Deterioration of Agricultural Productivity Due to Climate Change in Haryana

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Abstract:

The present study is an attempt to measure the impact of climate change on production of agriculture in Haryana over the period 2000-2012. Climate Change in India among others manifests itself in temperature increases, rainfall reduction in the arid plains, production reduction and increases in the monsoon areas and accelerates the glacial melt. The impact of climate change is studied in many aspects in different locations in the country and it was found that there is high impact of climate change on agriculture as compared to any other sector. A study revealed that the climatic variation such as occurrences of drought have high level of impact on the yield of rain fed crops. About the Haryana, A study project that with short periods of exposure of wheat crops to temperatures of 28ºC to 32ºC result in significant decrease in yield by 20% or more unpredictable moisture deficits during crop growth are a major constraint to productivity (HSAPCC, 2011). Further, a study claims that climate change will reduce the major crop yields by 4.5 to 9 percent over the period 2010-2039. Therefore, changing climatic variables have reduced and are reducing the agricultural productivity and thus posing a threat to long term food security. This motivates to study the impact of climate change on the agriculture production in Haryana. For the purpose, the data of wheat production has been regressed with the average annual rainfall and average temperature in Haryana over the period of 2000-2012. The findings of the study reveal that there is a significant impact of climate change on agricultural production in Haryana.

Key Words: Climate change, Rainfall, Temperature, Agricultural production, Haryana

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1. Introduction:

Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. Climate is the main determinants of agricultural production. Throughout the world there is significant concern about the effects of climate change and its variability on agricultural production. Researchers and administrators are concerned with the potential damages and benefits that may arise in future from climate change impacts on agriculture, since these will affect domestic and international policies, trading pattern, resource use and food security. The Climate change is any change in climate over time that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural climate variability observed over comparable time periods (IPCC, 2007).Since climatic factors serve as direct inputs to agriculture, any change in climatic factors is bound to have a significant impact on crop yields and production. Climate change scenarios include higher temperatures, changes in precipitation, and higher atmospheric CO2 concentrations. There are three ways in which the Greenhouse Effect may be important for agriculture. First, increased atmospheric CO2 concentrations can have a direct effect on the growth rate of crop plants and weeds. Secondly, CO2-induced changes of climate may alter levels of temperature, rainfall and sunshine that can influence plant and animal productivity. Finally, rises in sea level may lead to loss of farmland by inundation and increasing salinity of groundwater in coastal areas.

The greenhouse effect is a natural process that plays a major part in shaping the earth's climate. It produces the relatively warm and hospitable environment near the earth's surface where humans and other life-forms have been able to develop and prosper. However, the increased level of greenhouse gases (GHGs) (carbon dioxide (CO2), water vapor (H2O), methane (CH4), nitrous oxide (N2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF6) etc.) due to anthropogenic activities has contributed to an overall increase of the earth's temperature, leading to a global warming. The average global surface temperature have increased by 0.74 o C since the late 19th Century and is expected to increase by 1.4 o C - 5.8 o C by 2100 AD with significant regional variations (IPCC, 2007). The atmospheric CO2 concentration has increased from 280 ppm to 395 ppm, CH4 concentration increased from 715 ppb to 1882 ppb and N2O concentration from 227 ppb to 323 ppb from the year 1750 and 2012. The Global Warming Potential (GWP) of these gases i.e., CO2, CH4 and N2O are 1, 25 and 310 respectively. Projected scenarios of global warming indicate that the global average surface temperature could rise by 1.4 to 5.8°C by 2100. The projected rate of warming is unprecedented during last 10,000 years.

