CONCERNS OF CLIMATE CHANGE FOR INDIAN AGRICULTURE

Prof. Dr. P. S. Kamble

Department of Economics, Shivaji University, Kolhapur, Maharashtra (INDIA)

ABSRTACT:

The very important environmental problems before the World as a whole and India in particular is climate change, which is very closely associated with the global warming. They are very important on the ground that they have number of evil consequences on more or less all the spheres of the environment. It is not only India, but all the countries have been facing from the evil impacts of the climate change. It is adversely affecting the segments of the environments such as atmosphere, land, water and living things. Besides this the climate change is also adversely affecting the productive activities and sectors in the economies of the number of countries in the world as whole. It is therefore climate change has become at this moment a very importantly environmental problem of the globe as whole. And in the era of globalization and liberalization all countries of world are very closely interlinked and inter connected with the each other and India cannot be an exception to it. Hence India also has been severely affecting from the evil consequences of the climate change. It is a well known fact that at this moment also India is an agricultural country with over dependence of the people on agriculture as a means of lively hood, a major source of employment and a major population living in rural areas, whose prime economic activity is agriculture. This demands to discuss the interconnections and linkages between climate change and agriculture in the context of India. The prime objective of the present paper is identifying the things of serious concerns of climate change for the Indian agriculture. The study is exclusively relied on the secondary data concerning agriculture as well as climate change for the latest period prominently. The study concludes that the climate change has created severe adverse impacts on agriculture and thereby things of serious concerns , which are necessary to be tackled with the joint efforts of the government policy and active participation of the people and the society as a whole.

Key Words: Climate Change, Global Warming, Green House Gases, Agricultural Development, Area, Production, Yield, Impact, Things of Concerns, Impact

I) INTRODUCTION:

The very important environmental problems before the World as a whole and India in particular is climate change, which is very closely associated with the global warming. They are very important on the ground that they have number of evil consequences on more or less all the spheres of the environment. It is not only India, but all the countries have been facing from the evil impacts of the climate change. It is adversely affecting the segments of the environments such as atmosphere, land, water and living things. Besides this the climate change is also adversely affecting the productive activities and sectors in the economies of the number of countries in the world as whole. It is therefore climate change has become at this moment a very importantly environmental problem of the globe as whole. And in the era of globalization and liberalization all countries of world are very closely interlinked and inter connected with the each other and India cannot be an exception to it. Hence India also has been severely affecting from the evil consequences of the climate change. It is a well known fact that at this moment also India is an agricultural country with over dependence of the people on agriculture as a means of lively hood, a major source of employment and a major population living in rural areas, whose prime economic activity is agriculture. It is therefore urgent need of the hour to examine the inter linkages and inter connections between Indian agriculture and climate as a crucial global environmental problem. It is a debatable issue, to what extent India is responsible for the international environmental problem the climate change. But the number of evil effects of climate change is being visualized in Indian economy, and its impact on Indian agriculture is very much crucial one. This demands to discuss the interconnections and linkages between climate change and agriculture in the context of India. The prime objective of the present paper is identifying the things of serious concerns of climate change for the Indian agriculture.

II) RESEARCH METHODOLOGY:

The present research paper is a secondary data based study, which exclusively relies on the secondary data only. The data necessary for studying the major objective of identifying the things of serious concerns of climate change for agriculture of India has been collected. The secondary data collected can be divided into two categories namely data requires for the assessment of the present state of the agriculture of India, and data relating to the climate change and impact of climate change on Indian agriculture. The data relating the present state of Indian agriculture has been collected from the Economic Survey of India Government of India, State of Indian Agriculture by Government of India, Annual Reports of Ministry of Agriculture Government of India, Agricultural

Statistics Government of India, and data by Central Statistical Organization. The data comprises of Key Indicators of Agriculture sector, Area, production and yield of major crops, growth rates of area, production and yield. The period of study for assessing the present state of Indian agriculture is prominently 2009-10 to 2013-14, which is latest one. But besides this, for examining decadal growth in key agricultural indicators the period taken into account is from 1980-81 to 2013-14. The data relating to the climate change and its impact on agriculture includes the period from 2004 to 2013, even back to the 19th century also by considering the availability of the data. The relating to the climate change and its impact has been collected from Environmental Statistics by Ministry of Planning and Programme Implementation, Economic Survey Ministry of Finance government of India, State of Agriculture Ministry of Agriculture government of India, and from research articles and papers. So far as the analysis of the data is concerned, the simple statistical tools and techniques such as percentage share, growth over previous year, relative shares, per annum growth, and percentage to GDP have been used. Likewise, the use of scientific studies on the impacts of climate change on agriculture and other areas and productive sectors have been taken into consideration.

