INTRODUCTION

Climate encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall and other meteorological elements in a given region over a long period of time. When major changes in temperature, rainfall, and snow or wind pattern lasting for a decade or longer is called climate change. It indicates the abnormal changes in weather conditions which causes serious effects on human life. Climate change may affect hydrological cycle, precipitation, evapotranspiration, soil moisture etc. which would pose new challenges to agriculture.

The nature and pattern of crops are generally determined by physical, technological and biochemical factors. However agricultural potentiality and capabilities of a particular region is mostly dependent on the existing physical factors especially on soil and climatic conditions. Climate plays a key role in a farmer’s life as the cropping patterns are generally planned according to climatic conditions, soil types, irrigation water availability, crop rotation, water allocation policies etc. Remaining factors play a secondary role (Subramaniam and Bhaskar Rao, 1987). According to several studies the single most decisive factor responsible for the crop prosperity or failure is climate (Klages, 1958; Biswas and Nayar, 1984) Agriculture is always vulnerable to unfavorable weather events and climatic condition. Despite technological advances such as improved crop varieties and irrigation system, weather and climate are important factors, which play a significant role in agricultural production. The impacts of climate change on agriculture, food production and water resources are global concerns, especially in agrarian countries like India, the impact on agriculture is very important.

India is a vast country and its economy largely depends on agriculture. Indian agriculture is largely dependent on monsoon and climate change is likely to intensify the variability of summer monsoon dynamics and as a result there have been fluctuations in food production. Any changes in the in India’s south-west monsoon rainfall due to regional climatic changes are expected to result in severe droughts and intense flooding in many parts of the country. It is evident that changes in rainfall and its impact on agriculture are an important problem which
needs to be addressed on priority. The studies of climatic variability at regional scale and local scale are very important for agricultural planning and water resource development.

Chhattisgarh is situated in the eastern part of central India is mainly an agrarian state. The geographical location of Chhattisgarh is 17⁰46' North to 24⁰ 5' north latitude, and from 80⁰ 15' to 84⁰ 20' east longitude. The climate of Chhattisgarh is tropical. It is hot and humid because of its proximity to the topic of cancer and its dependence on the monsoon for rain. Agriculture is counted as the chief economic occupation of the state. About 80% of population of the state is rural and the main livelihood of the villagers is agriculture and agriculture based small industry. Here about 4.5 million hectares area is under cultivation during rainy season, out of this, about 3.6 million hectares area dominated by rice cultivation. Only 20-30 per cent area of the state is under irrigation and rest of the area is under rain fed condition (Sasti, 2009). Due to this, the productivity of rice and other crops is low and it has remained subsistence agriculture till now. Thus, agriculture of Chhattisgarh is largely dependent on favourable climatic condition, especially on rainfall. Agro-climatically Chhattisgarh may be divided into three distinct agro-climatic zones such as Chhattisgarh plain, Bastar plateau, and Northern hills. Out of these three zones Chhattisgarh plain is the most prosperous agrarian region because of its suitable soil, water and climatic conditions. Major portion of population of the state concentrated here. Rice is the main crop here. Along with rice, wheat, maize, kodo–kutki, tuar, teora, pea, and other millets and pulses, oilseeds, such as groundnuts, soyabeans, and sunflowers are also grown. Previous studies indicated that in some part of Chhattisgarh state the rainfall is significantly decreasing and as a result the climate is changing from sub-humid type to semi-arid type (Sastri, 2009). The changed climate has become a real threat for agriculture. Therefore challenges are faced by the agricultural sectors from the climatic condition; require systematic integration of environmental and economic development measure for a sustainable agriculture growth. Keeping the above aspects in view, an attempt is made in the present study to assess climate change and its impact on agriculture at local level of Chhattisgarh plain by using Thorthwaite’s (1955) water balance technique.

