MODELING OF CLIMATE CHANGE THROUGH TIME SERIES ANALYSIS -A CASE STUDY ON EASTERN PART OF INDIA

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ABSTRACT

Once upon a time, Mahatma Gandhi said: "EARTH PROVIDES ENOUGH TO SATISFY EVERY MAN's NEEDS, BUT NOT EVERY MANS GREED", so as the result of human's greed today the whole world is facing a serious and dangerous problem which is nothing but the drastic climatic change. The main focus in this study is the area of monsoon track, the coastal region of the eastern part of India. The analysis is done from the climatic data of 20 randomly selected grid points from the study area. The climatic parameters used in this study are Maximum temperature, precipitation, wind speed, relative humidity, and solar radiation. ARIMA short term forecasting model was used to predict all these climatic parameters for the next decade which is hypothesis tested. It is needed to validate the observed regional data with the global data through downscaling techniques but the high percentage of error is detected from the comparison. As no much work has been done from a gradient point of view in the field of climatic change, gradient analysis is done for the selected region. An increasing trend was found from the gradient analysis over each 5year for two decades of observed data and one decade of predicted data. It is surprising to see that maximum temperature is increasing by 0.2^{o}C in the summer season of each year for the upcoming decade in our study area. In the station, Sambalpur monsoon is shifting from the first week of June to the second week which will affect the cropping pattern .while comparing the concentration of percentage of rainfall in monsoon season and temperature gradient they both are in phase.

***Keywords**: P value- hypothesis testing value, p –auto regressive order, d- degree of differentiation, q- moving average, ARIMA Model.*

1. INTRODUCTION

The climate-change risks that have emerged in the wake of mass industrialization indicate the need for a transition to sustainable energy, but attempts to encourage people to adopt pro-environmental behavior often achieve only limited success. Indeed, despite the wealth of evidence that an energy transition is critical to our very survival, people in general are reluctant to change their energy related decisions and behaviors. "One of the biggest obstacles to making a start on climate change is that it has become a cliché before it has even been understood "Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events).
Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as global warming. Climate is the long-term statistical expression of short-term weather. Climate can be defined as "expected weather". When changes in the expected weather occur, we call these climate changes. They can be defined by the differences between average weather conditions at two separate times. Climate may change in different ways, over different time scales and at different geographical scales. In recent times, scientists have become interested in global warming, due to mankind's impact on the climate system, through the enhancement of the natural greenhouse effect. Most climate scientists agree the main cause of the current global warming trend is human expansion of the "greenhouse effect"1 —

warming those results when the atmosphere traps heat radiating from earth toward space. Certain gases in the atmosphere block heat from escaping. Long-lived gases that remain semi-permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change.

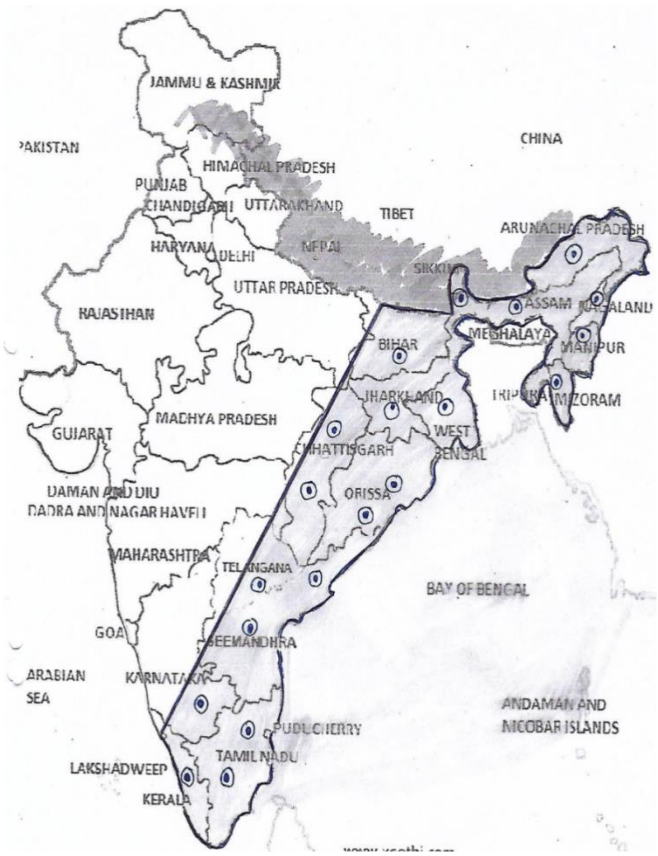
2. OBJECTIVE OF THE STUDY

The following objectives have been set for the present research

1. Prediction of climatic parameter like maximum temperature, precipitation, wind speed, relative humidity and solar radiation for the next decade by using the data from 1993 to 2013 for selected 20 grid points from total study area i.e. coastal eastern part of India.
2. To find out the co relation among gradient of each climatic parameters over $(5)_1$ year, $(5)_2$ year, 10 year interval and with respect to other climatic parameters.
3. Effect of climatic change on the extreme events like floods and droughts in the coastal area of India from the observed data.
4. To do the analysis on shifting monsoon period and relation of SPI value with the percentage of rain fall in monsoon season for Sambalpur station.

3. STUDY AREA

As monsoon is traveling from Karla to Himalaya and return back by hitting the Himalayas mountains , in this area the i.e. in this costal eastern part of India .the climate is changing so we selected this area as our study area and we want to do analysis of climatic change .Randomly 20 grid points are selected for the analysis .



SL.NO.	STATION
1	Ananthapuram
2	Wrangle
3	Visakhapatnam
4	Bhubaneswar
5	Sambalpur
6	Gumla
7	Howra
8	North Sikkim
9	Lawngtlai
10	Senapati
11	Mahasamud
12	Rajnandgaon
13	Kohima
14	Idukki
15	Chenai
16	Kanchipuram
17	Banglore
18	Tirap
19	Cachar
20	Nawada

Figure 1: Twenty stations in the eastern part of India are selected for the climatic study

4. METHODOLOGY OF DATA ANALYSIS

4.1 Time Series Analysis

Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on previously observed values. While regression analysis is often employed in such a way as to test theories that the current values of one or more independent time series affect the current value of another time series, this type of analysis of time series is not called "time series analysis", which focuses on comparing values of a single time series or multiple dependent time series at different points in time. The choice of the best model depends upon the following four criteria.