III) PRESENT STATE OF INDIAN AGRICULTURE:

Before examining the impacts of climate change on agriculture and serious things of concerns of climate change for Indian agriculture, it is of vital importance to study the present state of Indian agriculture. It is therefore here it is endeavoured to assess the present state of Indian agriculture by taking into account some important indicators of agricultural development for the latest period prominently and also considering the data availability.

Table 1: Agriculture sector: Key Indicators (per cent at 2004-05 prices)

Sr. No.	Item	2009-10	10-11	11-12	12-13	13-14
1	Growth in agri GDP	0.8	8.6	5	1.4	4.7*
	Share in total GDP	14.6	14.6	14.4	13.9	13.9*
	Of which, Agriculture	12.3	12.4	12.3	11.8	NA
2	Share in total GCF	7.3	6.3	7.0	7.1	NA
	Of which, Agriculture	6.7	5.8	6.5	6.5	NA
3	GCF as per cent of agri GDP	20.1	18.5	20.8	21.2	NA
	Of which, Private sector	16.7	15.7	18.0	18.1	NA
4	Agri exports (incl marine products) as per cent of total exports	8.2	8.0	10.1	11.8	11.9(P)

Source: Central Statistics Off ice (CSO) and Directorate General of Commercial Intelligence and Statistics (DGCI&S).

Notes: *Quarterly Estimates of GDP as of 30 May 2014; NA - Not Available; GCF-gross capital formation; P- provisional.

It is observed that agriculture sector has shown a significant growth in the year 2010-11 , and a considerable growth in 2011-12 and 2013-14 also. But its growth in 2009 and 2013-14 was dismal only and hence the thing of serious concern. The thing to be noted is that the share of agriculture sector to GDP is continuously falling and also remained at lower level at less than 15% during the period into consideration. Besides this and more importantly, the contribution of agriculture to GDP of India has remained at lower and also shows a declining trend, which was just 12% only during the period under study. The share of agriculture sector and agriculture in capital formation was also lower and indicated a falling trend. The contribution of agriculture to the exports of India is even lower, it is increasing is a thing to be noted. This adequately reveals that the importance of agriculture and agriculture sector India is falling on various counts which require to be improved for which agricultural development is very much necessary and the need of the hour.

The present state of Indian agriculture can be examined by taking into consideration some important indicators of agriculture development such as growth in area, production and yield. The necessary data about it is depicted below.

Table 2: Area, Production and Yield of Major Crops in 2013-14*, with Per Cent Change over 2012-13 (Area: Million ha; Prod: Million tonnes; Yield: kg/ha)

Group/Commodity	Area	Production	Yield
Foodgrainsa	126.2 (4.47)	264.4 (2.88)	2095 (-1.55)
Rice	43.9 (2.57)	106.3 (1.05)	2419 (-1.75)
Wheat	31.3 (4.33)	95.8 (2.46)	3059 (-1.86)
Coarse cereals	25.5 (2.98)	42.7 (6.64)	1672 (2.83)
Maize	9.3 (6.90)	24.2 (8.52)	2602 (1.40)
Bajra	7.9 (8.22)	9.2 (5.75)	1161 (-3.09)
Pulses	25.4 (9.01)	19.6 (7.10)	770 (-2.41)
Gram	10.2 (20.00)	9.9 (12.50)	974 (-5.98)
Tur	3.9 (0.00)	3.4 (13.33)	1149 (-1.63)
Oilseeds	28.2 (6.42)	32.4 (4.85)	1149 (-1.63)
Groundnut	5.5 (17.02)	9.5 (102.10)	1723 (73.17)
Rapeseed and mustard	6.5 (1.56)	7.8 (-2.50)	1208 (-4.28)
Cottonb	11.7 (-2.50)	36.5 (6.73)	529 (8.85)
Sugarcane	5.0 (0.00)	348 (2.11)	70 (0.00)

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation (DAC).
Notes: *3rd Advance Estimates; a - Includes cereals, coarse cereals and pulses;
b - million bales of 170 kgs each; Figures in brackets indicate per cent change over 2012-13.

