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Determinants of Agriculture Production in Uttar Pradesh, India:A Regional Analysis

Surendra Singh*

*ICAR-National Institute of Agricultural Economics and Policy Research, DPS Marg, PUSA, New Delhi (India)

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***Corresponding Author**
Email:surendra.singh735[at]gmail.com

ABSTRACT

Growth of agricultural sector of an economy depends mainly on economic, ecological, social, technological and institutional factors. Present study tries to take climatic factors in center and link with agricultural production and productivity of food and non-food grain crops during 1980-2010. Deceleration in rainfall and acceleration in temperatures is observed at regional level. Further, imbalance use of agricultural inputs viz., chemical fertilizers one hand and much use of ground water on other hand, has been increased cost of cultivation. Moreover, decline in mean land size is becoming vulnerable in the presence of climate change. Due to, price support policy, high price crops are increasing area share one hand and other hand cheap crops are losing their area share.

1. Introduction

Growth of agricultural sector of an economy depends mainly on economic, ecological, social, technological and institutional factors (Behera, et al., 2007). The economic factors include prices of agricultural inputs and outputs, proximity to inputs and output markets, infrastructure and its linkage to industry, contract farming, access to credit and investment (both public and private), land holding size and occupational pattern (Mathur, et al., 2006). The ecological factors, such as rainfall pattern and its variability, water resources (both ground and surface), quality of soil, temperature and its variability play crucial role on the acceleration of production and productivity of various crops (Husain, 1996). Social factors consists of demographic features, literacy rate determine definitely the qualitative improvement in agricultural sector, whereas the use technological factor, such as high yielding varieties of seeds (HYVs), modern tools and techniques, fertilizers, pesticides depend on the extent and dimension of the economic and social factors (Bowonder, 1981). Finally, institutional factors (both formal and informal) substantiate for accelerating the growth of farming and other allied activity in the agricultural sector (Behera, et al., 2007).

This paper is organised as follows. In the next section, the data set, information about the sources and technical aspects of the estimation model are discussed, which is followed by results and discussion in section III. Concluding remarks are made in the final section.

2. Methods and Materials

2.1 Study Area

Uttar Pradesh is between latitude 24^{o}-31^{o} N and longitude 77^{o} - 84^{o} E. It is the India's fourth largest and the most populated state (Census, 2011). It has a population of about 199,581,477. There is an average population density of 828 person per KM^2. With an area of 243, 290 KM^2, Uttar Pradesh covers a large part of the highly fertile and densely populated upper Gangetic Plain region. It also has more than 31 large and small rivers, major one being the Ganges, Yamuna, Sarayu and Ghaghara (GoI, 2017). The climate of Uttar Pradesh is predominantly sub-tropical; however, weather conditions change significantly with location and season (IMD, 2017). Depending on the elevation, the average temperatures vary from between 12.5-17.5^{0}C in January to 27.5-32.5^{0}C in May and June (IMD, 2017). Rainfall in the state ranges from between 1,000-2,000 millimetre in the east to 600-1,000 millimetre in the west (IMD, 2017). About 90 percent of the rainfall occurs during the southwest monsoon, lasting from approximately June to September (IMD, 2017). Uttar Pradesh consists four economic regions, viz., Western, Eastern, Central and Bundelkhand and 75 districts (Table A.1).

2.2 Data

The present study uses secondary data collected from the various government organizations of India, namely ministry of statistics and program implementation, department of agriculture, cooperation and farmers welfare, ministry of agriculture and farmers welfare. Indian meteorological department of India and department of economics and statistics, Uttar Pradesh. Further, data of major crops, viz., rice, wheat and sugarcane was collected during 1992-2011. Land size data was collected during 1996-2006. Rainfall and temperature data was collected during 1981-2010. Fertilizers consumption data was collected during 1971-2001. Sources of irrigation data was collected during 1971-2003.

2.3 Estimation Method

2.3.1 Compound Annual Growth Rate

The compound annual growth rates (CAGR) of area, production and yield for the selected cereals, pulses and oilseeds were estimated during 1998-2017. The CAGR are usually estimated by fitting a semi-log trend equation.

$$\ln Y = a + \beta t \quad (1)$$

Where, Y is the time series data (1998 to 2017) of area production and yield of the crop, *t* is the trend term and *a* is the constant coefficient. The slope coefficient *β* measures the relative change in *Y* for a given absolute change in the value of the explanatory variable *t*. If we multiply the relative change in Y by 100. We get the percentage change or growth rate in *Y* for an absolute change in variable *t*. the slope coefficient *β*

measures the instantaneous rate of growth. We can calculate the CAGR as follow.

CAGR (r) = (antilog b-1)*100) (2)

2.3.2 Instability Index

Instability index (IIN) has been estimated by regressing the individual land categories with time. When the parameters of log-linear trend found statistically significant, then IIN would be as follows.

$$IIN = CV \times (1-R^2)^{1/2} \quad (3)$$

CV is co-efficient variation of the time series data. If the estimated parameter in the regression is not statically significant, then IIN would be the CV only (Ramasamy et al, 2005).

