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Rainfall and temperature characterisation of eastern Ghat highland zone of Odisha for potential cultivation of off-season vegetables

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Abstract
The information on rainfall and temperature characterisation of a region is a significant tool in crop planning. In this study block wise rainfall and temperature data of 21years (2000-2020) of Eastern Ghat Highland Zone(EGHZ) covering Koraput & Nawarangpur districts of Odisha was used to characterize the agro climatology of this zone as well as delineating areas for potential off-season vegetable cultivation. The rainfall and temperature was analyzed using Weather Cock and TREND software. This study found that Mean annual rainfall of Eastern Ghat Highland Zone is 1597mm, with an average of 70 rainy days. CV of annual rainfall of different blocks varies between 17-50%. This zone receives 82% (Koraput) & 85% (Nawarangpur) of mean annual rainfall during SW monsoon. It was also observed that annual rainfall as well as south west monsoon rainfall in some of the blocks showing increasing whereas in some blocks decreasing trend. At 75% probability this zone received 1312 mm rainfall, which is a good amount of rainfall for crop production. The probability of consecutive wet for two weeks varied from 70% to 95% during SWM. Monsoon starts effectively from 22nd week (9th June to 15th June) in (EGHZ) and remain active up to 41st week (9th October to 13th October). LGP of the zone is ranging between 171-205 days in different blocks. Temperature analysis revealed that the mean annual maximum temperature of this zone was 31.4 ºC and minimum temperature was 17.9 °C. Number of extreme hot days (≥40 ºC) was highest (54days) in 2003 in Nawarangpur. In case of occurrence of cold days (≤10 ºC), it was highest (25 days) in 2004 in Koraput. Farming situation I of Koraput district which includes Narayanpatna, Pottangi, Semiliguda, Laxmipur, Bandhugaon, Dasmanthpur, Lamtaput, Koraput and Nandapur were identified for off season vegetables like cole crops, kharif potato, beans etc cultivation. Therefore, using the above information obtained in the study, an attempt was made to prepare suitable vegetable based crop planning block level considering the soil characteristics, rainfall and temperature characteristics, yield economics and using efficient cropping zone concept.

Keywords: EGHZ, rainfall and temperature trends, off-season, LGP

Introduction
Climate is a critical component of the overall environment in which organisms grow, and it has a significant impact on them. Different temperature regimes influence the geographic and agronomic distribution of plants, as well as the rate at which crops develop. Changes in temperature and rainfall have been reported in India, making it one of the worst affected countries (IPCC 2014). Climate characterisation aids in the description and analysis of the characteristics of site and region that are relevant to agriculture potential and output and to the nature of agricultural systems in region. The territory of Odisha may be divided into four distinct geographical regions-the Eastern Plateau, the Central River Basin, the Eastern Hill Region and the Coastal Region Belt. The two major agro climatic zones of Odisha are coastal and highlands which are further divided into 10 agro-climatic zones. This region is largely made up of the Eastern Ghats hills and mountains, which rise abruptly and steeply in the east and gently slope to a dissected plateau in the west, stretching from northeast (Mayurbhanj) to north-west (Malkangiri). The climate of the majority of the district, which is located on a plateau to the west of the Eastern Ghats, is more similar to that of the Deccan than that of the east-coast region. Because of the diverse agro climatic conditions available in different altitudes of the Eastern Ghat Highland Zone, experiences low temperature during rainy season favourable for vegetables production and can be marketed to other areas as off-season vegetables fetching higher price where those vegetables can't be grown during that period. In light of these considerations, the current research aims to provide baseline information on the rainfall and temperature characterisation of Eastern Ghat Highland Zone of Odisha for

potential cultivation of off-season vegetables through analysis of historical weather data. The thermal and rainfall characteristics of this Zone has been studied for the suitability of off- season vegetable cultivation.