1. Accuracy of prediction
2. Simplicity of the model
3. Consistency of the parameter estimates
4. Sensitivity of result to change in parameter values

Hence, the model developers are interested to test the accuracy of prediction such that the chosen error statistic is minimum. This is done to decide upon its applicability and use. The terms used by different researchers in these connections are calibration, verification and validation. The terms can be briefly defined to avoid ambiguity.

This is done by comparing the observed and predicted series with or without statistical test. Validation is the process by which the observed and predicted series are tested for their statistical acceptability over several locations and at all times.

5. RESULT AND DISCUSSION

Forecasting is very important for climatic change analysis. Here the detail description on analysis of time series data using ARIMA modeling method for forecasting. In this study Climatic parameters like maximum temperature, wind speed, precipitation, solar radiation and relative humidity are selected for analysis. The data from 1993 to 2013 monthly average for all five parameters are taken from selected 20 grid points and for the validation purpose the data of the year 2014 was used. After determining the p, d, q parameters randomly two ARIMA models for each year and each month and each parameter was selected. Then the percentage of error was calculated then the less error model was used for forecasting purpose .As ARIMA modeling is a stochastic process the entire prediction was proceeded by short term forecasting for one year. Then again it was continued the forecasting by including the new output data in new input for further forecasting for every climatic parameter .Most of the computational work for ARIMA was carried out by using NUM-XL, SYSTAT and Microsoft excel. For validate and comparing the observed data with the global data and to find out the correlations between observed data with other global data of climatic parameters the SDSM software was used .the observed climatic parameter data is used to model the climatic change in the study area. Also here the gradient of each parameter over five year and ten year was determined.

5.1 PREDICTION OF CLIMATE CHANGE OF PARAMETERS FOR THE NEXT DECADES

Maximum Temperature

By following the flowchart of the project from the chapter-3, page no.29, we found the p, d, q. then randomly we select two combination of p, d, q, Here in the table 1.1 it is clear mention that for station-1 the observed maximum temperature is 29.84 ^{o}c after finding out the p, d, q value randomly we selected two ARIMA model which is [1, 1, 1] and [0, 1, 2] then by using the maximum temperature for monthly from 1993 to 2013 we predicted the maximum temperature. In result for ARIMA [1, 1, 1] the maximum temperature is 29.77 ^{o}c and for ARIMA [0, 1, 2] the maximum temperature is 30.06 ^{o}c .then by comparing the observed data and newly predicted data we find out the percentage of error, it comes for ARIMA [1, 1, 1] is 0.235% and for ARIMA [0, 1, 2] is -0.737% .so less error is the best model we selected the ARIMA [0, 1, 2] for station-1 and for month of January .

Table 1: Monthly Maximum Temperature Validation For The January And February For Year 2014 For All Grid Points Of The Study Area

STATION	MAXIMUM TEMP.(ºC)(2014)(JANUARY)				MAXIMUM TEMP. (ºC)(2014)(FEBRUARY)			
	OBSERVED	ARIMA	PREDICTED	% OF ERROR	OBSERVED	ARIMA	PREDICTED	% OF ERROR
1	29.84	(1,1,1)	29.77	0.235	31.91	(1,1,1)	31.85	0.188
		(0,1,2)	30.06	-0.737		(2,1,0)	31.2	2.225
2	29.29	(1,1,1)	29.67	-1.297	31.77	(1,1,1)	31.55	0.692
		(1,1,0)	30.14	-2.902		(1,1,0)	31.94	-0.535
3	29.59	(1,1,1)	29.44	0.507	31.62	(1,1,1)	31.2	1.328
		(2,1,0)	29.99	-1.352		(0,1,2)	30.69	2.941
4	29.52	(1,1,1)	29.12	1.355	32.22	(1,1,1)	32.48	-0.807
		(1,1,2)	30.02	-1.694		(1,1,2)	31.95	0.838
5	29.44	(1,1,1)	29.14	1.019	32.25	(1,1,1)	32.41	-0.496
		(1,1,0)	29.95	-1.732		(1,1,2)	31.99	0.806
6	25.37	(1,1,1)	25.29	0.315	27.89	(1,1,1)	27.45	1.578
		(0,1,2)	25.03	1.340		(2,1,0)	27.59	1.076
7	26.30	(1,1,1)	26.01	1.103	28.58	(1,1,1)	28.22	1.260
		(1,1,2)	26.18	0.456		(0,1,2)	28.36	0.770
8	15.66	(1,1,1)	15.19	3.001	16.73	(1,1,1)	16.23	2.989
		(1,1,0)	15.4	1.660		(1,1,2)	16.47	1.554
9	27.59	(1,1,1)	27.61	-0.072	30.12	(1,1,1)	30.14	-0.066
		(0,1,2)	27.58	0.036		(0,1,2)	30.67	-1.826
10	18.46	(1,1,1)	18.02	2.384	19.29	(1,1,1)	19.07	1.140
		(2,1,0)	18.29	0.921		(2,1,0)	19.25	0.207
11	32.45	(1,1,1)	32.07	1.171	36.61	(1,1,1)	38.24	-4.452
		(2,1,2)	32.43	0.062		(0,1,2)	38.54	-5.272
12	29.48	(1,1,1)	29.29	0.645	32.01	(1,1,1)	31.14	2.718
		(0,1,2)	29.36	0.407		(2,1,2)	31.02	3.093
13	21.82	(1,1,1)	21.53	1.329	23.10	(1,1,1)	22.25	3.680
		(2,1,2)	21.42	1.833		(1,1,0)	22.84	1.126
14	35.05	(1,1,1)	35.94	-2.539	36.94	(1,1,1)	36.27	1.814
		(1,1,2)	35.14	-0.257		(2,1,0)	36.15	2.139
15	29.16	(1,1,1)	29.06	0.343	30.23	(1,1,1)	29.65	1.919
		(0,1,2)	29.77	-2.092		(0,1,2)	29.18	3.473
16	30.25	(1,1,1)	30.11	0.463	31.66	(1,1,1)	30.45	3.822
		(1,1,0)	30.98	-2.413		(1,1,0)	30.58	3.411
17	29.16	(1,1,1)	29.1	0.206	31.22	(1,1,1)	30.65	1.826
		(1,1,2)	29.08	0.274		(0,1,2)	30.27	3.043
18	21.22	(1,1,1)	21.3	-0.377	20.45	(1,1,1)	19.52	4.548
		(0,1,2)	21.48	-1.225		(1,1,2)	19.56	4.352
19	28.88	(1,1,1)	29.48	-2.078	28.85	(1,1,1)	28.61	0.832

After validate the maximum temperature we find all selected ARIMA model for forecasting for all station maximum temperature from 2015 to 2024 by repeating the same procedure which is in table 2 below.

