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Impacts of climate change on agriculture productivity: A case study of Haryana

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Abstract
Climate change is a burning issue of today. Generally, Climate Change means increasing tem of earth surface due to some physical and anthropogenic factors. It influences the earth by increasing its overall temperature. Increase in the temperature of earth accelerates the melting of Glaciers which causes rise in sea level that leads to submerging of more farmland area into sea water. On the other hand increase in temperature also causes reduction in rainfall in the arid plains. Less Rainfall results into reduction in agricultural production. The impact of climate change is being studied in many forms in different locations in various countries by many researchers and various national agencies. All they have a common finding that there is high impact of climate change on agriculture as in comparison 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. A study projected that with short periods of exposure of wheat crops to temperatures of 28ºC to 32ºC results in significant decrease in its yield by 20% or more. Unpredictable moisture deficits during crop growth are a major constraint to productivity. Furthermore, a study claims that climate change will reduce the major crop yields by 4.5 to 9 percent over the period of 2010-2039. Therefore, change in climate is reducing the agricultural productivity and thus posing a threat to long term food security. This factor motivates to study the impact of climate change on the agriculture production in Haryana.

Keywords: climate change, global warming, agricultural production, deterioration

1. Introduction
Climate change is one of the most important global environmental challenges we are facing at present times. Climate Change is affecting food production, natural ecosystems, freshwater supply, health, etc. Agriculture production depends heavily on Climate. Throughout the world there is significant concern about the effects of climate change on agricultural production. Researchers and administrators are much concerned with the potential damages of climate change that may arise in future on agriculture productions. Impact of Climate Change on agriculture will affect domestic and international policies, trading patterns, use of resources and food security. The Climate change over time and time is attributed directly or indirectly to human activity that alters the composition of the global atmosphere (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.
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) which includes carbon dioxide (CO2), water vapor (H2O), methane (CH4), nitrous oxide (N2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF6), etc. has contributed to an overall increase of the earth's temperature which is driving earth towards global warming. The average global surface temperature has increased by 0.74ºC since the late 19th Century and is expected to increase by 1.4ºC To 5.8ºC by 2100 AD with significant regional variations (IPCC, 2007). The atmospheric CO2 gas has increased from 280 ppm To 395 ppm, CH4 Methane gas has increased from 715 ppb to 1882 ppb and N2O concentration has increased from 227 ppb To 323 ppb in previous years. The Global Warming Potential (GWP) of these gases i.e., CO2, CH4 and N2O are 1, 25 and 310 respectively. Projected scenario of global warming indicates that the global average surface temperature could rise by 1.4ºC to 5.8°C by 2100. The projected rate of warming is unprecedented during last 10,000 years.

2. Agriculture Development in Haryana
Haryana is one of the richest states in food-grains. But at present time this state is facing a no of problems like, CC, GW in agricultural production. In present climatic scenario we take note of Haryana which is very hot in summer and cold in winters. The hottest months of year are May and June and the coldest being December and January. The temperature falls to the lowest in January and reaches up to 50ºC during the months of May and June. Winter months have average temperatures in the range 3ºC to 9ºC and the summer months temperatures are higher in the range of 35ºC to 48ºC. 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 about 65 lakh Hac with a cropping intensity of 180%.

3. Literature Review

S.K. Sinha and M. S. Swaminthan (1991) [1] 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.

The study of Gosain A. K. S., S. Rao (2006) [9], it has been revealed that under the GHG scenario the conditions may deteriorate in terms 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 ¼ of the area of Gujarat and 60 % 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.

Tata. N. Rao (2011), emphasise the role of human adoptions in responding to climate change. The study reveled 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 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.

4. Database 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 who maintain yearly agriculture production output, planted and cultivated area of Haryana. The data related to climate change had been collected from Indian Agriculture and climate Data Set by World Bank Research Group. The temperature and rainfall Data of the Haryana has been taken from Haryana Economic Survey Report released on yearly basis.

5. Climate Change in Haryana

Due to Industrial Revolution, Human activities have led to increase green house gases in the composition of earth's atmosphere. Haryana 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 31.4ºC To 17.4ºC. There is no significant trend in the mean maximum temperature. The minimum temperature shows an increase of about 1.0ºC To 1.2ºC in 37 years. The Districts of Fatehabad, Jhajjar and Karnal shows higher increase in the minimum temperature (1.1ºC To 1.3ºC). The seasonal average maximum temperature is higher during pre-monsoon and monsoon season.