Materials and Methods

The Eastern Ghat Highland Zone (EGHZ) is the sixth agro-climatic Zone of Odisha. The Zone comprises two revenue districts i.e. Koraput and Nawarangpur. It is situated between 21° 33'N and 20°10'N, and 81°50' E and 83°20' E and is bounded by Chhattisgarh in North-West and Andhra Pradesh in South East side’s (Fig 1). The Zone covers an area of 9.55 lakh hectares which is 6.15% of the total area of the State. The net cultivated area in the Zone constitutes 41.83% and gross cropped area constitutes 53.86% of the total area of the Zone. Koraput district has two subdivisions (Koraput and Jeypore) with 14 blocks. At present Nawarangpur District comprises one sub division (Nawarangpur), 10 blocks. In this study, software namely, ‘Weather Cock’ was used for weather data analysis. For this study annual, seasonal, monthly and weekly rainfall values were determined using daily data sets for 21 years period (2000-2021). Daily rainfall data at the block level was collected from the Government of Odisha's Special Relief Commissioner (SRC). The software “NASAPOWER” and KVK were used to collect daily temperature data (minimum and maximum temperature).

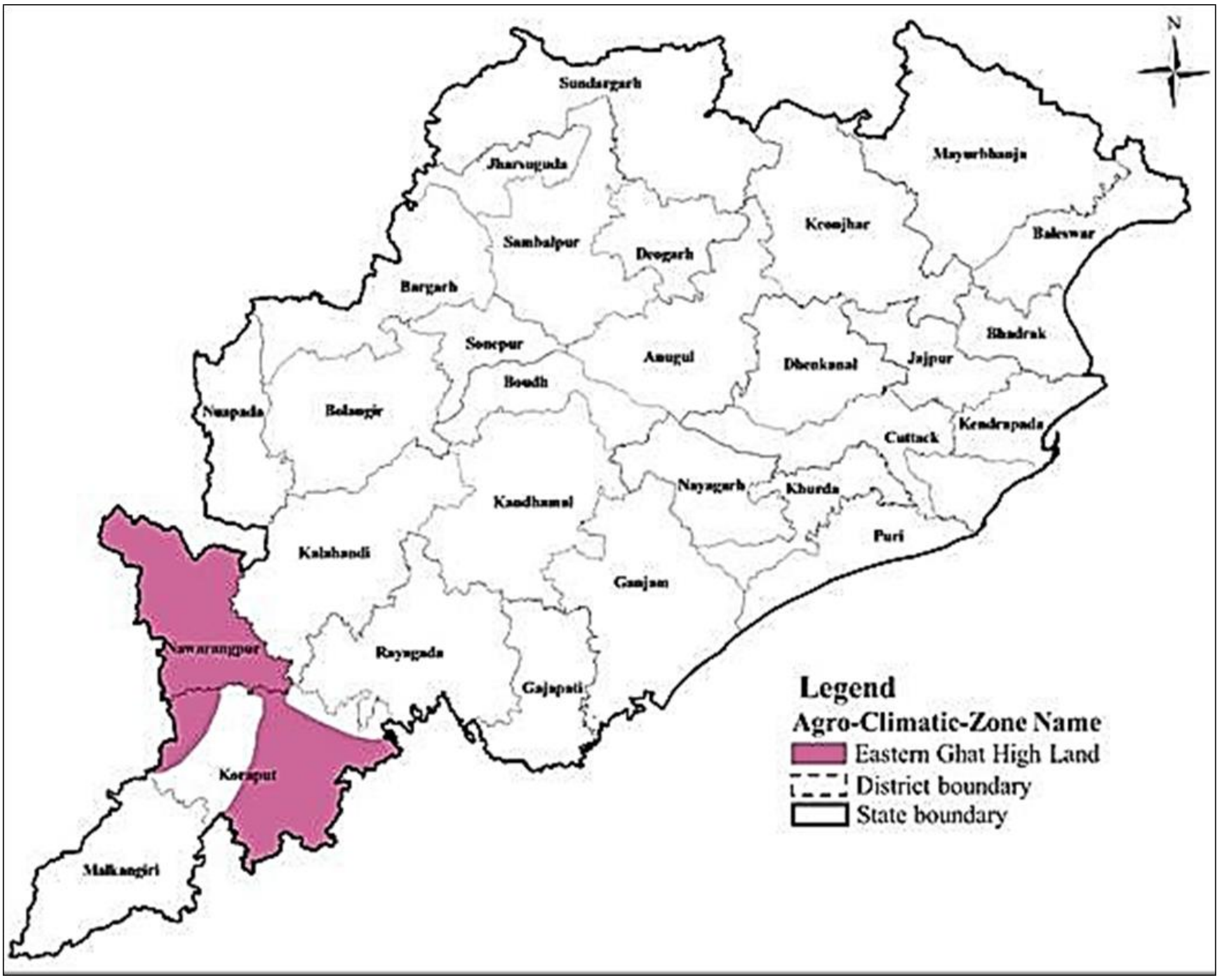

Fig 1: Study area

Rainfall characteristics

Block wise rainfall data of 21-year period was used to determine mean annual, seasonal, monthly, and daily rainfall variability. The data was collected from the Special Relief Commissioner (SRC) of Odisha and processed using Weather cock. The rainfall data was analysed with the “Rainy Day.exe” module.

Standard statistical measures of rainfall variability include the standard deviation (SD) and coefficient of variation (CV). The coefficient of variation (in percentages) is a measure of rainfall dependability. For yearly, seasonal, monthly and weekly rainfall, the threshold amounts for CV are 25 percent, 50 percent, 100 percent, and 150 percent, respectively.

Annual rainfall and rainy days

The "Rainy day.exe" module was used to calculate the mean annual rainfall and rainy days of each block in Koraput and Nawarangpur districts over a 21-year period. Statistical equations were used to compute the standard deviation (SD) and the coefficient of variance (CV). A day with rainfall amount equal or more than 2.5 mm was considered as a rainy day according to India Meteorological Department for Indian region.

