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Impact of Climate Change on Agriculture in Chhattisgarh

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and on socio-economic and related sectors like water resources, agriculture and food security, human health. India has undergone a series of ups and downs in agricultural production with the climatic conditions playing havoc in the years of abnormality. Currently, agro ecosystems are facing the problems of overexploitation of natural resources, decline in soil fertility, ground water level and agricultural productivity. One of the potential threats to agriculture is the impact of climate change in attaining sustainable development of agriculture coupled with food security. Climate change phenomenon is now a global reality. Chhattisgarh too faces the threat of climate change and its impacts. Available facts show that there is high chance of increase in the incidence and intensity of climate related natural hazards due to climate change and hence increase in probable threat due to climate change related natural disasters. In the (relative) absence of state level climate models and/or susceptibility studies, as well low community awareness, Chhattisgarh is potentially highly sensitive and exposed to climate change and its impacts. Agricultural productivity is nearly half the national average, mostly rain-fed and irrigation covers just 31 percent of the sown area. . In our paper we have tried to analyze the effects of climate change on Agriculture in Chhattisgarh.

Key Words: Climate change, Global Warming,Ecology, Biodiversity, Agriculture

1.1 Introduction: The official definition by the United Nations Framework Convention on Climate Change (UNFCCC) is that climate change is the change that can be attributed directly or indirectly to human activity that changes the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. However, scientists frequently use the term for any change in the climate, whether arising naturally or from human causes. In particular, the Intergovernmental Panel on Climate Change (IPCC) defines climate change as a change in the state of the climate that can be identified by changes in the mean and / or the variability of its properties and that persists for an extended period, typically decades or longer. Global warming of land and sea continues to increase, and the levels of warming have been rising steadily every decade. Last three decades have been warmer than any previous decade since the year 1850. Global average temperature rose by 0.85 degrees Celsius (°C) between 1850 and 2012. While global warming is not spatially uniform across the globe, there is

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almost no region in the world that has not experienced some rise in average temperature.[1]

The Earth's climate has varied considerably in the past, as shown by the geological evidence of ice ages and sea level changes, and by the available records of human history. The exact cause of past changes is not always clear but is generally known to be related to changes in ocean currents, solar activity, volcanic eruptions and other natural factors. The dissimilarity now is that global temperatures have risen extraordinarily rapidly over the last few decades. There is strong evidence of raise in average global air and ocean temperatures, extensive melting of snow and ice, and rising of average global sea levels.

1.2. Indian Scenario: Presently, agro ecosystems are facing the problems of overexploitation of natural resources, decline in soil fertility, ground water level and agricultural productivity. One of the possible threats to agriculture is the impact of climate change in attaining sustainable development of agriculture coupled with food security. A succinct criticism of contemporary mainstream models has been made by the report of the High Level Panel of Experts (HLPE) on Food Security and Climate Change of the Food and Agriculture Organization (FAO): "None of these global scenario efforts attempts to address distributional issues within countries and the possibility that climate change affects the vulnerable disproportionately". As per the United Nations Report of FAO, India stands to lose 125 million tones equivalent to 18% of its rain fed cereal production from climate change by 2015.It would also cause a worldwide drop in cereal crops, leaving 400 million more people at risk of hunger, and leaving three billion people at risk of flooding and without access to fresh water supplies[2].