The climate of Haryana is very hot in summer and cold in winters. The hottest months are May and June and the coldest being December and January. Haryana is very hot in summer and cold in winters. The temperature falls to the lowest in January and reaches up to 50^{o} C during the months of May and June. Winter months have average temperatures in the range 3^{o}C to 9^{o}C and the summer months temperatures are higher in the range of 48^{o}C to 35^{o}C. Haryana have two agro climatic zones. The north western part is suitable for Rice, Wheat, Vegetable and temperate fruits and the south western part are suitable for high quality agricultural produce, tropical fruits,

exotic vegetables and herbal and medicinal plants. Major land use in Haryana is agriculture (85%), Forest (2.4 %), about 7.2 % fallow and 5% waste land. Agriculture contributes 17% of the state's GDP and employs 65% of the total workforce. The net sown area is 85% of the total geographic area as compared to the national average of 46%, the gross cropped area is 65 lakh Ha with a cropping intensity of 180%. The long term analysis for trends in observed temperature over Haryana using IMD gridded temperature at daily time scales show that there is no significant trend in the mean maximum temperature and minimum temperature shows an increase of about 1.00C to 1.20C. Haryana emits nearly 2% of national greenhouse gases (GHG). Agriculture sector contributes about 82% and 91% of CH4 and N2O emissions of the state. Majority of CH4 emissions occur from enteric fermentation of livestock (62%) followed by rice cultivation (14%) and biomass burning (6%). While majority of N2O emissions occur from application of synthetic nitrogenous fertilizer (62%) followed by indirect N2O emissions (20%) and nitrogen from crop residue left (5%). Likely Impacts of Climate Change on Agriculture projects that with short periods of exposure of wheat crops to temperatures of 28 ºC to 32 º C results in significant decrease in yield by 20% or more. Unpredictable moisture deficits during crop growth are a major constraint to productivity, Sclerotinia stem root may become a serious threat to the successful cultivation of agriculture.

2. Review of Literature

S.K. Sinha and M.S.Swaminthan (1991) analyzed that a 2ºC increase in mean air temperature could decrease rice yield by about 0.75 ton/hectare in the high yield areas and by about 0.06 ton/hectare in the low yield coastal regions. Further, a 0.5ºC increase in winter temperature would reduce wheat crop duration by seven days and reduce yield by 0.45 ton/hectare. An increase in winter temperature of 0.5ºC would thereby translate into a 10 percent reduction in wheat production in the high yield states of Punjab, Haryana and Uttar Pradesh.

Gosain A.K.S.,S. Rao et al(2006), The study has revealed that under the GHG scenario the conditions may deteriorate in terms of severity of droughts in some parts of the country and enhanced intensity of floods in other parts of the country. However, there is a general overall reduction in the quantity of the available runoff under the GHG scenario. Luni with the west-flowing rivers Kutch and Saurastra which occupies about one fourth of the area of Gujarat and 60 per cent of the area of Rajasthan shall face acute water scarce conditions. River basins of Mahi, Pennar, Sabarmati and Tapi shall also face water shortage conditions.

Raymond Guiteras (2007) analyzed the impact of climate change on Indian agriculture. The study analysed the impact of change in weather on agriculture output in 200 Indian districts. He found that climate change over the period 2010 to 2039 reduce major crop productivity from 4.5 percent to 9 percent whereas the long run (2070 to 2099) impact is reducing yield by 25 percent more when there is not any long run adaptation the negative impact on climate change on agriculture also have impact on poverty. He suggested that climate change impose significant cost on Indian agriculture and it can be reduced only when there is quick and appropriate strategy use with the increase in temperature.

Tata.N.Rao (2011), emphasise the role of human adoptions in responding to climate change, possible regional impacts to agricultural system and potential change in pattern of food production and price. The study reviewed that by 2080, agriculture output in developing countries may decline by 20 percent due to climate change, while output in industrial countries is expected to decrease 6 percent and yields in developing countries is expected to decrease by 15 percent on an average. The climate is a primary determinant of agriculture productivity. The study states that the united nations framework convention on climate change(UNFCC)cities maintenance of our societal ability for food production in face of climate change as one of the key motivations for its existence and for its efforts in reducing greenhouse gas emission.

3. Data Source and Methodology

The study is based on the secondary data that has been collected from the records of Directorate of Agriculture, Directorate of Economics and Statistics Government of Haryana Indian Ministry of Agriculture, FAO (Food and Agriculture organization), CMIE (Central Monitoring of Indian Economy) and other official sources of yearly agriculture production, output and planted and cultivated area of Haryana. The data related to climate change will be collected from Indian Agriculture and climate Data Set by World Bank Research Group. Some data will be taken from various journals, reports, and periodicals on Agriculture and food security and climate change. The temperature and rainfall Data of the Haryana has been taken from http:/www.indiawaterportal.org/metdata and www.haryanastat.com.

