Climate Change and Food Security: Indian Perspective

Dr. Jiaul Islam, Assistant Professor, Department of Environmental Science, SambhuNath College, Labpur, Birbhum

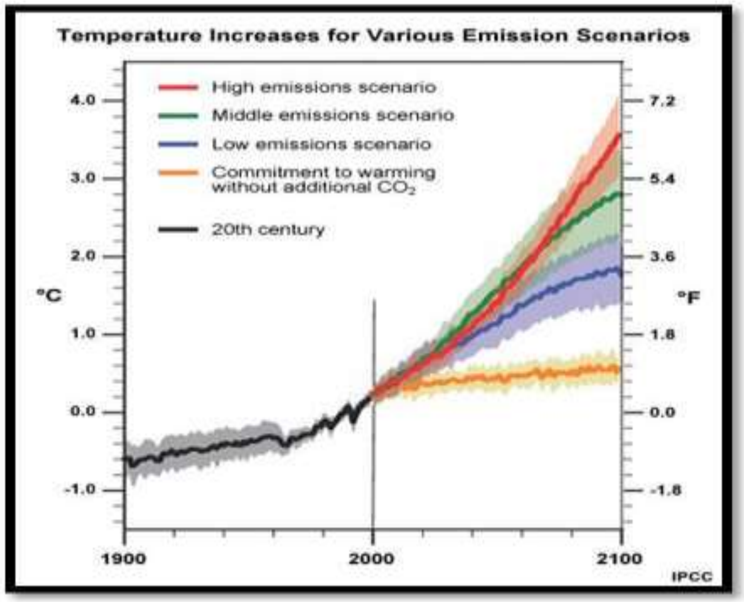
ABSTRACT: Since the beginning of the evolution of earth, the climate is changing naturally at its own pace. However, with the evidences of accelerated climate change, observed in the 21st century and possibility of more changes in near future, the food security and its regional impacts is a matter of grave concern. In the last century there has been increasing trend of surface temperature and changes in other climatic parameters in India. The more heat waves, experienced in recent times, will lead to increased variability in summer monsoon precipitation, resulting in drastic effects on the agricultural sector in India. The crop production may be seriously impaired with minor deviations from the normal weather leading to aggravating India's food security challenges. The objective of the present review paper is to study the present status of climate change and its impact on India's food security associated with impaired agricultural production. Several studies have already shown the decreasing trend in yield of several crops with the projection of accelerated yield loss in near future. So, under the future climate change scenario, ensuring food security including its availability, access, and absorption will be a formidable challenge. The adoption of sustainable agricultural practices, greater emphasis on urban food security and public health, provision of livelihood security, and long-term relief measures in the event of natural disasters are some of the measures to combat this challenge.

Key-words: Climate change, Crop production, Food security, India scenario.

I. Introduction

Climate change is any significant long-term change in the expected patterns of average weather of region (or the whole Earth) over a significant period of time due to natural or anthropogenic factors. These changes may take tens, hundreds or perhaps millions of year. But increase in anthropogenic activities such as industrialization, urbanization, deforestation, agriculture, change in land use pattern etc. leads to emission of increased level of greenhouse gases such as CO_2, CH_4, O_3, N_2O and CFC_s. The most imminent climatic change in recent times is the increase in the global atmospheric temperature in an increasing rate. However it also includes changes in precipitation, higher atmospheric CO_2 concentrations and changes in other weather parameters. Climate change may affect agriculture in different ways. Higher level of atmospheric CO_2 concentrations can have a direct effect on crop production. There can be CO_2-induced changes of magnitude of temperature, rainfall and sunshine that can influence plant productivity. Finally, sea level rise may lead to loss of farmland by inundation and increasing salinity of groundwater in coastal areas. The average global surface temperature in 2018 has increased by (0.99±0.13)°C above the pre-industrial baseline (1850-1900) (WMO, 2019).It is further expected to increase by 1.4 °C - 5.8 °C by 2100 AD with significant regional variations (Fig.1).