**REVIEW OF LITERATURE**

A review of Literature pertaining to agro – climatic studies on “Impact of climatic change on Agriculture in Chhattisgarh plain” carried out by researchers in Chhattisgarh, India and aboard has been briefly mentioned below.
Climatic Variability of rainfall and temperature

Jhajharia et al. (2007) carried out a case study of Agartala for climate and its variation using the monthly data of last 48 years from 1953 to 2000. The results of the study revealed that there was decreasing trend in the rainfall, the wind speed and the sunshine duration at the rate of 2.4 mm, 0.13 Kmph and 0.014 hrs per year respectively. They observed increasing trend was also for relative humidity at a rate of 0.069% per year and mean temperature at a rate of 0.32°C per decade. Ali et al. (2007) studied the trend of rainfall and temperature in different regions of Bangladesh for last five decades. They observed that there is no significant trend in annual rainfall, but significant decreasing trend of monthly rainfall during monsoon season at two stations. Time series of minimum temperature showed inconsistent trends throughout the year also in between stations.

Murty et al. (2008) calculated the moving averages for 3 year, 5 year and 10 year interval for minimum and maximum temperature of Ranichauri during 1982 – 2002. The found a decreasing trend in all the three cases. The seasonal analysis indicated that the minimum temperature had an increasing trend during summer, winter and post rainy season while decreasing trend was observed during rainy season. The moving average also depicted decrease in maximum temperature. Krishnakumar et al. (2008) analyzed the trends and variability in northeast monsoon rainfall in Kerala. They found an increasing trend of northeast monsoon rainfall during October and November and decreasing trend in December overall, there was a increase of 96.7 mm northeast monsoon rainfall in Kerala over a period of time.

Sing et al. (2009) analyzed the daily temperature and rainfall data of Jhansi for the period of 1969 to 2000 and observed seasonal and annual variability. Ray et al. (2009) analyzed 40 years data of all IMD stations in Gujarat to study climate variability and occurrence of extreme weather events. They found a significant increasing trend in maximum temperature during summer season and minimum temperature during winter season. They also observed that mean temperature over Gujarat state increased by 0.07°C in past 40 years (1969 – 2005).

Mukherjee and Banerjee (2009) studied the trend of climate change due to inherent problems of water holding capacity of soil in the red and laterite zone of West Bengal. Twenty rain gauge stations covering 3 districts namely Bankura, Birbhum and Purulia in the zone were considered for the analysis of rainfall pattern. They observed an increasing trend in annual rainfall. The analysis of average monthly temperature of summer month indicated a decreasing trend during
1990 – 2000 compared to that of 1970 – 1980, whether the minimum temperature showed and increasing trend over the zone.

Rao et al. (2010) analyzed the time series of annual mean maximum and minimum temperature at 47 weather stations spread across different region of India. They observed that the increasing trend in maximum temperature was highest in 75 percent of the stations in south zone and lowest in 20 percent stations in north zone while, increasing trend in minimum temperature was observed in above 60% of stations overall in India.

Deka (2009) observed the long – term changes and short time fluctuation in temperature of North – East India during 1901 – 2003. Long term linear trends were examined by using Mann Kendal rank statistics and moving average method while short term fluctuations were analyzed by applying Cramer’s test. The study revealed a significant decreasing trend in minimum temperature during monsoon and increasing trend in surface air temperature during past monsoon and winter season in North East India.

Haris et al. (2010) studied the rainfall and temperature trends at four station of Bihar, representing 3 agro ecological zones. They used monthly seasonal and annual precipitation as well as temperature data for about 45 years analyze climatic variability and possible trend Mann – Kendal test was used. The study showed an increasing trend in rainfall and minimum temperature but a decreasing trend in maximum temperature in the study area.

Sastri (2010) observed that the maximum temperature is increasing in West coast, north - east and north – central sub divisions of India especially during winter season than summer season. He also found that in 14 metrological sub-divisions the rainfall trend changed from positive during the period 1871 – 1960 to negative during the period of 1961 – 2008 while in 4 sub divisions the trend changed from negative to positive during the same period. In Chhattisgarh he observed that the rainfall had decreased from 35 to 0 percent in different parts of the state during the period 1951 – 2000 as compared to the normal values of the period 1901 – 1950.