It is revealed that in 2013-14 compared to 2012-13 not much increase area in agricultural commodities has taken place except a few items like gram, ground nut, Bajara, maize, pulses. The area under food grains have increased marginally only and same is the case of the agri. commodities like rice, wheat, coarse cereals. There are some commodities that shown either negative growth or stagnant position in the area under cultivation. So far as growth in production is concerned, the production of food grains, rice, wheat, rice and sugar cane have shown a marginal growth only , is a thing of concern which requires due attention. The agri. Commodities namely groundnut, tur, gram have shown a considerable growth is a thing of appreciation. As far as growth in yield is concerned, except ground nut, coarse cereals and cotton all others have registered negative growth is a thing of serious concern for food security in India, which requires necessary attempts for their positive change.

Besides this, a decadal growth in the agricultural development indicators like area, production and yield for the longer period is also necessary to examine to highlight the long term trends in agricultural development in India. It is presented in the table below.

Table 3 : Compound Growth Rates of Area, Production, and Yield of Principal Crops during 1980-81 to 1989-90, 1990-91 to 1999-2000 (Base : TE 1981-82=100), and for 2000-01 to 2013-14 (Base: TE 1993-94=100)

A - Growth rate of area, P - Growth rate of production, Y - Growth rate of Yield (% per annum)									
Crop	1980-81 to 1989-90			1990-91 to 1999-2000			2000-01 to 2013-14*		
	A	P	Y	A	P	Y	A	P	Y
Rice	0.41	3.62	3.19	0.68	2.02	1.34	0.00	1.82	1.82
Wheat	0.46	3.57	3.10	1.72	3.57	1.83	1.35	2.65	1.29
Coarse cereals	-1.34	0.40	1.62	-2.12	-0.02	1.82	0.25	2.96	2.70
Pulses	-0.09	1.52	1.61	-0.60	0.59	0.93	1.59	3.72	2.10
Sugarcane	1.44	2.70	1.24	-0.07	2.73	1.05	1.34	2.10	0.75
Nine oilseeds	1.51	5.20	2.43	0.86	1.63	1.15	2.35	4.71	2.31
Cotton	-1.25	2.80	4.10	2.71	2.29	-0.41	3.22	13.53	9.99

Source: Department of Agriculture and Cooperation.
Note: * As per 2nd AE; Nine oilseeds include groundnut, castor seed, sesamum, rapeseed & mustard, linseed, niger seed, safflower, sunflower, and soyabean.
TE : Triennium Ending

It is observed that so far as growth in area under agricultural commodities is concerned, not much increase is found during the period from 1980-81 to 2013-14. The growth in production is marginal only during the period under the consideration, except oilseeds and cotton. In the case of

growth in yield, only a marginal increase is found during the period under our study with the exception like cotton only. This demands a dismal performance of Indian agriculture and urgently demands rigorous and honest efforts for its progress and development very much necessary for dealing with the problems like food security, poverty, employment and growth of the economy also.

IV) CLIMATE CHANGE AND INDIA:

The Inter-Governmental Panel on Climate Change (IPCC) was established by United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear view on the current state of Climate Change and its potential environmental and socio-economic consequences. IPCC defines climate change as '*a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity*'. The definition provided by UNFCCC defines as '*a change that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods*' (Government of India, 2013, p17).

Climate is a vibrant phenomenon and undergoes continuous changes over centuries. There are natural forces like photosynthesis of the plants, eruption of volcanoes, emission of methane from agricultural activities, vapor emissions etc. The important factors, which are responsible for climate change and are causally contributed by human civilization on earth, are; • Greenhouse Gases • Deforestation• Land-use Change• Energy Usage• Vehicular Usage Human civilization and industrialization have amplified the emissions of 'Greenhouse Gases', which are considered to be one of the main causal factors accelerating climate change in the post industrialization era. GHGs constitute • Carbon Dioxide (CO2), • Methane (CH4), • Nitrous Oxide (N2O), • Hydrofluorocarbons (HFCs) • Perflurocarbons (PFCs) • Sulpurhexafluoride (SF6) In addition to this, water vapor, which absorbs the heat radiations from Sun and trap such radiations in the atmosphere making the earth warmer, is considered important. Emissions of GHGs beyond certain limits make earth's atmosphere hotter and induce climate change. The extent of GHGs in the atmosphere increased phenomenally from 280ppm1 (1750) to 379ppm in 2005 (IPCC-AR42) (Government of India, 2013, p21).