Table 1: Rainfall and Temperature variation in Haryana

Year	Average Annual Rainfall (mm)	Maximum Annual Temperature Variation
2006	377.7	45.0
2007	479.8	45.0
2008	632.9	43.0
2009	350.5	47.0
2010	597.7	48.0
2011	433.2	46.2
2012	313.6	46.7
2013	461.3	47.3
2014	305.6	47.1
2015	436.0	45.5

Table-1 is showing both Avg. Rainfall as well as Avg. Temperature Variation in Haryana. Fig 1 is showing that Maximum Annual Rainfall was 632.9 mm in year 2008 when the temperature was lowest and after that there is a decline in

rainfall and minimum Rainfall was at 305.0 mm in the year 2014 when the temperature was highest. The Average Rainfall in all these years was 438.83 mm. Now if we observe the Trends and patterns of Rainfall in all these Ten years the above Data is reflecting how the climate change or we can say rise in temperature is reducing the rainfall. We can say that reduction in rainfall will bring reduction in agricultural production.

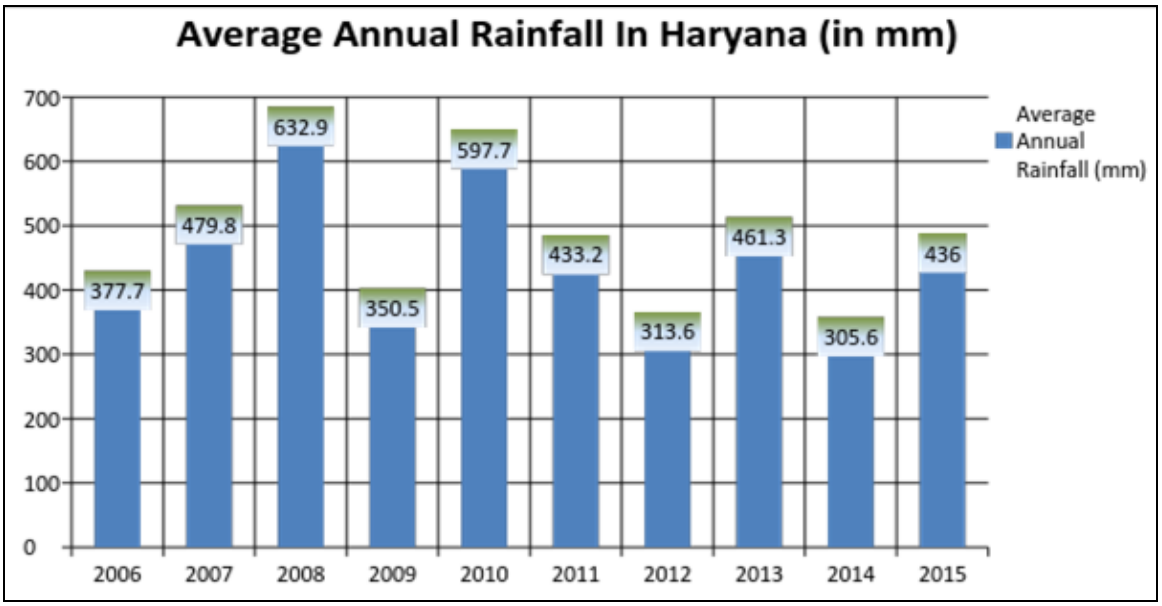

Fig 1: Source: Indian Meteorological Department

Fig-2 shows that maximum variation in temperature was in 2008 and after that it shows an increasing and decreasing trend continuously till 2015 and due to the climate change variation the temperature starts increasing from 43ºC To above 47ºC which is an alarming sign for agriculture due to the continuously increase in temperature.