Rai et al. (2012) examined the annual and weekly rainfall data for the period of 1941 – 2008 of Datia and 1939 – 2007 of Jaloum districts of Bundelkhand. They found significant decreasing trend in the total amount of rainfall in last 13 years. Rama et al. (2012) analyzed the trends in climate variability over Himachal Pradesh. The data analyzed in terms of day and night revealed that the increasing maximum temperature causes to warming. The rainfall showed a decreasing
trend in all over the region.

**Assessment and Impact of climate change**

Choudhary and Shastri (1999) studied the temporal variation of rainfall in all districts of Chhattisgarh for the last century. The study showed decreasing trends of rainfall in some pockets in this region. They also observed that along with the quantity of rainfall number of rainy days was also in decreasing trend during the cropping season. The Inter – Governmental panel on climate change (IPCC 2007) reported that the earth temperature had increased by 0.74 degree Celsius between 1906 and 2005 due to the emissions of greenhouse gases. By the end of this century the temperature is likely to be 1.8 – 4.0 degree Celsius that would lead to extreme events, such as hot extremes, floods, droughts, cyclones and gradual recession of glaciers. These events would affect the food production.

Climate change will affect the soil moisture, ground water recharge, frequency of flood or drought and finally ground water level in different regions(Huntington TG, 2003, Eckhardt K, Ulbrich U, 2003, Allen M et al, 2004). It also effect water cycle (Xu J,Shrestha AB, Vaidya R, Eriksson M, Hewitt K,2007).

**Impact of climate change on Agriculture**

Wilsie (1962) studied that if moisture supply is copiously high, a wide range of crop may be grown successfully, but under water stress conditions, only a few drought resistant crops can be grown. Baghel and Sastri (1992) studied the impact of regional climate change and its influence on agriculture in Chhattisgarh region Madhya Pradesh. They found that the quantum of annual rainfall was in decreasing trend in some pockets.

Martin Parry, et al. (1999) analyzed that climate change due to greenhouse gases affects crop yields differently from region to region across the globe. Under the HadCM2 climate change scenarios in this study, the effects on crop yields in mid and high latitude regions appear to be beneficial while those in low latitude regions are expected to be detrimental. The HadCM3 scenario suggests that the beneficial effects at higher latitudes will occur within a specific climate change. If this is exceeded then even high – mid latitudes will witness adverse effects of climate change on agriculture. Ultimate results are reduction in yields, decreases in production, increases in the risk of hunger and global food security.
K.S Kavi Kumar and Jyoti Parikh (2001) have explained the relationship between farm level net revenue and climate variables in India by using cross – sectional and time series data, to understand the climate sensitivity of Indian agriculture. Hanis Kumar Sinha and Chandra Sen (2004) made an attempt to study the effect of drought on the crop productivity and their effect on income and employment of various categories of farmers, in the Billia district of eastern Uttar Pradesh. They analyzed that due to drought the cost of cultivation of all crops in all categories of farms was decreased to a minor extent. This unfavorable climatic condition affected the cropping activities. This loss was so severe that the survival of farmers becomes too difficult.

Zaidi et al.(2004) studied that excessive moisture as well as extreme water deficiency conditions during critical growth period hampers crop production and are injurious to crop. Hema Malini (2005) studied the drought and its spatial spread in Andhra Pradesh and its impact on the agricultural yields. According to Parry et al. (2007), climate change and agriculture are interrelated processes. Due to its sensitivity, any change or fluctuation in climate can have significant changes in the crop yield (Mall et al.2006). According to FAO (2005), in developing countries 11% of the arable land could be affected due to climate change and there will be decline in the cereal production. Agarwal et al. (2009) studied that Indian agriculture will be adversely affected by climate change by a probable reduction in the in the yield of wheat, soybean, mustard, ground nut and potato by 3-7% for every one degree increase in temperature.

K.K Datta and Uttam Bhattacharya (2007) studied that inter and intra year fluctuation s in agriculture production is due to climate change. Drought, flood, extreme temperature and other climatic hazards have profound effects on agriculture, including crops, livestock, water resources, forestry and fisheries. India is considerably vulnerable to the impact of climate change. Adaption strategies are need to moderate potential damages or to benefit from opportunities associated with corresponding changes. Technology and climate policy also help to adapt changing conditions in agriculture emerging from climate change.

