustainable agricultural practice may create serious harm to surface and ground water, both in terms of quantity and quality. It is, thus, pertinent to carry out agricultural practices that would be sustainable through time. Therefore, the mission should focus on optimization of water use in agriculture, reduction in soil and water degradation, improve the livelihood of farmers, and ensure food security. In this respect a set of policy related interventions are recommended which are discussed in the paragraphs that follow.

4.1. Promotion of Organic Farming

Promotion of organic farming is desirable for maintaining soil fertility, preventing groundwater degradation and depletion through reduction in water requirement of crops, protecting human health, and finally diminishing non-point sources of water pollution. Organic farming is more labour and knowledge intensive; depends more on locally available resources; has potential to improve rural livelihood, reduces distress migration; and facilitates involvement of Self Help Groups (SHGs) in preparing bio-fertilizer and bio-pesticides and develop local markets for these products. This also reduces input costs, making agriculture far more profitable in the long run.

The documented literature and established practices have shown that 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 chemically accelerated farming. Low yields and no premium prices during transition period, lack of technical knowhow, inadequate access to genuine organic inputs, and operational difficulties in its adoption are some of the major constraints blocking its effective use towards sustainable agriculture practices. A Greenpeace study in 2011 reveals that out of 1000 farmers surveyed, 98% may use organic fertilizers if they are subsidized and made easily available.

The policy framework to support organic farming is very important to push its spread. In order to encourage farmers to adopt this alternative system of farming, their net income should be insured at least for three years either through subsidized inputs or through direct transfer of subsidies. This transfer could be much lower than the environmental and health costs that the society bears due to existing practice of chemicalization of agriculture and consequent pollution of water systems. Organic farming could be a viable option if the government supports farmers by protecting their farm income, developing marketing infrastructure, putting in place functional institutions of certification, quality check, branding, and training of farmers.

The following policy supports are required to promote organic farming:

- Building strong marketing networks linking farms, processing and distribution and the organization of production with the support of local non-governmental organizations (NGOs) with stringent certification programmes.

- Training and capacity building infrastructure at the block level should be created to enhance 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 source of cooking energy in rural households. In order to save animal dung for preparing manure for organic farming, rural households should be provided subsidized LPG connections for meeting out their cooking energy needs.

- Encourage social entrepreneurship in bio-gas energy production. There is immense potential for bio-energy generation from cattle dung. It would not only help to solve the rural energy problem but also provide compost for organic farming. Technological upgradation is required so that bio-gas be filled in cylinders and supplied to households as cooking fuel. To make the bio–energy–organic input production a commercially viable and sustainable stand-alone initiative, the new policy may encourage rural youth, primary organic producers, community based organizations (CBOs), civil society organizations (CSOs), private/ corporate sector to develop bio-energy producer companies, suitable mechanisms may be developed to support incorporation, handholding and technology backstopping to nurture these budding institutions.

- Assured markets for organic products through contract farming, risk coverage through insurance, consumers' awareness on organic products, identification of markets for organic products, development of infrastructure facilities for post-harvest management, processing and marketing, financial support, and certification are required for promotion of organic agriculture.

- Professional diploma/degree courses in organic agriculture should be introduced to produce qualified specialists in the area.

- Special Organic Zones (SOZ) should be set up in the areas and crops which have natural advantages for organic farming, such as hill areas of Uttarakhand and Bundelkhand Region of Uttar Pradesh, where chemical fertilizer use is quite low.

- Educated rural youths should be supported for establishing agri-clinics and agri-business centres for organic farming. At least one-third of total agricultural subsidy should be earmarked for promotion of organic farming.

4. 2. Water Use Efficiency

Agriculture is the largest consumer of water. Water-use efficiency is quite low ranging between 30 to 40%. Since water is becoming a scarce input and its demand is ever increasing for both agriculture and non-agricultural purposes, its efficient management and utilization becomes quite essential. Sincere efforts are required to improve water use efficiency through various interventions, including improvement in technologies, agronomic practices and cropping pattern.