India is one of the most susceptible countries to climate change that is affecting agricultural production. Forecasts are made by the Indian Council of Agricultural Research (ICAR) using crop simulation mathematical models incorporating future projections. The Indian economy is mostly agriculture based and for irrigation depends on monsoon. The year 2002 was a classical example to prove how Indian food grains' production is dependant on rainfall of July. All-India drought was declared this year, as the rainfall deficiency was 19% and 29% of the area was affected due to drought. The "All-India drought" is declared when the rainfall deficiency for the Country as a whole is more than 10% of normal, and when more than 20% of the Country's area is affected by drought conditions. The kharif season food grain production was adversely affected by a whopping fall of 19.1% due to "All–India drought" during monsoon 2002. India is second highest populated country of the world and has only 2.4% of the land area of the World. It is bound to feed17.5% of the world population. India's economy and a majority of its population are highly dependent on climate sensitive sectors such as agriculture, animal husbandry, fisheries, tourism, etc. Since climate change is likely to impact natural and human systems negatively by inducing changes in these systems, India can be considered extremely vulnerable. Climate change is only likely to exacerbate India's already high physical exposure to climate-related disasters (65 percent of India is drought prone, 12 percent flood prone and 8 percent susceptible to cyclones). As a result, climate change is likely to impact livelihoods by disturbing social, cultural, economic, ecological systems, physical infrastructure, and human assets, accentuating health risks, and as such, posing severe risks to the development of the country[3].

The simulation studies by Indian Institute of Tropical Meteorology (IITM), Pune, estimated that annual mean surface temperature is expected to raise by the end of century, ranges from 3 to 5° C with warming additionally pronounced

with in the northern area of India. Changes in key climate variables, specifically temperature, precipitation and humidity, may have important long-term implications for the quality and quantity of water. River systems of the Brahmaputra, the Ganga, and the Indus, which gains from melting snow in the lean season, are probably to be affected by the decline in snow cover. A decrease in total run-off for all river basins, except Narmada and Tapti, is projected in India's NATCOM I. A decline in run-off by more than two thirds is also anticipated for Sabarmati and Luni basins. Due to sea level rise, the fresh water sources near the coastal regions will suffer salt intrusion.

1.3. Impact on Agriculture and Food Production: The contribution of agriculture to the Gross Domestic Product (GDP) has declined from 57% in 1950–51 to around 14% due primarily to growth in other sectors of the economy[4]. Food production in India is susceptible to climate changes such as unpredictability of monsoon rainfall and temperature changes within a season. Studies by Indian Agricultural Research Institute (IARI) and others indicate greater expected loss in the Rabi crop. Every 1°C rise in temperature reduces wheat production by 4-5 Million Tonnes. Minute changes in temperature and rainfall have noteworthy effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Pathogens and insect populations are highly dependent upon temperature and humidity, and variation in these parameters may change their population dynamics.

Other effects on agricultural and related sectors include decline in yields from dairy cattle and decrease in fish breeding, migration, and harvests. Global reports point out a loss of 10-40% in crop production by 2100. Indian climate is dominated by the southwest monsoon, which brings most of the region‘s precipitation. It is critical for the availability of drinking water and irrigation for agriculture. Agricultural output is sensitive to two broad classes of climate-related effects (1) direct effects from variation in temperature, precipitation or carbon dioxide concentrations, and (2) indirect effects through changes in soil moisture and the distribution and frequency of invasion by pests and diseases. Rice and wheat yields could decline considerably with climatic changes [5].

The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C to 3.5 °C. Scientists also estimated that a 2°C rise in mean temperature and a 7% increase in mean precipitation would reduce net revenues by 12.3% for the country as a whole. Increase in temperatures will cause shifts in crop growing seasons, which in turn will affects food security. Rise in temperature will potentially severely increase rates of extinction for many habitats and species (up to 30 percent with a 2°C rise in temperature). A rise in extreme events will have effects on human health and lives as well as related environmental and economic impacts. Sinha and Swaminathan (1991)[6] showed that an increase of 2 degree Celsius in temperature could decrease rice yield by about 0.75 tons/ha in the high yield areas; and a 0.5 degree Celsius increase in winter temperature would decrease wheat yield by 0.45 ton/ha.

Agricultural productivity is nearly half the national average, mostly rain-fed and irrigation covers just 31 percent of the sown area. . In our paper we have tried to analyze the effects of climate change on Agriculture in Chhattisgarh.

Chhattisgarh too faces the threat of climate change and its impacts. Available evidence shows that there is high possibility of increase in the occurrence and intensity of climate related natural hazards due to climate change and hence increase in probable threat due to climate change related natural disasters. In the (relative) absence of state level climate models and/ or sus

ceptibility studies, as well low community awareness, Chhattisgarh is potentially highly sensitive and exposed to climate change and its impacts.

