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Indian Agriculture Performance and Climate Change: Emerging Challenges and Option

Dr. Sanjeev Kumar[1], Sanjay Kumar Upadhyay[2]
Department of Economics, University of Lucknow, Lucknow, INDIA

ABSTRACT

Agriculture sector has been playing very important role in the economic development of India. The performance of agricultural sector of India has been remarkable after post green revolution era with some fluctuations. However, there are various factors that influencing the growth of agriculture sector in India. Climate changes or climate sensitivity are one of the main factors which have a very strong linkage with agriculture growth. The growth of the agriculture sector is directly and indirectly effected from the climate changes. Climate changes in term of floods and droughts are affecting the food grain production and it has serious implication for food security at national level. Hence, an attempt is made to analyse the effect of climate variables on food grain production and productivity in India. This paper is also analyses the performance of Indian agriculture since independence. The study based on secondary data for the period of 1950-51 to 2014-15. The regression results show that the climate variables viz. maximum temperature, minimum temperature and rainfall have a significant impact on food-grain production and productivity in during the study period. Therefore, There is need to develop careful management of resources like soil, water and biodiversity to protect the agriculture and solve the problem of food security from the impact of climate changes. It is also necessary to act at the global, national, regional, and local levels, coping with the impact of climate on agriculture and food production.

Keywords-- Agricultural growth, Food-grains, Productivity and Climate changes

I. INTRODUCTION

Climate change plays very important role for increasing agricultural productivity as well as economic growth of the country. Raising temperature of the earth surface and in atmosphere, fluctuation in rainfall, declining ground water, flooding due to high rainfall, drought soil erosion, heavy wind, rising sea level due to melting of glacier, cyclone, wind speed, hail storm, fog, earthquake, and landslide are all the evidence of climate change. On the other hand, human activities are also responsible for changing climatic variables due to growing population, rapid urbanization, higher industrialization, use of modern technology, innovation, higher economic development, transport, building construction, decreasing forest area. Climate change has emerged major problems of the agriculture sector in India. Climate change is affecting agriculture sector in term of decreasing productivity, declining growth rates, and food security. Similarly, Climatic variations such as occurrence of drought and flood have high impact on agriculture sector as well as socio-economic conditions of the people in India.

Climate change has become very serious problems in the country and world. There are many evidences of climatic change such as rising temperature of earth surface, declining ground water, drought, fluctuation in rainfall, flooding, soil erosions, fluctuation in wind speed, rising sees level due to melting of glaciers, cyclone, hail storm, fog, earthquakes and landslides, increasing ocean temperature. It is clear that natural and human activities both are responsible for climate changes. Natural activities consists earth motion, sun's intensity volcanic eruption, forest fires and the circulation of the ocean. Volcanic eruption increases the large volumes of sulphur dioxide (SO2) and carbon fires in forest area increase the carbon dioxide and carbon mono-oxide. Sun's intensity also increases the many harmful gases in the atmosphere. On the other hand, On the other hand, human activities are also responsible for changing climatic variables due to growing population, rapid urbanization, higher industrialization, use of modern technology, innovation, higher economic development, transport, building construction, and decreasing forest area (Ahmad et al., 2011).These all activities are responsible for increasing Green House Gases (GHGs) in the atmosphere. Increasing quantity of GHGs in the atmosphere is a key factor for climatic variability.

It is noticed that human activities increase carbon dioxide, methane, nitrous oxide, chloro fluorocarbon

(CFC) and gases which are responsible for climate changes in India. It is observed that the concentration of methane (CH4) and carbon dioxide (CO2) gases are increasing in the atmosphere due to high involvement of human activities. Similarly, nitrous oxide (N2O) gases are also increasing in atmosphere due to natural and human activities. The demand of food is increasing in the country. It is observed that food demand will be double by 2050 due to growth of population and it also increase the use of land, water, and other important natural resources (Ahmad et al., 2011). Therefore, food security become major concern in many ways like increasing demand of food with growing population, poverty, and declining agricultural productivity due to climate change in India.

There are several studies on agriculture development as well as climate change at national level. Most of the studies have focused on the various issues on climate change and agriculture. Some of important studies are discussed here. Asha lata, K.V., et al. (2012) have found that climate variation such as occurrence of drought have high level of impact on the yield of rained condition such as yield reduction and reduction in net revenue in India. Joshi, K., & Chaturvedi, P. (2013) has noticed that global temperature is rising and climate conditions become more erratic threat to the vegetation, biodiversity progression and have enduring effect on the food security as well as human health in the country. Javeed, S., & Manuhaar, A. (2013) has shown that climate change is responsible for the decrease in the agricultural productivity. The most vulnerable impact of climate change is on the cereal crops like rice and wheat. Small and marginal farmers are most vulnerable groups because these people have small farm sizes, low capital and technological development. Kumar, K. K.S. (2007) has revealed that double carbon dioxide concentration level, in the latter half of 21st century, the gross domestic product (GDP) would decline by 1.4 to 3.0 percent due to climate change. Mahmood, N. (2012)has observed that temperature and precipitation variables have significant effect on the rice. It is clear that an increase in the temperature by 1.5^{0}C would increase the productivity by 2.09 percent and 4.33 percent respectively. However, an increase in precipitation by 5 percent and 15 percent during September –October adversely affect rice productivity by 5.71 percent and 15.26 percent respectively.