It has been assessed that even a 10 per cent increase in the present level of water-use efficiency in irrigation projects may help to provide life-saving irrigation to crops in large areas. Water-use efficiency can be enhanced by generating synergy with seed varieties, nutrients and farm implements (Government of India, 2007b).

4.2.1 Technological Interventions

The following technological interventions should be made to improve water-use efficiency in agriculture.

4.2.1.1 Promotion of Laser Leveling

Use of laser-land-leveling technology is estimated to curtail irrigation application losses up to 30 to 40 per cent. Other major benefits of using this technology may be stated as follows.

- 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 farmers using this technology), leading to better farm returns.

- Control of water-logging and salinity,
- 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.

4.2.1.2 Adoption of Zero Tillage Technology

Zero tillage technology is most suitable for paddy-wheat cropping system. Its use would not only reduce cost of cultivation but also save irrigation water. It has shown tremendous potential in the Indo-Gangetic Plans of India for improving soil quality and sustaining its fertility. Punjab and Haryana are using this technology but it is not widely used in the Ganga Basin, mainly due to high cost of machine and small size of holdings. Market for custom hiring of this technology should be developed with government intervention. Use of this technology can save 20-35% water, 6-9 tractor hours and 5-8 man days per hectare in wheat crop.

4.2.1.3 Micro Irrigation Systems

Available estimates indicate that water use efficiency under flood irrigation is only about 35 to 40 percent because of high distribution losses. Micro irrigation system can substantially increase water use efficiency. Government of India launched a centrally sponsored scheme (CSS) on micro-irrigation during the financial year 2005-06. This was up-scaled as National Mission on Micro Irrigation (NMMI) in 2010. Evidence shows that up to 40-80 per cent of water can be saved and water use efficiency can be enhanced up to 100 per cent in a properly designed and managed MI system (Palanisami, *et al*. 2011). However, the rate of adoption of MI has been slow as compared to the potential of the technology. The system is being adopted mostly in water-scarce states such as Rajasthan (723,810 ha), Maharashtra (697,020 ha), Andhra Pradesh (564,020 ha), Karnataka (405,950 ha), Haryana (525,500 ha) and Gujarat (305,950 ha). Its coverage in the Ganga Basin is quite low. Among the Ganga Basin states, West Bengal has the highest area (150,180 ha) covered under the scheme, followed by Uttar Pradesh (21,260 ha) while Bihar has a very small start (370 ha)[5]. Under the provisions of NMMI, government provides 50% subsidy to set up micro irrigation system (40% by the centre and 10% by the state). In case of small and marginal farmers, additional assistance of 10% of total cost of MI system is provided by the Centre (Government of India, 2010b). The scheme covers sugarcane, banana, coconut and maize in Bihar; vegetables, mango and sugarcane in Uttar Pradesh; orchard crops, potato and groundnut in Uttarakhand; and banana, maize and mango in West Bengal. The area is mostly under sprinkler irrigation system. Since sprinkler and drip irrigation systems are very costly, it cannot be adopted for all the crops in all areas. It can initially be applied to horticultural crops such as fruits and vegetables. Cost of MI systems may be reduced through tax rebates on raw materials and excise duties. Subsidized credit may also be provided to groups of small and marginal farmers who want to do group farming.

[5] For more details, see (Palanisami, et al. 2011).

4.3 Development of Custom Hiring Market for Farm Equipment

Productivity of farms depends considerably on the use of farm power derived from efficient farm implements and their judicious utilization. Mechanisation of various farming operations increases production and productivity of land, reduces drudgery associated with farm operations and helps in reducing socio-economic disparity among farmers. Contract farming companies should also provide latest farm equipment and machines to contracted farmers at nominal rent so that small and marginal farmers may adopt contract farming in high value crops.