Methods: This paper is mainly based on secondary sources, focusing on qualitative studies as well as quantitative Metrological data . For the present study the data were collected from Census Report, statistical reports and other sources also.

2.1. **Profile of study area: Chhattisgarh**: Chhattisgarh is a state in Central India and was formed on November 1, 2000 by partitioning 16 Chhattisgarhi-speaking southeastern districts of Madhya Pradesh. Chhattisgarh has 28 administrative districts. The new districts have been created by carving out the existing districts to facilitate more targeted, focused, and closer administration. Chhattisgarh borders the states of Madhya Pradesh in the northwest, Maharashtra in the west, Andhra Pradesh in the south, Orissa in the east, Jharkhand in the northeast and Uttar Pradesh in the north. Chhattisgarh is the 10th largest state in India, with an area of 135,190 km^2 . The northern and southern parts of the state are hilly, while the central part is a fertile plain. Deciduous forests of the Eastern Highlands Forests cover roughly 44 percent of the state. In the north lies the edge of the great Indo-Gangetic plain. The Rihand River, a tributary of the Ganges, drains this area.

2.2. Geography of Chhattisgarh: Chhattisgarh lies between 17°47' and 24°06'N latitude and 80°15' and 84°24'E longitude . The state measures 640 km from north to south and 336 km from east to west with a total area of 135,194 km^2 .The eastern end of the Satpura Range and the western edge of the Chhota Nagpur Plateau form an east-west belt of hills that divide the Mahanadi River basin from the Indo-Gangetic plain. The central part of the state lies in the fertile upper basin of the Mahanadi River and its tributaries. This area has extensive rice cultivation. The upper Mahanadi basin is separated from the upper Narmada basin to the west by the Maikal Hills (part of the Satpuras) and from the plains of Orissa to the east by ranges of hills. The southern part of the state lies on the Deccan plateau, in the watershed of the Godavari River and its tributary, the Indravati River. The Mahanadi is the chief river of the state. The other main rivers are Hasdo (a tributary of Mahanadi), Rihand, Indravati, Jonk, Arpa, and Shivnath.

Chhattisgarh has a tropical climate with three major seasons: summer , monsoon and winter. It is hot and humid because of its proximity to the Tropic of Cancer and its dependence on the monsoons for rains. Summer in Chhattisgarh is from April to June and temperatures can reach 48°C (100°F). The monsoon season is from late June to October and is a welcome respite from the heat. Chhattisgarh receives an average of 1,292 millimetres (50.9 in) of rain. Winter is from November to January and it is a good time to visit Chhattisgarh. Winters are pleasant with low temperatures and less humidity. The temperature varies between 30 and 47°C (86 and 117°F) in summer and between 5 and 25°C (41 and 77°F) during winter. However, extremes in temperature can be observed with scales falling to less than 0°C to 49°C.

2.3Demography of Chhattisgarh: The majority of the population of Chhattisgarh lives in rural areas (76.76%) as compared to urban population (23.24%). In actual numbers of males and females were 12832895 and 12712303 respectively. In rural area female sex ratio per 1000 males was 1001 while for the child (0-6 age) it was only 977 girls per 1000 boys. Child population forms 14.92 per cent of total rural population. Literacy rate in rural areas was 65.99 per cent in which 76.98% males were literate while female literacy rate of 55.15%. The population of urban male and female were 51.12, 48.87 per

cent to total population. Sex ratio in urban area was 956 females per 1000 males, while for child (0-6) sex ratio for urban area stood at 937 girls per 1000 boys. There were 12.41 % of children (0-6) in total population of urban areas average literacy rate in urban area was 84.05 per cent in which, males 90.58% literate, while female literacy stood at 73.39 per cent[7].

2.4 Economics of Chhattisgarh : According to the NSSO data (68th round) poverty ratio of Chhattisgarh is highest (39.93%) in India[8]. Almost 80 per cent of the population is dependent on agriculture or agriculture-related occupations [9].