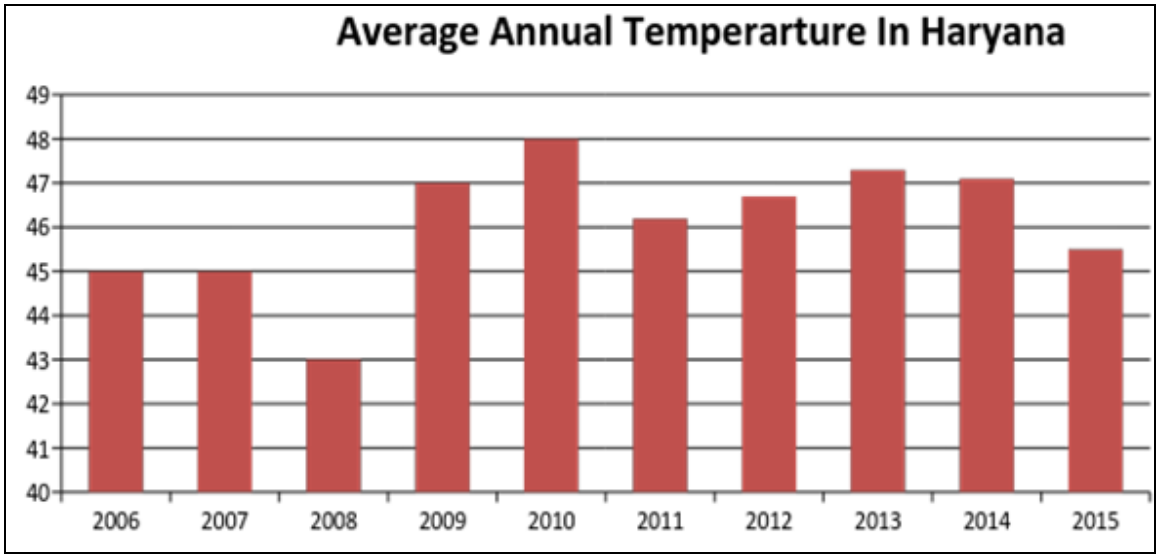

Fig 2: Source: Indian Meteorological Department

6. Trend of Wheat Production in Haryana

Wheat is the most important food grain in the world. It 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 Cultivation Area & Wheat Production

Year	Area Under Wheat Production (Hectare)	Total Wheat Production (Tonnes)
2006	2250	9450
2007	2376	10059
2008	2461	10232
2009	2462	11360
2010	2488	10629
2011	2504	11509
2012	2531	13119
2013	2497	11117
2014	2499	11800
2015	2601	10354

Table 2 is showing Area under Wheat Cultivation and Total Wheat Production in that Area. While
Fig-3 is showing the area under which wheat cultivation is done. The Graph is reflecting an increased trend from the year 2006 to 2015, and in between this time period the area under wheat production decrease and sometimes increases but overall it shows increasing trend.

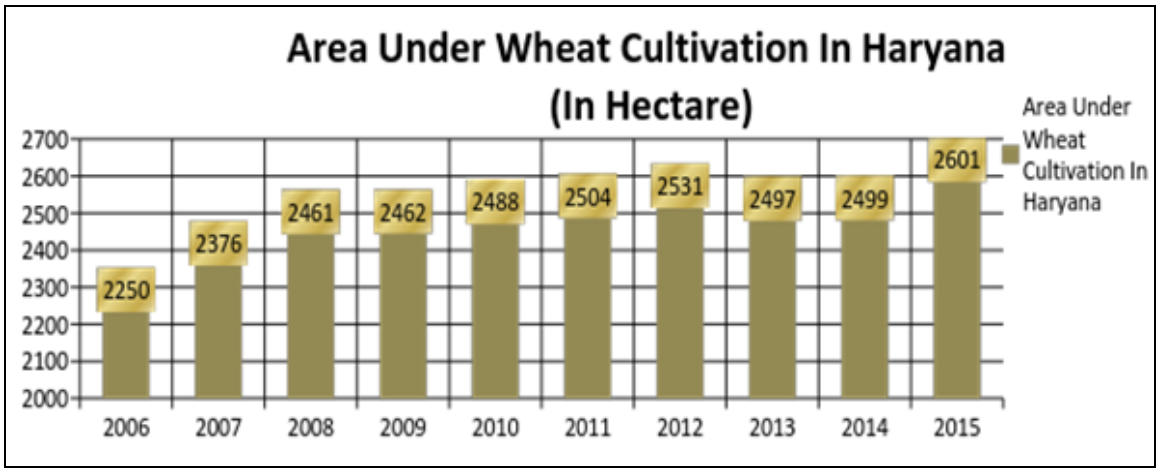

Fig 3: Source: Statistical Abstract Haryana

Fig-4 shows that maximum wheat production in Haryana was in 2012 and after that it is showing an increasing and decreasing trend continuously till 2015 and it also indicate that the wheat production in Haryana is also increasing from year 2006 onwards. But after few years the production declines and it was then again lowest in the year 2010 and then again it shows an increasing trend in wheat production in Haryana. Meanwhile the Table 1 is showing that due to the climate change variation the temperature starts increasing from 43ºC To above 47ºC which is an alarming sign for agriculture production.