4.4 Reforms in the Agricultural Practices

Organic farming is the most preferred farm practice for achieving sustainable agriculture in the Gang River Basin. However, due to various constraints, it cannot be adopted by all the farmers of the basin at least in short and medium term. Therefore, in addition to promoting organic farming as a strategy for sustainable agriculture, reforms in other existing agricultural practices are also required.

4.4.1 Integrated Nutrient Management

In conventional farming system, attention should be given to balanced use of nutrients. Correcting the distortion in relative prices of chemical fertilizers could help correct the imbalances in the use of primary plant nutrients-nitrogen, phosphorus, and potash and use of bio-fertilizers. Generally, NPK consumption ratio of 4:2:1 is considered desirable based on recommendation of 120:60:30 NPK kg/ha dose (4:2:1) for wheat/rice crop. This ratio is rarely maintained by farmers. During 2011-12, this ratio for Uttar Pradesh, Uttarakhand, Bihar and West Bengal was 18.4: 6.2: 1, 12.0:3.1:1, 8.4:2.6:1, and 2.7:1.5:1 respectively. This indicates that except for West Bengal, in all other states of the basin, NPK consumption ratio was inappropriate[6]. Farmers used more quantity of urea (nitrogen) than other nutrients. Government of India implemented the Nutrient Based Subsidy (NBS) scheme on P and K fertilizers with effect from April 1, 2010. However, urea has not been yet covered under the NBS scheme. Excessive use of chemical fertilizer, especially urea, has made the soil more hungry for fertilizers and thirsty for water. Fertilizer use has to be crop responsive and efficient to increase production while rationalizing input costs and minimizing environmental degradation. Soil testing should be made mandatory for each farmer and based on the testing reports doses of different nutrients in each crop should be recommended.

4.4.2. Changes in Cropping Pattern

As mentioned earlier, the 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 in the Middle Ganga Basin is used for cultivation of wheat, paddy and sugarcane which are

[6] For more details, see official website of Department of Agriculture and Coorperation, Ministry of Agriculture, Government of India. http://agricoop.nic.in/documentreport.html

more water and chemical fertilizer intensive.[7] 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.

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 desirable activities for marginal landholders as they have relatively more availability of family labour per unit of land. There is a need to converge the scheme of National Horticulture Mission (NHM) with the activities of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Annual action plans and labour budget prepared for the MGNREGS can 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.

Apart from horticulture and agro-forestry, dairy, poultry and fishing are other alternative livelihood options within the agriculture and allied sector that could be included as components in the overall basin management plan. There is need to construct a network of ponds, even on the private land. These ponds, if planed properly, would help not only in 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 execute works related to horticulture, minor irrigation, land development, construction of ponds, etc. on the private land too.

Transportation of agricultural commodities from the remote hill regions of Upper Ganga Basin to the market places is another major problem. It is therefore, necessary to diversify hill agriculture from traditional crops to high value and low volume products, such as herbal and medicinal plants, aromatic plants, mushroom, spices, soybean and pulses, off-season vegetables and fruits. Primary processing of some of the above mentioned products can be done in the village itself and secondary and tertiary processing may be done in the industrial clusters. This would not only help in reducing the volume but also make value addition to the growers. SHGs could be formed and trained to do the primary processing. Diversification towards these high value and labour intensive commodities can provide fair income and employment to the farmers dependent on small size of farms. Contract farming may be promoted as an institutional arrangement to realize economies of scale, promote technology adoption, and supply of needed quality inputs.

[7] See IIT Consortium's GRBMP reports on agriculture for more details.

4.5. Removal of Knowledge-deficit and Building Human Capital Base

Sustainable agriculture, including organic farming, is more knowledge and technology based and removal of knowledge-deficit and building human capital base is a must for its promotion. Training and capacity building infrastructure at 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-farming and organizational skills. Training programmes should be organized on a regular basis for adopting modern technologies more effectively. Irrigation literacy of farmers should be improved through electronic and print media to optimize water use in agriculture.

Literate and educated rural youth would be the critical mass to be quickly brought on board to accelerate the pace of policy implementation, generate meaningful livelihood and employment opportunities, developing a cadre of independent trained and professional service providers to the millions of organic producers.