Fig.1: Scenario of Global Climate Change



(Source: IPCC, 2007)

The past four years (2015-2018) rank were the top four warmest on record with the year 2018 being the fourth warmest since records began in the 1850s. The global sea level has risen by 3.8 mm in2018 compared to 2017 and it was highest on record. Over the period January, 1993 to December, 2018 the average rate of rise was (3.15±0.3) mm yr^{-1}level. Arctic ice content was well below the average throughout 2018 and was at record low levels for the first two months of the year. Arctic sea ice level reaches its minimum each September. Arctic Sea in September is now declining at a rate 13.3% per decade relative to 1981-2010 average level. Sea ice content in 2012 was lowest since 1979 based on satellite observations. Since 2012, land ice at Antarctica has been losing at a rate of 134 giga tonnes ice per year. For Greenland this rate is more alarming with 287 giga tonnes ice per year (climate.nasa.gov). In the last days of 2018, the daily Antarctic-sea ice content reached a record minimum. With these evidences of observed climate change there is much concern about future changes in our climate and its direct or indirect effect on agriculture (Krupa, 2003; Aggarwal, 2003; and Mall et. al., 2007). The atmospheric concentration of CO_2, the main greenhouse gas, has increased from 280 ppm in pre-industrial period (1850) to 405 ppmin 2016 at an average rate of 1.5-1.8 ppm per year. Table below makes it clear that the level of atmospheric $CO_2$is going to increase even faster than ever in near future under business-as-usual scenario.

Table 1. Estimated and projected level of atmospheric carbon-di-oxide in recent past and future:

Year	CO_2level(ppm)
2000	369
2010-15	388-398
2016 (October)	405
2050-60	463-623
2100	478-1099

(Source: Mall et. al. 2006; nasa.gov.in)

One of the biggest issues confronting Indian agriculture is low productivity. India's cereal yields are drastically lower than those of developed regions such as North America (6671 kg per ha), East Asia and the Pacific (5,184 kg per ha), and the Euro area (5855.4 kg per ha) (Table 2). Table 3. shows that yield per hectare of food grains has stagnated in India since the 1980s.

Table 2: Cereal yields (kg ha^{-1}) in 2013

Country/ Region	Kg per hectare
East Asia & Pacific (developing only)	5,184.0
Central Europe and the Baltics	4,131.1
Sub-Saharan Africa	1,433.5
Europe & Central Asia (all income levels)	3,661.6
Euro area	5,855.4
North America	6,671.0
India	2,961.6
World	3,851.3

(World Bank Database)

Table 3: Growth rate of yield per hectare (%) of food grains

Period	Rice	Wheat	Coarse Cereals	Pulses	Total Foodgrains
1980-81 to 1990-91	2.7	3.4	2.6	2.0	3.0
1990-91 to 2000-01	0.9	1.7	1.3	-0.6	1.7
2000-01 to 2010-11	1.6	1.0	4.1	2.4	1.7
2010-11 to 2014-15	1.6	-1.0	3.1	1.9	1.8

(Reserve Bank of India Database)

Food security consists of food availability, access to food and food absorption. As a significant chunk of India's population remains malnourished, India remains at the 72nd position in the Global Food Security Index among 113 countries, indicating there is a lot to achieve. The ill-effects of climate change can destabilise food systems through drastically reducing crop productivity driving several into starvation and malnutrition.