3. Results and Discussion

3.1 Agricultural Growth and Production

The growth of agricultural products of major crops at all India level has been declining during 90's till recent years (Mathur, et al., 2006). The CAGR of agriculture and allied sector was around 4 percent during 80's and this has come down to 3.5 percent during the first half and 3 percent during the latter half of 90's (Table 1). In the last five years of this decade, this sector has registered only 2 percent growth rate at 1993-94 prices. Further, this is accompanied with recent decline in yields per hectare for number of food crops. There are vast inter-state difference in growth rate of agriculture and even more so for food-grains (Mathur, et al., 2006). The deceleration in growth of major crops in various regions of Uttar Pradesh is also accompanied by decline of yields of major crops during the last 15 years. The CAGR of yield of rice has been declined from 5.6 percent in 80's to 1.15 percent in 90's and again declined in -2.27 percent in the present decade in the state. The growth rates for various crops in different regions also showing either negative growth or deceleration in the recent years. This deceleration can be mainly due to decline of slow growth in productivity or decline of area under cultivation or by both. Further, decline of productivity in recent deceleration syndrome in the state can be attributed due to various reasons such as declining growth under canal irrigation, depletion of groundwater under critical stages in different regions of the state, disproportionate use chemical fertilizer, lowering of the credit deposit ratio, market induced production has made farmers more vulnerable, the process of land reforms is in the back seat, accumulation of environmental degradation to land resources etc. (Diwakar, 2007 andNayak, 2007). Further, the important factor determining for deceleration in yield of important crops in various regions of Uttar Pradesh is accompanied by slow growth in cropping intensity as well as irrigation intensity. So far as cropping intensity is concerned, it is highest in Western region and lowest in Bundelkhand region. It is also accompanied with slow growth in irrigation intensity. Similar regional variation is also observed in case of irrigation intensity over the period under study. No wonder, in all aspects, Western region has highest cropping and irrigation intensity, whereas it is lowest in Bundlekhandregion. The intensity of irrigation clearly reveals that none of the regions have an upward movement during the last 15 years.

Table 1: Region wise CAGR of Major Crops in Uttar Pradesh

Region	Rice		Wheat		Sugarcane	
	1992-02	2003-11	1992-02	2003-11	1992-02	2003-11
Western Region	2.44***	0.43^{NS}	2.62*	0.62^{NS}	9.42^{NS}	-6.95*
	(2.10)	(0.45)	(5.96)	(1.15)	(1.45)	(-4.91)
Central Region	1.15^{NS}	-0.14^{NS}	30.50*	3.06*	4.38*	-7.00*
	(1.12)	(-0.14)	(5.80)	(4.02)	(8.87)	(-4.87)
Bundelkhand	2.04^{NS}	-3.66^{NS}	3.60*	2.08^{NS}	7.38*	69.10*
Region	(0.74)	(-0.52)	(4.74)	(0.62)	(7.93)	(4.67)
Eastern Region	2.54**	-4.74**	2.09*	2.35^{NS}	-5.73^{NS}	2.13^{NS}
	(2.61)	(-2.64)	(3.30)	(-1.87)	(-0.49)	(1.29)
Uttar Pradesh	1.51^{NS}	-2.27**	2.15*	0.35^{NS}	0.93^{NS}	-3.94*
	(1.52)	(-2.61)	(4.40)	(0.44)	(1.52)	(-3.55)

Source: Estimated from the Department of Economics and Statistics, Uttar Pradesh, Parenthesis values are t- values.

3.2 Factors affecting the Agricultural Sector

3.2.1 Economics factors

A. Land Holding Size

Operational holding provides minimum land base for subsistence living standard of the people who depend on it. Average operational holding was 0.81 hectare in the state in 1995-96 and it has declined marginally to 0.80 in 2005-06 hectare mainly due to increase in number of hand holders in one hand and decline in the operational holdings on the other hand. In addition, Eastern and Central region have lower average operation holding compared to the state level and Bundelkhand region has higher operational holding than other regions (Table 2). This may be attributed that this region has more wasteland/unused land compared to other regions.

Table 2: Region-wise Average LandHolding size in Uttar Pradesh

Region	Marginal	Small	Semi-Medium	Medium	Large	Average
1995-96						
Western	0.42	1.42	1.56	5.47	14.80	0.91
Central	0.42	1.44	2.37	5.41	15.33	0.81
Bundelkhand	0.48	1.48	2.82	5.88	14.41	1.73
Eastern	0.35	1.36	2.46	5.47	15.99	0.64
Uttar Pradesh	0.39	1.41	2.11	5.53	15.04	0.81
2000-01						
Western	0.41	1.42	2.77	5.46	14.81	0.96
Central	0.43	1.41	2.71	5.44	12.65	0.80
Bundelkhand	0.49	1.47	2.79	5.94	13.63	1.56
Eastern	0.37	1.39	2.69	5.54	16.99	0.65
Uttar Pradesh	0.40	1.41	2.74	5.57	15.07	0.83
2005-2006						
Western	0.42	1.42	2.75	5.45	15.48	0.93
Central	0.42	1.40	2.70	5.40	15.56	0.76
Bundelkhand	0.46	1.37	2.76	5.86	14.03	1.49
Eastern	0.37	1.39	2.69	5.47	16.54	0.62
Uttar Pradesh	0.40	1.40	2.73	5.55	15.20	0.80

Source: Agricultural Census in Uttar Pradesh.

Moreover, inequity in the distribution of operational land holders and area under cultivation plays a crucial distributional factor for poverty reduction vis-à-vis economic development of a region. Nearly, 77 percent of the total land holders are marginal farmers, who hold only 37 percent of the total area under operation in the state during 2000-01(Table 2). On the other hand, 14 percent of the total land holders are small farmers, who hold 24 percent of the total area under operation. Similarly, semi-medium and medium farmers constitute 9 percent of the total operational holders, who holds nearly 36 percent of the total area. Importantly, large farmers constitute nearly 0.14 percent of the total operational holders hold nearly 3 percent of the total area under cultivation. Similarly kind of disproportionate distribution of area under operational land among various categories of farmers is observed in Western region followed by Central, Eastern and Bundelkhand region. The estimation of Gini-coefficient also confirms the level of inequality of operational holding and area under cultivation among different category of farmers in the State (Table 2). However, highest level of inequality prevails in Bundelkhand region followed by Western, Central and Eastern region of the State (Table 3).