Sushila Kaul and Ghasi Ram (2008) studied that excessive rains and extreme variation in temperature would affect the productivity of rice crop adversely, thereby affecting the incomes of farming families in a negative manner. Marginal and small farmers are affected too much. Thus suitable strategies are to be adapted for mitigating the harmful effects of climate change.

Temesgen Tedesse Deressa, et. al. (2009) studied that Nile Basin of Ethiopia’s agriculture is
negatively affected by climate change and also identified the major methods used by the farmers
to adapt the climate change and the factors which affect their methods and barriers to adaption.
Anamika Singh and B.N. Singh (2010) in their article “A Study on Climatic Variability over
Varanasi” explained the nature and extent of climatic variability over Varanasi on the basis of
climatologically data. The departure of the temperature from its normal value is little but long
term shows the gradual rise in temperature of Varanasi. The rainfall is also gradually decreasing
specially during last few decades and will certainly be responsible for change in cropping
pattern and to some extent for rain fed crops failure specially paddy cultivation.

Douglas W. Gamble, Donovan Cambell, Theodore L. Allen, David Barka, Scott Curtis and Jeff
Popke (2010) provided a basic idea of drought and climate change in south west Jamaika
through an integration of local knowledge and perception of drought and it’s physical
characteristics, which are investigated through a survey of 60 farmers, who are concern about an
increasing drought occurrence as satellite precipitation time series suggest that early growing
season is more drier. Farmers should increase the capacity to adapt the climate change with the
help of local knowledge and scientific information.

A.S.R.A.S. Sastri (2010) in his article “Climate Change in Indian Sub-Continent and its impact
on Agriculture” analyzed that the climate in India, vary from region to region, and there are
considerable changes in temperature and rainfall. He also analyzed the climate of Chhattisgarh
and found that the rainfall was decreased during the period 1961-2008, and climate type also
changed from moist sub humid to semi-arid in many parts, which has negative effect on wheat
and rice production.

A. Abdul Haris, Vandna Chhabra and Sandeep Biswas (2011) in their article “Trends in Paddy
Production and Productivity in the Gangetic Plains of Bihar as Influenced by Rainfall Pattern”,
studied that paddy cultivation in Bihar is largely dependent on south western monsoon rain.
Kharif is the main rice growing season. At present Bihar’s total rice producing area is 3.18
million hectare, out of total area 1.58 million hectare is rain fed area, where rainfall is the only
source for rice production, and any fluctuation in rainfall pattern and amount affects rice
production in an adverse manner.

Anamica Singh and B.N Singh in their article “Delineation of Agro-Climatic Zones in Eastern
Uttar Pradesh”, (2011) explored the idea of agro-climatic zones of eastern Uttar Pradesh on the
basis of moisture adequacy index and also prepared the agro-climatic zone map by
superimposition of all this map and established the idea that climatic condition of an area have abroad control on agricultural operation, especially on cropping pattern and production.

Anupam Khajuria and N.H Rabindranath (2012) analyzed that agriculture plays a key role in overall economy and social wellbeing of India. Agriculture is extremely vulnerable to climate change and facing ecological and economic challenges. There are many climate induced impact on agricultural sector. Only adaption can reduce the vulnerability and improve the agricultural management in context of climate change.

Anna Ranuzzy and Richa Srivastava (2012) explores the interrelationship between climate change and food security and multiple effects that global warming and climate change could have on food production and food security. Only adaption and mitigation strategies can make the agriculture sustainable. This study assessed interlinkage between ecosystem and food production.

**Identification of the research problem and selection of the study area**

The Chhattisgarh plain extends over a large central portion of Chhattisgarh, it is a fertile plain, dominated by subsistence agriculture and majority of agriculture is rain-fed where more or less 80% population depends on agriculture for their livelihood.

Previous studies of rainfall pattern in different location of Chhattisgarh plain indicated that the rainfall is in decreasing trend in several places during 20th century and there is a spatial variability of decreasing trend of rainfall in Chhattisgarh plain. Temperature is also increasing here. Decrease of water storage with increasing evaporation would further widen the gap between water supply and water demand. As a consequence of decreasing rainfall and increasing temperature, there is a chance of water scarcity and drought in various places.