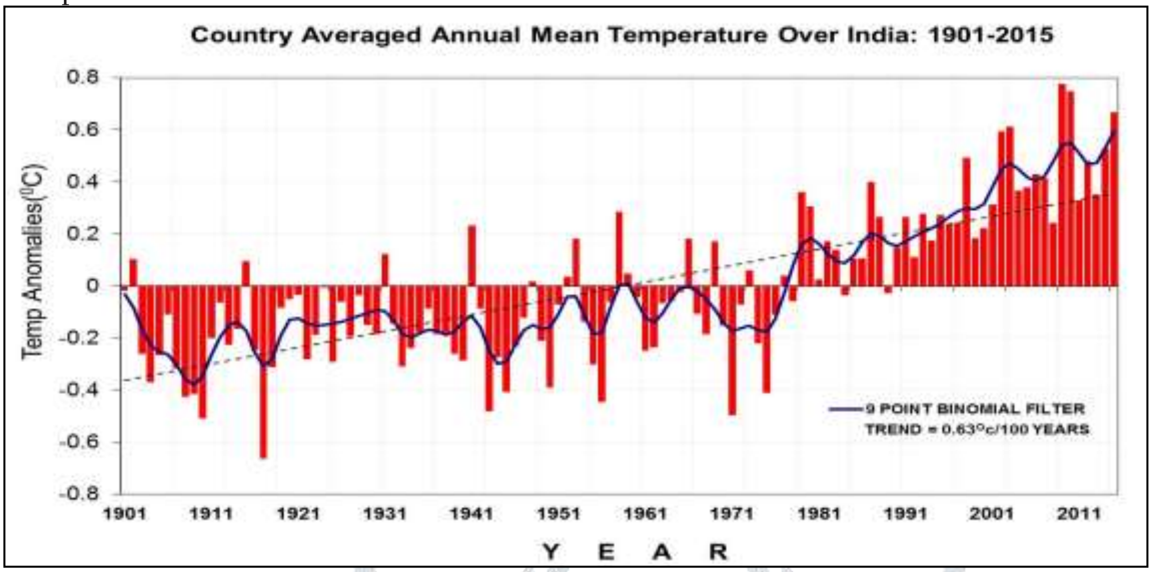
II. Climate Change Scenarios in India

Temperature: In India, the analysis of seasonal and annual surface air temperatures has shown a significant warming trend of 0.57°C per hundred years (Mall et.al. 2006). Since 1880 the monsoon temperatures increased by 1.1°C while, winter temperature has increased by 1°C. The spatial variation of warming is characterized by sharp decrease in minimum air temperature during 1955-72 and then sharp increase till date in north India. However, increasing trend of minimum temperature has been noticed in south India during same period (Lal, 2003). Sea surface temperature of Arabian Sea and Bay of Bengal has shown increasing trend in the last century. East coast of the country has experienced more extreme weather events in recent past. The frequency of occurrence of cyclonic storms showed increasing trend in the month of November. There is also increase in number of cyclonic storms in Indian coast.

The annual mean land surface air temperature in 2018 for the country was +0.67 ^{0}C above the 1961-1990 average (Fig.2), thus making the year 2015 as the third warmest year on record since 1901. The other five warmest years on record in order are: 2009 (+0.77^{0}C), 2010 (+0.75^{0}C), 2003(+0.61^{0}C), and 2002(+0.59^{0}C) and 2014 (+0.53^{0}C). It may be mentioned that 12 out of the 15 warmest years were during the recent past fifteen years (2001-2015). Also the past decade (2006-2015) was the warmest decade on record. During 1901-2015, the annual mean temperature showed an increasing trend of 0.63^{0}C/100 years with significant increasing trend in maximum temperature (1.04^{0}C/100 years), and relatively lower increasing trend (0.22^{0}C/100 years) in minimum temperature. The country's average seasonal mean temperatures were also above the average during all the four seasons with the southwest monsoon season (June to September,

+0.72^{0}C) being fourth warmest and the post monsoon season (October – December, +1.22^{0}C) being warmest ever since 1901(IMD, 2016).

Fig.2: Annual mean land surface air temperatures anomalies averaged over India for the period1901-2015.