Sustainable agriculture requires continuing investments in human resource development, agricultural R&D, improved information and extension, market, roads and related infrastructure development and efficient small-scale, farmer-controlled irrigation technologies, and custom hiring services.

4.6 Protection of Livelihood of Small and Marginal Farmers

Integrated farming having combination of crops, horticulture, livestock, fisheries, is becoming important. Farm profitability and viability of small and marginal farmers are crucial for achieving inclusive growth. A farm activity may be profitable to a farmer but it may not necessarily be economically viable. For example, a small size of holding may generate profit but amount of profit may not be adequate enough to meet household consumption and investment needs. For economic viability of agriculture, a farm household should generate a total net income that is sufficient to meet its consumption as well as investment needs on sustainable basis. The ongoing price policy driven agricultural growth in India may not be sustainable if it is not properly integrated with technological breakthrough in agriculture to raise productivity per unit of land, labour, water and other resources. The following interventions may be made to improve livelihood of small and marginal farmers.

- Group farming should be promoted among small and marginal farmers for achieving economies of scale.
- Small farmers' cooperatives would, therefore, be encouraged and supported to take up activities such as processing, value addition and marketing of agro products.
- Develop custom hiring market for farm machinery.
- Reform in land lease market.
- Subsidies on modern technology and inputs.
- Training & Capacity building of group members.
- Promotion of contract farming for small holders.

4.7 Other Interventions

- Enhancement in water use efficiency by de-incentivizing the use of flood irrigation.
- Improvement in the efficiencies of existing irrigation water delivery systems by upgrading field channels and regular maintenance.
- System of Rice Intensification (SRI) method should be promoted to increase productivity, save water, reduce production costs and increase farm income.
- Introduce new water rate structures that encourage efficient use of water.
- Tax rebates on efficient irrigation equipment to achieve broader social or environmental benefits.

5. Policy Consideration

The following policies and incentives are needed to be implemented for water-saving technologies and sustainable farm practices.

1. A water credit system should be instituted to encourage farmers to make efficient use of irrigation water and save water for river ecosystem services. The credit may be given to individual farmers or the entire village community. Water saving can be estimated through various ways, such as, shift in cropping pattern from high water to low water intensive crops, recharge of groundwater table and net decline in canal water use. As water management and irrigation is the subject of Panchayati Raj Institutions at the village level, participation of Gram Panchayat and Gram Sabha should be ensured in distribution of credits to individual farmers. Some percent of total credits distributed to a village should be given to Gram Panchayat as an incentive and to generate financial resources of the Gram Panchayat.

2. Soil health index should be prepared and farmers maintaining proper soil health should be provided 'soil health bonus'.

3. There is need to develop appropriate decision support systems and agriculture advisory services for farmers so that they may get timely advice on various aspects related to sustainable farm practices.

4. So far there is no clarity on who owns the ground water. It is, therefore, necessary to institute secure water rights to users and develop water market and water pricing so that water-saving technologies may be encouraged.

5. The mission should examine various issues, regulatory concerns, water laws and legislations, R&D development and technology dissemination, social mobilization and participatory and community involvement. Cultivation of water intensive cash crops, such as sugarcane should be regulated in overexploited zones. R&D should focus on developing new seeds that require less water per unit of output produced.

6. Both environment and livelihood issues should be kept in view while providing subsidies on agricultural inputs. Environmental considerations should be in-built in the subsidy structure to make efficient use of inputs, including land and water. Subsidies should be rationalized and redirected towards organic and sustainable agriculture initiatives.

7. The minimum support price (MSP) programme may be used as a policy instrument to achieve diversification of agriculture towards high value and low water consuming crops. There is also need to estimate the social cost of chemicalised farming and internalize its negative externalities.

8. 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 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 execute works related to horticulture, minor irrigation, land development, construction of ponds, etc. on the private land also.