A favorable water regime in the field is desirable for almost all farming activities: for land preparation, to plant a crop, to manage weeds, to enable efficient use of fertilizer, to promote nutrient uptake, to reduce nutrient losses, to maintain soil softness, to avoid soil cracking and so on. All these things are important for an healthy agriculture, but in Chhattisgarh plain where over 70% of agriculture is rain fed, water insufficiency may adversely affects the crop yields, crop growth, production etc. even diseases and pests are strongly dependent upon the temperature and humidity, any changes in them, can significantly alter the scenario, which ultimately may result in yield loss.
Thus agriculture of Chhattisgarh plain is largely dependent upon climatic conditions, especially summer rainfall; any fluctuation in climate may responsible for crop yield loss. As the farmers of that area have small and marginal land holdings and they are economically and technically backward, they are not much capable to adapt the change. On the way to identify the climatic variability /changes over the region and its impact on agriculture, a scientific research is necessary. So, an attempt has been taken to analyze the impact of climatic change on agriculture in Chhattisgarh Plain.

**Importance of the Study**

The importance of study is mentioned below under following points.

This work on “Impact of climatic change on Agriculture in Chhattisgarh plain” is helpful for the local government to cope with any changes in climate regime or natural resources. This might involve targeted poverty reduction, early warning planning and disasters response planning.

The study provides an idea on existing cropping pattern under the variable climate. It also analyzed crop calendar and agro-climatic zone at regional as well as local level that will help the farmers, policy makers for sustainable agriculture in the region.

**Objectives of the study**

Following are the objectives of this present study.

1. To study the spatial distribution of water balance elements namely potential evapotranspiration, actual evapotranspiration, water deficit and water surplus.
2. To classify the climate in Chhattisgarh plain.
3. To study the rainfall and temperature trends over Chhattisgarh plain.
4. To analyze the spatial and temporal variability in annual and seasonal rainfall.
5. To identify the climatic shifts, drought incidences and agro climatic regions.
6. To analyze the existing cropping pattern of Chhattisgarh plain.
7. To analyze the impact of climate change on crop production, yield and cropped area.

**Hypotheses**

1) Temperature is increasing in Chhattisgarh plain.
2) There are spatial variations in temperature and rainfall distribution over Chhattisgarh Plain.

3) Cropping pattern, crop production and crop yield are influenced by climatic change in Chhattisgarh plain

**Study Area**

The Chhattisgarh plain extends over a large central portion of the state, it’s longitudinal and latitudinal extensions are 80° 30' to 82° 30' east and 20° to 22° north, forming upper Mahanadi basin. The region is about 100 miles (160 km) wide and it is bounded by the Chotonagpur plateau to the north, Raigarh hills to the north – east, the Bastar plateau to the south, and the Maikala range to the west.

This region is roughly fan-like, stretches about 385 km east-west with maximum north- south extent of 400 km., the average height of the plain is 220 m. and increasing towards the highland. It covers an area of 72184.16Sq. Km. and composed of sedimentary rocks. This region includes Hasdo- Mand Plain, Bilaspur Plain, Shivnath Plain, Mahanadi- Seonath Doab, and Mahanadi Plain.

The region has the average maximum temperature in summer is about 42°C, and the average minimum in winter is about 12° C. In the higher elevations of the north and south temperatures are cooler throughout the year. The region receives heavy rainfall from summer monsoon. The average annual rainfall is more than 1500 mm in the eastern region, and 1300 mm in the western region.

The plain comprises many administrative districts, namely Korba, Bilaspur, Champa, Kawardha, Raipur, Mahasamund, Rajnandgaon, Dhamtari, Durg, Mungeli, Kabirdham, Baloda bazaar, Bametara, balod, Gariyaband, Kanker (northern part and kanker block), and part of Raigarh.