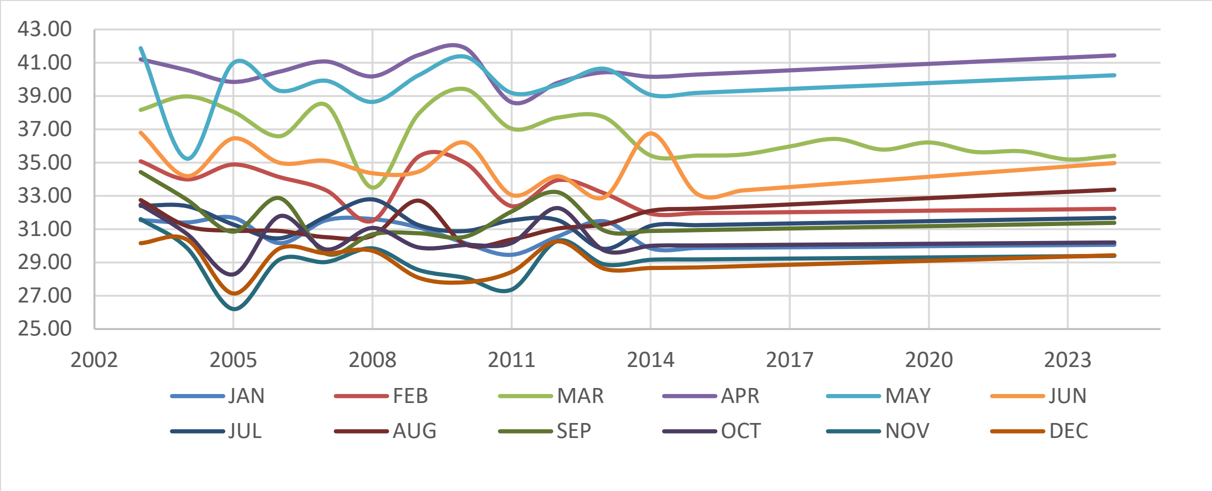


Figure 2: Station-1 Maximum Temperature

TABLE 2: Monthly Maximum Temperature Forecasting Form 2015 to 2024 for Station-1 from January to December

	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STATION-1	2015	29.87	31.95	35.41	40.29	39.18	33.11	31.23	32.22	30.93	30.01	29.17	28.69
	2016	29.89	31.98	35.48	40.41	39.30	33.32	31.28	32.34	30.98	30.03	29.20	28.77
	2017	29.91	32.01	35.96	40.54	39.42	33.52	31.33	32.47	31.03	30.05	29.22	28.85
	2018	29.93	32.04	36.41	40.67	39.54	33.73	31.38	32.60	31.08	30.07	29.25	28.93
	2019	29.95	32.07	35.77	40.80	39.65	33.93	31.42	32.73	31.13	30.09	29.21	29.01
	2020	29.98	32.10	36.20	40.93	39.77	34.14	31.47	32.85	31.17	30.11	29.29	29.09
	2021	30.00	32.13	35.63	41.06	39.89	34.35	31.52	32.98	31.22	30.13	29.31	29.17
	2022	30.02	32.15	35.67	41.19	40.01	34.55	31.57	33.11	31.27	30.15	29.34	29.26
	2023	30.04	32.18	35.18	41.31	40.12	34.76	31.62	33.23	31.32	30.17	29.36	29.34
	2024	30.06	32.21	35.40	41.44	40.24	34.96	31.67	33.36	31.37	30.19	29.39	29.42

5.2 DEVELOPMENT OF EQUATION FOR ALL CLIMATIC PARAMETERS FOR EACH MONTH

As the climate modeling is one the main objective of this study, climate is a cyclic process throughout the year all seasons and monsoon is coming in a specific period of time period, but from the observed and predicted data of different climatic parameters, it is clearly observed that all seasons and monsoon are not arriving in the time, few are coming before the time. Here the curve is fitted for each month, which shows the trend of the maximum temperature i.e. for other parameters also .from this equation by changing the x value we can know temperature for the future for the zone.

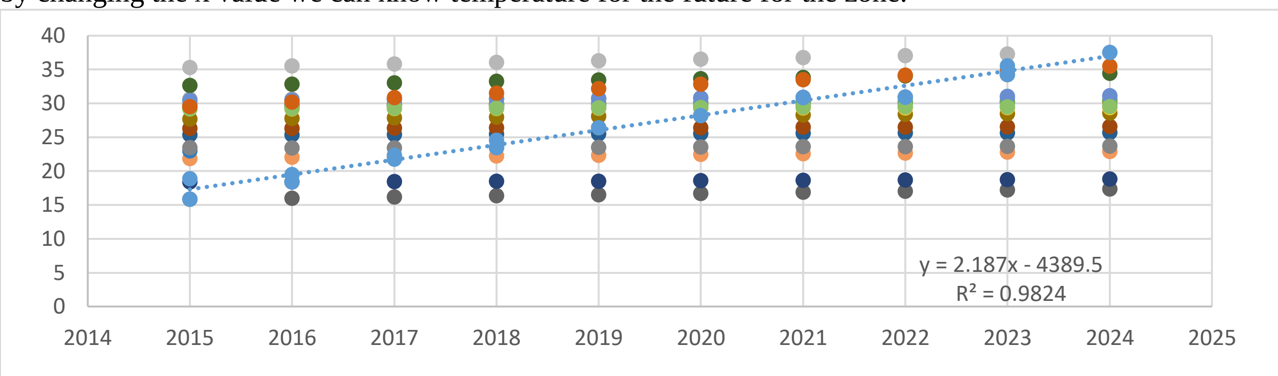


Figure 3 : Maximum Temperature– January For Total Zone From 2015 To 2024

5.3 CO-RELATION AMONG GRADIENT OF EACH PARAMETER WITH RESPECT TO TIME

Here is the gradient of maximum temperature over 30years from the selected 20 grid points of the study area is calculated for the entire zone monthly, the maximum temperature for the five interval years 1995,1990,2004,2005,2010,2014,2015,2020,2024 is calculated . The maximum temperature gradient over 1st five years, 2nd five years, 3rd five years, 4th five years, 5th five years, 6th five years, 1st ten years, 2nd ten years and 3rd ten years is found .which is there in below table 7.1.

