IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 10, Issue 3, March 2020, ||Series -I|| PP 59-73

Long Term Assessment of Rainfall over Different Districts of Odisha: [A Case Study]

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Received 28 February 2019; Accepted 13 March 2020

ABSTRACT: Climate change possesses a threat to life on earth. Number of natural calamities like cyclone, drought, flood, rising of sea level, severe heat and cold wave, melting of snow etc. are some of ready effects that has been directly felt in variation portion of the globe. Climate change can be defined broadly as a change in the state of the climate that can be identified by changes in the mean or the variability of its properties that persist for an extended period typically decade or longer. It refers to any change in climate over time whether due to natural variability or as a result of human activity. This study may be a small step towards recognizing the climate change and its impact on water bodies of the study area. The statistical analysis shows the characteristics of the rainfall.The trend analysis of rainfall has been done by using IDW technique which signifies the amount of rainfall is more in western Odisha during month of July and gradually decreases towards end of monsoon. The IDW map shows the rate of rainfall is high in coastal areas during post-monsoon. This effect is due to the cyclonic effects on Odisha in October month.
KEYWORDS: Climate change, Rainfall, Statistical analysis, Trend, IDW.

I. INTRODUCTION

Climate change is unavoidable and insuperable in its temperament. Climate change is the phenomenon due to emissions of greenhouse gases from deforestation, fuel combustion and industrialization resulting variation in solar energy, precipitation and temperature. Temperature and precipitation are the most overwhelming climate drivers for river hydrology. Climate Change occurs due to internal variability within the climate system and external factors (anthropogenic and natural).

Climate change is a plague to the lives, that affects water resources, freshwater habitats, coastal regions, agriculture, forests and vegetation, snow melting and snow cover, and geological processes such as floods, desertification and landslide, and has long-term effects in human health as well as food security and also threaten livelihood and economic stability. Throughout the world there is significant concern about the climate change effect and its variability on inflow of water bodies. Current climate change is the reason for worldwide rising temperature and hence sways the rainfall.

The ***specific objectives of the research*** are to

- Statistical analysis of rainfall of all districts of Odisha
- Finding long-term rainfall trends in the districts of Odisha state.
- Theimpact of climate change onwater bodies of Odisha.
- Projection of future Precipitation of Odisha.

II. REVIEW OF LITERATURE

A compendious review as carried out on various facets of climate change due to temperature and rainfall factors and trend analysis is summarized as bellow:

Leonard Robert Gardner (2009) discussed on climate change effect on runoff through an equation:

$$dR = exp(-PET/P)*[1+PET/P]*Dp-[5544 \text{ X } 10^{10} *exp(-PET/P)*exp(-4620/T_k)*T_k^{-2}]*dT_k$$

This equation was used for the estimation of decrement runoff in a scenario of increased temperature and constant precipitation. They showed the changes in runoff in future scenarios were due to the effect of climate change. They gave the scope for further evaluation of presented model for other different basin, related to the climate effect of annual mean runoff.

Niels Van Steenbergen&PrtrickWillems (2012) presented a method to check precision of rainfall-runoff models. Here they checked, whether the flow changes due to change in rainfall with respect to climate change or not. They used 3 rainfall-runoff models (PDM, NAM and VHM) to evaluate the changes in the peak flow due to the change in rainfall. As compare to the traditional calibration and validation statistics, the hydrological model or rainfall-runoff model analysis was very useful for better result.

Dingbao Wang et *al*. (2013)studied the effect of climate change on precipitation and uncertainty over hydrological extremes. Tow RCMs (RCM3-GFDL and HRM3-HADCM3) were selected by them for evaluating the potential of climate change sway on IDF curves. For the determination of bias correction on future IDF curves, they took two methods; (1) sequential bias correction and (2) Maximum intensity percentile method. Results of HRM3-HADCM3 showed a higher intensity of rainfall in downstream station and no significant change in upstream and middle stream station. Nearly same results came out from the RCM3-GFDL.

Heng Chan Thoeun (2015)presented a scenario of climate change with the help of a programme known as MGICC-SCENGEN program. It was linked with regional and global climate change scenarios emission. The RCM along with GCM with 50 ×50km resolution was adopted for the generation of future climate model. He reached at a decision of that the climate of Combodia was changing, from the historical analysis and PRECIS. The future aspects of this paper were to generate the future scenarios by using daily data of the study area, which would give better results for the future climate projection.

XIA Jun et *al*. (2017) Studied the effect of climate change on water resources and cycle in a monsoon region of China. They concluded that water resources were affected due to the uncertainty and complexity of climate. All the changes was happening due to the emission of green gas (CO_2, CFC etc.) which directly affecting the environment and water resources. The hydrological extremes (floods and droughts) were highly affected by change of the climate. The rising temperature was affecting the agriculture, for which the water consumption of irrigated land was increasing with respect to the increase in temperature (with an increase of 1ºC of temperature, the rate of water consumption will increase up to 4% of total water requirement)

Amogne et al. (2017) examined the spatiotemporal dynamics of metrological variables in the contexture of climate change; focusing the rainfed agriculture areas of Africa. Temperature and rainfall trend analysis was done by using the non - parametric test (Mann-Kendall test). Increment of mean annual temperature showed the increment of the minimum temperature throughout the year. The anomaly of rainfall was the case of droughts which directly affect the agriculture of the study area.