9. 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 supported for procurement of modern water saving technology, such as, sprinkler and drip irrigation in these blocks (Singh, 2008).

10. 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.

11. In addition, constant monitoring of groundwater tables in the river basin districts is necessary for evaluating its status from time to time. In order to utilize the groundwater resources for agricultural use and other development activities in the Ganga River Basin on a sustainable basis, it is necessary to ensure that extraction of groundwater is less than or equal to the rate of recharge. This will ensure that the groundwater resources are not overexploited.

12. Encouraging better crop planning measures will be a key determinant in regulating water usage. These measures could include regulations on the time of sowing of crops as has been done in Punjab and Haryana through a legislative measure viz., ‘Preservation of Sub-soil Water Bill, 2009’ which restricts paddy plantation before June

15, and 10 June respectively. About 20% water used in paddy can be saved through these regulations.

13. Information database, comprising data on rainfall, groundwater recharge and utilization, water demand for different purposes, land use pattern, cropping intensity and cropping pattern, customary water rights, irrigation system and practices, etc. should be maintained at the block level and updated annually. It should be linked with national level database through MIS in the same manner as is being done in case of MGNREGS.

6. Summary of Key Actionable Points

- Institutionalization of water credit system in agriculture.
- Effective participation of Gram Panchayats in irrigation water management; rationalization of water pricing and equitable access of water to all categories of farmers.
- Micro-irrigation (sprinkler and drip), being very costly systems, may initially be applied to horticultural crops in the Ganga River Basin.
- Develop custom-hiring market in costly agricultural machines (such as laser land leveler and zero tillage technology) to ensure better access to farmers, especially small and marginal ones.
- Promote organic farming through budgetary support and involvement of contract farming companies.
- In order to encourage farmers to adopt organic farming, insure their net income during the transition period (at least for three years) either though input subsidy or direct cash transfer.
- Set up Special Organic Zones (SOZ) in the areas and crops which have natural advantages for organic farming, such as hill areas of Uttarakhand.
- Rationalize agricultural subsidies and transfer, at least, one-third of subsidies from chemical fertilizers to bio-fertilizers and organic nutrients.
- Reorient agriculture R&D, extension and training system towards development and transfer of technology suited to the sustainable agriculture practices.
- Encourage corporate sector to use a part of its CSR funds towards training, skill formation and capacity building of farmers so that they may adopt water efficient, cost-effective and sustainable farming system.
- Promote group farming among small and marginal farmers for achieving economies of scale in production and marketing. The group may also be encouraged to take up activities, such as, preparing of organic manure, vermi-compost, bio-fertilizers and pesticides.

- Diversify agriculture towards high value and less water intensive crops and livestock through policy support, influencing price signals and market conditions, and contractual arrangements, as rice-wheat-sugarcane system of farming being adopted in the basin would not be economically and environmentally ecologically and economically sustainable for a longer period.
- Make soil testing mandatory for each farmer and recommend doses of different nutrients in each crop based on the testing reports.
- Apart from horticulture and agro-forestry, dairy, poultry and fishing are other alternative livelihood options within the agriculture and allied sector that could also be included as components in the action plan of sustainable agriculture mission.
- Build training and capacity building infrastructure at the block level to enhance the knowledge and skills of farmers through effective training programmes related to organic farming, composting techniques, bio-pesticides and bio-fertilizers, value addition techniques, group-farming and organizational skills.
- Create Information Database at the block level comprising data on rainfall, groundwater recharge and utilization, water demand for difference purposes, land use and cropping pattern, cropping intensity, customary water rights, irrigation system and practices, socio-economic and demographic data, etc. and link it with national level database through management information system (MIS).