The anomalies were computed with respect to base period of 1961-1990 (Source: IMD, 2016)

Rainfall: The rainfall fluctuations in India have been largely random over the century, with no systematic change detectable in summer monsoon season. As per report of GOI, 2016 the monsoon rainfall at all India level does not show any trend and seems mainly random in nature over a long period of time. However, some pockets of significant long-term rainfall have been recorded along the west coast, north Andhra Pradesh and North West India (+10 to +12% of normal/100 years). Areas of decreasing trend are found over east Madhya Pradesh and adjoining areas, north-east India and parts of Gujarat and Kerala (-6 to -8% of normal/100 years). The rainfall in 2014-15 was deficient by 12% of long period average (LPA) and characterized by unseasonal rains and hailstorm. The cumulative monsoon rainfall for country as a whole was 14% lower than LPA. As per IMD report, 2016 the annual rainfall in 2015-16 over the country was 91 % of Long Period (1951-2000) Average (LPA) and was 22nd lowest annual rainfall recorded ever since 1901. The five lowest ever annual rainfall was recorded in 2009 (80% of LPA), 1972 (80.8%of LPA), 2002 (80.9% of LPA), 1918 (82.3% of LPA) & 1965 (83.7% of LPA). The seasonal rainfall over the northeast monsoon region of the south peninsula (comprising of 5 subdivisions viz. Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu and Puducherry, South interior Karnataka and Kerala) in 2014-15 was significantly above average (132% of LPA) which was the 14th highest ever recorded for the region during the last 115 years (1901-2015) and third highest during the last 15 years. Highest NE monsoon season rainfall over south India was recorded in 2005 (163% of LPA) followed by 2010 (154 % of LPA). During the NE monsoon season, south peninsula recorded significantly above normal rainfall in November (227%

of LPA) and December (152% of LPA) of 2015 resulting severe floods occurred in many parts of the region in general and Tamil Nadu in particular (IMD,2016). So, the rainfall pattern in India is characterized by greater temporal and spatial variability with no specific trend.

Extreme Weather Events: In the year 2015, four cyclonic storms formed over the north Indian seas with three formed over the Arabian Sea, one each in the month of June, October and November and one over the Bay of Bengal in July. The country experienced six depressions during the monsoon season and one during the northeast monsoon season of last year. Apart from these, there were also other high impact weather events such as severe hailstorm over northwest, central and adjoining peninsula during March and severe heat wave incidences in May over the south peninsula and eastern parts of the country. Various parts of Odisha, Maharashtra and Telangana experienced exceptional lightning. There was extremely heavy rainfall over Madhya Pradesh, Gujarat, and Rajasthan during southwest monsoon while exceptional heavy rainfall events occurred over Tamil Nadu and Andhra Pradesh during northeast monsoon (IMD, 2016).

Glaciers: Gangotri glacier is receding since 1870 when data records began. It has lost its 1147 meters between 1936 and 1996 with the annual rate of 19 meters. Over one percent of water in the Ganges and Indus basins is currently due to run off from loss of permanent ice from glacier (Venkat V, 2016). Siachen glacier, the highest battle ground of world saw severe avalanches in 2016 probably due to global warming leading to death of several Indian army men.

Sea Level: The sea level of Indian Ocean and Bay of Bengal is currently rising at 1 mm per year on an average. The rise is highest along the gulf of Kutchh in Gujarat and the west coast of West Bengal, while there is a relative decrease in sea level along the Karnataka coast. Much of this rise has been attributed to warming of sea water that increases its volume (Thompson et. al., 2016).

III. Impact of climate change on food security

Crop production in India is mainly determined by the nature of monsoons. Good monsoon year fetches higher food grain production. Any change in monsoon trends drastically affects agricultural production. The increasing temperature is already affecting Indian agriculture. In the Indo-Gangetic plain (IGP), these pre-monsoon changes will primarily affect the wheat crop (>0.5^0C increase in time slice of 2010-2039) (IPCC, 2007). In the states of Jharkhand, Odisha and Chhattisgarh alone, rice production losses during severe droughts (about one in fiveyear) average about 40 percent of total production.Increase in CO_2 to 550 ppm is projected to increase yields of rice, wheat, legumes and oilseeds by 10 to 20 percent. A 1^0C increase in temperature may reduce yields of wheat, soybeans, mustards, groundnuts, and potatoes by 3 to 7 percent. There would be higher losses at higher temperatures. Productivity of most crops may decrease only marginally by 2020 but by 10 to 40 percent by 2100 due to increase in temperature, rainfall variability, and decreases in irrigation water (Srivastav, 2016).