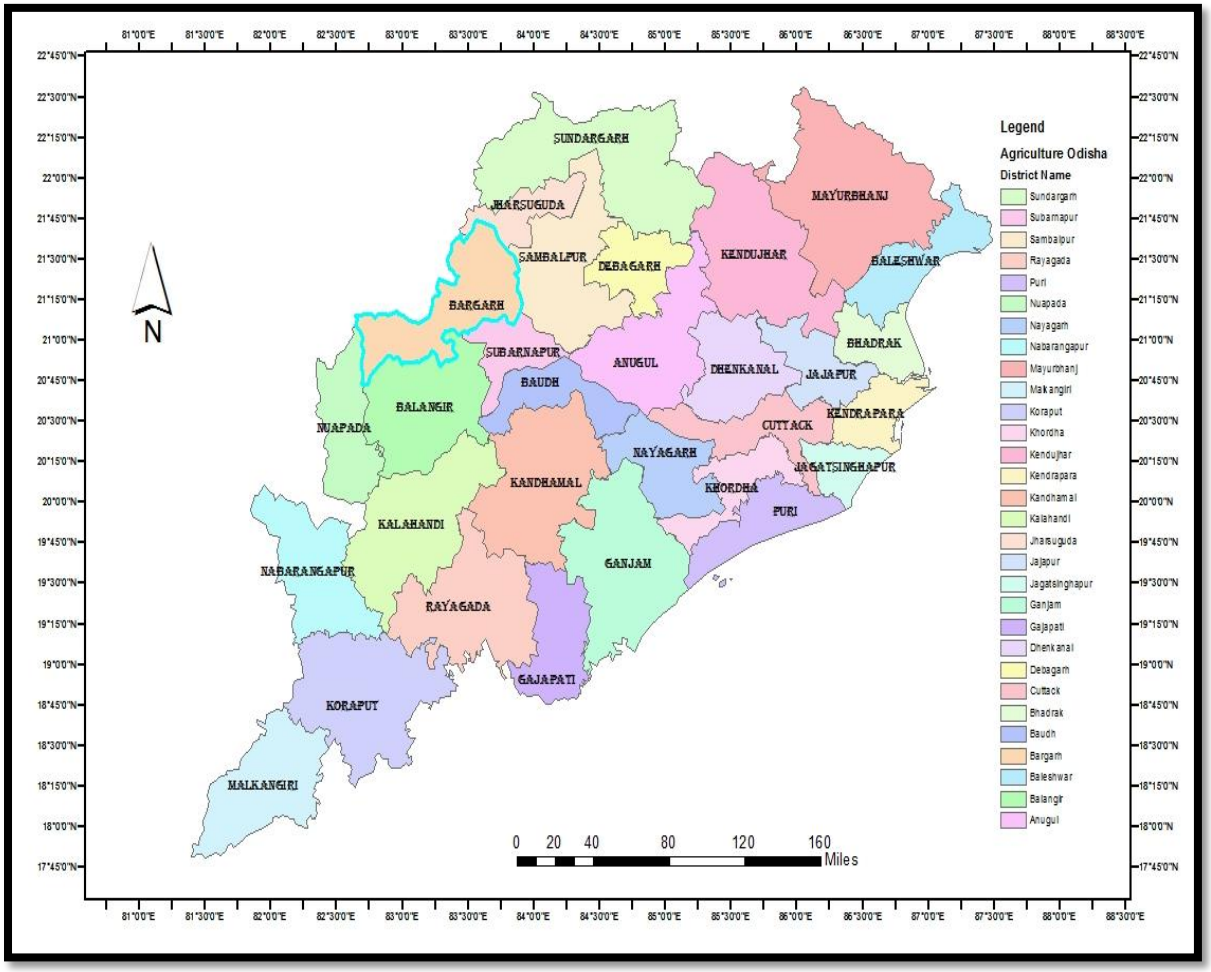
A.E. Coles et al. (2017) they studied the climatic impact on hillslope runoff due to climate change on the area of northern Grate plains. By taking some hydrological and climatological data of 52 years data from 1962-2013, they assed trends using time series analysis. Mostly they have taken snow cover, rainfall, soil water content temperature and runoff as variables in their study. Runoff is highly affected by the reduction of snow-melt and snowfall but no significant change due to increase of rainfall. Hillslope runoff plays a vital role for the dry-land crop.

Navneet Kumar et al. (2017) studied the effect of climate change on catchment. The trend analysis of temperature and rainfall was done by them through PRECIS. By the help of SWAT model, hydrological simulation had done. They concluded about the up gradation of flood from the relationship of under and over proportional. The water balance component was supressed by the effect of rainfall pattern of climate projection. They showed a relationship between percolation and rainfall; changes in rainfall and its impact on percolation showed an opposite behaviour.

III. STUDY AREA AND DATA COLLECTION

STUDY SITE:

On the eastern seaboard of India, Odisha state is situated somewhere in the range of 17º49’ and 22º36’ North latitude and 81º36’mand 87º18’ East longitudes. The state has 30 districts, which spreads over a region of 1, 55,707sq.km.It occupies total 4.87% area of India. It is extensively isolated into 4 geographical regions i.e. Eastern Hills, Northern plateau, coastal plains and Central river basin. It has 480 km coastline along the Bay of Bengal on its east. It extends from the Subarnarekha River in the north to theRushikulya River in the south.



IV. METHODOLOGY

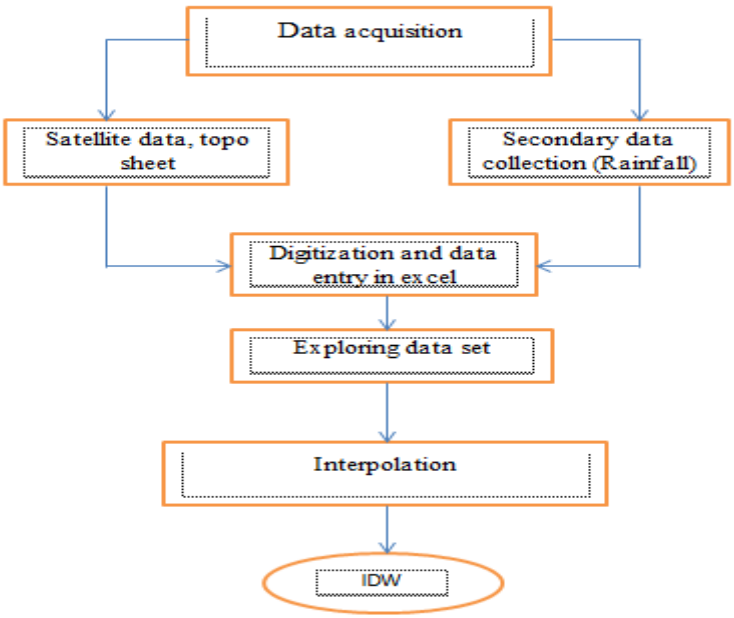
Methodology is the general research procedure that diagrams the manner by which research is to be undertaken. The methodology defines the means or mode of data collection and some times, how a specific result is to be calculated. In general, it shows the correct path for finding out the results through several steps.

INVERSE DISTANCE WEIGHT (IDW)

Interpolationpredicts values for cells in a raster from a limited number of sample data points it can be used to predict values at unknownlocation. Among all the methods of interpolation IDW is most commonly used method for determining of the unknown values of any geographic point data. Estimation of IDW was made dependent on adjacent known areas or locations. The interpolation weights of points are inversely proportional to the distance from that point. The points, closer to the interpolated point are having more weight than those of far points and vice versa.

$$Z(x_0) = \frac{\sum_{i=1}^{n} \frac{x_i}{h_{ij}^{\beta}}}{\sum_{i=1}^{n} \frac{1}{h_{ij}^{\beta}}}$$

Where, $Z(x_0)$ is the interpolated value, total number of sample data value is denoted as n, x_i represents the i^{th} data value, h_{ij} is separating the distance between the sample data and interpolated value and β denotes the weight power.



V. RESULTS AND DISCUSSIONS

DEPICTION OF STATISTICS AND VARIABILITY ANALYSIS (RAINFALL)

The present study delineates the statistics of rainfall of Odisha. The statistical parameters, mean, skewness,minimum, maximum, standard deviation, and coefficient of variation (C_v) are calculated. These parameters help in explaining the characteristics of precipitation (rainfall).

The mean of annual rainfall during the study period of 117years is found as 1415.4mm with the standard deviation of 634.07mm and Coefficient of variation (C_v) 11.16%. The maximum and minimum rainfall of all over Odisha in monsoon during study period was 1224.3 mm and 520.9mm respectively. In recent decades (1988-2017) the amount of rainfall is gradually increasing as compared to the past three decades (1958-1987).