2.5 Labour Force Participation: The total working population belongs to cultivators (49.45%) followed by others (26.30%), agriculture labour (22.00%) and household industry workers (2.25%) . The total rural working population was found to be maximum in the rural areas (83.40%) as compared to the urban areas (16.60%). In rural areas the maximum working population related of cultivators (58.54%) followed by agriculture labour (25.74%), other (13.73%) and household industry workers (1.99%), while in urban areas contributed of other workers (89.50%) was found to be maximum followed by cultivators (3.76%), household industry workers (3.59%) and agriculture labour (3.16%).

2.6Crops of Chhattisgarh: The various crops are grown by the cultivators in Chhattisgarh. The rice (68.8%) was found to be major crop of the state. The cultivators are also found to be grown tiwra (6.5%), gram (4.6%), paddy (2.6%), kodo-kutki (2.3%) and wheat (1.9%). The maize, urd, niger, soybean, arhar, mustard, kulthi, alsi, groundnut, til, masoor, pea, moong, moong, jwar, urd, sunflower, kulthi and safflower are also grown in small proportion by the cultivators in the state.

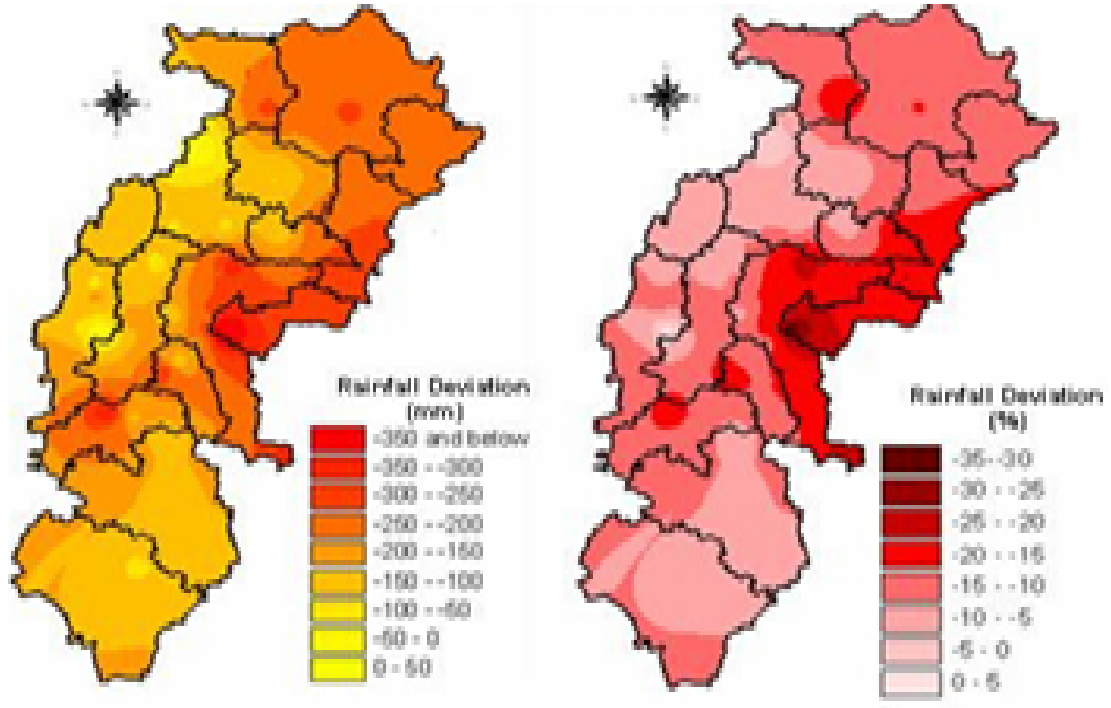
3.1Data Analysis: The change in cropping pattern of Chhattisgarh: It is observed from the data[10] that gross cropped area of Chhattisgarh has been found to be decreased by1.09per cent in the year 2011-12 (4571.57thousand ha.) over the year 2000-01 (4622.35 thousand ha.). The area under pulses, oilseeds and cereals found to be increased by 31.5, 10.0 and 1.4 per cent during this period. As regards to the change in area under different crops the cultivated, area under soybean (448.3%) increased maximum followed by sunflower (288.5%), summer paddy (175.3%), gram (81.0%), pea (60.2%), rabi moong (45.4%), tiwra (43.2%), wheat (33.2%), niger (28.9%), masoor (27.8%), maize (10.0%), other kharif cereals (10.5%), arhar (10.3%), other kharif pulses (8.6%), mustard (4.4%), and rice, (1.9%), while the area under barley & other (-90.3%), rabi alsi (-58.4%), kharif kodo-kutki (-46.1%), jwar (-40.0%), rabi kulthi (-39.5%), sunflower & others (-38.6%), kharif kulthi (-20.8%), rabi urd (-17.3%), til (-16.1%), safflower (-15.8%), groundnut (- 13.5%), kharif urd (-12.4%) and kharif moong (-7.0%), were found to be decreased in the year 2011-12 as compared to 2000-01.