Monthly rainfall and rainy days

The same software that was used in seasonal and yearly rainfall analysis was utilised to determine mean monthly rainfall and wet days for each block. Statistical formulae were used to obtain the standard deviation and coefficient of variance for each month.

Seasonal rainfall and rainy days

On the basis of the percentage of contribution to the annual rainfall, Odisha experiences four distinct periods of rainfall namely the Southwest monsoon rainfall season with strong south west wind (June-September), the post-monsoon with dominant northeast wind during October and November (Northeast monsoon), the winter season (December-February) and the summer season (March-May). SD and CV were also computed for four seasons. Seasonal rainy days and rainfall analysis for each block were also done by the same module which was used for annual rainfall and rainy days analysis.

Trend analysis of annual rainfall

TREND, software programme, was used to calculate trend of rainfall and temperature. It conducted a trend analysis using the Mann-Kendall test. TREND includes 12 statistical tests for detecting trends, changes, and unpredictability in hydrological and other time series data. One of the 12 tests is the Mann-Kendall test. Trend of annual rainfall as well as of SWM season has been evaluated block wise. Annual and SWM season rainfall data of 21 years (2000-2020) for each block were computed and put in 'Trend calculator'. The output of trend analysis is obtained in the form of critical values of test statistics at significance levels of $\alpha = 0.01$, $\alpha = 0.05$ and $\alpha = 0.1$.It indicates 99%, 95% and 90% significance respectively. Trend was also observed by plotting graph of annual and as well as of SWM season rainfall against year for each block.

Analysis of annual rainfall probability

The module "Incomplete Gamma Probability.exe" was used to determine annual rainfall probabilities for both districts. Block wise weekly rainfall data is used as an input to calculate block wise annual rainfall probabilities at levels of 90%, 75% and 50%.