CO2 is the most important anthropogenic GHG as it constitutes about 70% of the total emissions. CO2 originates from burning of fossil fuel (56.6%), deforestation and decay of biomass (17.3%), agriculture etc. The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry while deforestation, agriculture and

residential/commercial buildings are only minor contributing factors. The available global data on CO2 since 1970 indicates that the annual emissions have grown at about 80% from 21 to 38 gigatons, which represents 77% of the total anthropogenic emissions. The global increases in CO2 concentrations are primarily due to • Fossil Fuel Use • Land-use and Land-use Change • Agricultural activities• Industrial Development • Forestry. India's share of CO2 in the total emissions in the world is very insignificant in per-capita terms. The per-capita emission of an Indian citizen is 1.2 tons of Carbon dioxide whereas his counterpart in USA contributing 20.6 tons as per UNDP Human Development Report 2007/2008. The per-capita emissions of UK and Japan are 8 and of USA 17 times higher than that of India. India's contribution to the world total is only 4.6% when compared to USA's contribution of 20.9% followed by 17.3% of China. The energy sector is the major producer of CO2. 58.6 %* of our energy needs are met from coal, which is abundant, locally available and cheap when compared to alternative fuels. The global atmospheric concentration of Methane has increased from pre-industrial value of about 715ppb (Particles per Billion) to 1774ppb in 2005 (The Intergovernmental Panel on Climate Change 4th Annual Report (IPCC-AR4). Methane is generated due to the activities: • Agriculture • Energy Sources like biomass burning, coal mining and handling and flaring of natural gas systems • Waste disposal• Land-use • Land-use Change • Forestry • Shifting Cultivation practice. In India, the Methane emissions in the year 1994 were 18,583 Gg, (Giga gram) out of which 78% came from agriculture, 16% from energy sources and 6% from waste disposal. The rest is contributed by other activities mentioned above. Global Nitrous Oxide concentration increased from about 270ppb (1750) to 319ppb (2005). Many halocarbons including hydro-fluro-carbons have also increased from a near-zero level to significant levels primarily due to human activities (Government of India, 2013, p22).

There is considerable reduction in the forest cover due to encroachment and land use change and economic development activities like construction of roads, canals and power stations. Forests are the major source of carbon sequestration and the womb of the biodiversity, which acts as the main artery of any environment and ecosystem. National Action Plan on Climate Change (NAPCC) estimates that 77 to 68% of the forest areas in the country are likely to experience shift in forest types by the end of the 21st century, which needs our immediate attention. Land-use change is another major predicament to be viewed seriously. As per the data available, after the enactment of Forest Conservation Act, 1980, a huge portion of forestland is diverted for non-forest use. The reported figure for the year 1981 is 1331 ha whereas the cumulative figure till 2004 is 9,54,839 Ha. A relative growth in the land-use change is also visible in urban and rural areas due to urbanization and industrialization. Fragmentation of forests and habitats are another major reason for loss of

biodiversity. There are no data which gives any indication of loss of biodiversity and loss of biomass due to this land use change. After the liberalization and globalization, India is on a high growth path and envisages about 7-8% GDP growth rate per annum. The energy generation has grown manifold due to the ever increasing demand for energy since 1992. Coal, Gas and Diesel being the major sources of power in India, the emissions of GHGs are also on the rise. The number of vehicles registered in India is on the increase over the last 7 years at an average annual cumulative rate of 10% (data from 2004 to 2011). It indicates the increases in the use of fossil fuel and thereby an increases in GHG emissions (Government of India, 2013, p. 23).

V) CLIMATE CHANGE AND INDIAN AGRICULTURE:

Agriculture lies at the heart of many fundamental global challenges faced by humanity including food security, economic development, environmental degradation, and climate change. There is no humanitarian goal more crucial than feeding a world population projected to expand beyond nine billion by 2050. Meeting increases in food demands associated with growing population and income levels is likely to require increases in total food production of 50 percent or more by mid-century. Agriculture provides employment for 2.6 billion people worldwide and accounts for 20 to 60 percent of the gross domestic product of many developing countries, forming the backbone of rural economies, contributing to local employment, and ensuring food security for poorer populations (California Environmental Associates, 2014, p11). Global climate change is a change in the long-term weather patterns that characterize the regions of the world. The term "weather" refers to the short-term (daily) changes in temperature, wind, and/or precipitation of a region (Merritts *et al.* 1998). In the long run, the climatic change could affect agriculture in several ways such as quantity and quality of crops in terms of productivity, growth rates, photosynthesis and transpiration rates, moisture availability etc. Climate change is likely to directly impact food production across the globe. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce the yield. In areas where temperatures are already close to the physiological maxima for crops, warming will impact yields more immediately (IPCC, 2007). Drivers of climate change through alterations in atmospheric composition can also influence food production directly by its impacts on plant physiology. The consequences climate change, and its negative impact on agriculture, is severe which is projected to have a great impact on food production and may threaten the food security and hence, require special agricultural measures to combat with (Mahato, 2014, p1).