Table 3: Region-wise Inequality of Operation holding and Area under Cultivation in Uttar Pradesh

Region	1995-96	2000-01	2005-06
Western	0.42	0.46	0.43
Central	0.40	0.40	0.38
Bundelkhand	0.51	0.49	0.50
Eastern	0.40	0.38	0.35
Uttar Pradesh	0.44	0.44	0.42

Source: Estimated from Agricultural Census in Uttar Pradesh.

3.1.2 Ecological factors

Climate is one of the significant factors that determine the agricultural land use, cropping pattern and change in productivity. Climate consists of rainfall, temperature, humidity, sunshine, and length of growing seasons, fog frost, moisture conditions and winds (Husain, 1996). All these climatic elements individually and collectively determine the cropping pattern of a region. Climatic factors are also inter-related. The effect of each is modified by the other. Daily and annual variations in any or all of the climatic elements are also important in determining the efficiency of crop growth and output per unit of area. The micro climate and weather conditions around the plant are also of vital significance because they affect the output of crops favorably or adversely (Husain, 1996). Hence, it is important to analyse the link between climatic condition and suitability of different crops in these regions.

A. Rainfall

Rainfall is crucial factor, which determine the production and yield of major crops of a particular region. However, the variation of the annual rainfall or the variation of rainfall during a crop season plays a crucial role for the variation of the yield rate of major crops as the surface and groundwater also

directly or indirectly depend on rainfall. The average annual rainfall in Uttar Pradesh has declined from 960 cm in 80's to 901 cm in 90's and again drastically declined to 795cms.during 2001-10. Highest precipitation occurs in Eastern region, whereas it is lowest in Western region of the state. However, highest level of productivity along with production occurred in western region is mainly due to assured irrigation services. More than 78 percent of the rainfall is received during the period from June to October (Table 4). Rainfall during a year is highly uneven and uncertain in the regional level as well as state level. From June to October, the wet crop like paddy production is possible if monsoon is favorable. As the data show, rainfall becomes very much negligible and sometimes becomes nil during the period from October to March. Therefore, irrigation (both surface and groundwater) is highly essential for increasing cropping intensity, changing cropping pattern towards high valued crops, productivity and eventually eradicating poverty.

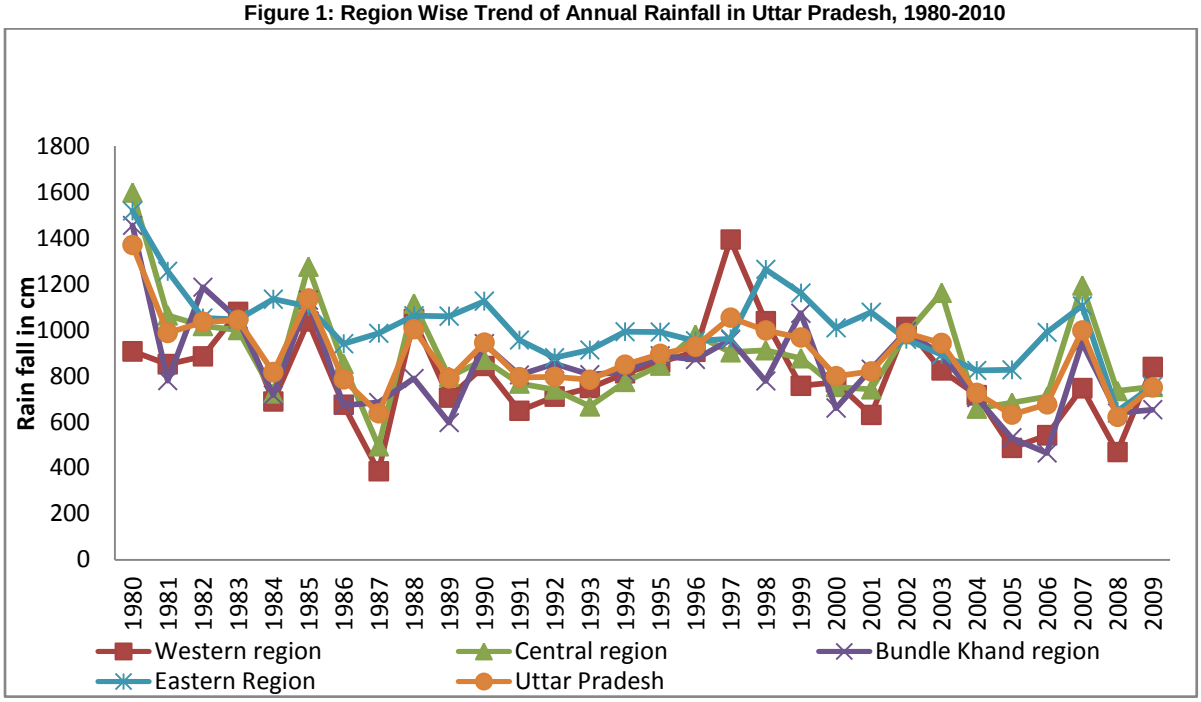
Table 4: Decade wise Mean of Annual Rainfall in various Regions of the State

Period	Western	Central	Bundelkhand	Western	Uttar Pradesh*
1981-1990	826.16	994.15	905.43	1115.10	960.21
1991-2000	871.44	834.20	878.71	1019.35	900.92
2001-2010	703.83	837.50	731.15	908.28	795.19

Source: Estimated from Agricultural Statistics, Department of Agriculture, Government of Uttar Pradesh. Note: The rainfall of Hill region is excluded for easiness in estimation.