Markov chain probability model for dry and wet spell analysis

In this study, weekly rainfall values have been computed from daily data series and were used for estimation of initial, conditional probabilities and consecutive dry and wet spell analysis based on "Markov chain probability model" as described by (Pandarinath 1991). In this method, 20 mm or more rainfall in a week is considered as wet week otherwise dry as the previous researchers (Pandarinath, 1991; Dash and Senapati, 1992) also used 20 mm as the threshold value.

Initial probability

It is the probability of getting certain amount of rainfall in a given week

P (D) = F (D)/N

P (W) = F (W)/N

Conditional probabilities

It is the probability of getting wet or dry week provided the current week is wet or dry.

P (DD) = F (DD)/F (D).

P (WW) = F (WW)/F (W).

P (WD) = 1-P (DD).

P (DW) = 1-P (WW).

P (D) = Probability of the week being dry.

F (D) = Frequency of dry weeks.

P (W) = Probability of the week being wet.

F (W) = Frequency of wet weeks.

N = Total number of years of data being used.

P(DD) = Probability of a week being dry preceded by another dry week.

F(DD) = Frequency of dry week preceded by another dry week.

P(WW) = Probability of a week being wet preceded by another wet week.

F(WW) = frequency of a wet week preceded by another wet week.

P(WD) = probability of a wet week preceded by a dry week.

P(DW) = probability of a dry week preceded by a wet week.

Thresholds of rainfall for crop planning initial and conditional probabilities

For the purpose of agricultural planning, we have applied Markov Chain model by choosing 10, 20, 40 and 80mm/week as threshold limits. These threshold levels were considered as adequate for the crop activities such as land preparation (10mm), crop planting or sowing (20mm) and application of fertilizer and/or weeding (40mm) (Reddy, 1993). According to Reddy, if a given week 'i' of a given year received more than 20mm/week at more than 50% (W/W) threshold level, then week 'i' is the right time for planting. If weeding/fertilizer application is to be carried out in week 'i' then the week should have at least 75% (W/W) probability at 40mm/week. If the interest is when we should not apply fertilizer/pesticides, then one can use the probability estimate at 0mm/week. If fertilizer and/or insecticides/pesticides are applied on week 'i' then should not exceed 25% probability level at 80mm/week.

Thermal characteristics Mean monthly temperature

Using the software "Weather Cock," annual, seasonal and monthly typical temperatures (Tmax and Tmin) were computed. The input data file contained daily Tmax and Tmin values for the years 2000 to 2020. To calculate seasonal and monthly normal temperatures, Weather Cock's "Normal.exe" module is utilized. The difference between the year's highest and lowest temperature is used to calculate the annual pattern of air temperature.

Extreme temperature frequency

Extreme temperature frequency was calculated by using daily Tmax and Tmin data separately. Extreme temperatures were taken as ≥400C and ≤100C for Tmax and Tmin respectively. Temperature frequency was computed to identify the trend of temperature over the past 21 years (2000-2020). The modules namely, "Maximum Temperature. Exe" and "Minimum Temperature. Exe" were used to compute the extreme temperatures frequency.

Length of growing period

The length of the growth season (LGP) is defined as the time when the moisture in the root zone of crop plants is sufficient to meet the plant's water requirements, as well as the number of days in a year when rainfall plus moisture stored in the soil exceeds half of potential Evapo-transpiration.

LGP = Duration of rainy season in days + [(Post monsoon rainfall, mm + AWHC, mm)/Average evaporative demand of atmosphere]

Average evaporative demand of the atmosphere from agricultural field was assumed to be 3.7mm/day during post monsoon and winter season. As per soil characteristics, the available water holding capacity (AWHC) per meter depth was assumed as 100 mm, 120mm and 150mm.