Total Average Annual Rainfall of Odisha Districts		
Sl. No.	Districts	Total Rainfall (mm)
1	ANGUL	1254
2	SAMBALPUR	1357
3	CUTTACK	1322
4	DEVGARH	1344
5	BALANGIR	1288
6	JHARSUGUDA	1399
7	BALASORE	1532
8	JAJPUR	1421
9	DHENKANAL	1311
10	MAYURBHANJ	1405
11	KENDUJHAR	1354
12	SUNDARGARH	1408
13	KORAPUT	1316
14	BHADRAK	1446
15	KENDRAPADA	1468
16	JAGATSINGHPUR	1341
17	KHORDHA	1244
18	PURI	1178
19	GANJAM	1130
20	GAJPATI	1084
21	RAYAGADA	1272
22	MALKANGIRI	1179
23	NABARANGPUR	1451

24	KANDHAMAL	1246
25	KALAHANDI	1380
26	BOUDH	1237
27	BARGARH	1293
28	NUAPADA	1306
29	NAYAGARH	1232
30	SONPUR	1257

Table (Annual rainfall average of 30 districts of Odisha)

Statistical analysis of all districts of Odisha

ANGUL

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	97.7	129.9	166.6	128.7	149.0	482.4	685.5	598.1	490.6	356.6	84.2	35.5
MIN	0.0	0.0	0.0	0.0	3.4	56.7	50.1	122.5	67.3	7.2	0.0	0.0
Mean	9.2	28.0	8.6	32.2	46.0	199.0	296.1	321.7	199.0	89.8	22.4	2.3
SD	14.6	29.5	32.3	29.8	33.1	90.0	104.8	88.3	73.6	59.6	24.3	5.5
CV(%)	158.1	105.4	373.8	92.4	72.0	45.2	35.4	27.4	37.0	66.4	108.4	246.2

BHADRAK

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	65.7	120.0	153.7	119.2	235.6	497.0	560.6	490.2	574.6	661.6	123.5	50.5
MIN	0.0	0.0	0.0	0.0	5.1	60.1	113.9	162.4	91.3	4.6	0.0	0.0
Mean	11.0	27.0	27.5	37.8	80.6	210.5	290.1	324.3	249.2	157.1	26.3	5.0
SD	14.8	28.9	30.9	30.1	51.3	92.5	86.7	73.9	83.1	105.1	32.4	9.0
CV(%)	134.7	107.0	112.7	79.5	63.6	43.9	29.9	22.8	33.4	66.9	122.8	180.5

BALANGIR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	51.3	69.0	87.4	161.1	139.3	427.3	943.7	607.4	526.7	208.3	55.4	36.1
MIN	0.0	0.0	0.0	0.0	0.0	48.1	116.4	141.9	75.2	2.6	0.0	0.0
Mean	7.7	13.2	14.7	28.0	31.8	195.5	352.5	347.9	221.4	62.0	10.3	3.0
SD	11.2	16.3	16.7	24.6	24.0	78.4	114.0	100.0	79.4	41.2	12.4	6.3
CV(%)	145.2	122.9	113.4	87.9	75.5	40.1	32.3	28.8	35.9	66.4	120.1	214.1

BALASORE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	78.3	131.7	180.4	173.5	285.0	657.2	589.4	582.3	614.3	746.0	103.6	55.8
MIN	0.0	0.0	0.0	0.5	5.6	72.4	78.6	174.0	109.1	12.9	0.0	0.0
Mean	11.8	30.4	32.4	51.8	95.6	230.6	286.0	342.6	265.9	157.7	21.7	4.7
SD	15.9	30.7	36.2	40.2	58.4	105.8	90.5	87.7	93.1	110.8	26.1	9.0
CV%	134.8	101.0	111.9	77.6	61.0	45.9	31.6	25.6	35.0	70.2	120.1	191.7

BOUDH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	50.0	96.4	134.6	142.9	126.0	436.2	704.4	786.8	433.8	321.9	74.0	41.3
MIN	0.0	0.0	0.0	0.0	0.0	36.5	53.0	111.8	49.9	1.1	0.0	0.0
Mean	7.6	19.5	19.3	28.8	35.4	193.0	315.1	319.7	201.5	77.1	17.5	2.8
SD	10.8	23.7	27.1	31.4	27.1	81.5	114.5	103.6	70.9	52.0	19.1	5.8
CV%	141.8	121.5	140.3	109.0	76.7	42.2	36.3	32.4	35.2	67.5	109.1	209.4

BARGARH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	45.5	70.7	109.1	126.4	94.5	397.4	736.8	871.7	553.2	186.6	54.3	25.4
MIN	0.0	0.0	0.0	0.0	0.0	13.7	137.6	200.0	74.0	0.2	0.0	0.0
Mean	7.2	15.6	18.8	21.7	23.3	185.4	370.9	380.5	209.3	51.9	6.4	2.5
SD	9.3	17.9	20.6	20.2	18.2	76.4	107.4	108.8	75.0	36.0	8.6	4.6
CV%	129.8	115.0	109.9	93.1	77.8	41.2	29.0	28.6	35.9	69.5	134.1	186.4

CUTTACK

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	76.2	116.6	124.5	95.9	182.9	436.8	712.9	683.3	630.8	634.0	183.5	46.9
MIN	0.0	0.0	0.0	0.0	1.9	43.4	69.7	109.1	24.2	13.4	0.0	0.0
Mean	11.5	22.4	20.8	26.4	52.3	183.5	274.8	284.4	227.8	173.2	40.3	3.6
SD	17.1	27.4	25.6	24.0	39.7	87.7	99.8	82.0	89.1	104.0	50.2	7.5
CV%	148.4	122.1	122.9	90.9	75.9	47.8	36.3	28.8	39.1	60.0	124.6	206.3

DEVGARH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	120.8	117.4	160.1	106.2	131.6	508.3	658.7	631.4	513.5	277.6	50.6	28.9
MIN	0.0	0.0	0.0	0.0	2.2	59.9	65.0	155.7	58.9	4.8	0.0	0.0
Mean	7.9	26.0	24.7	23.8	36.5	199.8	345.2	386.4	210.0	68.4	12.6	3.1
SD	14.2	27.9	30.9	23.2	26.4	92.3	99.7	100.5	76.2	45.9	14.3	5.8
CV%	180.5	107.3	124.8	97.3	72.5	46.2	28.9	26.0	36.3	67.2	113.6	184.6

DHENKANAL

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	123.3	146.4	159.5	125.1	191.6	497.8	761.9	609.1	413.9	454.9	124.7	48.4
MIN	0.0	0.0	0.0	0.1	1.6	52.2	51.5	112.5	42.2	10.7	0.0	0.0
Mean	9.8	26.6	25.2	33.4	55.9	197.2	289.3	301.7	211.3	129.9	28.1	2.0
SD	16.7	32.7	31.1	30.7	39.8	95.4	104.0	78.8	73.0	79.5	34.4	5.7
CV%	171.2	122.9	123.4	91.9	71.1	48.4	35.9	26.1	34.5	61.2	122.3	278.2