India's past has not been easy in terms of food security. Famines, malnutrition and productivity stagnation have all been a part of India's agricultural struggle. The Green Revolution in the 1960s and the White Revolution in 1980s were unique, helping to meet the hunger of millions. However, our ever increasing population still requires a large amount of food. The World Food Summit in 1996 defined food security thus: "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Malancha, 2016).According to this definition, there are three main dimensions to food security: food availability, access to food, and food absorption. Thus, adequate food production alone is not a sufficient condition for a country's food security.Food security is one of the leading concerns associated with climate change (Parry *et. al*, 2009). Climate change affects food security in complex ways. It impacts crops, livestock, forestry, fisheries and aquaculture, and can cause grave social and economic consequences in the form of reduced incomes, eroded livelihoods, trade disruption and adverse health impacts. However, it is important to note that the net impact of climate change depends not only on the extent of the climatic variability but also on the underlying vulnerabilities. According to the Food and Agriculture Organization (2016), both biophysical and social vulnerabilities determine the net impact of climate change on food security (FAO, 2016).

The major impacts of climate change will be on rain fed or un-irrigated crops, which are cultivated on nearly 60 percent of cropland. A temperature rise by 0.5^0C in winter temperature is projected to reduce rain fed wheat yield by 0.45 tons per hectare. Possibly there might be some improvement in yields of chickpea, rabi maize, sorghum and millets and coconut on the west coast and less loss in potato, mustard and vegetables in north-western India due to reduced frost damage. Increased droughts and floods are likely to increase production variability (Mahato, 2014).Studies done at the Indian Agricultural Research Institute, New Delhi indicate the possibility of a loss of between 4 and 5 million tons in wheat production in the future with every rise of 1^0C temperature throughout the growing period. Rice production is slated to decrease by almost 1tonne/hectare if the temperature rises by 2 ^{0}C (Aggarwal, 2003). Significant impacts on crop yield are already being felt at 0.8^0C warming and as temperature rises from 2^0C to 4^0C by 2100 with 40% chance, the crop production is expected to be seriously affected (World Bank, 2014).

The impact of climate change on water availability will be particularly severe for India because large parts of the country already suffer from water scarcity, to begin with, and largely depend on groundwater for irrigation. The decline in precipitation and droughts in India has led to the drying up of wetlands and severe degradation of ecosystems. About 54 percent of India faces high to extremely high water stress. Large parts of north-western India, notably the states of Punjab and Haryana, which account for the bulk of the country's rice and wheat output, are extremely water-stressed (Chakrabartry, 2016). With increased periods of low precipitation and dry spells due to climate change, India's groundwater resources will become even more important for irrigation, leading to greater pressure on water resources. According to the World Bank projections, with a global mean warming of 2°C above pre-industrial levels, food water requirements in India will exceed green water availability. The mismatch between demand and supply of water is likely to have far-reaching implications on food grain production and India's food security.

Mall and Singh (2000) observed that small changes in the growing season temperature over the years appeared to be the key aspect of weather affecting yearly wheat yield fluctuations. Pathaket. al. (2003) concluded that the negative trends in solar radiation and an increase in minimum temperature resulted in declining trends of potential yields of rice and wheat in the Indo-Gangetic plains of India. In Delhi the minimum and maximum temperature shows a rising trend both in '*Kharif* ' growing season (June–October) as well as '*rabi*' or winter growing season. There was also a small declining trend in solar radiation during *rabi* and *Kharif* season after 1980. These changes indicate warming trend. Since solar radiation is closely related to crop growth, any decrease in this will significantly reduce agricultural productivity. The accompanied increase in minimum temperatures increases maintenance respiration requirement of the crops and thus further reduces net growth and productivity (Aggarwal, 2003).