Results and Discussion

Rainfall characteristics and rainfall variability Annual rainfall and rainy days

The average annual rainfall of Eastern Ghat Highland Zone was 1597 mm. Out of 2 district highest rainfall was received in Nawarangpur district i.e.1656 mm. Variability of the annual rainfall was 17% to 50%. Average annual rainy days of this Zone is 70days (Fig 2). Average annual rainfall of Nawarangpur district 1656mm. variability of district annual rainfall varies from 17-33%. Rainfall of Koraput district 1538 mm. Variability of district annual Rainfall varies 18-50%.

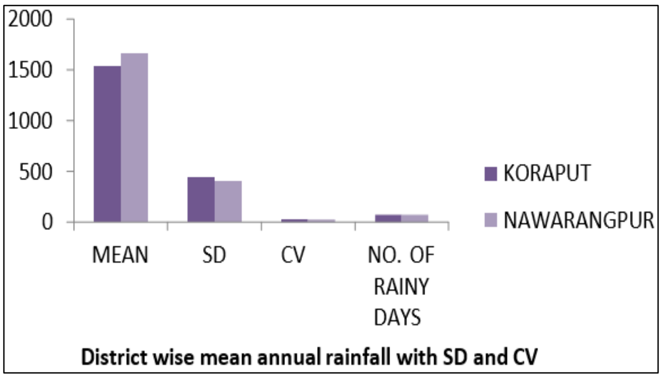

Fig 2: District wise mean annual rainfall with SD and CV

Monthly rainfall

August month received the highest rainfall in both Koraput and Nawarangpur district (407 mm and 461 mm respectively) followed by July month (354 mm and 421 mm respectively). The lowest rainfall received in January and February (3mm and 7mm) in both Koraput and Nawarangpur district followed by December month (8mm) (Fig 3 & Fig 4).

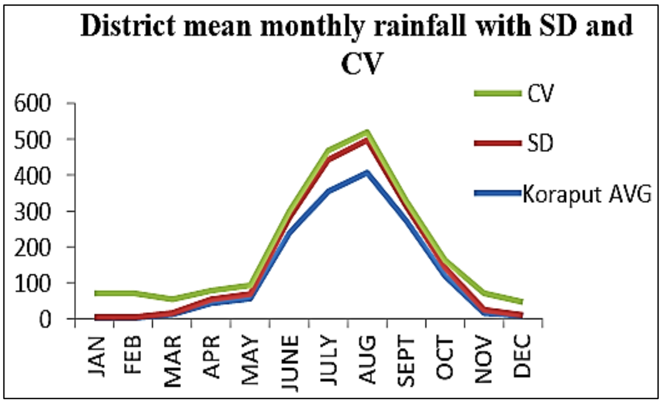

Fig 3: Mean monthly rainfall with SD and CV of Koraput

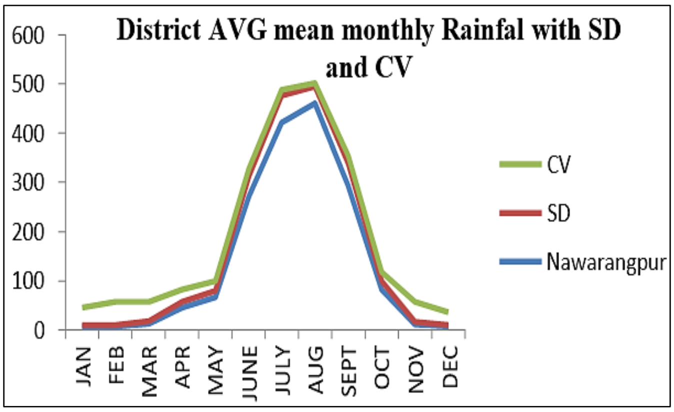

Fig 4: Mean monthly rainfall with SD and CV of Nawarangpur

Seasonal rainfall and rainy days

Seasonal analysis of rainfall was done for four seasons: SW monsoon (June to September), post-monsoon (October to November), winter (December to February) and summer (March to May). The Southwest (SW) monsoon rainfall is the major period of rainfall for Eastern Ghat Highland Zone accounting for nearly 84% of the annual rainfall. The average SWM rainfall of this Zone was 1360mm. Normal rainfall of Koraput and Nabarangpur district during SW monsoon was 1274 mm and 1445mm, which is about 82.4% and 85.6% of the normal annual rainfall respectively (Fig 5).