GAJPATI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	46.8	57.4	87.8	160.1	265.6	341.6	505.8	431.4	483.9	548.3	235.2	77.5
MIN	0.0	0.0	0.0	0.2	2.3	28.9	22.0	40.8	25.5	15.1	0.0	0.0
Mean	7.0	10.8	13.6	35.4	51.9	147.6	192.2	206.3	197.3	167.7	51.0	2.8
SD	9.9	13.5	20.8	38.8	42.8	63.1	84.3	73.7	81.5	110.6	55.2	8.2
CV%	140.7	125.5	152.7	109.6	82.5	42.8	43.9	35.7	41.3	65.9	108.2	293.9

GANJAM

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	66.8	86.3	97.2	124.0	145.1	294.8	503.5	410.8	401.7	772.0	268.8	87.6
MIN	0.0	0.0	0.0	0.3	3.1	41.8	37.2	67.7	39.7	14.9	0.0	0.0
Mean	10.1	16.9	15.3	29.7	44.3	152.7	212.2	222.1	202.7	169.3	50.3	3.9
SD	14.1	20.2	21.2	30.2	32.2	61.5	84.9	67.1	74.2	112.4	57.1	9.8
CV%	140.3	119.4	139.1	102.0	72.7	40.3	40.0	30.2	36.6	66.4	113.5	250.6

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JAGATSINGHPUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	69.1	99.4	88.5	50.8	173.7	444.1	507.7	433.6	520.9	409.7	198.3	59.4
MIN	0.0	0.2	0.2	0.2	2.0	45.0	118.2	133.3	24.6	7.9	0.4	0.0
Mean	11.8	19.4	18.8	14.7	47.4	188.4	267.4	280.5	228.4	184.3	46.1	5.8
SD	16.2	22.1	22.1	13.0	32.9	85.4	82.7	66.3	83.0	93.6	55.4	10.8
CV%	136.8	114.3	117.4	87.9	69.4	45.3	30.9	23.6	36.3	50.8	120.3	184.5

JHARSUGUDA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	41.6	74.6	126.3	296.5	80.7	419.3	689.0	803.7	670.4	193.5	48.3	44.8
MIN	0.0	0.0	0.0	0.0	0.3	11.9	147.6	217.8	69.2	0.0	0.0	0.0
Mean	7.6	18.7	20.9	19.9	18.7	183.7	397.6	451.5	221.2	50.4	5.4	3.7
SD	9.3	19.8	25.1	30.6	14.5	82.3	110.6	128.2	83.4	35.8	7.5	7.1
CV%	121.4	105.9	120.0	153.7	77.3	44.8	27.8	28.4	37.7	71.0	138.6	191.8

JAJPUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	102.7	126.2	156.6	122.2	217.8	479.2	559.0	506.9	570.0	646.6	129.9	40.6
MIN	0.0	0.0	0.0	0.3	2.7	58.7	70.1	132.5	57.6	12.1	0.0	0.0
Mean	10.6	26.1	26.9	35.1	69.2	204.9	303.6	316.5	242.9	152.2	28.6	4.0
SD	16.3	29.6	31.1	29.5	46.0	95.4	98.9	76.5	92.1	97.1	35.1	7.9
CV%	154.2	113.3	115.5	84.0	66.4	46.6	32.6	24.2	37.9	63.8	122.8	194.3

KENDRAPADA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	59.6	111.0	118.3	88.7	232.4	506.3	667.3	543.0	589.5	646.7	169.7	64.5
MIN	0.0	0.0	0.0	0.0	5.1	58.7	145.8	123.7	50.6	8.8	0.0	0.0
Mean	10.4	21.1	23.3	25.8	74.8	215.4	306.8	316.7	254.2	174.0	38.4	6.5
SD	14.4	24.4	27.3	22.6	49.0	97.2	94.9	76.3	90.3	106.7	47.4	11.9
CV%	138.6	115.8	117.1	87.9	65.5	45.1	30.9	24.1	35.5	61.4	123.4	183.6

KENDUJHAR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	89.8	159.0	174.4	129.0	191.9	570.8	537.7	545.6	631.6	381.9	66.6	41.0
MIN	0.0	0.0	0.0	0.4	1.7	57.5	63.5	160.4	80.8	6.9	0.0	0.0
Mean	10.1	34.0	29.0	38.7	66.5	218.0	288.4	332.8	220.2	99.6	16.5	2.4
SD	14.5	36.2	32.2	31.4	45.0	102.9	82.4	81.3	83.1	63.8	19.0	5.5
CV%	143.3	106.3	111.0	81.1	67.7	47.2	28.6	24.4	37.7	64.0	115.4	232.8

KHORDHA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	79.0	105.1	105.1	96.5	160.3	398.5	614.8	559.2	513.1	663.9	237.0	57.7
MIN	0.0	0.0	0.0	0.0	1.3	33.2	55.4	96.3	19.9	16.9	0.0	0.0
mean	11.7	20.9	16.8	25.4	45.7	166.7	240.2	247.9	216.6	196.4	51.8	4.1
SD	17.0	26.0	22.5	23.5	34.7	77.8	89.4	71.5	80.1	119.5	63.6	8.6
CV%	145.8	124.5	133.5	92.5	76.0	46.7	37.2	28.9	37.0	60.8	122.8	210.0

KALAHANDI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	51.8	62.7	82.4	236.3	189.8	505.9	881.1	786.2	503.0	270.8	87.3	49.7
MIN	0.0	0.0	0.0	0.0	0.5	50.7	126.8	132.2	63.1	3.3	0.0	0.0
Mean	7.3	10.8	13.7	40.0	50.8	212.6	348.7	357.4	234.3	82.9	17.0	4.0
SD	11.0	14.8	16.9	38.1	35.4	90.1	121.7	116.9	86.5	55.4	20.5	8.8
CV%	150.4	136.3	123.1	95.4	69.6	42.4	34.9	32.7	36.9	66.8	120.5	220.2

KANDHAMAL

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
MAX	96.8	80.6	121.0	164.2	175.6	454.4	878.9	1059.0	613.9	405.9	104.7	51.8
MIN	0.0	0.0	0.0	0.0	1.7	36.9	30.4	72.3	38.7	3.0	0.0	0.0
Mean	9.1	16.0	16.4	36.1	43.3	184.8	290.2	299.7	218.1	103.7	25.7	2.5
SD	14.4	19.6	23.5	38.7	33.0	72.9	127.1	118.6	90.9	72.5	27.3	7.1
CV%	158.0	122.5	143.4	107.1	76.1	39.5	43.8	39.6	41.7	69.9	105.8	279.7

KORAPUT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	41.0	53.1	110.6	263.2	226.2	847.3	783.8	972.8	680.7	345.9	178.7	53.2
MIN	0.0	0.0	0.0	0.5	0.0	16.2	104.7	77.7	61.6	8.8	0.0	0.0
Mean	5.7	8.6	12.3	50.5	57.7	179.0	294.7	304.0	228.9	126.8	41.6	5.2
SD	9.1	12.1	17.6	46.8	37.7	102.3	114.3	112.8	97.0	75.5	45.0	10.2
CV%	159.2	140.9	142.7	92.7	65.3	57.2	38.8	37.1	42.4	59.6	108.1	193.6