Mahato, A. (2014) has found that climate is one of the most important inputs factors of agricultural sector in the word. However, climate change is effecting agriculture in several ways such as quantity and quality of crops in term of productivity, growth rates, photosynthesis, transpiration rates, and moisture availability. Neenu, S., et al. (2013) have found that climate effects crop productivity in term of quality and quantity. The precipitation conditions and CO_2 contents are rapidly increasing in the atmosphere due to increasing temperature, which are effecting the crop productivity. Rising temperature has decreased the soil moisture and increased the demand of crops for water. Solar radiation also effects on photosynthesis and crop yield. They suggested that the effect of inter-relationship between the climatic factors like temperature, rainfall, solar radiation, CO_2 concentration and crop yield need to be understood to take necessary adaptation measures to maintain crop yield.

There are large numbers of studies highlight that the impact of climate changes on agricultural sector at national level. Many studies found that climate changes are affecting agricultural productivity and food security. But very few studies have attempted to analyse the effect of climate variables such as temperature and rainfall on food-grain production and productivity at national level. Hence, an attempt is made to analyze the impact of climate change on food- grain production and productivity in India.

The major objective of the paper is to analyze systematically the growth of production and productivity under food grain crops and highlighting the impact of climate changes on food grains production and productivity in India. This paper also seeks to explore the issues and challenges of climate changes on agriculture sector in India. The study based on secondary data for the duration 1950-51 to 2014-15.

II. PERFORMANCE OF INDIAN AGRICULTURE DURING PLAN PERIODS

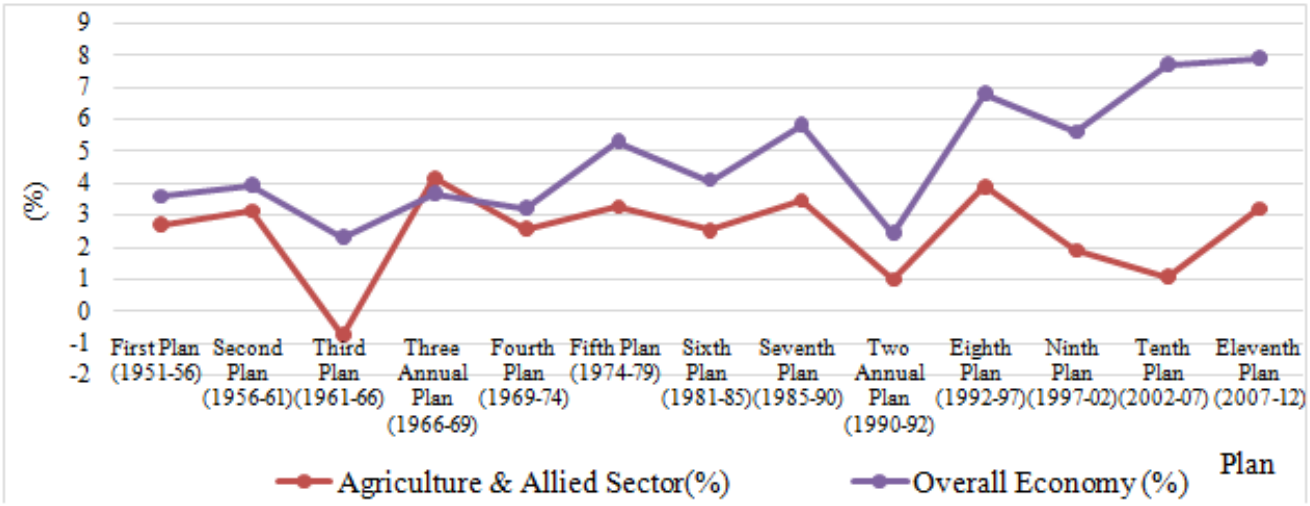
The growth of agriculture sector plays very vital role in the overall economic development of the country. The growth of the agriculture and allied sector was not significant at national level during 1950-51. Therefore, during 1950-51 the aim of the government was to solve the problem of the agriculture sector and achieve higher growth rate. But during this period, the agriculture sector was suffering from various constraints as lack of the capital, lack of irrigation facilities, lack of agricultural machinery, lack of improved fertilizers & pesticides, high yielding varieties of seeds, transportation, power, and marketing, agricultural research institution's, institutional credit and land holdings. The government of India had focused to develop these factors to increase the agricultural growth. Plan wise growth status of India has been shown in the following table-1 and Figure-1. The figures of the tables reflects that the growth of agriculture and allied sector was 2.71 percent and the overall economic growth was 3.60 percent during 1st plan period(1951-56) and increased to3.2 percent and 7.94 percent during XIth plan period(2007-2012) in India.

Table-1: Growth Rate of Agriculture and Allied Sector during the Plan Period in India

SR. NO	Plan	Agriculture & Allied Sector (%)	Overall Economy (%)
1	First Plan (1951-56)	2.71	3.60
2	Second Plan (1956-61)	3.15	3.95
3	Third Plan (1961-66)	-0.73	2.32
4	Three Annual Plan (1966-69)	4.16	3.69
5	Fourth Plan (1969-74)	2.57	3.25
6	Fifth Plan (1974-79)	3.28	5.30
7	Sixth Plan (1981-85)	2.52	4.10
8	Seventh Plan (1985-90)	3.47	5.80
9	Two Annual Plan (1990-92)	1.01	2.47
10	Eighth Plan (1992-97)	3.90	6.80
11	Ninth Plan (1997-02)	1.90	5.60
12	Tenth Plan (2002-07)	1.10	7.70
13	Eleventh Plan(2007-12)	3.2	7.94

Sources-Uttar Pradesh Planning Commission

Fighure-1: Comparative growth rate of Agriculture and allied sector during the plan period in India



Sources- Planning Commission, Govt. of India.