Climate change will exacerbate India's existing problems of food insecurity of both rural and urban area. The highest risks related to climate change are likely to be concentrated among the low-income groups residing in informal settlements which are often located in areas exposed to floods and landslides and where housing is especially vulnerable to extreme weather events such as wind and water hazards. Mumbai and Chennai are especially prone to bear the brunt of climate change. Dasgupta et al (2012) add Kolkata to the list of cities that are particularly vulnerable to climatic risks, as climate change is likely to intensify the frequent flooding in the Hooghly river during monsoon. The poor inhabitants of Kolkata are most vulnerable as their homes are located in low-lying areas or wetlands that are particularly prone to tidal and storm surges (Parry, *et. al.*, 2009).

Given that food is the single largest expenditure for poor households, displacement, loss of livelihood or damage to productive assets due to any such extreme weather event will have a direct impact on household food security. The poor people has also been identified as the group most vulnerable to increases in food prices following production shocks and declines that are projected under future climate change.

Conclusion

Global climate change driven by faster greenhouse gas emission is now a happening phenomenon. Agriculture sector in India is the most vulnerable sector as it will have a direct bearing on the living of 1.2 billion people, endangering the food security of the poor. However, based on the several reported studies, impact of climate change on Indian agriculture is characterized by greater uncertainties. For the multi-layered interconnections between climate change and food security, a multi-pronged approach is required to create a sustainable solution for India's future. Achieving food security in the context of climate change calls for an improvement in the livelihoods of the poor and food-insecure to not only help them escape poverty and hunger but also withstand, recover from, and adapt to the climate risks, they are exposed to. India's National Rural Employment Guarantee Act (NREGA) of 2005 marked a global milestone in the history of poverty alleviation. Given the vulnerability of Indian agriculture to climate-induced natural disasters and their long-term impacts on agricultural output, livelihoods and nutrition, a short-sighted approach towards disaster relief will only prove inadequate. The government needs to take a long-term view of disaster relief. Moreover, given the adverse impacts of natural disasters on child nutrition, long-term under nutrition prevention programmes must be implemented in disaster-affected regions. Additional efforts must be directed towards reducing the risk in agriculture. Such schemes should be specially targeted towards small farmers.

The impact of climate change on Indian agriculture and food security, both in the present as well as in a future, appears to be broadly in line with the considerations for global scenario. Providing more specific predictions of the impact of climate change on food security associated with impaired crop productivity require detailed study encompassing all the physical, social and economic factors of the different regions of the country. To develop climate-resilient strategies and make adequate policy interventions, there is a need for an integrated assessment of the impact of climate change on India's food security. So far, there are fewer studies on the impact of climate change on other dimensions of food security besides crop production. Research efforts should be directed towards assessing and quantifying the possible impact of climate change on food availability, access and food absorption in an integrated way.

References:

Aggarwal P.K. (2003). Impact of climate change on Indian agriculture. *J. Plant Biology***30**(2): 189-198.

Aggarwal P.K. (2008). Global climate change and Indian agriculture: Impacts, adaptation and mitigation. *Indian J. Agricultural Sciences***78**(10): 911-919.

Bhattacharya T, Panda RK (2013). Effect of climate change on rice yield at Kharagpur, West Bengal. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)***4**(2): 6-12.

Chakrabarty M. (2016). Climate change and food security in India.*ORF- Observer Research Foundation, Issue Briefs and Special reports, Sept 09, 2016* https://www.orfonline.org/research/climate-change-and-food-security-in-india/

Dasgupta, S, Roy, S. and Sarraf, M. (2012). Urban Flooding in a Changing Climate: Case Study of Kolkata, India", *Asian-African Journal of Economics and Econometrics*, 12(2012): 135 http://www.serialsjournals.com/serialjournalmanager/pdf/1436348337.pdf

Dash S K,Jenamani R K,Kalsi S. R. andPanda S. K.(2007).Someevidenceofclimate changeintwentieth-centuryIndia.*Climatic Change*, **85**(3): 299-321.