Variation of the annual rainfall affects the pattern and productivity of the crops in various regions because the level moisture, groundwater recharge and level of surface irrigation depend on level of current as well as previous year's rainfall. The trend of region wise rainfall shows high degree of variability during 1980-81 to 2009-10 in various regions as well as state level (Figure 1). Heavy fluctuations in rainfall pattern in a particular place affect the cropping pattern, productivity, profitability and living pattern of the people. It is clearly reflected here that the amount of rainfall in a particular year or season is not at all constant, which could be conducive for particular crop.

Figure 1: Region Wise Trend of Annual Rainfall in Uttar Pradesh, 1980-2010



Source: Estimated from Indian Meteorological Department of India, Pune, India.

The instabilityof the rainfall analyses the level of variation across the years, which affect the crop production and productivity in regions. However, the variation of rainfall in the state is highest for the present decade followed by 80's and 90's. The regional analysis reveals clearly that the level of instability is highest in case of Western region followed by Central, Bundelkhand and Eastern region (Table 5). The level of instability in Western region is highest during the present decade, which confirms with the lowest growth of food grains and other crops in the present decade. The degree of variability in rainfall is highest in the present decade in central region of the state, where majority of the crops are decelerated during the last 5 recent years. The fate of Bundelkhand region also facing same situation as it has low rainfall with high variability. The Eastern region faces high level of rainfall compared to other regions with low instability, which favors better yields but other factors might have affect much more for the low productivity in the region.

Table 5: Region wise Instability of Rainfall during 1980-81 to 2009-10

Period	Western	Central	Bundelkhand	Western	Uttar Pradesh
1980-1990	23.77	27.16	25.33	11.47	15.54
1991-2000	23.69	10.82	12.96	9.26	11.35
2001-2010	29.81	21.01	25.18	19.11	21.17
1980-2010	26.60	22.93	22.76	15.21	17.53

Source: Estimated from Agricultural Statistics, Department of Agriculture, Government of Uttar Pradesh.

B. Temperature

The growth of crops, the agricultural operations and agricultural patterns are closely influenced by the prevailing temperature of a region. The agricultural scientists have proved that each crop requires a specific temperature below/above which it cannot be grown (Husain, 1979). There is also an optimal temperature in which the crop produces greatest strength. The upper temperature limit for plant growth is 60^0c and over 40^0c crops dry up if moisture supplies are inadequate. Moreover, under high temperature, the growth of plants is retarded (Husain, 1996). In contrast to the high temperature, the crops have also a minimum temperature limit. The chilling and freezing temperature have great adverse impact on the germination, growth, ripening and yields of crops.There is no much variation in the highest and lowest temperature in the regions of the state during 1980-2010 (Table 6). However, maximum highest temperature is observed in Bundelkhand region followed by Central, Eastern and Western region in the State. Similarly, minimum lowest temperature is observed in the Western region followed by Western, Eastern, Bundelkhand and Central regions of the state.

Table 6: Region wise mean of Highest and Lowest Temperature during 1980-81 to 2009-10

Temperatures	Year	Western	Central	Bundelkhand	Eastern	UttarPradesh
Average of Highest Temperature	1980-90	43.91	44.03	45.53	43.96	43.13
	1991-2000	44.92	44.63	47.14	44.73	43.77
	2001-10	43.40	43.91	44.93	44.60	44.46
Average of Lowest Temperature	1980-90	3.87	4.55	4.70	5.23	4.21
	1991-2000	4.00	4.58	4.25	4.60	3.89
	2001-10	3.44	4.57	4.68	4.21	4.23

Source: Various Volumes of Statistical Dairy, Government of Uttar Pradesh.

3.1.3 Technological Factors

A. Soil Fertility Decline

Decline in the fertility of soil is precisely described as deterioration in physical, chemical and biological properties of the soils. It occurs through a combination of lowering of soil organic matter and loss of nutrients. The main processes involved such as lowering of soil organic matter with associated decline in soil biological activity, degradation of soil physical properties (structure, aeration, water holding capacity) as brought about by reduced organic matter, adverse changes in soil nutrient resources, including reduction in availability of the major nutrients, i.e., nitrogen, phosphorous, potassium, buildup of toxicities, primarily acidification through incorrect fertilizer use.

Over the last 35 years, there has been a large increase in fertilizer consumption in India associated with the introduction of
high yielding crop varieties. This has become major reason for increase of crop productivity. However, inter related set of soil fertility problems has been reported, directly or indirectly associated with fertilizer consumption (Bowonder, 1981). Soil fertility problem have been reported due to imbalances in fertilizer application. Fertilizer use in the region is dominated by nitrogen, N: P and N: K ratios are higher than in the other parts of the world. The N: P: K ratio for India is 1:0.33:0.17 compared with 1:0.52:0.40 for the world (FAO, 1994). When fertilisers are first applied to a soil, high response is frequently obtained from nitrogen. The improved crop growth depletes the soil of other nutrients (FAO, 1994). The consumption of nitrogen and potassium has been increasing dramatically over the years in the state. Similar kind of trend is also observed in all the regions of the state (Table 7). Moreover, the NPK ratio is observed unbelievable in Bundelkhand region due to the application of negligible amount potassium in the soil.