It is observed from the table-1& figure-1 that the growth of agricultural & allied sector was above 4 percent during three annual plan (1966-69)in India. The growth rate of agriculture and allied sector was higher during the three annual plan period compared to all other plans in the country. During the three annual plan period the government of India and other agencies emphasized on various agricultural reforms such as High Yielding Varieties Seeds (HYVs), efficient use of agricultural resources, energy and new technology. However, this plan also emphasized on agricultural credit, land reform, irrigation and high value output to boost the agricultural growth and development at national level.

III. LAND USE PATTERN

Land is very important factor of production. It is also is very vital resource for economic development, acquiring higher growth and achieving maximum output in the country. Land has features of fixity in supply and scarcity so the programme and policies must be highly attention for efficient of land. According to Dr. Marshal "By land is meant not merely land in the strict sense of the word, but whole of the materials and forces which nature gives freely for man's aid in land, water, in air and light and heat."

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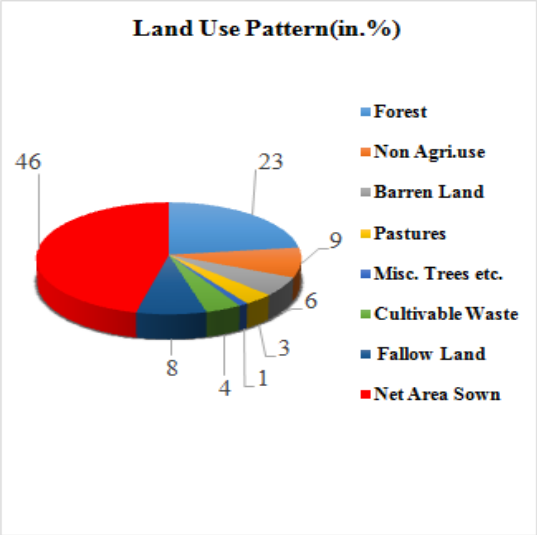
Table-2: Land Use of India during (2010-11) Figure-2: Land Use of India during (2010-11)

S. No.	Particular	India(in'000 hectare)
1	Reporting Area	305920
2	Forest	70028
3	Non Agricultural use	26399
4	Barren Land	17175
5	Pastures	10305
6	Misc. Trees etc.	3204
7	Cultivable Waste	12646
8	(other fallow	10323
9	Current Fallow	14275
10	Net Area Sown	141563
11	Total cropped Area	197563
11	Area sown more than once	56000
12	Gross cropped area	197563
13	Cropping Intensity	139.6



Sources- Official website of Govt. of India

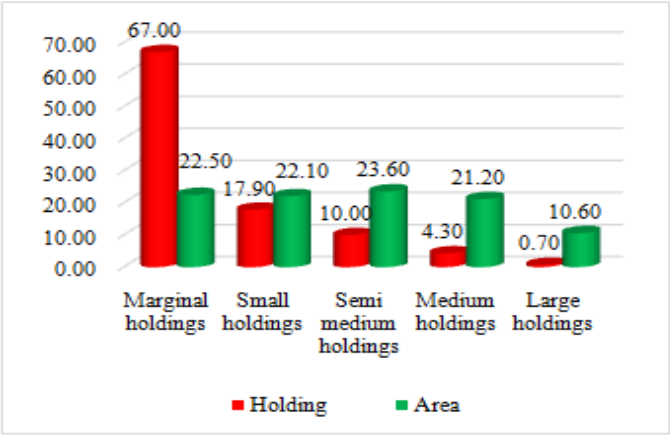
Table-2 and Figure-2shows that the land uses pattern of India in the year-2010-11. The figures-2 shows that the net area sown was 46 percent and 23 percent area was under forest of the total land in the country. The percentage of barren land and non-agricultural use is 6 & 9 percent of the total land the percentage of misc. land and cultivable waste land was 1 percent and 4 percent while the percentage of pasture land was 3 percent respectively during 2010-11 in India. The percentage of fallow land was 8 percent and cropping intensity was 139.6 percent in 2010-11. It is found from the table that 85563 (141563-56000) thousand hectare area under single cropping during the year 2010-11.It is observed that there is huge possibility of agricultural development through increase in net area sown and intensity because the country has major area is under fallow land and others. There is also huge scope of multiple cropping patterns to increase agricultural productivity in the country. It is observed that major area of the country is either degraded or not use for productive purpose. Therefore, there is need to change the strategy of cultivation of agriculture and adopting new technology for agriculture purpose in India.

Small and Marginal farmers are backbone of the agriculture sector in India. Majority of the small and marginal farmers are depends on agriculture sector for their livelihood. It observed that the number of small and marginal operational land holdings is increasing in India.

Table-3: Percentage distribution of Operational holdings and area by size groups in India during (2010-11).

Category	Holding	Area
Marginal holdings(Less than 1 Hectares)	67.00	22.50
Small holdings(1.0 to 2.0 Hectares)	17.90	22.10
Semi medium holdings(2.0 to 4.0 Hectares)	10.00	23.60
Medium holdings(4.0 to 10.0 Hectares)	4.30	21.20
Large holdings(10.0 & Hectares)	0.7	10.60

Figure-3: Percentage distribution of Operational holdings and area by size group in India during (2010-11)



Source: Agricultural Directorate, Government of India.