The review study on impact of climate change provides a global overview on the subject. Some of the projected impacts for different regions are: Crop yields can increase by 20% in East and South-East Asia, while it may decrease by 30% in Central and South Asia by middle of 21st century. Comparative change in total agricultural production (%) under doubled CO2 scenario in Africa, Asia, and Latin America were -13 to -9, -6 to 0 and -15 to -6, respectively. Net cereal production in South Asian countries is projected to decline by at least 4-10% by end of this century. Climate related increase in crop yields are expected in Northern Europe. However, general decrease in yield is expected in Southern Europe. Crop suitability is likely to change throughout Europe. An increase of 5-8% of arid and semi-arid land in Africa is projected by 2080. Reduction in maize production under increased ENSO conditions in Southern Africa. North American agriculture will be exposed to many severe weather extremes from time to time. Moderate climate change is likely to increase yield for rain fed agriculture by 5 to 20%. Rice yield is likely to decline after 2020 in Latin America. Increase in temperature and precipitation in South–Eastern South America are likely to increase soybean yield. Production from agriculture is projected to decline over South and East Australia and East New Zealand due to increase in drought. Due to increase in heat waves there is likely increase in intensity and frequency of floods, landslides, droughts and storm surges. Hence, climate change has the potential to change significantly the productivity of agriculture (Kashyapi, Hage and Kulkarni, 2013, p89). The rise in temperature, change in precipitation patterns, sea level rise, melting of snow cover and mountain glaciers, coastal erosion and occurrence of health hazards and disaster events are perceived as the visible impacts of climate change. The following are the main dimensions/impacts of climate change and some of these are explained in brief in the sub- sections which follow. • Temperature • Rainfall (Precipitation) • Mountain Glaciers • Sea Level Rise • Health • Agriculture• Coastal Erosion• Biodiversity Loss• Storm/Storm Events• Soil Moisture Availability• Sea Surface Temperature (Government of India, 2013, p 23).

Indian monsoon rains are the backbone of Indian economy as most of our agricultural activities; rivers and replenishment of ground water sources have a direct dependence on monsoon rains. Monsoon rains are a manifestation of the complex interactions between land, ocean and atmosphere. Rainfall data are collected by the India Meteorological Department (IMD) in respect of the meteorological subdivisions of the country on day-to-day basis. A significantly long series of rainfall data are therefore available to analyze patterns of change in distribution, intensity and duration of rainfall. The All-India rainfall data do not show any significant trend in monsoon rains, however, there are some regional variations. A trend of about 10 to 12% (of the normal) increase in monsoon rains were reported along the west coast, northern Andhra Pradesh and north-western

India during the last century. A decreasing trend of about 6 to 8% is observed over the last 100 years over eastern Madhya Pradesh, North-Eastern India and some parts of Gujarat and Kerala (NAPCC, 2008).

Population in coastal regions are vulnerable to natural disasters like cyclones, floods, droughts, soil and land erosion leading to irreparable loss or damage to sown areas in arid and semi-arid zones caused by climate change. About 40 million hectares of land is flood-prone, including river-deltas on three sides of the country stretching over 6000 km of coastal belt, affecting about 30 million people on an average each year. India is one of the species-rich countries in the world and about 6% of the world's biodiversity is reported from India. Some interesting findings here are the reduction in the number of known species in India of 'Fern & Fernallics' from 1200 to 1135 during the reference period (2001-2007). The 'Storm Event' is a rainfall event that produces more than 0.1 inch of precipitation and that, which is separated from the previous storm event by at least 72 hours of dry weather. 'Soil moisture' is the ability of the soil to hold water. Soil moisture impacts the distribution and growth of vegetation, soil aeration, soil microbial activity, soil erosion, concentration of toxic substance, the movement of nutrients within the soil and to the roots. Sea surface temperature is the temperature of the water close to the surface of the sea (Government of India, 2013, p. 26). India is a predominantly agriculture-oriented economy, as 52% of the population directly depends on agriculture either as farmers or agricultural laborers, and their concentration is higher at 76% in the villages. Variation in climate will have a direct impact on the majority of the livelihood of the people. Food production in India is sensitive to climate change like variations in temperature and monsoon rainfall. Rise in temperature has a direct impact on the Rabi crop and every 10C rise will reduce wheat production by 4 to 5 Million Tons. Every small change in temperature and rainfall has significant effect on the quality and quantity of fruits, vegetables, tea, coffee, basmati rice and aromatic and medicinal plants. It is predicted that a loss of 10 to 40% in production may occur by 2100 due to climate change (NAPCC) (Government of India, 2013, p 25).