The analysis of data will be made through both descriptive and inferential statistics. In Descriptive analysis data will be presented through maps, flow charts, tables and figures. Statistical analysis will be made through some appropriate statistical tools as per the requirement of the research like percentages, averages, correlation etc. Multiple Regression test has been used to analyze the impact of climate change on wheat production in Haryana.

4. Climate Change in Haryana

Due to Industrial Revolution, Human activities have led to increase in the composition of earth's atmosphere. The Haryana state also falls within the area of greatest climate sensitivity. In an era of climate change, Haryana is likely to suffer further water shortage due to overall reduction in rainfall. Haryana has limited rainfall ranging from 300 mm in the southwest to 1,100 mm in the northeast in the state. The state lies in the basins of the Indus and the Yamuna Rivers and receives water from Sutlej and Yamuna Rivers and its share from the surplus water of rivers Ravi and Beas, as per various inter-state agreements. There are no perennial rivers in Haryana; Ghaggar is the only seasonal river, which flows through the northern fringes of the state. The Ghaggar rises in the outer Himalayas, between the Yamuna and the Sutlej and enters Haryana near Pinjore, Panchkula district. Passing through Ambala and Hissar, it reaches Bikaner in Rajasthan and runs a course of 467 km before disappearing into the deserts of Rajasthan. In Haryana temperature varies from 31.4^{0}C to 17.4^{0}C. There is no significant trend in the mean

maximum temperature; minimum temperature shows an increase of about 1.0^{0}C to 1.2^{0}C in 37 years. Districts of Fatehabad, Jhajjar and Karnal show higher increase in the minimum temperature (1.1^{0}C to 1.3^{0}C). Inter annual variation is not significant. Spatial variation in annual maximum and minimum temperature found to be around 2^{0}C. The seasonal average maximum temperature is higher during pre-monsoon and monsoon season and ranges between 35.4^{0}C to 36.2^{0}C. Similarly seasonal average minimum temperature is lowest during winter period and ranges from 6.9^{0}C to 7.6^{0}C.

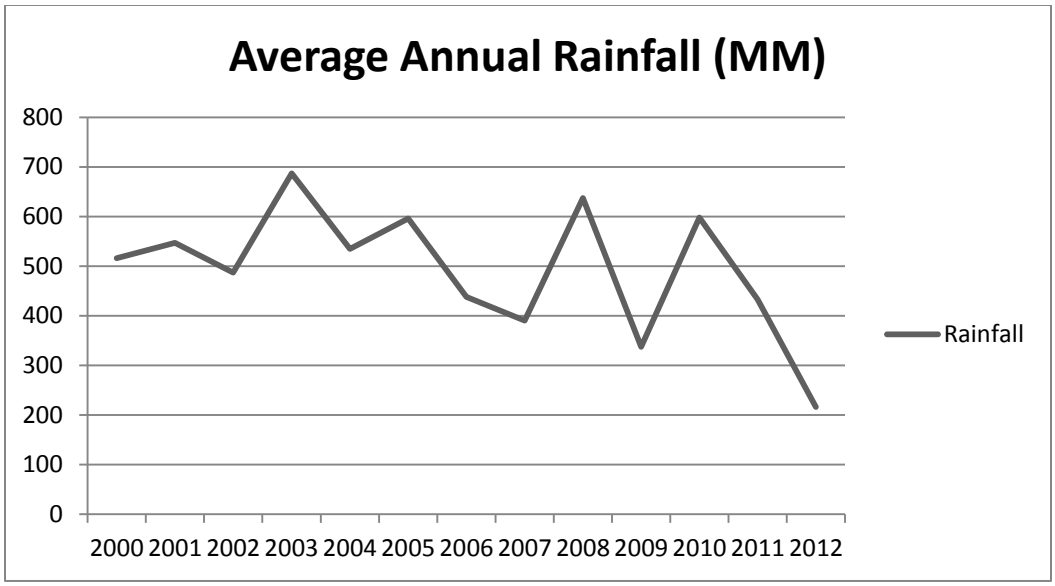
Table-1. Rainfall and Temperature variation in Haryana