TABLE 3: Maximum Temperature Gradient for Total Zone over 30years

TOTAL ZONE MAXIMUM RELATIVE HUMIDITY GRADIENT FOR 30YEARS						
1st DECADE GRADIENT INFORMTION						
MONTH	1995 maximum temperature	2000 maximum temperature	2004 maximum temperature	$(\Delta t/5yr)_1$.of zone	$(\Delta t/5yr)_2$.of zone	$(\Delta t/10yr)_1$.of zone
JAN	31.29	31.64	32.07	0.07	0.09	0.08
FEB	32.76	32.93	39.29	0.03	1.27	0.65
MAR	35.96	35.65	42.28	-0.06	1.33	0.63
APR	39.35	41.25	44.09	0.38	0.57	0.47
MAY	39.86	41.08	45.73	0.24	0.93	0.59
JUN	39.33	36.52	38.89	-0.56	0.47	-0.04
JUL	35.21	35.04	37.21	-0.04	0.44	0.20
AUG	34.30	34.32	38.30	0.00	0.80	0.40
SEP	34.29	34.38	35.17	0.02	0.16	0.09
OCT	32.26	33.22	32.17	0.19	-0.21	-0.01
NOV	30.92	31.01	31.33	0.02	0.07	0.04
DEC	30.28	30.59	30.84	0.06	0.05	0.06
2nd DECADE GRADIENT INFORMTION						
MONTH	2005 maximum temperature	2010 maximum temperature	2014 maximum temperature	$(\Delta t/5yr)_3$.of zone	$(\Delta t/5yr)_4$.of zone	$(\Delta t/10yr)_2$.of zone
JAN	33.19	34.18	35.06	0.20	0.17	0.19
FEB	38.55	41.23	36.94	0.54	-0.86	-0.16
MAR	42.02	43.98	43.33	0.39	-0.13	0.13
APR	43.96	47.50	45.50	0.71	-0.40	0.15
MAY	46.61	44.88	44.63	-0.34	-0.05	-0.20
JUN	45.02	42.90	43.90	-0.42	0.20	-0.11
JUL	36.53	36.10	38.17	-0.09	0.41	0.16
AUG	38.35	35.77	38.72	-0.52	0.59	0.04
SEP	36.39	35.43	36.57	-0.19	0.23	0.02
OCT	32.71	34.69	35.11	0.40	0.08	0.24
NOV	29.99	31.50	32.30	0.30	0.16	0.23
DEC	29.88	27.85	29.98	-0.41	0.43	0.01
3rd DECADE GRADIENT INFORMTION						
MONTH	2015 maximum temperature	2020 maximum temperature	2024 maximum temperature	$(\Delta t/5yr)_5$.of zone	$(\Delta t/5yr)_6$.of zone	$(\Delta t/10yr)_3$.of zone
JAN	35.31	36.54	37.53	0.25	0.20	0.22
FEB	38.86	40.36	41.56	0.30	0.24	0.27
MAR	43.76	45.88	47.58	0.42	0.34	0.38
APR	45.73	46.88	48.64	0.23	0.35	0.29
MAY	45.08	47.33	49.13	0.45	0.36	0.41
JUN	44.19	45.63	46.79	0.29	0.23	0.26
JUL	38.28	38.84	39.28	0.11	0.09	0.10
AUG	38.85	39.81	40.58	0.19	0.15	0.17
SEP	36.89	37.48	37.96	0.12	0.10	0.11

OCT	34.92	35.69	36.30	0.15	0.12	0.14
NOV	31.91	34.50	36.60	0.52	0.42	0.47
DEC	31.37	31.64	33.64	0.05	0.40	0.23

In the predicted monthly maximum temperature it can be observed that the gradient of maximum temperature in the month of April and May is going to prevent till January, which was not observed in the previous decade, hence it is predicted that the rise of temperature is also encouraged in the backward direction of the month. so it has bearing on the arrival of the monsoon, which can be studied in further part of the study.

TABLE 4: MAXIMUM TEMPERATURE GRADIENT FOR TOTAL ZONE OVER 30YEARS

DECADE	GRADIENT	TOTAL ZONE TEMPR ATURE GRADIENT FOR 30YEARS											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1ST DECADE FROM (1995 TO 2004)	$(\Delta t/5yr)_1$.of zone	0.07	0.03	-0.06	0.38	0.24	-0.56	-0.04	0.00	0.02	0.19	0.02	0.06
	$(\Delta t/5yr)_2$.of zone	0.09	1.27	1.33	0.57	0.93	0.47	0.44	0.80	0.16	-0.21	0.07	0.05
	$(\Delta t/10yr)_1$.of zone	0.08	0.65	0.63	0.47	0.59	-0.04	0.20	0.40	0.09	-0.01	0.04	0.06
2nd DECADE FROM (2005 TO 2014)	$(\Delta t/5yr)_3$.of zone	0.20	0.54	0.39	0.71	-0.34	-0.42	-0.09	-0.52	-0.19	0.40	0.30	-0.41
	$(\Delta t/5yr)_4$.of zone	0.17	-0.86	-0.13	-0.40	-0.05	0.20	0.41	0.59	0.23	0.08	0.16	0.43
	$(\Delta t/10yr)_2$.of zone	0.19	-0.16	0.13	0.15	-0.20	-0.11	0.16	0.04	0.02	0.24	0.23	0.01
3rd DECADE FROM (2015 TO 2024)	$(\Delta t/5yr)_5$.of zone	0.25	0.30	0.42	0.23	0.45	0.29	0.11	0.19	0.12	0.15	0.52	0.05
	$(\Delta t/5yr)_6$.of zone	0.20	0.24	0.34	0.35	0.36	0.23	0.09	0.15	0.10	0.12	0.42	0.40
	$(\Delta t/10yr)_3$.of zone	0.22	0.27	0.38	0.29	0.41	0.26	0.10	0.17	0.11	0.14	0.47	0.23