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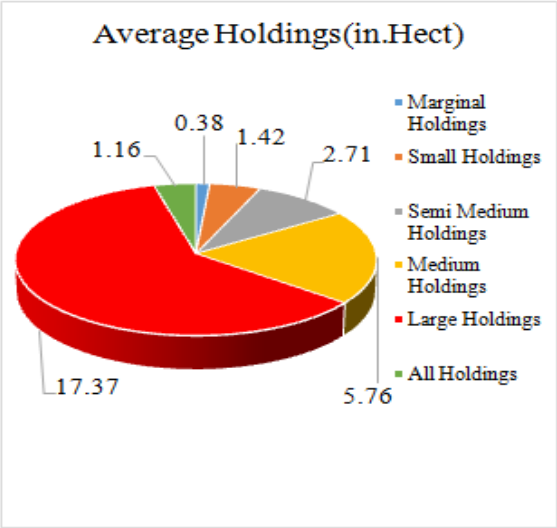
Table-3 and figure-3 reveals the percentage distribution of operational holdings and area in India in the year 2010-11. The operational holdings and area of small and marginal farmers is 17 percent, 67 percent and 22 percent and 24.50 percent in 2010-11. Similarly, the operational holdings of semi medium, medium and large category farmers is 10 percent, 4 percent, 0.70 percent and area 23.60 percent, 21.20 percent and 10.60 percent in 2010-11 respectively in India. It is observed that majority of land holdings consist of small and marginal farmers. However, these small and marginal farmers have the poor economic conditions. Consequently, it has an adverse effect on the growth of agriculture sector. This is because the average cost of cultivating the crops on tiny land holdings is higher as compare to the cultivation of crops on large land holdings. Therefore, the growth of agriculture sector can be encouraged in the country with active support of government to these small and marginal farmers in the country.

The average land holdings have been described by the table-4 and figure-4 in the year 2010-11 in India. It shows that the average size of land holdings of small and marginal farmers is 1.42 hectare and 0.38 hectare in 2010-11. Similarly, the average size of land holdings of semi-medium, medium and large category farmers is 2.71 hectare, 5.76 hectare and 17.37 hectare in 2010-11 in the country. The average size of all holdings is 1.16 hectare in 2010-11in India.

Table-4: Average size of land holdings during 2010-11 in India.

Category	Average Holdings (in. Hect)
Marginal Holdings	0.38
Small Holdings	1.42
Semi Medium Holdings	2.71
Medium Holdings	5.76
Large Holdings	17.37
All Holdings	1.16

Figure-4: Average size of land holdings during 2010-11 in India.



Source: Agricultural Directorate, Govt. of India

It is observed that the main reason of this reduction in average land holding size is sharp increment in population size, fragmentation of land holdings, inheritance laws of equal distribution of property leads to division of land into small blocks. It is also observed that the majority of farmers in India are small and marginal farmers. Their average land holdings are very less compare to other category farmers in the country. Consequently, these small and marginal holdings increase disguised unemployment and decrease productivity due to over manned. These small and marginal holdings become operationally non-viable because the high division of land restricted and hindered diffusion of modern technology in the agriculture. Apart from characterized by the largest proportion of small and marginal land holdings among all size class, there is also high incidence of tenancy cultivation in the country dominated largely by large farmers. This has decreased the growth prospects of the country because such small segments of land remained out of investment. Moreover, there are also several tenancy restrictions in the country. There is rapid need to improve the rule and regulation of tenancy in India.

IV. PERFORMANCE OF FOOD-GRAIN CROPS

The agriculture sector has been playing an important role in the economic development of India. The country is basically agrarian economy and majority of the population are dependent on agriculture sector for their livelihood. However, agriculture sector has been emerged a challenge for the farmers because diversification of crops is increasing towards traditional crops (rice, wheat, coarse cereals, pulses etc) to commercialized crops (sugarcane, cotton, oilseeds, potato etc) in India. Consequently, the production of food grains crops is decreasing while the production of commercial crops is increasing in India. The food security problem is increasing in the country.

Agriculture sector is not only growing but also increasing structural transformation. It is observed that the share of agricultural workers in total workers has been decreasing slowly than the decline in the share of agriculture in the GDP. The share of agriculture in the total gross domestic product (GDP) was 52 percent in 1951-52 and become 17.6 percent in 2014-15 in India. Even though half of the population is dependent on agriculture sector for their livelihood in India. It is noticed that the area under food-grains has remained stagnant but increased for rice and wheat crops etc. As, the area under rice was 30.81 million hectare in 1950-51 increased to 43.86 million hectare in 2014-15. Similarly, the area under wheat was 9.75 million hectare in 1950-51 become 30.97 million hectare in 2014-15. The area under coarse cereals was 37.67 million hectare in 1950-51decreased to 24.17 million hectare in 2014-15. In the same way, the area under pulses was 19.09 million hectare in 1950-51 increased to 23.10 million hectare during the above period. However, the area under food grains was 97.32 million hectare in 1950-51 and become 122.07 million hectare in 2014 -15 in India.

The production of rice was 20.58 million tons in 1950-51 increased to 105.48 million tons in 2014-15. Similarly, the production of wheat was 6.46 million tons in 1950-51 become 86.53 million tons in 2014-15. The production of coarse cereals was 15.38 million tons in 1950-51 become 42.86 million tons in 2014-15. In the same way, the production of pulses was 8.41 million tons in 1950-51 increased to 17.15 million tons during the above period. However, the production foodgrains was 50.83 million tons in 1950-51 and become 252.02 million tons in 2014 -15 in India.

The performance of production of coarse cereals and pulses is not much better compared to rice and wheat during the same period in India. It is noticed that the compound growth rate of area of rice was higher during pre-green revolution period as compare to green revolution period.