Post-monsoon

Post monsoon rainfall of Koraput district was 145.7mm which was nearly 10% of total annual rainfall. The variability of post-monsoon rainfall in the district was 74%. Number of rainy days in the district was 7. Post monsoon rainfall of Nawarangpur district was 104mm which was 6% of total annual rainfall. The variability of post-monsoon rainfall in the district was (90%). Number of rainy days in the district was 5 (Fig 5).

Winter

The winter rainfall contributes lowest amount of rainfall less than 1% for both the district Koraput and Nawarangpur (0.35 and 0.85%) respectively towards the normal annual rainfall of the Zone and the average winter rainfall in this Zone was 10mm. Nawarangpur district received maximum nearly (14 mm) winter rainfall followed by Koraput district (6mm). Winter rainfall was highly variable in Koraput district (219%) and variability accounted up to 160% in Nawarangpur district. Average number of rainy days of both the district in winter was nearly 1 (Fig 5).

Summer

The average summer rainfall in this Zone was 118 mm i.e. for Koraput district (112mm) & for Nawarangpur dist. (125mm) which is 7% of total annual rainfall of both the district. Variability of summer rainfall is 78% & 55% for Koraput and Nawarangpur respectively. Mean summer rainy days of the Zone 8 days. For Koraput district it was 7 days and 8days for Nawarangpur district (Fig 5).

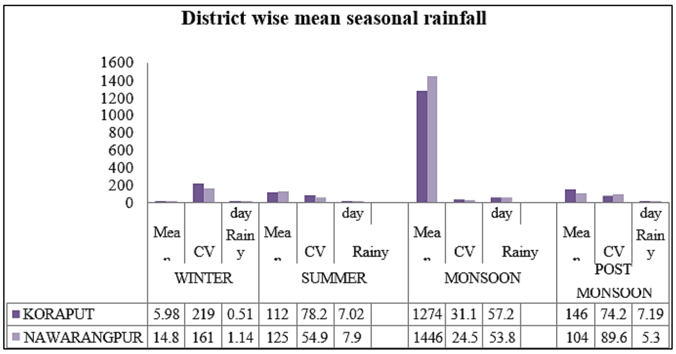

Fig 5: Mean seasonal rainfall of Koraput and Nabarangapur

Trend of rainfall variability over year's Annual rainfall variability

Block level rainfall data of 21 years (2000-2020) of Koraput and Nawarangpur districts were subjected to Mann-Kendall test for detecting trend in annual rainfall at three different significance level i.e.90%, 95% and 99%. In Koraput, out of fourteen blocks, Boipariguda, Borigumma, Kotpad, Kundra, Lamtaput and Semiliguda showed an increasing trend at 90% & 99% significance level. Pottangi and Dasmanthpur showed decreasing trend but wasn't significant (Table 1). In Nawarangpur, out of ten blocks, Nandahandi showed an increasing trend at 90% significance level. Umerkote, Raighar, Chandahandi and Jharigaon showed decreasing trend but not of significant level (Table 2).