Food and Agriculture Organisation (2016).Climate change and food security: risks and responses".Retrieved from http://www.fao.org/3/a-i5188e.pdf

IPCC (Intergovernmental Panel for Climate Change) (2007).Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change *2007*. Parry M. L., Canziani O. F.,Palutikof J. P., Van der Linden P.J.and Hanson C.E.(eds.).

IPCC (Intergovernmental Panel for Climate Change) (2001).*Climate Change 2001 – The ScientificBasis*, Contribution of Working Group I to the Third Assessment Report of the IntergovernmentalPanel on Climate Change 2001. Houghton, J. T., Ding Y. ,Griggs D. J., M. Noguer, M and Van der Linden P. J. (eds.).

Krupa, S.(2003).Atmosphere and agriculture in the new millennium. *Environmental Pollution,* **126**:293–300.

Kumar R. and Gautam H.R. (2014).Climate Change and its Impact on Agricultural Productivity in India.*Climatol Weather Forecasting* 2:109. doi:10.4172/2332-2594.1000109.

Lal, M., Nozawa T., Emori S., Harasawa H., Takahashi, K., Kimoto M., Abe-Ouchi A., Nakajima T.,Takemura T. and Numaguti A. (2001). Future climate change: Implications for Indiansummer monsoon and its variability.*Current Science*, **81**: 1196–1207.

Mahato A. (2014). Climate change and its impact on agriculture.*International Journal of Scientific and Research Publications,* **4**(4): 1-6.

Mall, R. K. and Singh, K. K. (2000).Climate variability and wheat yield progress in Punjab using the CERES-wheat and WTGROWS models. *Yayu Mandal,* **30**(3–4): 35–41.

Mall, R. K., Lal, M., Bhatia, V. S., Rathore, L. S. and Singh, R. (2004).Mitigating climatechange impact on Soybean productivity in India: A simulation study. *Agricultural and Forest Metorology*, **121** (1-2): 113-125.

Mall, R.K, Singh, R., Gupta, A., Srinivasan, G., &Rathore, L.S. (2006). Impact of Climate Change on Indian Agriculture : A Review. *Climatic Change*, **78**: 445–478.

Parry, M., Evans, A., Rosegrant, W.M. and Wheeler, T. (2009). *Climate change and hunger: Responding to the Challenge*. World Food Programme, Via C.G. Viola, 68-70, Rome , Italy.

Pathak, H., Ladha J.K., Aggarwal, P. K., Peng, S., Das, S., Singh, Y., Singh, B., Kamra, S. K., Mishra, B., Sastri, A. S. R. A. S., Aggarwal, H. P., Das, D. K., and Gupta R. K. (2003). Trends of climatic potential and on-farm yields of rice and wheat in the Indo-GangeticPlains. *Field Crops Research* **80**: 223–234.

Shrivastava A. (2016). Climate Change and Indian Agriculture.*International Policy Digest*. World News/22 Aug 2016.

Thompson, P. R., Piecuch C.G., Merrifield M.A., McCreary J.P., *and* Firing E. *(*2016*),* Forcing of recent decadal variability in the Equatorial and North Indian Ocean, *J. Geophys. Res: Oceans*, **121:** 6762–6778,*doi:*10.1002/2016JC012132.

Venkat V. (2016). Gangotri glacier retreated by 3 km in two centuries. *The Hindu*.

World Bank (2014). Turn Down the Heat: Confronting the New Climate Normal. Washington, DC: World Bank. License: *Creative Commons Attribution- Non Commercial – No Derivatives* 3.0 IGO (CC BY- NC- ND 3.0 IGO).

World Meteorological Organization (2019).*WMO statement on the state of the global climate in 2018.* (WMO Technical Report Series 1233). Geneva, Switzerland.

http://www.ipcc.ch/pdf/assessmentreport

http://www.envfor.nic.in/public-information/annual-report

http://www.natcomindia.org

http://www. climate.nasa.gov

http://www.imd.gov.in/ims/PDF/climate_2015.pdf