The overall period the growth rate of area under foodgrains was positive (0.20 percent) but not significant compare to pre-green revolution period. The mean and standard deviation of area under food grains was 120.68 and 7.4 in India.

The growth rate of production of wheat has shown an impressive trend during the phase-I of green revolution period. The growth rate of wheat production was 3.80 percent during pre-green revolution period while the growth rate of wheat production has become 6.58 percent during phase -1 in India. The overall growth rate of wheat production was 4.45 percent whereas the mean and standard deviation of wheat production was 42.66 and 27.92 during 1950-51 to 2014-15 in India. The overall growth of yield of wheat was 2.71 percent while mean and standard deviation was 1800.77 and 821.56 during 1950-51 to 2014-15 in India.

It is clear that the growth rate of yield of coarse cereals was 1.34 percent in pre-reform, 1.85 percent in phase-I, 1.73 percent in phase-II, and 2.71 percent in phase-III in India. The overall growth of yield of coarse cereals was 2.01 percent while mean and standard deviation was 830.15 and 345.43 during 1950-51 to 2014-15 in India. It is noticed that the productivity of coarse cereals was significant during phase-III compared to other phase.

With regard to Pulses, the yield grew at a compound rate of 0.14 percent in pre-green revolution period. The growth rate of yield of pulses was negative (-0.14 percent) in phase-1, 1.30 percent in phase-II, and 1.04 percent at national level. The overall growth rate of yield of pulses was 0.66 percent during 1950-51 to 2014-15. The mean and standard deviation of productivity of pulses was 542.66 and 86.21 during 1950-51 to 2014-15 in India.

The growth rate of foodgrains was 1.72 percent in pre- green revolution period, 2.30 percent in phase-I, 3.09 percent in phase-II, and grew at a 1.68 percent during phase-III in India. The overall growth rate of yield of foodgrains was 2.22 during 1950-51 to 2014-15 in India. The average productivity and standard deviation of foodgrains was 1178.48 and 481.38 during 1950-51 to 2014-15 in India. Overall it is noticed that the growth rate of food-grains is not significant during 1950-51-2014-15 in India.

Table- 5: CAGR of Area, Production, and Yield of Rice, Wheat, Coarse Cereals, Pulses, and Foodgrains during (1950-51 to 2014-15) in India.

Period	Rice			Wheat			Coarse Cereal			Pulses			Food-grains Crops		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
P.G.R.P (1950-51 to 1965-66)	1.37	3.69	2.29	2.32	3.80	1.45	0.71	2.26	1.34	1.47	1.61	0.14	1.23	2.96	1.72
G.R.P (1966-67 to 2013-14)	0.41	2.39	1.97	1.25	3.64	2.36	-1.36	0.85	2.23	0.08	0.97	0.89	-0.02	2.28	2.30
G.R.P-I (1966-67 to 1980-81)	0.82	2.71	1.87	3.43	6.58	3.04	-0.88	0.94	1.85	0.40	0.25	-0.14	0.51	2.82	2.30
G.R.P-II(1981-82 to 1989-90)	0.47	4.13	3.65	0.26	3.19	2.93	-1.42	0.28	1.73	-0.36	0.94	1.30	-0.32	2.76	3.09
G.R.P-III(1990-91 to 2013-14)	0.07	1.45	1.37	0.92	2.10	1.18	-1.20	1.50	2.71	0.30	1.31	1.04	-0.01	1.67	1.68
T.P(1950-51 To 2014-15)	0.58	2.48	1.90	1.72	4.47	2.71	-0.93	1.06	2.01	0.08	0.74	0.66	0.20	2.43	2.22
Mean	39.25	59.67	1468.94	20.99	42.66	1800.8	37.64	29.17	830.15	22.81	12.42	542.66	120.68	143.93	1178.5
Standard Deviation(S.D)	4.39	26.10	516.21	6.30	27.92	821.56	7.02	6.47	345.43	1.37	2.34	86.21	7.14	61.58	481.38

Source: Ministry of Agriculture & farmers Welfare, Government of India.

Note:
P.G.R.P: Pre Green Revolution Period (1950-51 to 1965-66)
G.R.P : Green Revolution Period (1966-67 to 2013-14)
G.R.P-I: Green Revolution Phase-I (1966-67 to 1980-81)
G.R.P-II Green Revolution Phase-II(1981-82 to 1989-90)
G.R.P-III Green Revolution Phase-III (1990-91 to 2014-15)
T.P: Overall Period (1950-51 To 2014-15)
CAGR: Compound Annual Growth Rate

V. TRENDS OF CLIMATE VARIABLES

Rainfall: India has a tropical monsoon climate and rainfall is an important element for the economic development of India. It is noticed that about 60 percent population is depend on agriculture and 40 percent of cropped area does not have any kind of irrigation facility other than the rains. Majority of population wait for the rains for sewing of major seeds and depend on monsoon for agricultural activities. It is said that Indian agriculture has been gamble of monsoon. It is observed that deficient rainfall decrease the productivity of agriculture sector and increase food prices. There is a strong positive and negative linkage between growth of agriculture and rainfall in India. The figure-5 shows the annual rainfall (in mile meter) during 1950-51 to 2014-15 in India. The figure reveals that the annual fall was 1174.20 mm in 1950-51 and become 1045.20 mm in 2014-15 in India. Similarly, the mean of the annual rainfall was 1168 mm whereas the standard deviation of the annual rain fall was 105. 37 mm during 1950-51 to 2014-15. It is observed that annual rainfall has fluctuating trends during the same periods. It is observed that that the annual rainfall has been decreased during 1950-51 to 2014-15 in India.