MALKANGIRI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	171.2	146.4	180.4	296.5	285.0	657.2	878.9	1059.0	670.4	772.0	268.8	278.2
MIN	0.0	0.0	0.0	0.0	0.0	11.9	27.8	22.8	19.9	0.0	0.0	0.0
Mean	47.6	54.2	61.5	60.7	70.9	169.5	239.6	246.9	193.7	176.2	67.1	54.5
SD	54.9	49.5	58.0	61.2	68.9	167.5	247.9	250.2	202.2	220.1	65.9	81.2
CV%	115.3	91.4	94.4	100.7	97.2	98.8	103.5	101.3	104.4	124.9	98.3	149.0

MAYURBHANJ

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	69.1	141.6	175.4	144.8	248.5	652.3	554.2	547.9	529.6	624.8	60.9	31.6
MIN	0.0	0.0	0.0	0.4	4.3	57.2	69.7	159.0	101.1	7.5	0.0	0.0
Mean	11.9	34.3	31.1	45.4	85.6	221.6	269.3	327.5	242.7	117.2	14.8	3.3
SD	14.4	33.6	32.6	34.8	52.2	99.7	84.3	79.5	78.5	81.4	16.7	6.2
CV%	120.5	97.9	104.6	76.5	61.0	45.0	31.3	24.3	32.4	69.5	113.2	185.2

NAYAGARH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	103.3	108.5	120.2	123.4	178.9	429.2	861.1	491.9	463.0	761.0	190.4	62.0
MIN	0.0	0.0	0.0	0.3	2.9	42.2	35.1	71.3	26.4	0.0	0.0	0.0
Mean	11.4	21.9	19.2	31.9	46.2	174.0	255.8	256.5	207.8	162.0	41.6	2.7
SD	17.4	26.3	25.3	31.0	35.8	80.2	113.6	76.8	76.9	106.7	49.5	7.5
CV%	152.7	119.9	131.4	97.2	77.4	46.1	44.4	29.9	37.0	65.9	119.0	276.0

NABRANGPUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	51.9	56.1	67.7	256.6	223.3	671.3	771.8	780.3	552.8	338.4	110.9	77.4
MIN	0.0	0.0	0.0	0.0	0.0	40.8	78.0	119.3	66.5	0.7	0.0	0.0
Mean	6.7	9.0	13.4	46.1	56.6	228.5	358.8	364.7	245.1	93.9	21.3	5.8
SD	11.2	12.9	14.9	38.7	34.8	108.3	124.6	123.3	103.9	70.6	26.9	13.4
CV%	167.1	144.5	111.4	83.9	61.5	47.4	34.7	33.8	42.4	75.1	126.0	233.3

NUAPADA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	77.0	54.5	78.0	174.9	155.7	418.9	746.8	714.6	503.6	225.4	50.7	46.7
MIN	0.0	0.0	0.0	0.0	0.0	38.9	85.4	122.3	67.0	0.0	0.0	0.0
Mean	7.7	9.5	14.2	29.1	31.3	201.1	361.1	353.4	225.4	61.1	8.6	3.7
SD	12.2	12.5	15.5	26.6	24.3	82.3	118.2	107.7	84.2	45.1	11.2	8.2
CV%	158.9	131.6	109.3	91.6	77.8	40.9	32.7	30.5	37.4	73.8	130.0	221.4

PURI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	66.3	85.2	78.1	87.6	164.8	400.5	639.4	822.5	401.4	586.2	209.1	77.9
MIN	0.0	0.0	0.0	0.0	1.3	40.2	99.0	107.8	30.0	4.0	0.0	0.0
Mean	9.8	16.3	13.9	20.9	47.9	168.7	236.7	242.9	202.0	163.1	48.8	6.8
SD	14.4	20.4	17.9	20.6	35.4	76.1	88.7	82.6	74.5	98.4	57.1	13.3
CV%	145.9	124.9	128.9	98.4	73.8	45.1	37.5	34.0	36.9	60.3	117.0	194.6

RAYAGARH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	47.2	43.6	97.2	236.7	204.6	397.2	750.2	592.7	474.2	275.4	134.7	44.9
MIN	0.0	0.0	0.0	0.4	0.7	48.9	90.6	100.3	32.0	3.7	0.0	0.0
Mean	6.9	8.9	14.1	48.5	56.6	177.0	295.4	305.4	216.8	109.9	30.2	2.4
SD	10.3	11.2	20.4	51.3	39.4	70.8	119.5	100.2	80.6	68.2	32.4	5.6
CV%	150.0	125.2	143.9	105.6	69.7	40.0	40.5	32.8	37.2	62.0	107.5	230.8

SAMBALPUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	94.3	95.5	141.1	108.5	100.3	437.1	733.7	739.5	674.8	248.1	46.9	50.4
MIN	0.0	0.0	0.0	0.0	0.0	53.3	73.1	188.7	65.3	2.9	0.0	0.0
Mean	8.0	21.7	22.1	22.2	25.5	191.6	375.5	414.0	210.4	57.3	8.6	3.4
SD	12.1	22.8	28.3	22.6	19.0	81.8	113.0	121.9	82.2	40.1	9.6	6.8
CV%	150.8	105.1	127.6	101.9	74.8	42.7	30.1	29.5	39.0	69.9	110.7	198.3

SUNDARGARH

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	52.7	92.2	136.3	86.7	258.2	481.2	649.9	723.6	599.9	209.9	59.9	42.7
MIN	0.0	0.0	0.0	0.1	1.8	62.3	112.8	219.2	89.7	3.6	0.0	0.0
Mean	8.9	23.5	22.5	18.6	28.0	190.5	379.0	449.9	220.2	57.1	7.1	3.3
SD	10.7	23.5	26.6	17.6	29.4	87.3	101.9	120.2	76.2	39.5	9.0	6.4
CV%	119.4	100.1	118.6	94.6	104.9	45.8	26.9	26.7	34.6	69.2	127.7	194.3

SONPUR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAX	82.7	88.3	116.4	139.7	110.9	502.7	1023.3	1224.3	439.3	217.0	49.1	25.3
MIN	0.0	0.0	0.0	0.0	0.0	53.2	97.4	162.0	53.1	1.3	0.0	0.0
Mean	7.9	18.8	17.8	26.3	27.7	189.9	345.6	347.5	201.4	60.8	11.1	2.4
SD	12.1	21.6	23.8	28.0	20.9	81.2	128.6	128.1	69.3	41.1	12.5	4.3
CV%	151.7	115.1	133.8	106.6	75.6	42.7	37.2	36.9	34.4	67.5	113.4	184.4

INVERSE DISTANCE WEIGHTED (IDW)

A deterministic interpolation method- IDW is used for this study to determine the rainfall at unknown point of location.In spite of the fact that the exactness of this procedure for discovering the obscure point isn't acceptable, yet this procedure can demonstrate the rainfall pattern in the entire Odisha.