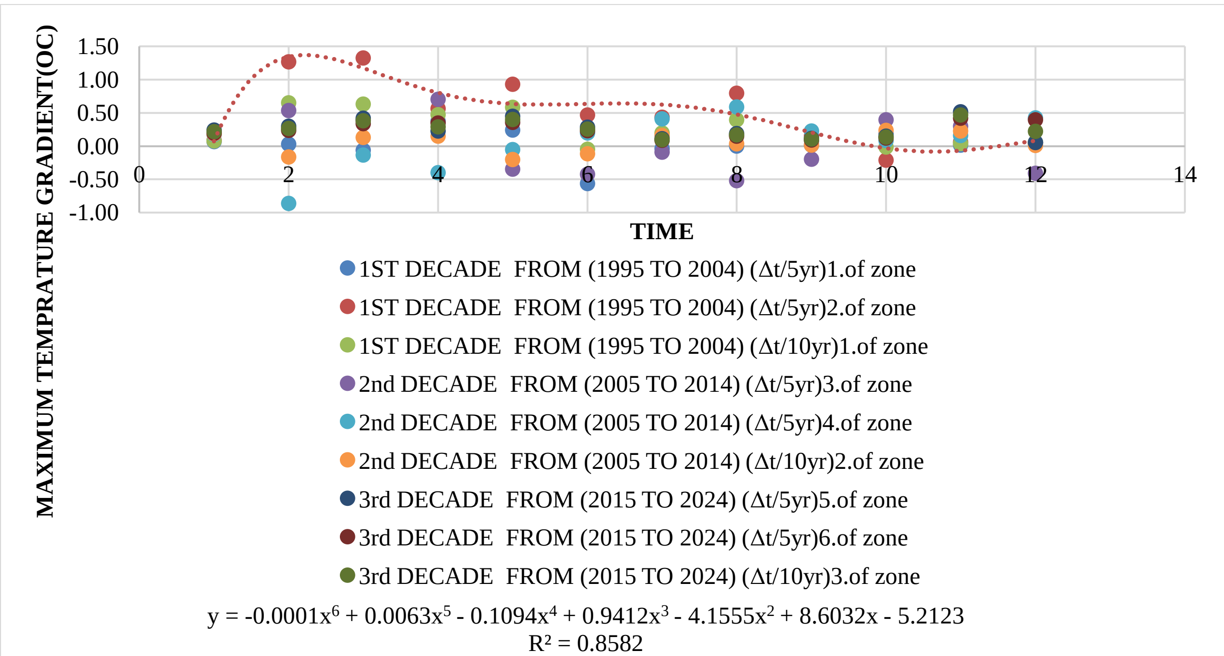


Figure.4 : Maximum Temperature Gradient Curve Fitting

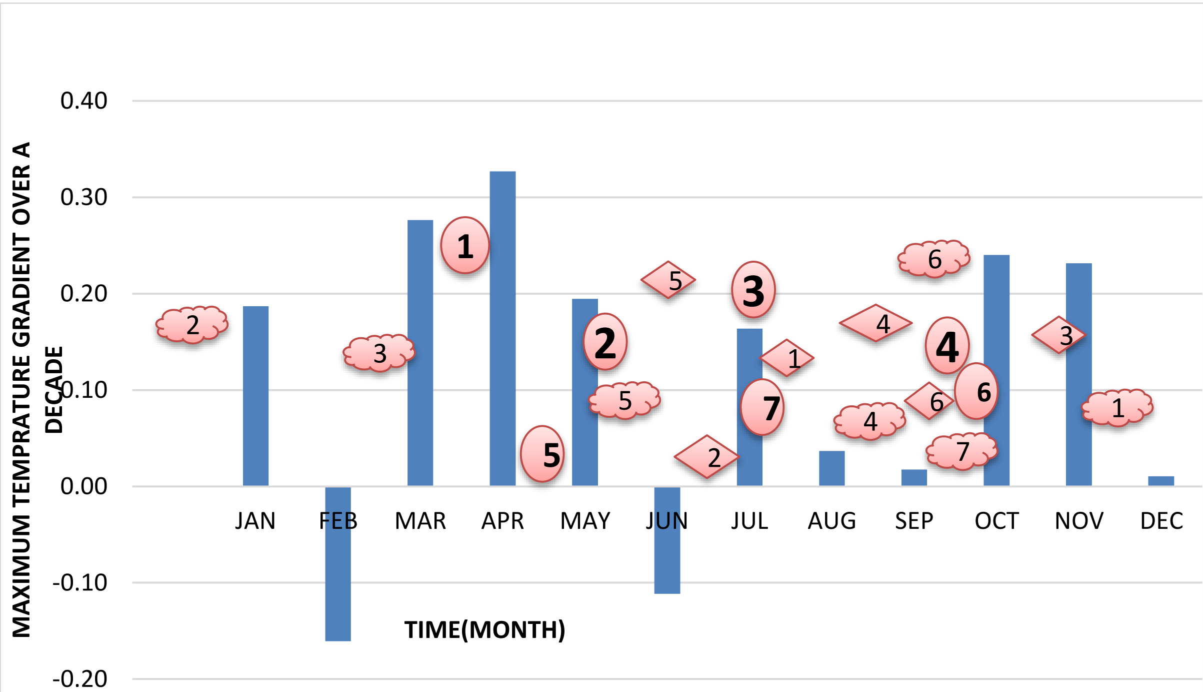
Table 5: change in gradient for maximum temperature observed to predicted

MONTH	$(\Delta t/10yr)_2$.of zone(2005 to 2014)	$(\Delta t/10yr)_3$.of zone(2015 to 2024)	Change In Maximum Temperature Gradient(^{O}C)
JAN	0.19	0.22	0.03
FEB	-0.16	0.27	0.43
MAR	0.13	0.38	0.25
APR	0.15	0.29	0.14
MAY	-0.20	0.41	0.51
JUN	-0.11	0.26	0.37
JUL	0.16	0.10	-0.06
AUG	0.04	0.17	0.13
SEP	0.02	0.11	0.09
OCT	0.24	0.14	-0.1
NOV	0.23	0.47	0.24
DEC	0.01	0.23	0.22

Here is the gradient of maximum precipitation over 30years from the selected 20 grid points .From the entire zone monthly maximum precipitation, we found out the maximum from them for the five interval years from 1990 to 2024 .Then we will find out the maximum precipitation gradient over 1st five years ,2nd five years ,3rd five years ,4th five years, 5th five years ,6th five years ,1st ten years ,2nd ten years and 3rd ten years .which is there in table 4.