3.2 Changes in Production: The total production of kharif crops in Chhattisgarh found to be increased by 40.98 per cent in the year 2011-12 (6444.73 MT) over the year 2000-01 (2641.32 MT), while the total production of Rabi crops increased with 35.77 per cent. The production of cereals, pulses and oilseeds was found to be increased by 167.5, 106.1 and 95.5 per cent. As regards to production of all major crops the production summer paddy (84.0%), niger (54.8%), gram (32.2%), rice (63.50%), tiwra (10. 4%), soyabean (-3.4%), til (73.9%), rabi moong (71.3%), wheat (53.2%), Pea (49.5%), masoor (47.1%), maize (47.8%), jwar (44.6%), sunflower (21.8%), rabi groundnut (16.8%), arhar (12.8%) and kharif moong (11.3%), was found to be increased while, the production of linseed (-58.2%), kulthi (-37.1%), kharif kulthi (-23.4%),

mustard (- 21.8%), safflower (-17.2%), kodo-kutki (-16.8%), rabi urd (-11.2%), kharif urd (-10.0%) and other cereals (-3.1%), was found to be decreased in the year 2011-12 as compared to 2000-01.

The rainfall variability during past century in Chhattisgarh was studied using rainfall statistics of 100 years i.e. 1901-2000.About 40 rain gauge stations located in different districts of Chhattisgarh were considered for study[11]. For understanding the rainfall pattern difference between average rainfall during 1900-1950 and 1951-2000 were worked. A GIS map was generated using GIS tools and the same are show in enclosed figure

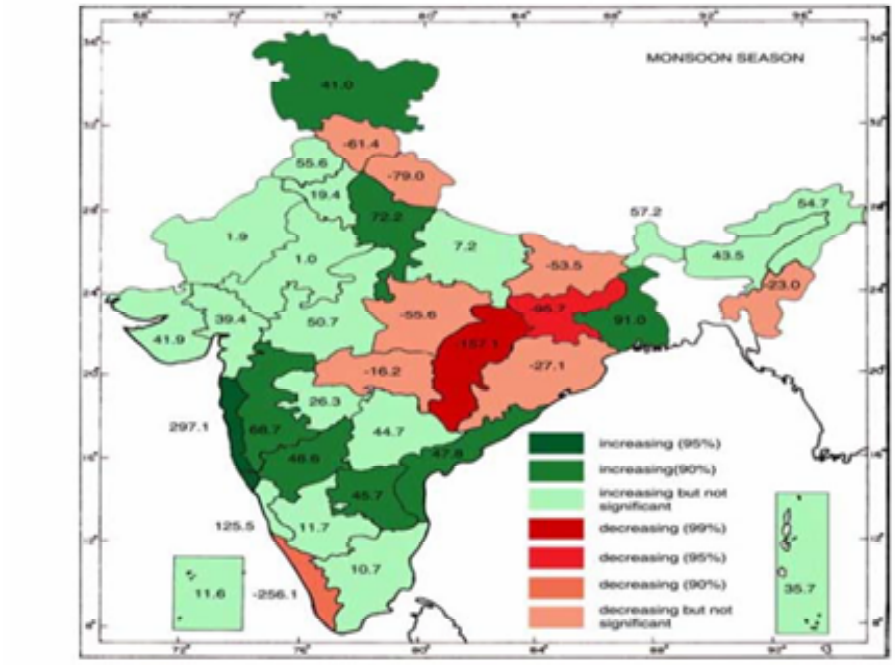
Rainfall decrease during the period 1951-2000 as compared to normal (1901-50) values in Chhattisgrh