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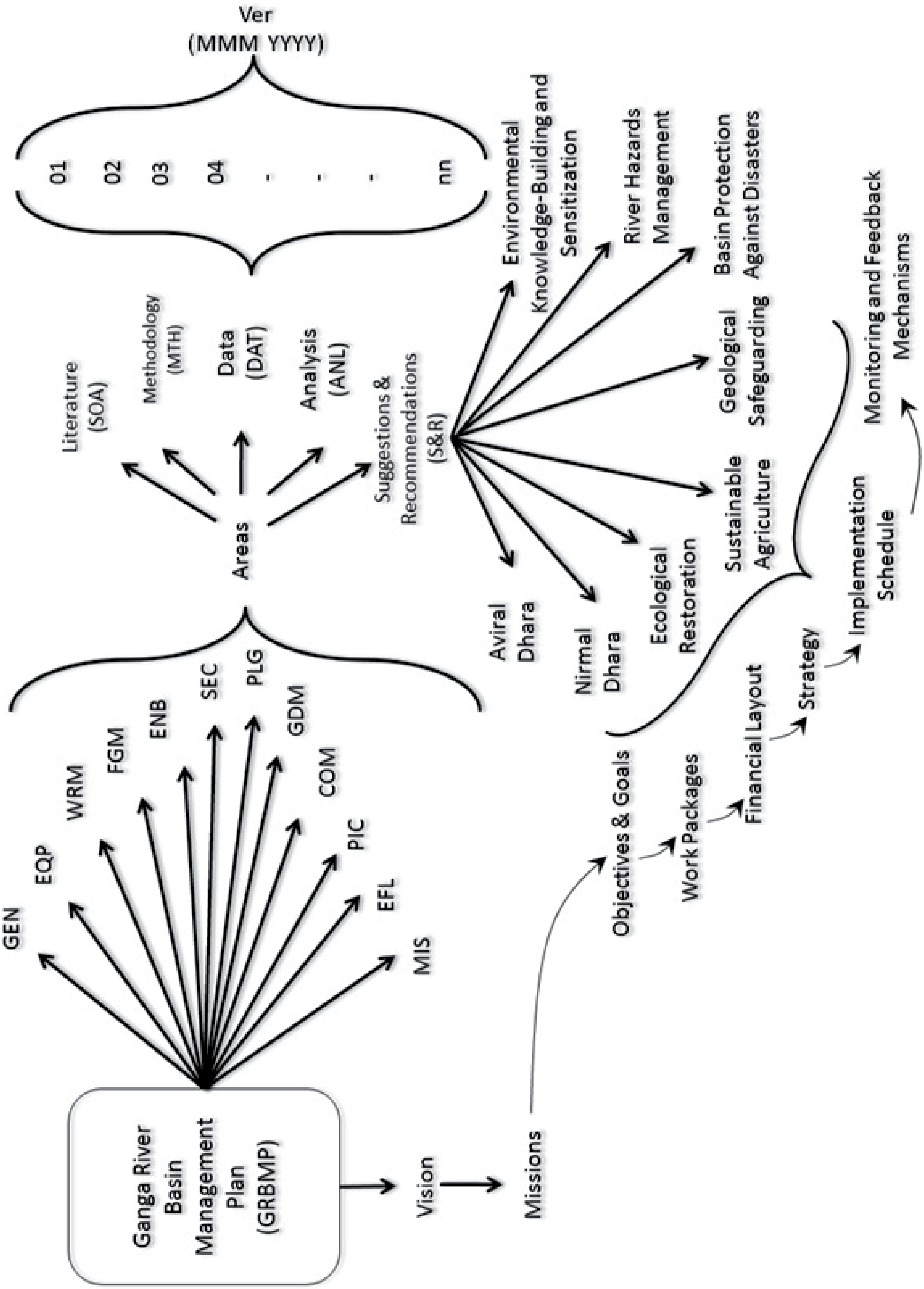