Observations of Intergovernmental Panel on Climate Change (IPCC) indicate that adverse impact of climate change due to rising temperatures and extreme weather events on food production system could impact agricultural growth. Consistent warming trends and more frequent and intense extreme weather events are being observed across India in recent decades. Several areas have been identified as risk prone due to impact of climate change like coastal areas, Indo-Gangetic plains and the drought and flood prone regions of the country. Besides production from crops and livestock, fresh water and marine ecosystem is also likely to be affected due to warming of sea surface temperatures. Such climatic fluctuations could adversely affect agricultural sustainability

resulting in unforeseen situational shortages which could also impact other economic sectors. Climate change is likely to significantly alter the dynamics of extreme events such as tropical cyclones, associated storm surges and extreme rainfall events; possibly increasing their frequency and intensity. Low lying regions, including small islands, will face highest exposure to rising sea levels, which will increase risk of floods bringing more cultivable area under submergence and degradation. Vulnerability of India in the even to climate change is more pronounced due to its ever increasing dependency on agriculture, excessive pressure on natural resources and poor coping mechanisms. While in the short run impact might not be severe, most crops are likely to witness yield decline after 2020 when temperature threshold limit of many crops might get breached. A one degree Celsius rise in mean temperature is likely to affect wheat yield in the heartland of green revolution. There is already evidence of negative impacts on yield of wheat and paddy in parts of India due to increased temperatures, increasing water stress and reduction in number of rainy days. Irrigation requirements in arid and semiarid regions are estimated to increase by 10% for every 10°C rise in temperature. Rise in sea level is likely to have adverse effects on the livelihoods of fisher and coastal communities (Government of India, 2012-13, p32). With 60 per cent of total food grains and oilseeds produced being grown in the kharif season, and with just 35 per cent of total arable area being irrigated, Indian agriculture is still heavily dependent on rainfall. Significant warming of temperatures, lower mean rainfalls and higher rainfall variability has been recorded by the Indian Meteorological Department (IMD) over successive plan periods. Three of the 5 years of the Eleventh Plan period had annual rainfall less than 95 per cent of the long period average (LPA), as compared to 5 in the previous 15 years (Twelfth Five Year Plan, Vol. II: 2-3). The LPA of the season rainfall over the country as a whole for the period 1951-2000 is 89 cm (Government of India, 2013-14, pp139-40).

The south-west (SW) monsoon (from June to September) accounts for nearly 75 per cent of total annual rainfall in India and thus substantially affects agricultural performance. In 2013, the actual season rainfall over the country was 106 per cent of LPA. The second long-range forecast for the SW monsoon season released by the IMD on 9 June, indicates that the monsoon rainfall is likely to be 93 per cent of the LPA (model error ± 4 per cent), with 71 per cent probability of sub-normal /deficient rainfall and 70 per cent occurrence of El Niño. Rainfall distribution data can aid in gauging the likelihood of an El Niño occurrence. Significantly, the number of divisions reporting deficient/scanty rainfall cumulative from 1 June is higher this year than in the previous five years with (-) 44 per cent rainfall departure. Further, 80 per cent of districts had deficient rainfall/no rain in this period (Government of India, 2013-14, pp140-41).