The soils of Chhattisgarh plain are suitable to the cultivation of rice, it consists of Bhata (laterite), Matasi (sandy loam), Dorsa (clay loam), Kanhar (clay). The plain consists of rich rice fields, cotton and oil seeds are the important commercial crops of the region. Wheat, groundnuts, kodo- kutki, dal etc. also cultivated here. This region is rich in mineral resources like iron ore, asbestos, limestone, bauxite, manganese, are available in that region.
Data sets and Methodology

Data for study

Metrological data

To carry out the present study, mean monthly maximum and minimum temperature and mean monthly rainfall data of seven IMD stations (Raipur, Pendra, Bilaspur, Durg, Raigarh, Janjgir Champa, Rajnandgaon) of the study region are obtained from the publication of India Metrological Department for the period of 1986 – 2015. The mean monthly temperature data are computed from the obtained data of maximum and minimum temperature.

Agricultural Data

The long term crop data regarding area, production and productivity for major crops have been collected from Department of Agriculture, Government of Chhattisgarh. Data of irrigated area, different sources of irrigation, tools and equipment, fertilizers, pesticides etc. have been obtained from Directorate of Economics and Statistics, Chhattisgarh and district hand books.

Other Data

Soil maps of Chhattisgarh have been collected from the National Bureau of soil survey and land use planning, Nagpur. The soil types of the region have been interpreted from the soil maps and field capacities of soils also have estimated. Data on forest cover are collected from chief conservator of forest, Chhattisgarh and data regarding ground water level, recharge of different districts of the study region have been obtained from CGWB (Chhattisgarh Ground Water Board). Population related data have been acquired from 2011 census.

Apart from above, data and related information have been collected from several Government reports, publications, research papers, books and journals and also from concern websites.

Methodology

- To achieve the above mentioned objectives of the study, water balance techniques of Thornthwaite and Mather (1955) have been used. For this purpose, potential evapotranspiration (PE) or thermal efficiency (TE) values are estimated from the mean monthly temperature of all individual stations for the study period. The potential
Evapotranspiration serves as an index of thermal potentiality of a region based on soil type and vegetation, filed capacities of each station have been estimated from the tables, prepared by Thornthwaite and Mather (1956) using the book keeping procedure, the monthly water balance of all the stations are computed for individual years (from 1986 to 2015). The parameters, derived from the water balance are – actual evapotranspiration, soil moisture storage, and water surplus and water deficit. The seasonal analysis of water balance elements carried out for the four seasons namely, Cold weather season, hot weather, south – west monsoon season and retreating monsoon season.

- The water balance elements of all the stations are graphically presented. To understand the spatial pattern, maps of all the water balance elements are prepared in GIS environment. The maps are prepared on the basis of annual as well as seasonal distribution. From the water balance computation, the indices namely Index of aridity (Ia) Index of humidity (Ih), Index of moisture (Im) and Index of moisture adequacy (Ima) were derived.

- On the basis of Thornthwaite’s thermal as well as moisture regimes, the climates of Chhattisgarh plain are classified. Spatial patterns have been shown in the maps.

- Time trend analysis has been done (monthly, seasonal as well as annual trend of temperature and rainfall) for the period of 1886 to 2015, In order to make out the nature and trends in climates, derivation of climates of each station from its normal climates over a period have been analyzed and presented. Mann-Kendall test has been done for analyzing the trends of rainfall and temperature, whether these are significantly decreasing or increasing at different weather stations of Chhattisgarh Plain. ‘F’ test has also been carried out for analyzing the spatial variation of temperature and rainfall in Chhattisgarh plain, whether the variation is significantly differing or not.

- Droughts events are categorized based on their intensity by using a statistical technique namely standard derivation. The spatial patterns of drought intensities have been presented through maps and drought proneness is calculated and drought prone areas are also delineated.

- Agro - climatic regions are derived by assessing soil moisture adequacy (Ima) indices, which is the percentage ratio of actual evapotranspiration (AE) to potential evapotranspiration (PE).
• The different aspects of agriculture have been analyzed applying different formulas such as agricultural intensity which was measured by following Jarrhbir Shing’s formula.
• Weaver’s method has been used for delineating crop combination region. Crop diversification is measured by applying Gibbs and Martin’s formula.
• Crop concentration regions are delineated using Bhatia’s formula and the crop productivity is computed applying Enyedi’s crop productivity method.
• The relationships between crop production, productivity and cropped area with climatic elements have been analyzed using correlation coefficients. Time trends analysis have also been worked out for cropped area, production and productivity using regression equation.
• Maps are prepared using Geographical Information System and Elsevier reference style has been followed in this research work.
• ‘t’ test has been done to find out whether the differences of cropped area, production and yield are significant or not in respect of climatic variabilities.