Table 7: Region wise Fertilizer Consumption in Uttar Pradesh ('000' tones)

Region	Year	Total Fertilizer	Nitrogen	Phosphatic	Potassic	Ratios
Uttar Pradesh	1970-71	410.54	291.43	74.51	44.61	7:2:1
	1980-81	1150.59	860.64	209.34	80.61	11:3:1
	1990-91	2240.91	1690.66	453.98	96.26	18:5:1
	2000-01	2961.82	2206.5	662.09	93.24	24:7:1
	2010-11	5088.409	3476.864	1253.453	358.092	10.4.1
Central	1970-71	27.51	20.32	4.47	2.73	7:2:1
	1980-81	97.15	75.21	15.47	6.47	12:2:1
	1990-91	207.06	156.72	41.79	8.54	18:5:1
	2000-01	304.24	216.51	80.84	6.9	32:12:1
	2010-11	973.85	6671.16	245.51	61.17	109:4:1
Eastern	1970-71	151.71	104.18	28.31	19.22	5:1.50:1
	1980-81	399.91	295.55	71.89	32.45	9:2:1
	1990-91	696.46	496.27	163.69	36.51	14:4.50:1
	2000-01	913.54	684.52	196.51	32.53	21:6:1
	2010-11	1760.42	1161.23	467.06	132.12	9:4:1
Bundelkhand	1970-71	7.45	4.83	1.89	0.75	6.5:2.5:1
	1980-81	27.76	17.56	9.13	1.06	17:9:1
	1990-91	58.99	36.88	21.61	0.52	71:42:1
	2000-01	79.11	45.3	33.63	0.21	215:160:1
	2010-11	242.91	152.76	75.60	12.55	12:6:1
Western	1970-71	195.2	141.61	35.05	18.58	8:2:1
	1980-81	546.57	416.51	96.07	34.01	12:3:1
	1990-91	1020.24	762.74	220.78	36.7	21:6:1
	2000-01	1367.89	1051.34	270.91	45.61	23:6:1
	2010-11	2111.21	1495.70	465.27	150.23	10:3:1

Source: Various Volumes of Centre for Monitoring Indian Economy and Statistical Abstract.

The impact of excess and disproportionate consumption of fertilizers has been explained variously. The crops and plants cannot take all the fertilizers applied and significant portion is lost in the soils. It means application of more than the required quantity of fertilizers remains in the field, ultimately leads to polluting the soils. The excess or inappropriate consumption of various fertilizers than the recommended quantity or ratio leads to polluting the soil, which ultimately causes for the decline of productivity of various crops. The excess amount of nitrogen applied in the soils automatically converts into nitrate. As nitrate is not observed by most soils, it remains in solution. If it is not taken up by plant roots, it is either washed into the drainage water or biologically reduced to dinitrogen gas. Nitrate that is washed out of the soil represents an economic loss to the farmers and possible health hazard if it reaches drainage water (Wild, 2003). Dev et al. (1995) found that one of the effects of excessive fertilizer use is the contamination of ground water. Rao (1994) found that the major source of environmental degradation in rural areas is the misapplication of yield increasing inputs like water, chemical fertilizers, and pesticides causing waterlogging, salinity and pollution of drinking water and loss of fish etc. The subsidy on urea has resulted in an unbalanced use of nitrogen, phosphorous, and potassium fertilisers, which was in the ration of 8.5:3.1:1 in 1998-99 as against the desirable ratio of 4:2:1. This has led to decline in the productivity of fertilisers apart from depleting soil nutrients. A change towards balanced use of NPK by raising both P and K per unit of N would raise output by 2 million tones in India (Rao, 2005). However, chemicalization of agriculture may pose a greater threat to the rural economy at much higher levels of application of chemical fertilizers and pesticides. High doses of fertilizer lead to salinity in the soil (Singh, 1997).

3.1.4 Institutional Factors

A. Irrigation Pattern

Irrigation is the most important input, which acts as catalyst for sustainable agricultural growth and promotes for the use of other inputs such as chemical fertilizer, HYV seeds. Therefore, sustainable use of irrigation (both surface and groundwater) is prime concern for the survival of the agricultural sector. However, irrigation sector in recent years in Uttar Pradesh especially after mid-90's faces serious bolt in growth of canal irrigation, changes towards heavy use of groundwater and faces other ecological, policy and institutional hindrances.

B. Growth of Irrigation in the State

The declining or constant trend of major crops inthe recent years in the state is largely depending on the performance of the irrigation sector as irrigation covers nearly 75 percent of the net sown areas. However, the net irrigated area has increased from 62.55 lakhs hectares in 1966-67 to 94.53 lakh hectares in 1980-81 and again increased to 128.28 lakhs hectares in 2001-02. The proportion of net irrigated area to net cropped area has increased from 36.12 percent in 1966-67 to 54.89 percent in 1980-81, again increased to 73.70 percent in 2000-01 and

76.30 percent in 2001-02. Moreover, the net irrigated area by private sources such as private tube-well/pump sets constitute nearly 87.09 lakh hectares, which is 68 percent of the net irrigated area, whereas major and medium sources through canal irrigation possesses at 27.19 lakh hectares, which is nearly 21 percent of the net irrigated area in the same year. The canal irrigation has increased continuously up to 1985-86, after that showed constant trend till 1995-96. Beyond 1995-96, the expansion of canal irrigation shows a continuous declining trend. It is observed that there has been disproportionate growth of irrigation by sources during the study period in the state. The growth rate of net irrigated area shows continuous positive growth in all sub-periods, where as it has declined from 2.70 percent in seventies to 0.80 percent in eighties and marginally increased to 1.30 percent in nineties. However, the growth of net irrigated area is mainly supplemented by a continuous positive growth in private tube-well in all the sub-periods (Table8). On the other hand, growth of canal irrigation shows a dismal performance, as it declined from 2.60 percent in seventies to -0.70 percent in eighties and again declined to -1.80 percent in nineties. However, the proportion of other forms irrigation is not much significant. It is clear that growth of net irrigation in nineties is lower than that of seventies.