Year	**Average Annual rainfall(mm)**	**Maximum Annual Temperature Variation**
2000	516	35.1
2001	547	31.2
2002	487	37
2003	687	36.6
2004	535	38
2005	596	35.2
2006	438	36.3
2007	390	35.3
2008	637	43
2009	337.5	43.5
2010	598.1	44.4
2011	433	41.4
2012	216.1	

		42.8

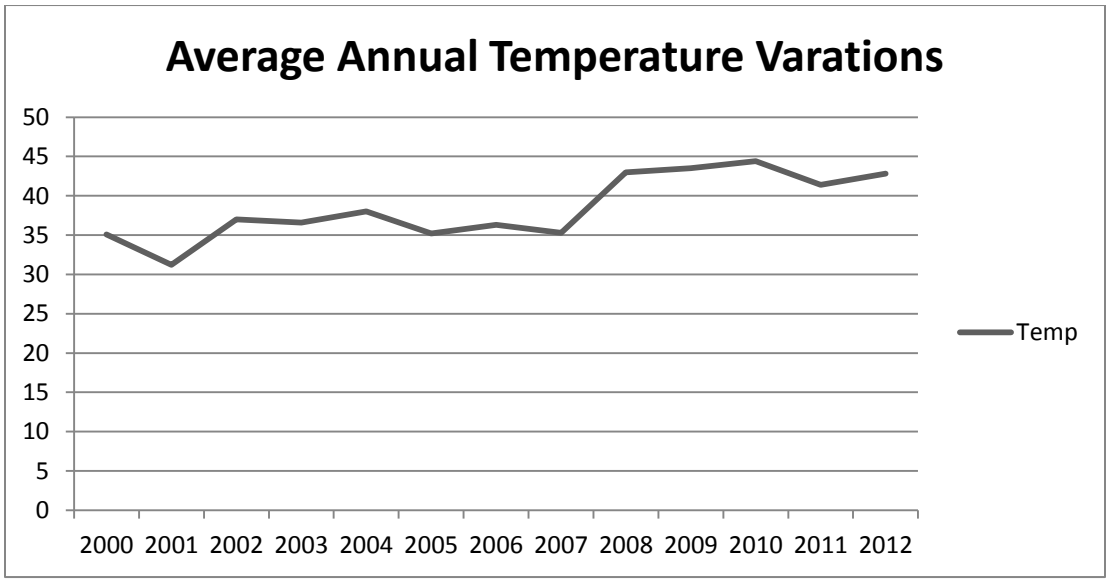
Source: Indian Meteorological department

Figure-1 Average Annual Rainfall in Rajasthan



The table and graph 1 shows that Maximum Annual Rainfall was 687 mm in year 2003 and after that there is decline in rainfall and minimum Rainfall was in the year 2012 with average annual rainfall 216.1 mm this show how the climate change is effecting the rainfall and this reduction in rainfall will bring crises in agricultural production in Haryana.

Figure-2.Average Annual Temperature Variation in Haryana



The figure 2 shows that maximum variation in temperature was in 2000 and after that it shows an increasing and decreasing trend continuously till 2012 and due to the climate change variation

the temperature starts increasing from 30^0C to above 40^0C which is an alarming sign for an agriculture due to the continuously flection in temperature.

5. Trend in Wheat Production in Haryana

Wheat is the most important food grain in the world that rank second in total production as a cereal crop, behind maize and ahead of rice. Wheat is the staple food of millions of people. Despite recent industrial development, Haryana is primarily an agricultural state. About 70% of residents are engaged in agriculture. Wheat and rice are the major crops. Haryana is self-sufficient in food production and the second largest contributor to India's central pool of food grains. The main crops of Haryana are wheat, rice, sugarcane, cotton, oilseeds, gram, barley, corn, millet etc. About 86% of the area is arable, and of that 96% is cultivated. About 75% of the area is irrigated, through tube wells and an extensive system of canals. Haryana contributed significantly to the Green Revolution in India in the 1970s that made the country self-sufficient in food production.