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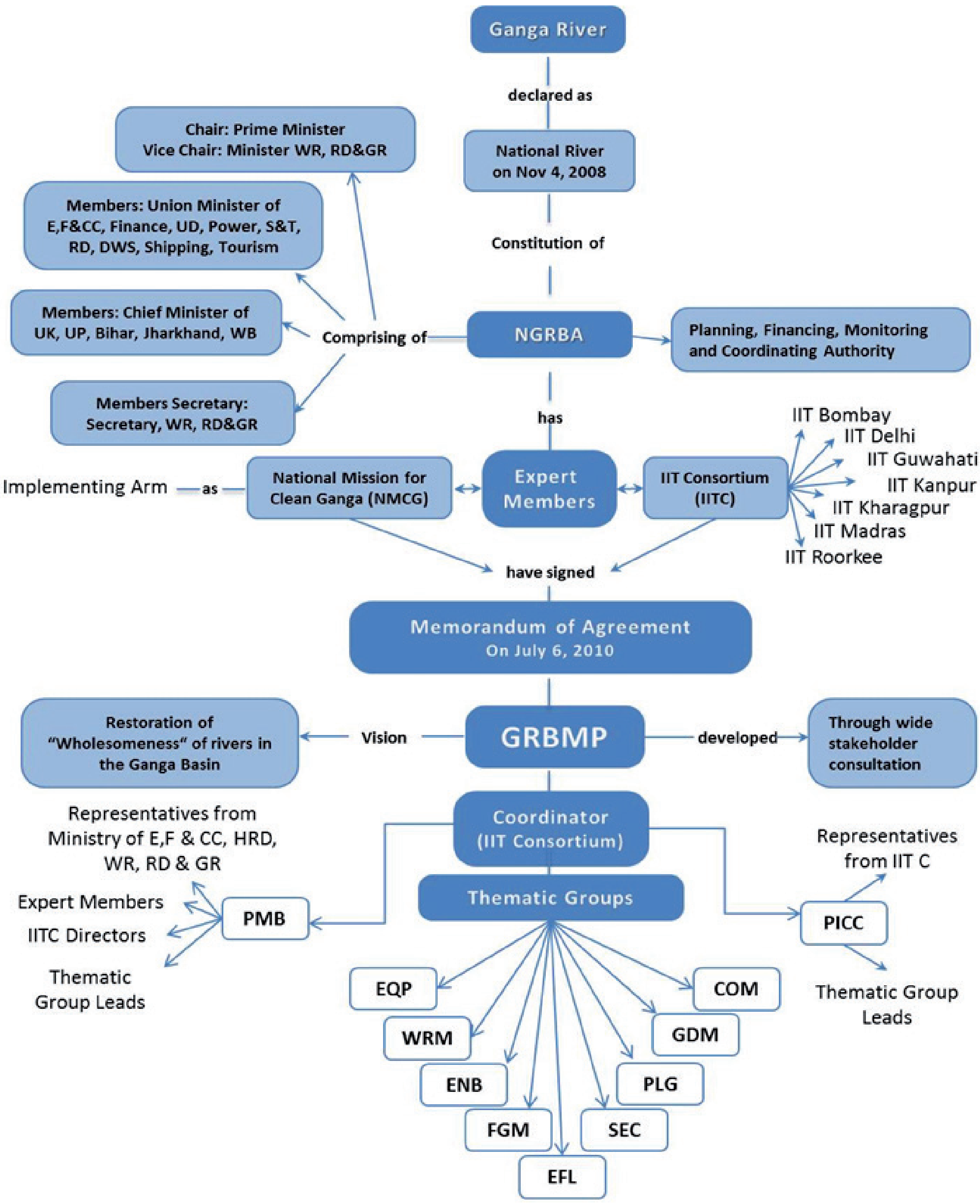
ORGANIZATIONAL STRUCTURE FOR PREPARING GRBMP



NGRBA: National Ganga River Basin Authority
NMCG: National Mission for Clean Ganga
MoEF: Ministry of Environment and Forests
MHRD: Ministry of Human Resource and Development
MoWR, RD&GR: Ministry of Water Resources, River Development and Ganga Rejuvenation
GRBMP: Ganga River Basin Management Plan
IITC: IIT Consortium
PMB: Project Management Board
PICC: Project Implementation and Coordination Committee

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