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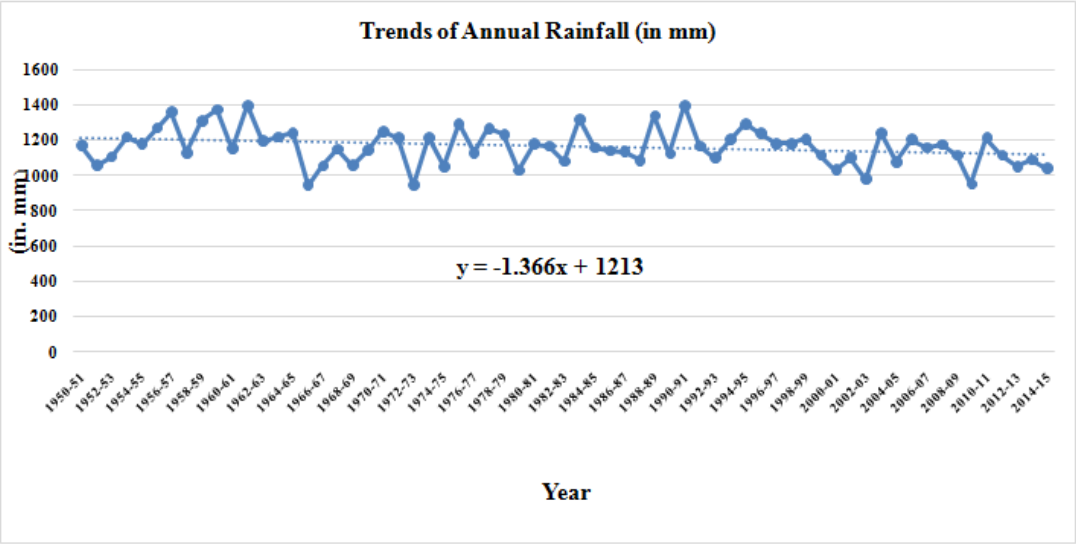
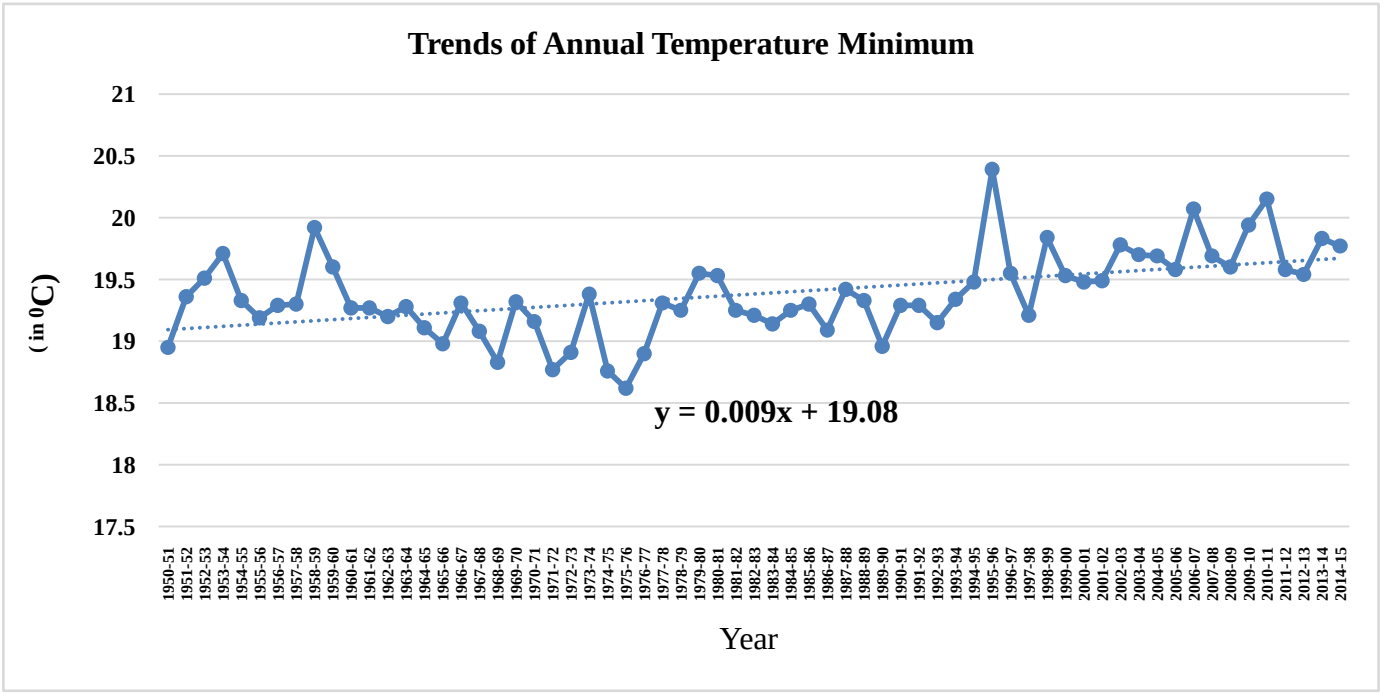
Figure-5: Trends of Annual Rainfall during 1951-52 to 2014-15 in India



Source: *Source: www.data.gov.in*

Minimum Temperature: Temperature is one of the very important climatic factor for the agriculture development of India. However, the temperature is fluctuating between minimum and maximum temperature.Figure-6 shows the annual minimum temperature during 1950-51 to 2014-15 in India. The figure highlights that the annual minimum temperature was 18.95 ^{0}C in 1950-51 and increased to 19.77 ^{0}C in 2014-15 in India. The mean of the annual minimum temperature was 19.38 ^{0}C and the standard deviation 0.34 ^{0}C during the same period in India. It is observed that about 1^{0}C minimum temperature has been increased during 1950-51 to 2014-15 in India.