Table-2 Wheat production and Area under Wheat Production

Year	**Area under Wheat Production (Hectors)**	**Wheat Production in (Tones)**
2000	2355	9669
2001	2300	9437
2002	2267	9188
2003	2315	9114
2004	2322	9058
2005	2250	9450
2006	2376	10059
2007	2461	10232
2008	2462	11360

2009	2488	10629
2010	2504	11509
2011	2531	13119
2012	2497	11117

Sources- Statistical abstract Haryana

Figure -3 Areas under Wheat Cultivation in Haryana

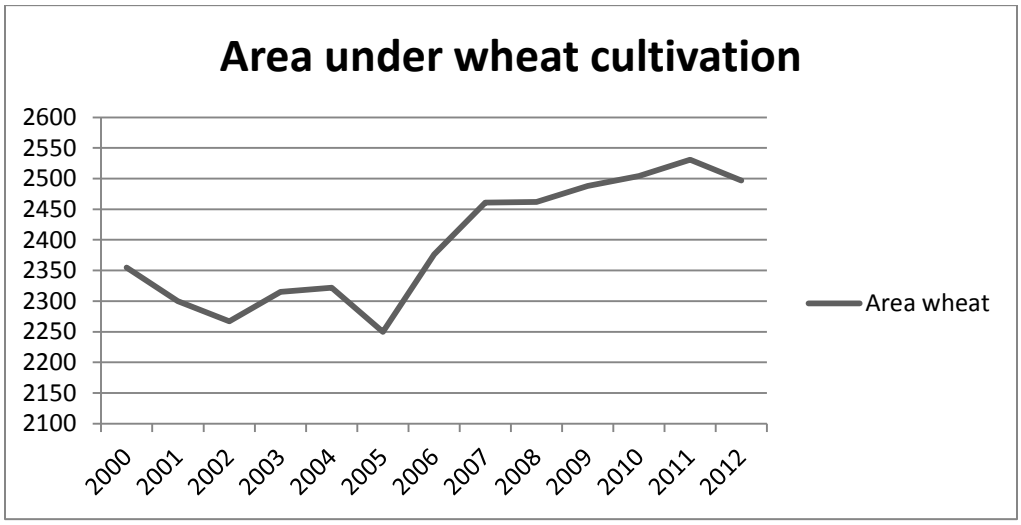


Figure-4. Wheat Production of Haryana in Tones

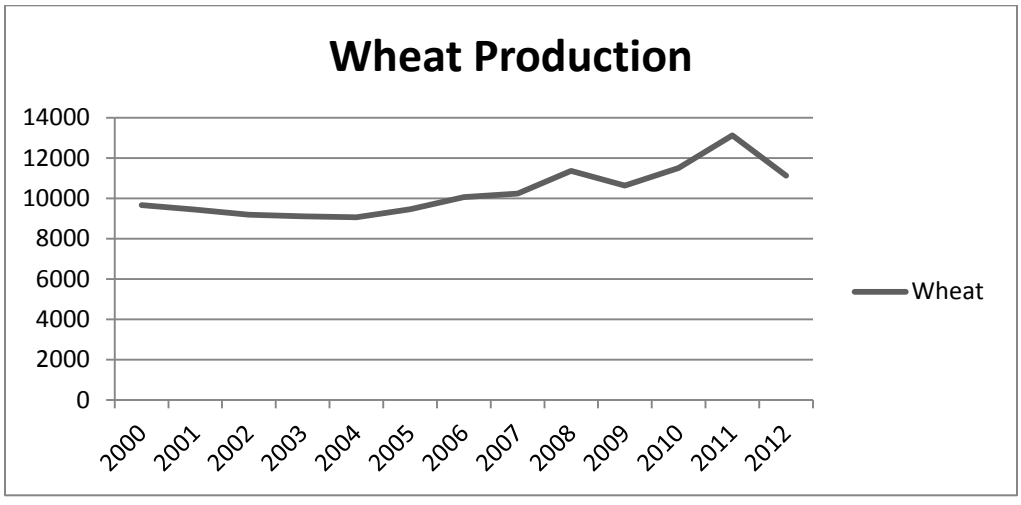


Table 2 and Figures 3 and 4 shows that area under wheat cultivation shows an increased trend from the year 2000 to 2012, and in between this time period the area under wheat production decrease and sometimes increases but overall it shows increasing trend. It also Indicate that the wheat production in Haryana is also increasing from year 2000 onwards. But after few years the production declines and it was lowest in the year 2004 and after that it shows a fluctuating trend in wheat production in Haryana.