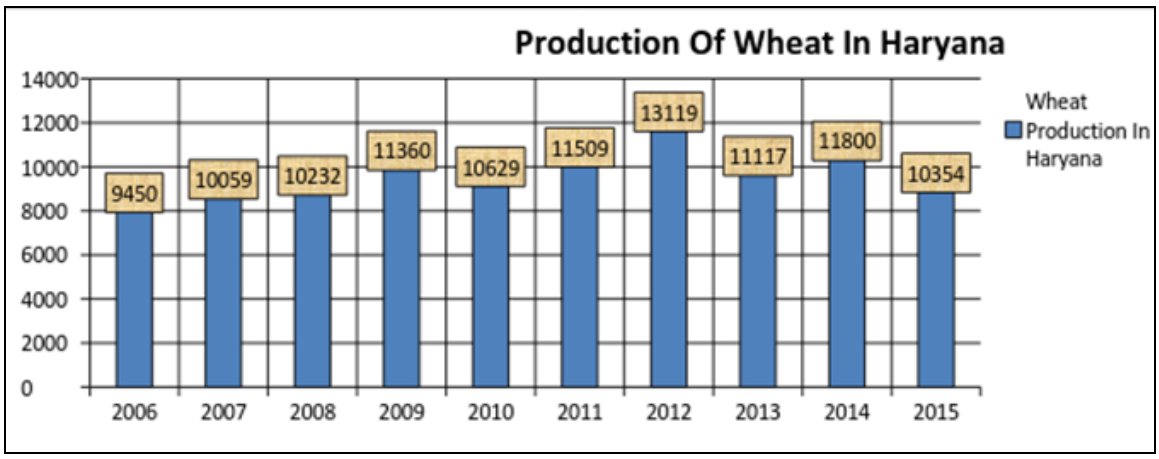

Fig 4: Source: Statistical Abstract Haryana

7. Analysis of Result of Study

The global warming effects have not even kept Haryana untouched. The earlier data comparative study reflects 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:-

$Y = \alpha o + \beta 1X1 + \beta 2X2 + \mu$

Y = Wheat Production
X1 = Variation in Temperature
X2 = Average Annual Rainfall
M = Disturbance Term

Results of the Model

Table 3

Wheat Production	Coef.	Std. Err.	t	R x R	Obs
Rainfall	-1.257727	.2119222	-0.59	0.85	13
Temperature	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 2006-2015 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. 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 % decrease in rainfall will lead to -1.25 % decrease in production.

8. Conclusions and Suggestions

So after the analysis of the above result we can say that climate change is adversely impacting the productivity in agriculture in Haryana because agriculture production in Haryana mainly depends upon rainfall. Due to change in climate there is increase in Maximum and Minimum temperature, the length period of each season is also changed. Climate change is increasing uncertainties in raining season period and frequency of rainfall, heavy rainfall or inappropriate timely rainfall and lack of rainfall when there is need of rainfall in agriculture, increasing frequency of droughts etc. But there is no separate policy and agenda for sustainable development of agriculture. To overcome the impact of climate change on agriculture some suggestion are to be introduced. The suggestions are divided into two categories.

1. Adaption
2. Mitigation.

All Adaption and Mitigation for climate change are as following.

1. Crop insurance for climate variability is necessary to overcome the loss of climate change on agriculture.
2. Use of new varsities and certified seeds that cannot be much affected by the change in climate change.
3. Early warning must be given to the farmers so that they can use alternative techniques to protect themselves from these types of change.
4. More emphasize on those crops which are not climatic sensitive and crop diversification should be adopted as the solutions of this problem.
5. Insure farmer's crops against climate related weather changes.
6. Water conservation and increase in efficiency of water use.

So there is need to reduce the impact on climate by Agriculture Sector adopting some methods. Farmers must use less fertilizer and adopt organic farming, etc.

As global citizens are getting aware with the term Climate Change which will result in increased temperatures and decrease in rainfall. This initiative is gathering momentum in 21st century. Various economic researches have attempted to quantify the possible effects 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 available evidence indicates 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. This study suggests that as the impact of climate change is intensifying day by day it should be addressed through proper policy at the earliest.

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