El Niño effect occurs when surface temperatures in the Pacific Ocean continuously rise above average for several months, which in turn adversely affects weather in many parts of the world. On an average it occurs every 3-5 years, often begins to form during June-August, and typically lasts 9-12 months. The event gains significance in India since its effect is felt around August, during the SW monsoon. While the majority of drought years in India coincide with the occurrence of the El Niño, the reverse link is not that strong. While in the previous ten El Niño years India suffered a rainfall deficit of 10 per cent or more only in six; in 1997, when the impact of El Niño was reported to be the worst, India had 2 per cent higher than normal rainfall. In the past decade, the El Niño occurred in 2002, 2004, 2006, and 2009. While 2002-03 was the only year that India showed negative agri sector growth with average rainfall dropping 20 per cent below normal, 2009-10 experienced the most severe drought in nearly 40 years with total rainfall being 23 per cent below normal. A comparison of the changes in kharif and rabi production during the last four occurrences of El Niño reveals that the impact was more in the kharif season. The Extended Range Forecast System (ERFS provided by the IMD) seasonal forecast for this monsoon season indicates the probability of lower rainfall in the rain fed regions of central, south, and north-west India, which may affect crops like rice, soybean, cotton, maize, jowar, groundnut, and sugarcane. The fifth South Asian Climate Outlook Forum (SASCOF-5) session forecast monsoon deficit rainfall mainly in the southern peninsula and central India. Occurrence of El Niño is associated with deficit rainfall in the states of Maharashtra, Gujarat, Rajasthan, Karnataka, Jharkhand, and Bihar. Against the backdrop of the IMD's forecast on El Niño, the delayed onset of the monsoon coupled with uneven distribution may affect crop growth, especially of kharif pulses and oilseeds, and the exact quantum of yield losses depends upon the duration and intensity of stress (Government of India , 2013-14, pp140-41). The details about variations in rainfall in India are presented in the table below.

Table 4 : Category-wise Rainfall Distribution in Subdivisions and Districts and All India Rainfall Departure from Normal 2009-14 (cumulative rainfall since 1 June)

Category	11.6.2014	12.6.2013	13.6.2012	08.6.2011	09.6.2010	10.6.2009
Number of Subdivisions						
Excess/normal	8	30	23	3	11	2
Deficient /scanty	28	6	8	19	19	18
No rain	0	0	5	14	6	16
Rainfall departure from normal (%)	-44	23	-42	17	-6	-39
Per Cent Distribution of Districts						
Excess/normal	20	62	15	48	33	25

Deficient /scanty	50	32	63	34	39	47
No rain	30	6	22	18	28	28

Source: IMD, Weekly Report dated 11.06.2014.

Notes: Excess: +20% or more; Normal: +19% to -19%; Deficient: -20% to -59%; Scanty: -60% to -99%; No rain: -100%.

India's energy intensity shows a rapid decline. Further, all modeling results show that it will continue to decline. This is the reason behind a GDP growth rate of 8 percent per annum being accomplished at no more than 3.7 percent increase in energy use (Narain et al , 2009, p27). There are two options available to address the problems which may arise out of pollutions caused to the air, water or soil. i) Mitigation refers to measures for reduction of emissions of GHGs that cause climate change like switching from fossil fuel based power generation to alternative sources of renewable energy like solar, wind, nuclear etc. ii)'Adaptation' involves actions that reduce the impact of the event or process without changing the likelihood that it will occur. The process may include relocating the communities living close to the sea level or switching to crops that can withstand higher temperature etc Under the ambit of NAPCC, 8 Missions have been initiated to implement the programmes related to mitigation and adaptation. The missions are: • National Solar Mission • National Mission for Enhanced Energy Efficiency in Industry • National Mission on Sustainable Habitat • National Water Mission • National Mission for Sustaining the Himalayan Ecosystem • National Mission for a 'Green India' • National Mission for Sustainable Agriculture • National Mission on Strategic Knowledge for Climate Change (Government of India, 2013, p26). The government has in place contingency measures in about 500 districts. Further, the National Mission for Sustainable Agriculture (NMSA) is one of the eight missions of the National Action Plan on Climate Change, whose focus is on encouraging judicious utilization of common resources through a community based approach. The Rain-fed Area Development Programme (RADP), which adopts a holistic approach to enhance farmers' incomes in rain fed areas, was implemented in 22 states in 2013-14 and will be substantially up scaled during the Twelfth Plan. Other initiatives include the National Initiative on Climate Resilient Agriculture (NICRA) under the Indian Council of Agricultural Research (ICAR) to enhance resilience of Indian agriculture to climate change and vulnerability through strategic research and technology demonstration, capacity building, and sponsored/competitive grants. The Earth System Science Organization (ESSO) issues agro-meteorological advisories in 12 languages to 600 districts, which are currently subscribed to by over

4.8 million farmers, while Gramin Krishi Mausam Sewa has initiated these advisory services at block level (Government of India, 2-13-14, p141).