6. Results of the study

The global warming effects have not even kept Haryana untouched. The earlier chapters have shown that the temperature and rainfall has changed during past few decades. The variation in Maximum and Minimum temperature has increased and the number of rainy days has also decreased. Agriculture is the only sector which is highly influenced by the changing climatic conditions. Multiple regression models find to what extent climatic changes have affected wheat production of Haryana.

The Following Model is build:-

Model-1

$$Y = \alpha_o + \beta_1 X_1 + \beta_2 X_2 + \mu$$

Y = Wheat production
X1 =Variation in temperature
X_2 =Average Annual rainfall
μ = Disturbance term

Results of the Model

Table-3 Result of the Model

Wheat Production	**Coef**	**Std .Err**	**t**	**R^2**	**Obs**
Rainfall	-1.257727	.2119222	-0.59	o.85	13
Temp	1.94977	6.693371	2.91	0.57	13

Above table shows the results of Multi regression between Rainfall, Temperature and agricultural production of Haryana from the year 2000-2012 in which Wheat production is

regressed on temperature and rainfall. It is assumed that the climate variation measure in term of Variation in rainfall and temperature have an impact on wheat production over the period of time. The result of model reveals that the climate change (increase in Temp and Decrease in Rainfall) has a negative impact on agricultural production of Haryana. The model does not show any significant impact of temperature on the wheat production of Haryana. This is because that the wheat production is cultivated in winters and in winters the temperature is below the 10ºC which will not affect the production of wheat in Haryana. On the other hand the rainfall have significant impact on wheat production, the results of model show if there is 1 percent decrease in rainfall will lead -1.25 percent decrease in production.

7. Conclusions and suggestions

As discuss earlier, the climate change is adversely impacting the Haryana agriculture which is mainly depend on rainfall. Due to change in climate there is increase in Maximum and Minimum temperature, the length period of every season is also change and large uncertainties in rainfall period and frequency of rainfall, heavy rainfall on inappropriate time period for agriculture and lack of rainfall when there is need of rainfall in agriculture, increasing frequency of droughts etc.

But there is not any separate policy and agenda for sustainable development of agriculture. To overcome the impact of climate change on agriculture some suggestion are introduce. The all suggestion is dividing into two categories Adaption and Mitigation. All Adaption and Mitigation for climate change are as following.

1. Crop insurance for climate variability is necessary for overcome the loss of climate change on agriculture.
2. Use of new varsities and certified seeds that cannot very much affected by the change in climate change.
3. Early warning should give to the farmers so that they can use the other and alternative way to protect him from these types of changes.
4. More emphasizes on those crops which are not much climatic sensitive and crop diversification should be adopted for take the solutions of this problem.
5. Insures farmers against climate related weather changes. Water conservation and increase in efficiency of water use.
6. Agriculture sector is also contributes(about 14 percent of annual GHG's emission) to climate change (Agriculture is an important source of two powerful GHGs: nitrous oxide (N2O) and methane (CH4) so there is need to reduce the impact of agriculture on climate like less use of fertilizer, adaptation of organic farming etc.

As the scientific consensus that significant climate change, in particular increased temperatures and decrease in rainfall, is very likely to occur during the 21st century gathers momentum,

economic research has attempted to quantify the possible implications of climate change on society and agriculture. The vulnerability to climate change may be greater in developing countries such as India, where agriculture typically plays a larger economic role. The study notes that the impact of climate change will vary across crops, regions and climate change scenarios. The evidences indicate a decrease in production of crops in Haryana with a decrease in Rainfall. Our study finds that climate change is likely to reduce agricultural yields significantly and the damage could be severe unless the adaptation to higher temperatures is rapid and complete. The study suggests that as the impact of climate change is intensifying day by day it should be addressed through policy perspective at the earliest to avoid short term effect such as yield and income loss and long-term effects such as quitting agricultural profession by the Rain fed farmers.

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