Source: National Climate Centre, IMD , Pune-2006

3.3Trends In Regional Distribution of Rainfall: Analysis based on IMD[12] rainfall series indicated that during the monsoon season , three subdivisions viz. Jharkhand, Chhattisgarh, Kerala show significant decreasing trend and eight subdivisions viz. Gangetic West Bengal, West Uttar Pradesh, Jammu & Kashmir, Konkan & Goa, Madhya Maharashtra, Rayalseema, Coastal Andhra Pradesh and North Interior Karnataka show significant increasing trends . However, analysis of IITM rainfall series (1871-2011) indicates presence of significant trend only in case of Chhattisgarh (decreasing) and Konkan and Goa (increasing) (non parametric Mann Kendall Test, Run test). Both these were observed to have strongest trend even in IMD series study (99 and 95 per cent level of significance respectively).

Trends in Regional Distribution of Rainfall



Increase/ decrease in rainfall in mm in 100 years for each of 36 Sub Divisions for SW Monsoon season Different level of significance are shaded with colors

Source: National Climate Centre, IMD , Pune-2006

3.4 Discussion : Quantification of climate change is very necessary to cope up with ever changing conditions. The trend analysis is made for Chhattisgarh for monthly rainfall data for the period of 1901-2002 is performed using non-parametric Mann-Kendall and Sen Slope Estimator test. The results reveal a values are 1.0351,-1.4775, 0.1099, 0.0289, 0.8154, -0.9484, -1.2317, -1.1103, -2.1165, 0.5204, 0.0405and -1.2028 for January to December respectively. The months of February, June, July, August, September and December clearly show a significant declining trend in rainfall whereas the months of March, April and May represent no trend for monthly rainfall for 1901-2002. The months of January, May and October exhibit an increasing trend of rainfall, but among them, trend in January only can be considered as remarkably increasing. So far as Chhattisgarh, is concern, we highlight the significance of studying both present climate changeability and future climate change at local levels. While rainfall variability is an important factor contributing to short-term variations in agricultural output, we suggest the need to move away from this traditional emphasis by also taking into account temperature variation. The concentrations of the greenhouse gases carbon dioxide and nitrous oxide in the atmosphere are now at levels that “substantially exceed” the highest levels of these concentrations known on earth for the last 800,000 years.

3.5 Conclusion : The data indicate that the decrease in monsoon-time precipitation in Chhattisgarh, and the increase in precipitation in the Konkan and Goa sub-divisions, are statisti

cally significant. Climate change will have wide-ranging effects on the ecology, biodiversity and environment, and on socio-economic and related sectors like water resources, agriculture and food security, human health. India has undergone a series of ups and downs in agricultural production with the climatic conditions playing havoc in the years of abnormality.

There is evidence[13] that greater climate variation alone can lower yields to an extent comparable to (or greater than) the impact of increased mean temperature. Ongoing climate change through rising temperatures has had a negative impact on crop production in different parts of the world, though this impact has been more than offset in practice by better management and other technological factors. There is little evidence at present that climate change has had any widespread impact on yields or on total agricultural production in India[14]. The impact of variations in temperature and precipitation on agriculture is an important source of information for coping with the impact of climate change on agriculture in the future. In particular, apart from variations in rainfall, which have traditionally been the primary concern with regard to the relation between climate and agriculture in Chhattisgarh, the impact of temperature variations also needs seriously to be considered.

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