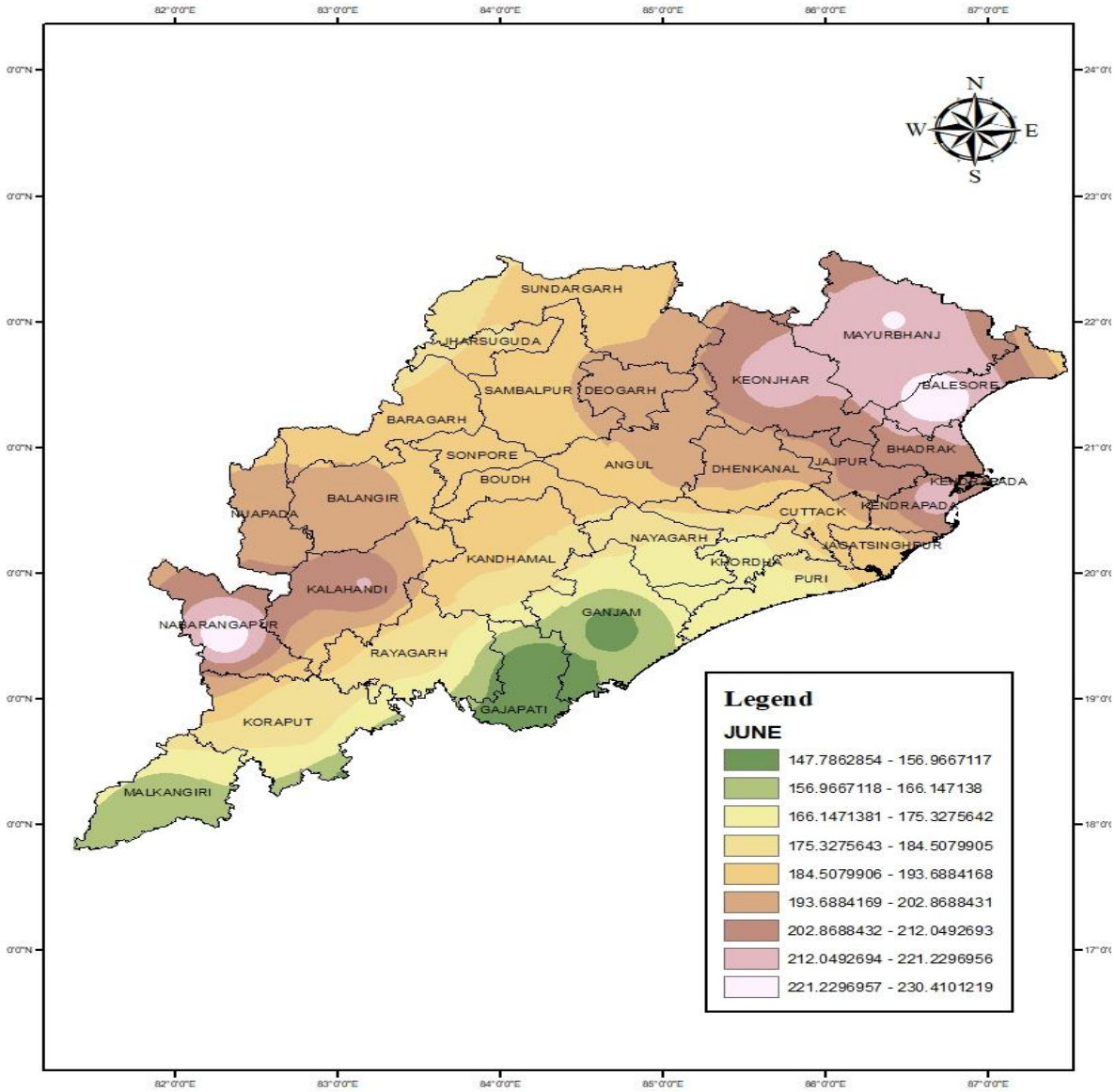

Fig. Rainfall in the month of June by IDW method

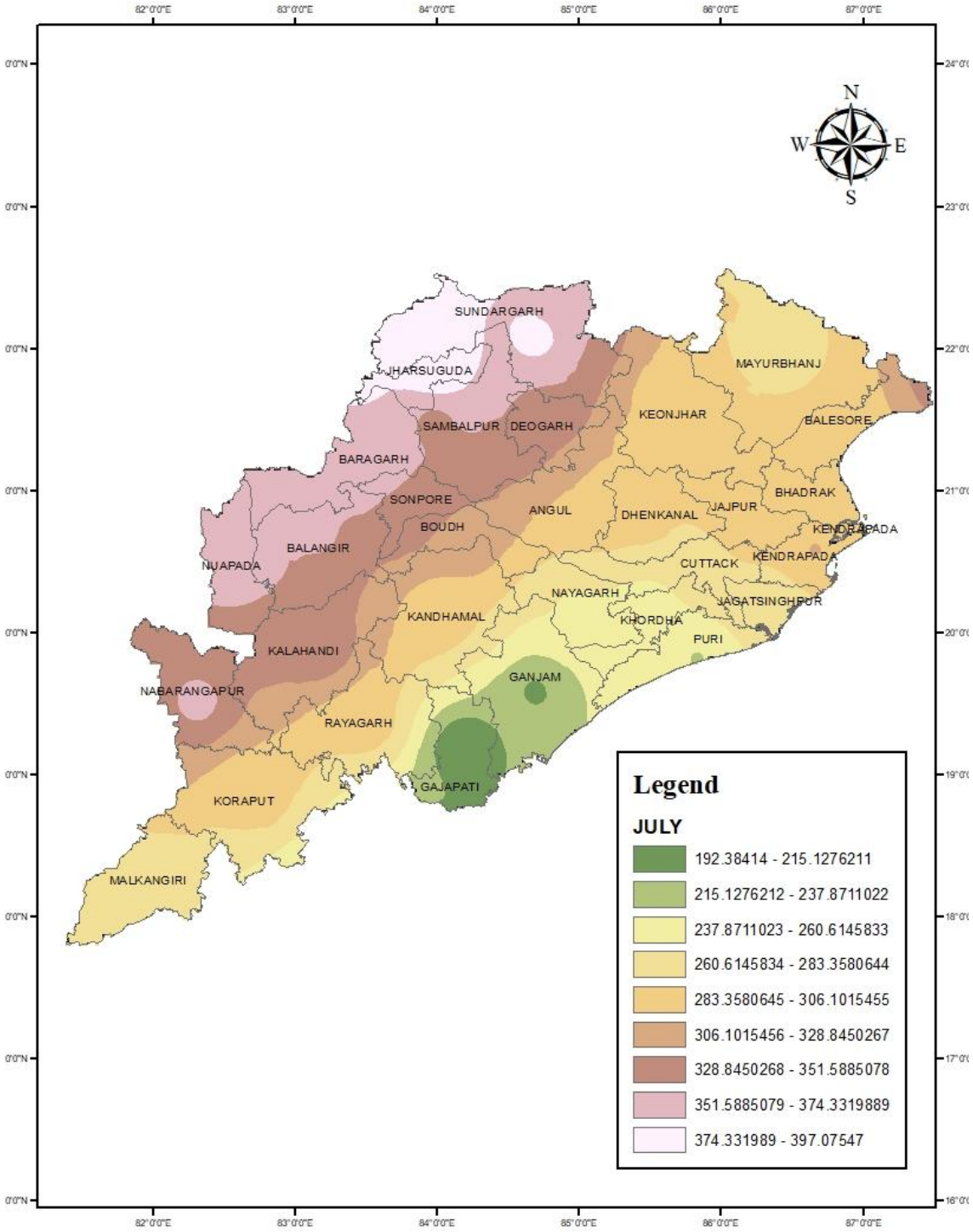

Fig. Rainfall in the month of July by IDW method

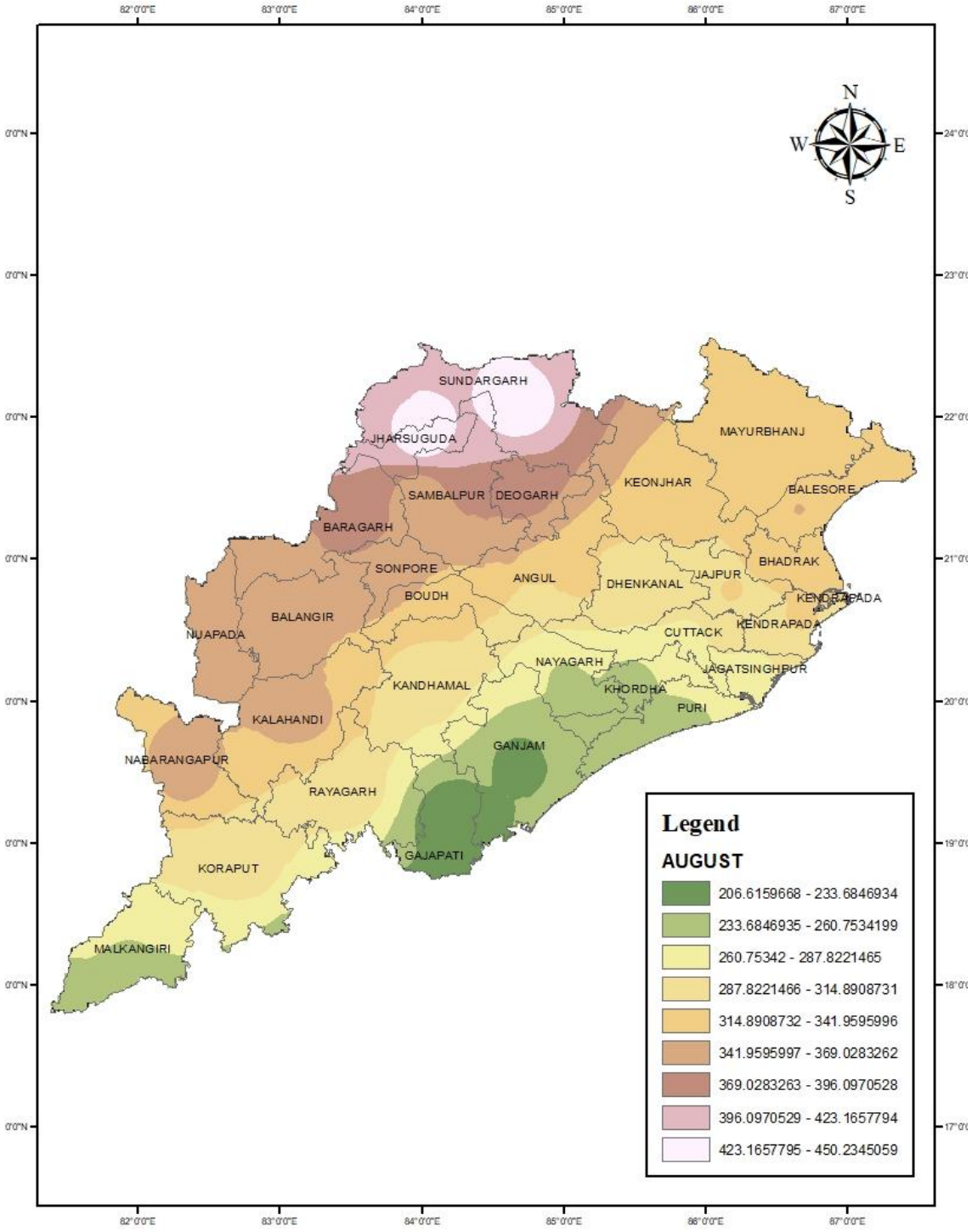

Fig. Rainfall in the month of August by IDW method

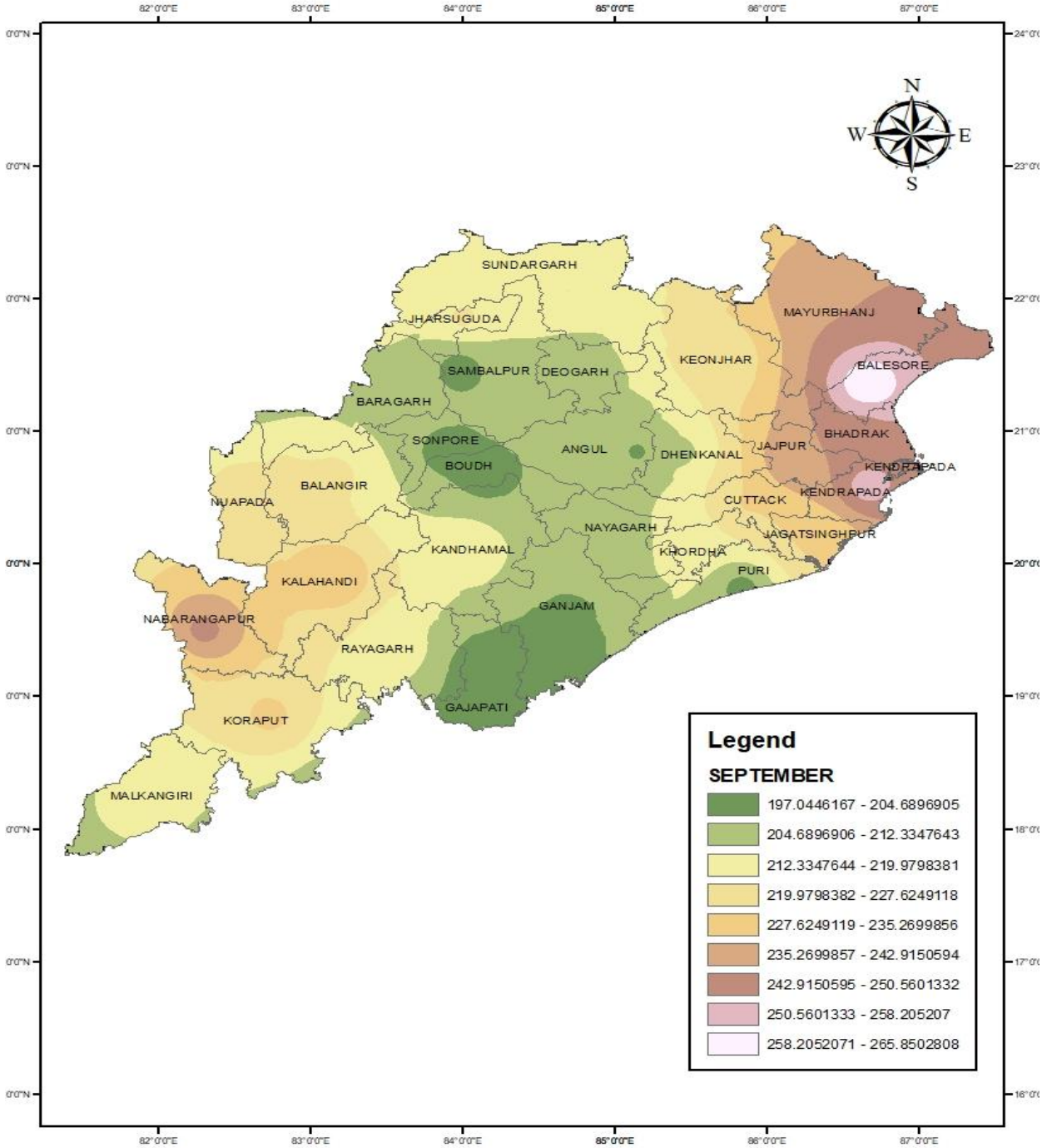

Fig. Rainfall in the month of September by IDW method

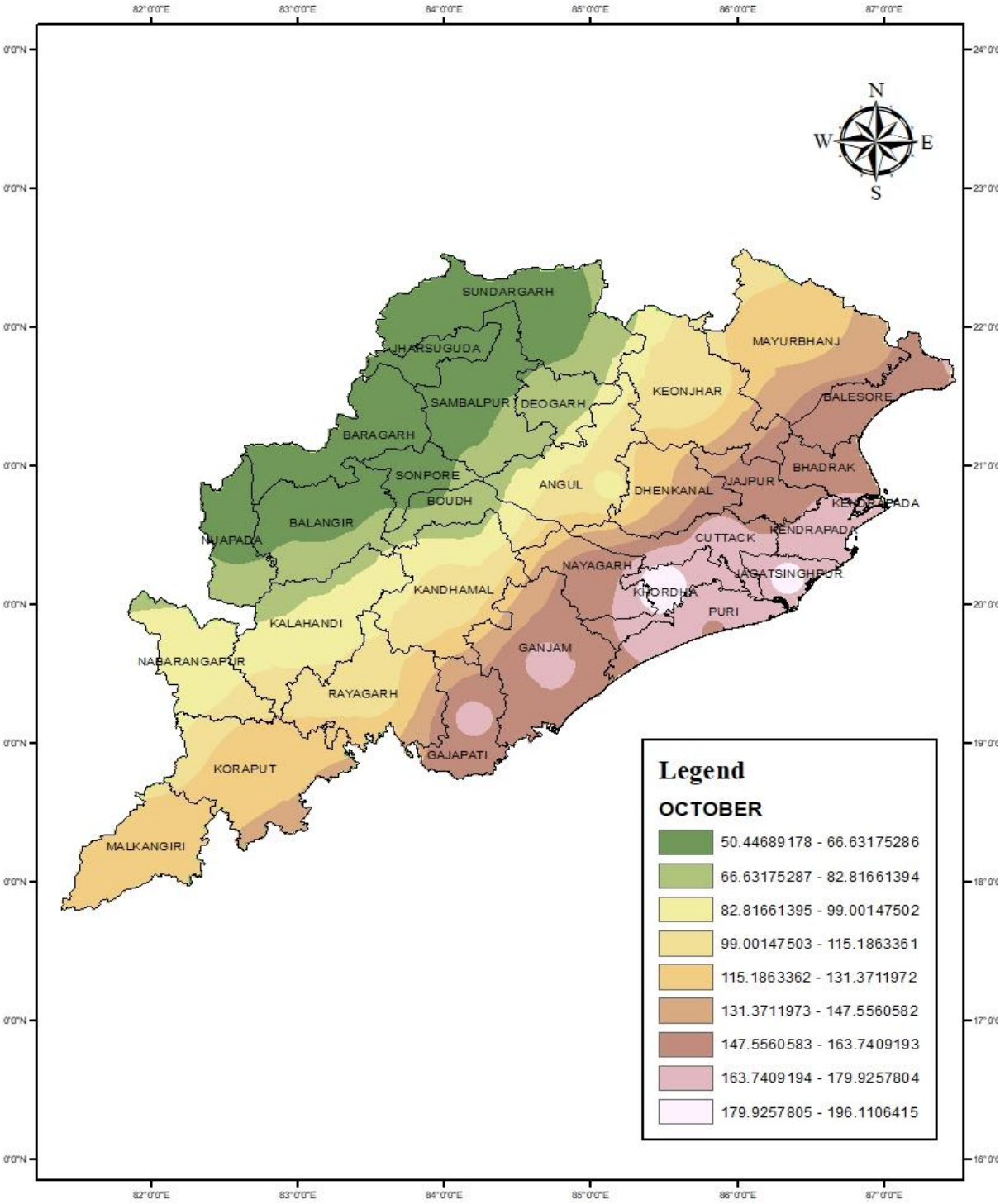

Fig. Rainfall in the month of October by IDW method

The above figure shows that, the amount of rainfall is more in western Odisha during month of July and gradually decreases towards end of monsoon. The IDW map shows the rate of rainfall is high in coastal areas during post-monsoon. This effect is due to the cyclonic effects on Odisha in October month. This anomaly affects the Kharif crops in coastal area. There passive adaptation may require to overcoming this loss of farmers.

VI. CONCLUSIONS

India totally lies north of Equator, so it is in the northern hemisphere. The geographical location of Odisha is responsible for receiving maximum rainfall during monsoon period. The statistics like annual mean, minimum, maximum, standard deviation, coefficient of variation (C_v) for district wise monthly rainfall data of 117 years are calculated. These parameters help in explaining the characteristics of rainfall. Adaption for horticulture is impulse to have a decent reap. The future scenarios of precipitation for the state would help for passive adaptation to climate change. The anomaly of rainfall pattern is directly affecting the runoff of the reservoir. The concluding remarks are summarized below.

- The statistical analysis shows the total average rainfall over Odisha is 1415mm with standard deviation of 634.07mm and coefficient of variation (C_v) 11.16%.
- In recent three decades (1988-2017) the amount of rainfall is gradually increasing as compared to past decades.
- The IDW maps give the view over rainfall pattern throughout the monsoon period of the state. It is shown that amount of rainfall is less during monsoon in coastal area, which indicates that water consumption will be more for the irrigation. Extreme rainfall may harm the Kharif crops during harvesting period. The farmers of coastal area may need adaptation for better harvest.

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