6 EFFECT OF CLIMATE CHANGE ON THE EXTREME NATURAL EVENTS

Natural hazards that lead to disasters can cause tremendous impacts on societies, the environment, and economic wealth of the affected countries. Sectors that are closely related to climate, such as agriculture, tourism, and water, are facing a great burden by extreme events. Some forms of climate extreme events have been on the rise over the last few decades. What is their link to human-caused climate change and how will a changing climate affect the occurrence of hazards in the future? Are past disasters going to be the future's norm? This section draws largely from the special report on extreme events as well as change in maximum temperature gradient .Here it is a focus on tropical cyclones and their relationship with climate change.



Floods		Cyclone(wind speed and its intensity)			Highest rain fall/within 2 or 3 days	
1	75,000 cusecs	**1**	50km/hr.	988hpa	**1**	486mm
2	66,000 cusecs	**2**	80km/hr.	940hpa	**2**	550mm
3	79,845 cusecs	**3**	50km/hr.	550hpa	**3**	602mm
4	900,000 cusecs	**4**	120km/hr.	986hpa	**4**	778mm
5	88,7120 cusecs	**5**	260km/hr.	990hpa	**5**	660mm
6	63,951 cusecs	**6**	45km/hr.	788hpa	**6**	630mm
7	72,5000 cusecs	**7**	215km/hr.	940hpa	**7**	589mm

Figure 5 Extreme Events Vs Maximum Temperature Gradient For The Decade 2005 To 2014

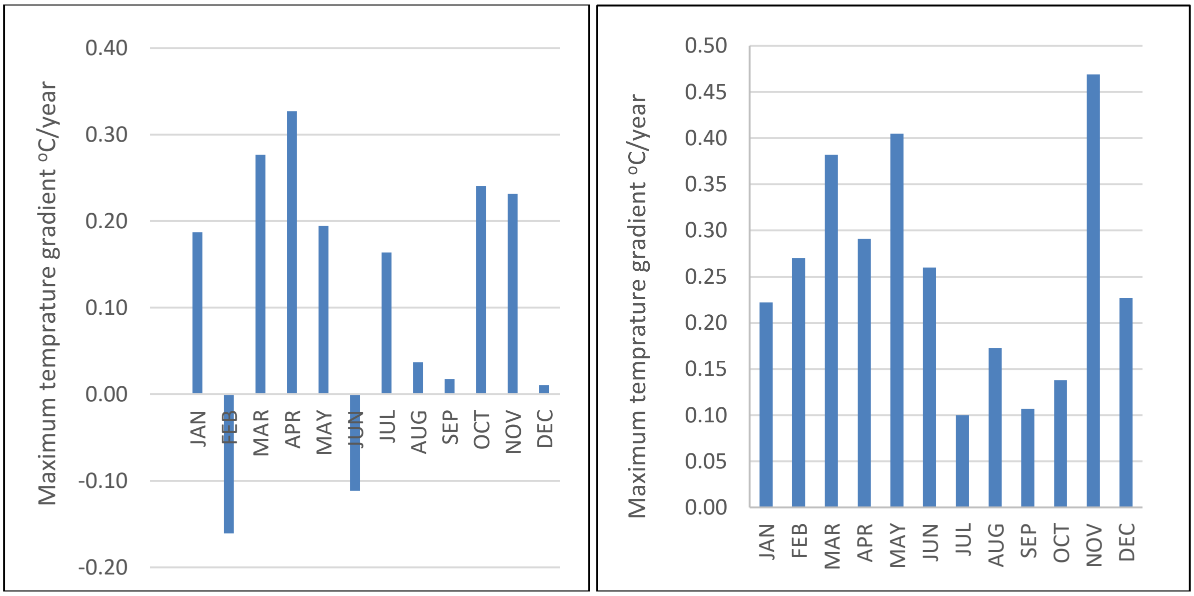


Figure 6 Maximum temperature gradient for 2005 to 2014(observed) and (predicted)

From the above **Figure 5** it can be observed while there is a significant change in maximum temperature gradient at the same change a natural extreme event occurs from the observation. Also in prediction the maximum temperature increases in few month where there is a drastic change in future decade chances are there for occurring natural extreme events.

7 ANALYSIS OF SHIFTING OF MONSOON FOR SAMBALPUR

Sambalpur is located at 21°.27' North Latitude and 83°.58' East Longitude. The average elevation is 150.75 meters above the mean sea level. Sambalpur falls under the Zone-3 seismic number, which shows the possibility of an earthquake. Sambalpur lies on the bank of the river Mahanadi. The river flows to the west of the city and separates Burla from Sambalpur and Hirakud. Sambalpur experiences an extreme type of climate with hot and dry summers followed by humid monsoon and cold winters. The hot season commences from the first week of March and lasts until the second half of June. In May, the temperature rises to 47°. In December, the temperature comes down to 5 °C. Sambalpur gets rainfall from the south western monsoon. The most pleasant months in Sambalpur are from October to February, during which time the humidity and heat are at their lowest. During this period, temperatures during the day stay below 30 °C (86 °F) and drop to about 20 °C (68 °F) at night. This season is followed by a hot summer, from March to May. The summer gives way to the monsoon season. Since 1982 as per the data available with District Emergency section, Sambalpur, there has not been a single occurrence of cyclone in Sambalpur. There are possibilities of strong winds with the speed of 53 km/ph before the onset of monsoon. The relative humidity is high during the rainy season, generally being over 75%. After the rainy season the humidity gradually decreases and the weather becomes dry towards the winter.