NMSA is one of the eight Missions under National Action Plan on Climate Change (NAPCC). It seeks to address issues on '*Sustainable Agriculture*' in the context of risks associated with climate change by devising appropriate adaptation and mitigation strategies for ensuring food security, enhancing livelihood opportunities and contributing to economic stability at National Level. NMSA seeks to transform Indian agriculture into a climate resilient production system through suitable adaptation and mitigation measures in domains of both crops and animal husbandry. NMSA indentifies 10 key dimensions for promoting suitable agricultural practices, which will be realized by implementing a Programme of Action (PoA) that covers both adaptation and mitigation measures through four functional areas, namely, **Research and Development, Technologies, Products and practices, Infrastructure and Capacity building**. While recognizing role of modern technologies and research in promoting sustainability of agriculture production this Mission also emphasizes on need to harness traditional knowledge and agricultural heritage for in-situ conservation of genetic resources (Government of India, 2012-13. pp32-33). The adaptation strategies seem to be the most immediate needs to save livelihoods and ensure food security. India has to maintain the sustainability of its ecosystems to meet the food and non-food needs of a growing population. The main thrust of the programmes to combat the impact of climate change on food security should be on activities relating to rainwater harvesting and soil conservation (Narain et al , 2009, p37).

VI) CONCLUSION:

The impact of climate change on Indian agriculture has created the serious things of concerns for India, which are urgently needed to deal with in absence of which it can very badly and severely affect India and its billion population. The severe concerns of climate change on Indian agriculture are; in the situation of enhancing production, productivity of agriculture climate change will adversely affect and its contribution to the development of the economy will be further marginalized. The uncertainty and variations in rainfall will hamper production especially of food grains and intensify the want for food and food security of the majority of Indians especially from the socially and economically deprived sections of the society. The climate change will adversely affect the water supply through rivers and further intensify drinking water availability and irrigation facilities for the development of the agriculture of India. Such climatic fluctuations could adversely affect agricultural sustainability resulting in unforeseen situational shortages which could also impact other economic sectors. The hampered growth of agriculture by the climate change will also

affect unemployment, poverty and inequality in Indian economy. This can further adversely influence the development of non agriculture activities and their contributions to the overall development of the Indian economy. It can also result in foreign trade of India, especially exports, and export led growth of Indian economy can have adverse effects. Climate change is an important obstacle in the sustainable development of agriculture as well as of the economy as a whole. Along with the measures and policies being implemented by the government the education, knowledge and awareness among the people about the adverse impact of climate change the active and whole hearted participation of the people and society as whole is very much necessary.

VII) REFERENCES:

Government of India (2013-14), Economic Survey 2013-14, Ministry of Finance, New Delhi

Government of India (2012-13), State of Agriculture 2012-13, Ministry of Agriculture, New Delhi

Government of India (2013), Statistics Related to Climate Change – India, Statistics & Programme Implementation Government of India, New Delhi. www.mospi.gov.in

Kashyapi, Hage and Kulkarni (2013), IMPACT OF CLIMATE CHANGE ON WORLD AGRICULTURE: A REVIEW, ISPRS Archives XXXVIII-8/W3 Workshop Proceedings: Impact of Climate Change on Agriculture.

California Environmental Associates (2014), Strategies for Mitigating Climate Change in Agriculture: Abridged Report.

Mahato, Anupama (2014), Climate Change and its Impact on Agriculture, International Journal of Scientific and Research Publications, Volume 4, Issue 4, April 2014 1 ISSN 2250-3153 ‘www.ijsrp.org

Narain et al (2009), Climate Change: P E R S P E C T I V E S F R O M I N D I A, UNDP, New Delhi.

World Bank (2008), *Climate Change Impacts in Drought and Flood Affected Areas: Case Studies in India’,* Report No. 43946-IN, World Bank, New Delhi, 2008

Agrawal, K P, (2008), *‘Climate change and its impact on agriculture and food security’,* LEISA (Low External Input and Sustainable Agriculture), India, December 2008

Sahai, Dr Suman, accessed from http://www.cbd.int/doc/external/mop-04/gc-en. pdf , ‘India can beat the food crisis’

TERI, *‘Adapting to climate change – strategies for water and food security in India’*

Chaudhary, Dr. Anita, ‘Climate Change And Food Security in India’ at http://www. whoindia.org/LinkFiles/Health_&_Environment_Nat_Wrksp_Climate_Change_Lonavala_p09.pdf

Down to Earth (2009), ‘It’s raining GDP’, Centre for Environmental Communication, New Delhi, 31 July 2009

Saxena, NC, (2004), *‘Integrating the Rural Poor into Markets’,* Academic Foundation, New Delhi, 2004