Table 8: CAGR of Are under various forms in Irrigation in Uttar Pradesh during 1970-2003

Irrigation systems	1970-71 to 1980-81	1980-81 to 1990-91	1990-91 to 2002-03	1970-71 to 2002-03
Canal	2.60*	-0.70***	-1.80*	0.40**
Tube-well	8.30*	2.50*	2.80*	4.20*
Other Tube-wells	-16.30**	-6.80*	3.00***	-3.40*
Tanks	-7.70*	-5.40*	0.30***	-5.20*
Others	0.70	0.80	-13.30	-1.20*
Net Irrigated Area	2.70*	0.80*	1.30*	1.90*
Irrigation Intensity	-0.20	2.30*	-0.10	0.90*
Gross irrigated area	2.80*	3.00*	1.5*	1.5*

Source: Various Volumes of Centre for Monitoring Indian Economy.

The decline of productivity is mainly due to decline of gross irrigated area, though there has been marginal increase of net irrigated area. The gross irrigated was increased from 52 lakh hectares in 1950-51 to 84 lakh hectares in 1970-71. However, it was increased again 148 lakh hectares in 1990-91. The trend of gross irrigated areas become uneven during nineties, as there is no clear positive trend during the same period. However, both gross irrigated area and net irrigated area have been remaining constant or declining during 1998-99 to 2002-03, as the canal irrigation was declining constantly during the same period. The trend of gross irrigated area is supplemented by irrigation intensity in the state. However, irrigation intensity depends on the irrigation areas in Kharif, Rabi and Zaid seasons. Out of 160 lakhs gross irrigated area, irrigation in Kharif season constitute nearly 54 lakhs, irrigation in Rabi season constitute nearly 100 lakh hectares, whereas irrigation in the Zaid season is having 6 lakhs only in 1992-93. Whereas, the gross irrigated area increased to 182 lakh hectares in 2001-02. Out of 182 lakh hectares, irrigation in Kharif season constitute nearly 68 lakhs, irrigation in Rabi season constitute nearly 108 lakh hectares, whereas irrigation in the Zaid season remain constant at 6 lakhs only during 2001-02. Moreover, out of 168 hectares of net sown area, only 108 lakhs hectares are irrigated in the Rabi season. Hence, there is plenty of scope to increase the net irrigated area under crops in the Rabi season by canal as well tube-well irrigation. It has been observed that irrigation area under Zaid season remains constant or marginal increase during the last 10 years. Hence, due to slow increase irrigation intensity causes slow progress of gross irrigated area make slow growth of total production, that eventually makes the productivity trend constant or decline. Therefore, it may attribute here that there is lot scope to increase the potential for irrigation in the Rabi and Zaid season through both canal and ground water extraction in under exploited areas of the state.

The private and public irrigation is broadly classified under groundwater, minor surface irrigation, and major and medium canal irrigation. Groundwater irrigation mainly used both by private and public tube-well, shallow tube-wells, dug-well and deep tube-wells. However, minor surface irrigation is mainly by both public and private sector consists of the development of tank irrigation, reservoir, and lake. Finally, major and medium irrigation (canal irrigation) is mainly developed by public sources through the construction of dams over the rivers. It is urgently felt the role of both private and public sector irrigation under these major sources at the national and state level.

It is observed that the share of canal irrigation (both major and medium irrigation) and surface minor irrigation has declined on the one hand and the share of ground water irrigation (private and public) has increased drastically on the other hand. In a broad sense, the share of public irrigation has declined on the one hand and the share of private irrigation has increased on the other hand. As a consequence of the use of large number of private tube-well and state tube-well, the irrigated area under tube-well has increased from 23.30 lakh hectares (32 percent of the net irrigated area) in 1970-71 to 91.58 lakhs hectares (72 percent of the net irrigated area) in the state during 2001-02 (Table 9). This is reflected that the CAGR of private pump sets in eighties is 9.20 percent and it has declined to 5.50 percent in nineties and again declined to 4.12 percent in first four years of the present decade. It is reflected that tube-well irrigation is the dominant form of irrigation among all types of irrigation as it has its own advantages. This has been resulted due to the introduction of free boring scheme, which recommended heavy doses of subsidy for the development of groundwater in the state. Under the programme, free boring facility to the extent of Rs. 3000 was provided to small and marginal farmers. Additionally, subsidies of 33.3 percent and 50 percent were provided to small and marginal SC and ST farmers respectively for the purchase of electric or diesel pumps (Pant, 2004: 2005). As a

result, the number of both diesel and electric pumps sets has increased 17.63 lakhs in 1990-91 to 37.76 lakhs in 2004-05. This has been resulted to increase the share of private irrigation from 54 percent in 1970-71 to 75 percent in 2001-02 on the one hand and sharp decline of the share of public irrigation from 45.82 percent in 1970-71 to 24.70 percent in 2001-02.