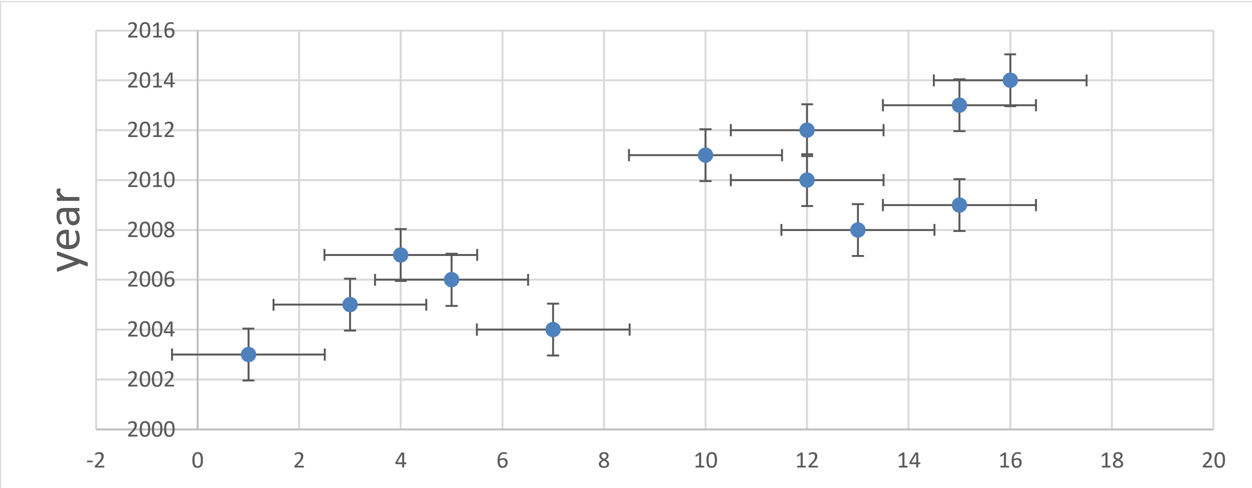


Figure.7 : Monsoon shifting day by day for the station sambalpur from 2003 to 2014 for the month of June

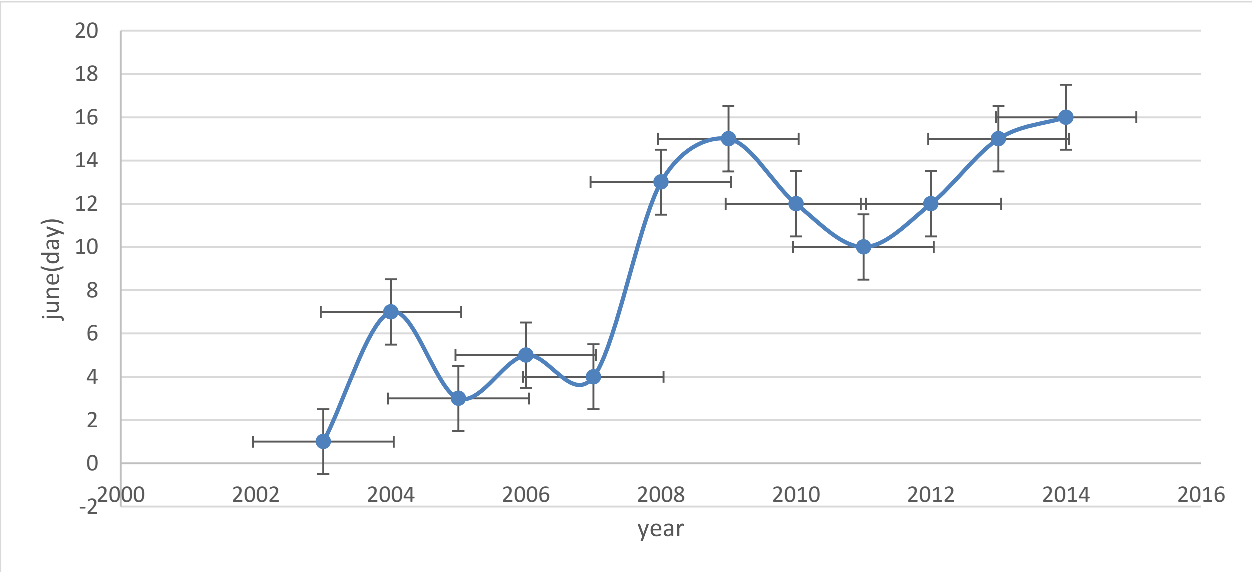


Figure.8 Monsoon shifting day by day for the station sambalpur

From the above graph, we can observe the shifting of arrival of monsoon from year to year at sambalpur station. The arrival of monsoon is slowly shifting from 1st week to 2nd week of June from 2003 to 2014 as observed and showed in above graph.

Table 6: Percentage of rain fall and Temperature Gradient

SAMBALPUR					
YEAR	TOTAL AMOUNT OF RAIN FALL	PRE MANSOON	MANSOON	POST MANSOON	TEMPRATURE GRADIENT $\Delta t = t_h - t_l$
2003	1366	0.11%	89.23%	10.18%	48.416
2004	1445	1.24%	89.83%	8.08%	47.45
2005	1445	0.39%	79.43%	14.40%	49.26
2006	1828	2.77%	88.41%	8.80%	51.20
2007	1769	0.97%	92.20%	6.53%	50.88
2008	1620	0.85%	93.66%	3.85%	46.25
2009	1784	0.44%	87.84%	11.72%	47.15
2010	2127	0.63%	83.23%	15.38%	45.26
2011	2000	1.24%	95.84%	2.38%	44.58
2012	1876	0.21%	93.10%	4.49%	49.87
2013	1246	2.27%	73.11%	23.83%	46.57
2014	1524	1.34%	76.44%	22.22%	51.96