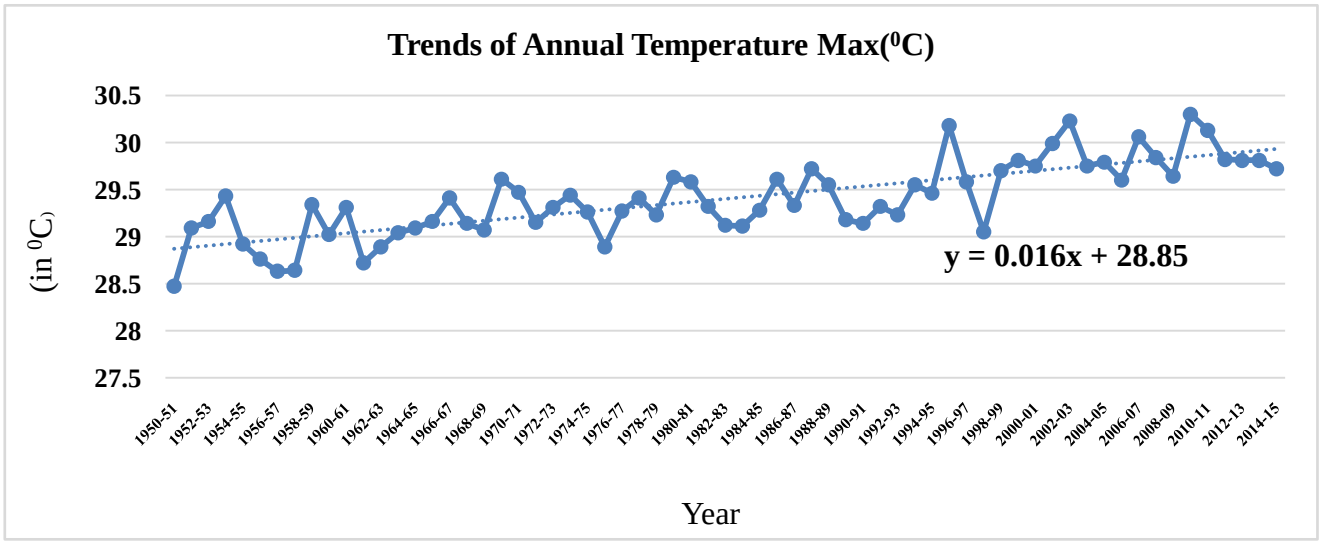
Figure-6: Trends of Annual Minimum Temperature during 1951-52 to 2014-15 in India



Source: *Source: www.data.gov.in*

Maximum Temperature: The figure-7 shows that the annual maximum temperature during 1950-51 to 2014-15 in India. The figure reveals that the annual maximum temperature was 28.47^{0}C in 1950-51 and increased to 29.72^{0}C in 2014-15 in India. The mean of the annual maximum temperature was 29.40^{0}C and the standard deviation 0.40^{0}C during the same period in India.

Figure-7: Trends of Annual maximum temperature during 1951-52 to 2014-15 in India



Source: www.data.gov.in

It observed that the annual maximum temperature has been increased during 1950-51 to 2014-15 in India. It is found that increased temperature has been effecting either positively or negatively the productivity of agriculture and food security in India. It is observed that if the temperature goes upto 20^{0}C then the rice production will be decreased by almost one tonne / hectare. Similarly, 10^{0}c rise in mean temperature, wheat yield decreases 7 million tonnes or around $1.5 billion at current prices per year in India (Ranuzzi, A., & Richa, S., 2012).

VI. REGRESSION RESULT ANALYSIS

The growth and performance of agriculture sector is influenced by several factors such as use of agricultural inputs, capital formation, irrigation facilities, climate changes, and government policies. It is very difficult to analyse the effect of all the factors in simple framework. However, we have taken the climatic variables such as in temperature and rainfall to analyse the effect on food grain production & productivity during 1950-51 to 2014-15 in India. The aggregate production function can be written as:

$$FGP = F\ (TEMP_{MAX},\ TEMP_{MIN},\ RAIN_{ANNUAL}) \quad (I)$$

Whereas, FGP is the food grain production, $TEMP_{MAX}$ is annual maximum temperature, $TEMP_{MIN}$ is annual minimum temperature, and $RAIN_{ANNUAL}$ is annual rainfall (in mm). The specification form of the model is:

$$FGP = \alpha + \beta_1 TEMP_{MAX} + \beta_2 TEMP_{MIN} + \beta_3 RAIN_{ANNUAL} + u_i \quad (II)$$

The model was estimated through the multiple regression model and results are presented in Table-6.Three models were estimated because of multicollinearity. We have estimated the equation – (II) in three phases such as phase-(I): overall period is (1950-51 to 2014-15), phase-(II): before economic reform period (1950-51 to 1989-90), and phase-(III): after economic reform period (1990-91 to 2014-15). All dependent and independent variables of overall period and before economic reform period are in annual growth rate form and all variables of after economic reform period are annual growth rate form except rainfall. The effect of maximum temperature and rainfall has positive and significant impact whereas minimum temperature has negative and significant impact on food grain production during 1950-51 to 2014-15. Similarly, The effect of maximum temperature and rainfall have positive and significant impact on food grain production whereas minimum temperature has negative but significant impact on food grain production during 1950-51 to 1989-90. In the same way, the effect of maximum temperature and minimum temperature has negative effect and insignificant on food grain production while rainfall has positive and significant impact on food grain production during the period 1990-91 to 2014-15 in India.