Table 9: Development of Various types of Irrigation in Uttar Pradesh (in lakh hectares)

Year	Canal (Major and Medium)	Tube-wells (Groundwater)	Minor surface	Total Public	Total Private	Total
1970-71	24.98	23.30	23.91	33.07	39.11	72.18
	(34.60)	(32.28)	(33.12)	(45.82)	(54.18)	(100)
1980-81	31.78	50.53	12.22	31.78	12.22	44.00
	(33.62)	(53.45)	(12.93)	(72.23)	(27.77)	(100)
1990-91	31.93	65.63	7.86	39.04	66.38	105.42
	(30.29)	(62.26)	(7.46)	(37.04)	(62.96)	(100)
2000-01	27.49	89.42	7.09	33.40	90.60	124.00
	(22.17)	(72.11)	(5.72)	(26.94)	(73.06)	(100)
2001-02	27.19	91.58	9.51	31.68	96.60	128.28
	(21.20)	(71.39)	(7.41)	(24.70)	(75.30)	(100)
2010-11	25.39	96.07	11.54	41.80	91.29	133.13
	(18.90)	(71.50)	(8.60)	(31.40)	(68.60)	(100)

Source: Various Volumes of Statistical Dairy, Government of Uttar Pradesh. Note: Parenthesis values are percentage

The trend of gross irrigated areas become highly slow 90's, as there is no clear positive trend during the same period. The declining trend of gross irrigated area is mainly due to declining trend of canal irrigated area. However, net irrigated area have been remaining constant or declining during 1998-99 to 2004-05, as the canal irrigation was declining constantly during the same period (Nayak, 2006a). It has been observed that irrigation area under Zaid season remains constant or marginal increase during the last 10 years. Hence, due to slow increase irrigation intensity causes slow progress of gross irrigated area make slow growth of total production, that eventually makes the productivity trend constant or decline. It is observed that the share of canal irrigation (both major and medium irrigation) and surface minor irrigation has declined on the one hand and the share of ground water irrigation (private and public) has increased drastically on the other hand. In totality, the share of public irrigation has declined on the one hand and the share of private irrigation has increased on the other hand. As a consequence of the use of large number of private tube-well and state tube-well, the irrigated area under tube-well has increased from 23.30 lakh hectares (32 percent of the net irrigated area) in 1970-71 to 94 lakhs hectares (72 percent of the net irrigated area) in the state during 2004-05.

4. Conclusion

The agricultural growth depends on the combined effect of ecological, economic, technical and institutional factors of the country. Further, the overall economic development of the nation and its regions depend on the overall agricultural performance of the state. The study observed that there has been drastic decline of average annual rainfall during 1980-90 to 1990-2000 and 2001-2010 in all regions of the state. This is further substantiated by very high level variation in annual rainfall in all the regions of the state. The regional analysis of instability of rainfall further reveals that the level of instability is highest in case of Western region followed by Central, Bundlekhand and Eastern region of the state. This is probable one of the most important factors which influence the agricultural performance of the state. However, mean of both maximum and minimum temperature have not been distorted much at the regions of the state. Moreover, the irrigation sector plays a crucial role for stabilizing the uncertainty of rainfall for overall development of the agricultural sector in the state. However, the interlude of this sector is mostly due to failure of public and institutional policy, which eventually resulted serious environmental degradation in the form of waterlogging and salinity in the state. Further , some of the economic factors such as high proportion of marginal and non-workers, decline of land-man ration and increase in the inequity in distribution of operational holding along with above mentioned factors affects the agricultural growth and economic development of various regions of the state.

References

1. Behera B and P Mishra 2007. Acceleration in Agricultural Growth in India: Suggestive Policy Framework.Economic Political Weekly, 42(42): 4268-4271.
2. Bowonder, B. 1981. The Myth and Reality of High Yield varieties in Indian Agriculture,Development and Change 12(20): 293-313.
3. Diwakar D M 2007. Growth Linkages in Agriculture of Uttar Pradesh. In Development Challenges: Afflicting Uttar Pradesh, D M Diwakar and Sanatan N (eds.). Manak Publication, New Delhi. 125-140.