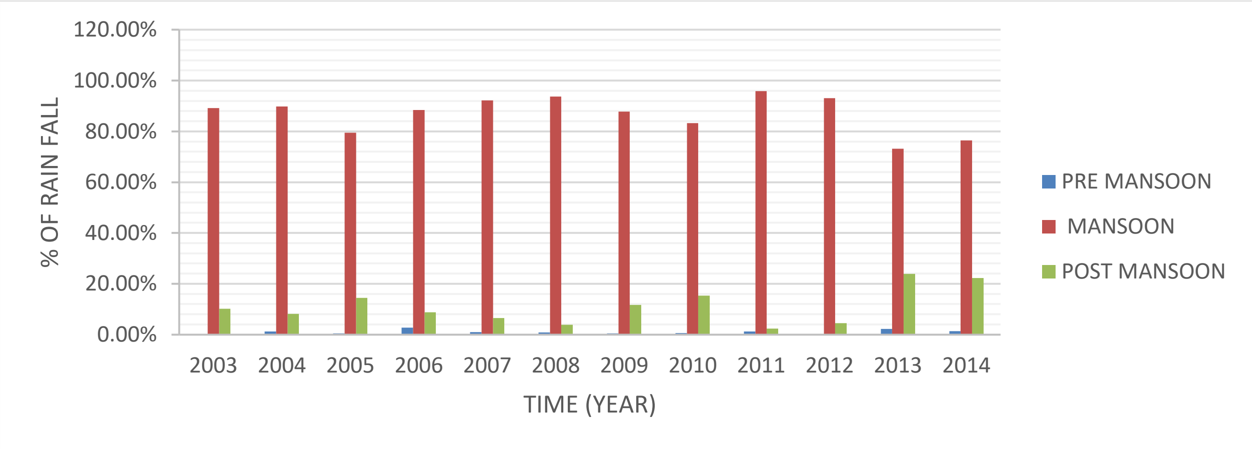


Figure.7 Percentage of Rain Fall Vs Time (Year) For Sambalpur

From the above graph it is clearly found that more than 80% of annual rain fall is occurring in the period of monsoon only .but as monsoon arrival is shifting slowly it can be observed in 2013 and 2014 the percentage of rain fall in post monsoon season increases .as a cyclic order is observed in the above graph, so a comparison between temperature gradient and % of rain fall is done below.

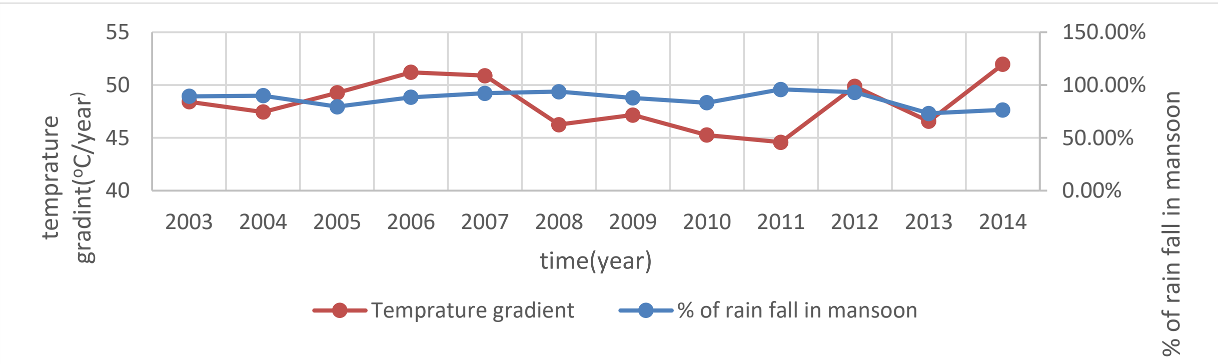


Figure.8: Graph between % of rain fall in monsoon and temperature gradient from 2003 to 2014 for the station sambalpur (observed)

From the above graph it is observed that the relationship between the percentage of rain fall in monsoon season and maximum temperature gradient are in phase.it mean the amount of rain fall from the total annual rain fall is depends up on the temperature gradient of the particular year at Sambalpur station.

Table: 7 Concentration of percentage of rain fall per month from annual rain fall

[SAMBALPUR]													
YEAR	TOTAL AMOUNT OF RAIN FALL	PERCENTAGE OF RAIN FALL IN EACH MONTH											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003	1366	0	0	0	0	0	18	27	21	23	8	1	1
2004	1445	1	0	0	0	1	13	29	29	19	8	0	0
2005	1445	5	1	0	0	0	11	31	18	20	14	0	0
2006	1828	0	0	2	1	0	6	28	39	15	5	3	0
2007	1769	0	0	0	0	1	10	30	30	22	5	1	0
2008	1620	1	0	0	0	0	20	29	25	20	3	1	0
2009	1784	0	0	0	0	0	4	41	26	16	8	4	0
2010	2127	1	0	0	0	1	4	32	29	19	9	3	4
2011	2000	0	1	0	0	1	14	18	30	34	1	0	1
2012	1876	2	0	0	0	0	32	24	22	15	3	1	0
2013	1246	0	1	0	2	0	14	25	21	13	24	0	0
2014	1524	0	0	0	2	0	13	32	20	19	14	0	0

8 CONCLUSIONS

The following conclusions are drawn concerning the modelling of climatic parameters, specifically their gradients with respect to time and the inherent relationship among the gradients of climatic parameters. Further the shifting of monsoon over time for the Sambalpur station is also been analysed with the objective to obtain the standard precipitation index. As it is observed that the most of the rain fall occurs during the monsoon period in the Sambalpur

1. The Average Maximum temperature is increasing by 0.2 ^{O}C/month from the last decades.
2. In the upcoming decade the maximum temperature is going to increase, mainly in the month of May (0.41 ^{O}C/month) and in month of November (0.47 ^{O}C/month).
3. Monthly equations are developed for the future prediction and analysis of maximum temperature for this zone.
4. There is an increase in the rain fall in the month of July (4.23mm/month to 44.68 mm/month) and august (3.32 mm/month to 42.81 mm/month) in the decade 2004 to 2014 which has impact the change of next months like September (49.95 mm/month to 00.00 mm/month mm/month), October (28.08 mm/month to 00.00 mm/month), November (14.08 mm/month to 00 mm/month), December (00 mm/month to 2.95 mm/month).
5. There is no such overall change found in the wind speed for the study area for next decade until 2024, except few natural disasters. The relevant change in wind speed is 0.18m/s/month, 0.22m/s/month,0.09m/s/month with respect to April, May and June.
6. The relative humidity for the next decade until 2024 for the total zone is varying, which is 0.01integer/month, 0.007integer/month with respect to March and April.
7. The solar radiation is going to increase by 0.282MJ/m^2/month, 0.457MJ/m^2/month,0.480MJ/m^2/month with respect to April, May and June for the next decade until 2024.

8. The arrival of monsoon in Sambalpur from the last 10years of observed in the month of June is shifting from first week to second week which is depicted in chapter no.4 graph 4.8.1 while we fit the date of shifting to a smooth curve it shows an increasing trend .
9. While comparing the percentage of concentration of rainfall in monsoon to the temperature gradient the graph comes in phase.

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