Scheme of Presentation

The research thesis has been outlined in seven chapters along with introduction section, summary and conclusion. The outlines of seven chapters are given below:

**Chapter 1: Geographical settings of Chhattisgarh plain**

This chapter is divided into physical settings and cultural setting. Physical setting consists of Location and Extension, Physiography, Geology, Drainage Pattern, soil, Climate and natural vegetation. Cultural and socio-economic setting includes Administrative set up, Population Distribution, Population Density, Growth Rate, Sex Ratio, Literacy, Livelihood Pattern and Occupational Structure, Transport And Communication, Findings.

**Chapter 2: Analysis of Climates in Chhattisgarh plain**

This chapter is divided into different sections such as Introduction, Conceptual Framework, Objectives, Data Sets and Methodology, Normal Climate of Chhattisgarh Plain (Climatic Water Balance), Nature and Distribution of Water Balance Elements (Potential Evapotranspiration, Actual Evapotranspiration, Water Deficit And Water Surplus) Analysis of Climates (Thermal Regime And Moisture Regime) Climate Change Vs. Variation in the existing Climate Type
(Change in the Thermal Regime Climates and Change in the Moisture Regime Climates) Conclusion and References.

**Chapter 3: Assessment of climate change in Chhattisgarh plain**

Third chapter includes Introduction, Objectives, Data Set and Methodology, Trend Analysis of Temperature and Rainfall, Climatic Shift Analysis, Drought Analysis, Agro Climatic Region Analysis, Global Warming vs. Crop Suitability, Conclusion and References.

**Chapter 4: Agricultural scenario of Chhattisgarh plain**

Fourth Chapter is divided into Introduction, Conceptual Framework, Objectives, Methodology, Agricultural Land Use, Cropping Pattern (Areal Distribution of Crops, Crop Combination, Crop Diversification and Crop Concentration Regions), Production and Productivity, Agricultural Infrastructures (Irrigation, Power, Tools and Equipments, Fertilizers, Pesticides, HYV Seeds), Conclusion and References.

**Chapter 5: Impact of climate change on agriculture**

This chapter is divided into Introduction, Conceptual Framework, Objectives, Impact of Climate Change on Cropped Area, Impact of Climate Change on Crop Production, Impact of Climate Change on Crop Productivity, Conclusion and References.

**Chapter 6: Socio Economic Impacts of Climate Change**

This chapter consists of Introduction, Conceptual Framework, Objectives, Data Sets and Methodology, Climate Change Impact on Food Security, Health Impact, Climate Change and Poverty, Climate Change and Water Resource, Climate Change and Involuntary Displacement, Migration (Labour Migration, Risk of Instability), Conclusion and References.

**Chapter 7: Agricultural adaptation strategies to climate change Impacts**

This chapter is divided into Introduction, Conceptual Framework, Agricultural Adaptation Strategies to Climate Change- Crop Adaptation Strategies (Planting of Drought Resistant Varieties of Crops, Crop Diversification, Change in Cropping Pattern and Calendar of Planting, Mixed Cropping), Improved Irrigation Efficiency, Adopting Soil Conservation Measures that Conserve Soil Moisture, Planting of Trees (Afforestation) and Agro Forestry, Other Adaptation
Strategies (Labour Migration, Income Diversification), Government response measure, Conclusion, Recommendation, References.

Limitations of this study

IMD stations at all the districts are not existed, only seven IMD stations are there over the study region which are considered for the study.

Long term agricultural data regarding cropped area, production and productivity of crops are not available as the state was separated from Madhya Pradesh in 2000, thus it is very difficult to collect all those data for long time. Only 30 years data have been collected. Even because of the changing administrative boundaries long term data could not be collected at district level.
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