Table- 6: Regression Results

A. Dependent Variable: Food grain Production									
Independent Variables	Period for Study (1950-51 to 2014-15)			Before Economic Reform (1950-51 to 1989-90)			After Economic Reform (1990-91 to 2014-15)		
	Coefficient	t- value	p-value	Coefficient	t- value	p-value	Coefficient	t- value	p-value
Maximum Temperature	4.975	3.73	0.000	5.294	2.89	0.007	-0.590	-0.27	0.793
Minimum Temperature	-3.950	-4.44	0.000	-3.779	-2.84	0.007	-1.203	-0.87	0.395
Rainfall	0.72	10.02	0.000	0.747	7.85	0.000	0.0004	2.80	0.011
Constant	0.024	3.34	0.001	0.027	2.62	0.013	-0.481	-2.68	0.014
R-squared	0.642			0.653			0.405		
F-Value	35.98			21.97			4.78		
No. of Obs.	64			39			25		

Sources: Authors Calculations

It is observed that that during overall period the model explains 64 percent variation, 65 percent variation explained during before economic reform, and least 40 percent variation explained during after economic reform on food grain production. Similarly, we have estimated the impact of temperature and rainfall on food grain productivity by following equation:

$$YOF = \alpha + \beta_1 TEMP_{MAX} + \beta_2 TEMP_{MIN+} \beta_3 RAIN_{ANNUAL} + u_i \quad (III)$$

Whereas, YOF is the yield of food grain. The model was also estimated through multiple regression model and results are presented in Table-7. Similar methods are used and all variables are similar form as in above given above analysis. The effect of maximum temperature and rainfall has positive and significant impact whereas minimum temperature has negative effect but is significant on yield of food grain during 1950-51 to 2014-15. Similarly, The effect of maximum temperature and rainfall have positive and significant impact on yield of food grain whereas minimum temperature has negative impact but is significant on yield of food grain during 1950-51 to 1989-90. In the same way, the effect of maximum temperature positive and insignificant on yield of food grain and minimum temperature has negative impact but significant on yield of food grain. The effect of rainfall has positive and significant impact on yield of food grain during the period 1990-91 to 2014-15 in India.

Table 7- Regression Results

B. Dependent Variable: Food grain Yield									
Independent Variables	**Period for Study (1950-51 to 2014-15)**			**Before Economic Reform (1950-51 to 1989-90)**			**After Economic Reform (1990-91 to 2014-15)**		
	Coefficient	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**	**Coefficient**	**t-value**	**p-value**
Maximum Temperature	4.358	3.97	0.000	4.391	2.78	0.009	1.277	0.89	0.381
Minimum Temperature	-3.428	-4.68	0.000	-3.202	-2.79	0.008	-1.984	-2.23	0.037
Rainfall	0.500	8.47	0.000	0.529	6.46	0.000	0.00034	3.42	0.003
Constant	0.020	3.38	0.001	0.021	2.29	0.028	-0.374	-3.24	0.004
R-squared	0.5537			0.5516			0.4668		

F-Value	24.82	14.35	6.13
No. of Obs.	64	39	25

Sources: Authors Calculations

It is found that during overall period the model explains 55 percent variation, 55 percent variation explained during before economic reform, and least 47 percent variation explained during after economic reform on yield of food grain in India.

VII. CONCLUSION AND POLICY IMPLICATION

Climate change has been influencing of agriculture sector in India. It is affecting the food grain production and productivity. Climatic variations such as occurrence of drought and flood have high impact on food grain as well as socio-economic conditions of the people in India. It is observed that the compound growth rate of food grain production is not significant during 1950-51 to 2014-15. Therefore, diversification of crops is increasing towards traditional crops to commercialized crops in India. As results, the production of food grain is decreasing and the production of commercial crops is increasing in India. On the other hand, regression result shows that climatic variables are influencing the food grain production and productivity. The effect of maximum temperature and rainfall has positive and significant impact whereas minimum temperature has negative and significant impact on food grain production during 1950-51 to 2014-15. The effect of maximum temperature and rainfall has positive and significant impact whereas minimum temperature has negative effect but is significant on yield of food grain during 1950-51 to 2014-15. It is found that least variation of climatic variables are explained during economic reform on production of food grain and yield of food grain in India.

There is need to intervention which can help the farmers to adopt climate changes and reduce the loss of agricultural production. Farmers should change the cropping pattern with the changing in rainfall and temperature. There is also key actions for adopting Indian agriculture to climate change are improved land management practices, development of resource conserving technologies, development of crop varieties, development of pre warning system, credit-insurance facility, new land use practices, development of water harvesting, mechanization of tiny land holdings, promote efficient water use, and develop eco-friendly system. Similarly, huge financial support for efficient land management in term of water conservation, carbon, energy, and balanced chemical & fertilisers use. Overall, for the development of the agriculture sector, the programmes and policies must be focused on reducing GHGs emission through raising the forest coverage areas, improve conservation and efficient management and development scientific instrument and more expenditure on agricultural research and development. The governmentshould focus towards the changing the type of crops which are grown to better match changed pattern of temperature and rainfall. Effective adaptation strategies, involving technological innovation and intuitional development which would help to improve food security.

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