4. Food and Agricultural Organisation 1994.Land Degradation in South Asia: Its Severity, Causes and Effects upon the People. World Soil Resources Report, Rome. 12-20.
5. Government of India 2002. 10th Five year Plan.2. Department of Planning, New Delhi. 136-150.
6. Government of India 2017. Annual Report. Indian Meteorological Department of India, New Delhi.
7. Government of Uttar Pradesh 2002-03. Tenth Five Year Plan and Annual Document. 1. State Planning Institute, Lucknow. 1-12.
8. Gulati A Ruth Meinzen-Dick. K.V. Raju 2005.Institutional Reforms in Indian Irrigation. Sage Publication, New Delhi. 56-70.
9. Husain M 1996.Agricultural Geography.Rawat Publications, New Delhi.45-60.
10. Indian Council of Agricultural Research 2006.Handbook of Agriculture, New Delhi. 1-15.
11. Jurel, R.S et al 2003. Impact of Groundwater Irrigation agriculture and Environment in the Gangetic plains of Uttar Pradesh. In National Symposium on Water Resources Management and Development with Reference to Ganga Basin.Organised by Irrigation Department, Government of Uttar Pradesh. 1.9.
12. Kolavalli S and J Kerr 2002. Scaling up participatory watershed development in India,Development and Change. 33(2): 213-235.
13. Krantz, L 2001. The Sustainable Livelihood Approach to Poverty Reduction: An Introduction. Swedish International Development Cooperation Agency. 25-31.
14. Mathur Archana S Surjit Das and Subhalakshmi S 2006. Status of Agriculture in India: Trends and Prospects. Economicand Political Weekly 41(52): 5327-5336.
15. Mishra Pranja P 2009. Coal Mining and Rural Livelihood: Case of the Ib Valley Coalfield, Orissa. Economic Political Weekly 44(44): 117-123.
16. Narayanamoorthy A 2007. Deceleration in Agricultural Growth: Technology Fatigue or Policy Fatigue?.Economic Political Weekly, 42(25): 2375-2379.
17. Nayak S 2006.Waterlogging in Eastern Region of Uttar Pradesh: Extent, Causes and Policy Interventions. A paper presented in the National Seminar on Conservation, Management and Development of Land Resources with Special Reference to Eastern Region of Uttar Pradesh, at G. B. Pant Social Science Institute, Allahabad. 1-16.
18. Nayak S 2006a. Agricultural Growth and Development of Irrigation in Uttar Pradesh: The Linkages.UPEA Economic Journal, 1(1): 35-36.
19. Nayak S (2006b. Are Groundwater irrigation Common Pool Resources? District level analysis in UP.UPEA Conference Volume, GIDS, Lucknow. 42-60.
20. Nayak S 2007.Plight of Irrigation Sector in Uttar Pradesh. In Development Challenges: Afflicting Uttar Pradesh. Diwakar, D. M. and SanatanNayak (eds.).Manak Publication, New Delhi. 52-65.
21. Nayak S 2008.Does Distributional Inequality led to Degradation of Natural Resources? An Analysis of Groundwater Irrigation in Villages of Uttar Pradesh, India.In "International Conference on Water Resources Policy in South Asia", held at Colombo during December 17-20, 2008, organised by SaciWATERs, Hyderabad. 35-41.
22. Nayak S 2009. Distributional Inequity and Groundwater Depletion: An Analysis across Major States in India.Indian Journal of Agriculture Economics, 64(1): 89-107.
23. Nayak S G S Mehta A K Singh 2007.Study on The Impact and Effectiveness of Training and Capacity Building Undertaken under the UP Sodic Land Reclamation Project-II, submitted to UPBSN, Giri Institute of Development Studies, Lucknow. 110-120.
24. Oblitas K JReymond P 1999.Transferring Irrigation Management to Farmers in Andhra Pradesh, India. The World Bank, Washington D.C. 20-36.
25. Rao and Simhadri 1989.Development Dynamics in Command Area of Major Irrigation Projects. Inter India Publications, New Delhi. 12-32.
26. Rao C H Hanumantha 1994. Agricultural Growth, Rural Poverty and Environmental Degradation. Oxford University Press, New Delhi. 1-25.
27. Rao C H Hanumatha 2005.Agriculture, Food Security, Poverty and Environment: Essays on Post-Reform India. Oxford University press, New Delhi. 17-30.
28. Saini G R 1971. Holding Size, Productivity and Some Related Aspects of Indian Agriculture.Economic Political Weekly, 6(26): 5-11.
29. Sengupta, N 2002. Traditional vs Modern Practices in Salinity Control. Economic Political Weekly,(37)13: 1247-1254.
30. Sharma H R and R K Sharma 2000. Farm Size Productivity Relationship: Empirical Evidence from an Agriculturally Developed Region of Himachal Pradesh.Indian Journal of Agriculture Economics, 55(4): 605-617.
31. Singh A K 1997.Land Use, Environment and Economic Growth in India. MD Publications Pvt. Ltd, New Delhi. 12-30.
32. Subrahmanyam S and P. S. Sekhar 2003. Agricultural Growth: Pattern and Prospects.Economic Political Weekly 38(12-13): 1202-1211.
33. Umali Dina L 1993. Irrigation-Induced Salinity: A Growing Problem for Development and the Environment.World Bank Technical Paper.215. The World Bank, Washington, D.C. 23-36.
34. WildA 2003.Soils, Land and Food: Managing the Land during the Twenty first Century. Cambridge University Press, Cambridge. 15-36.

Table A. 1: Economic Region Wise Distribution of the Districts in Uttar Pradesh

Economic Region	Location	Districts	Geographical Area (in Sq. Km.)
Western	Between 26°21'N to 30°25' to77° 10' Eto80°25' E	Saharanpur, Muzaffar Nagar,Bijnor, - Meerut, Moradabad,Bulandshahar, Rampur,Bareilly, Pilibhit,Sahajahnpur, Badaun,Aligargh, Ghaziabad, Mathura,Etah, Mainpuri, Farukhabad,Etawah, Firojabad and Agra	82,192
Central	Between 25°30'N to 28°40' to79°45' E to81°40' E	Lucknow, Barabanki,Sitapur, Hardoi,Raibareilly, Unnao, Fatehpur,Kanpur Nagar and Kanpur Dehat.	45,843
Eastern	Between 23°50'N to 28°25' to81°45' E to84°40' E	Baharaieh, Gonda, Basti,Siddharthnagar, Mahrajganj,Gorakhpur, Deoria, Ballia,Azamgarh, Mau, Faizabad,Sultanpur, Jaunpur,Ghaziabad, Varanasi,Mirzapur, Sonbhadra,Allahabad and Pratapgarh.	85,804
Bundelkhand	Between 24° 10'N to 26°25' to78°10' E to81°35'E	Banda, Hamirpur, Jalaun,Lalitpur and Jhansi	29,417

Source: Government of Uttar Pradesh, Uttar Pradesh, India