Table 1: Annual rainfall trend of Koraput using Mann Kendall Test

Mann-Kendall test						
Sl. No.	Block Name	Test statistic	Critical values			Result
			a=0.1	a=0.05	a=0.01	
1.	Bandhugaon	2.265	1.645	1.96	2.576	S (0.05)
2.	Boipariguda	1.419	1.645	1.96	2.576	NS
3.	Borigumma	1.54	1.645	1.96	2.576	NS
4.	Dasmanthpur	0.332	1.645	1.96	2.576	NS
5.	Jeypore	0.876	1.645	1.96	2.576	NS
6.	Koraput	0.513	1.645	1.96	2.576	NS
7.	Kotpad	3.835	1.645	1.96	2.576	S (0.01)
8.	Kundra	1.661	1.645	1.96	2.576	S (0.1)
9.	Lamtaput	3.352	1.645	1.96	2.576	S (0.01)
10.	Laxmipur	0.996	1.645	1.96	2.576	NS
11.	Nandapur	0.936	1.645	1.96	2.576	NS
12.	Narayanpatna	1.298	1.645	1.96	2.576	NS
13.	Pottangi	-0.513	1.645	1.96	2.576	NS
14.	Semiliguda	3.654	1.645	1.96	2.576	S (0.01)

Table 2: Annual rainfall trend of Nawarangpur using Mann Kendall test

Mann-Kendall test						
Sl. No.	Block name	Test statistic	Critical values			Result
			a=0.1	a=0.05	a=0.01	
1.	Chandahandi	-1.419	1.645	1.96	2.576	NS
2.	Dabugaon	0.574	1.645	1.96	2.576	NS
3.	Jharigaon	-0.332	1.645	1.96	2.576	NS
4.	Kosagumuda	0.272	1.645	1.96	2.576	NS
5.	Nandahandi	1.782	1.645	1.96	2.576	S (0.1)
6.	Nawarangpur	0.125	1.645	1.96	2.576	NS
7.	Papadahandi	1.238	1.645	1.96	2.576	NS
8.	Raighar	-1.117	1.645	1.96	2.576	NS
9.	Tentulikhunti	1.359	1.645	1.96	2.576	NS
10.	Umerkote	-0.393	1.645	1.96	2.576	NS

Initial and Conditional probability using markov chain model

The long-term frequency behavior of wet and dry episodes was studied using a Markov chain model. In a Markov chain, the likelihood of an event occurring on any given week is determined only by the conditions of the preceding weeks and is unaffected by the events of subsequent weeks. The week was taken into account in this analysis. Initial probabilities of dry weeks occurring during various stages of crop growth, as well as conditional probabilities (considering sequential events), provide the basic information on rainfall distribution characteristics required for agricultural operations such as irrigation scheduling, transplantation timing, and so on. In Koraput district the initial probability of occurrence of wet spell was <10% during 1-13 SMW, 23-28% during 14-22 SMW, >70% during 25-38 SMW and then afterwards suddenly decreased <40% during 43-52 SMW. On the contrary, the initial probability of occurrence of dry spell was found to be very high (>90%) during 1-20 SMW and 41-52 SMW, whereas from 21-40 SMW it is relatively very less The conditional probability of a wet spell followed by another wet spell, P (w/w) was very high (>70%) during 23-40 SMW (Table 3). However, the conditional probability of wet spell followed by a dry spell was least during this period and that of a dry week followed by wet week is very high during 5, 9, 11-18, 39-47, 50-52 SMW. On the contrary, probability of getting two dry spells one after another is high in most of the weeks except during 24-39 SMW when probability is less than 50%. In Nawarangpur district the initial probability of occurrence of wet spell was <10% during 1-13 SMW and 44-52 SMW in the district and 23-38% during 14-22 SMW, >60-90% during 23-38 SMW (South-west monsoon) and then afterwards suddenly decreased to less than 40% during SMW 43-52. On the contrary, the initial probability of occurrence of dry spell was found to be very high (>80%) during 1-20 and 44-52 SMW, whereas from 2-39 SMW it is relatively very less. The conditional probability of a wet spell followed by another wet spell, P (w/w) was >70% during 23-38 SMW. The conditional probability of dry spell followed by wet spell was >70% during 1-11, 16-22 and 45-47 SMW. On the contrary, probability of getting two dry spells one after another is high in most of the weeks except during 27-39 SMW when probability is less than 50%.

Temperature analysis

Temperature data used for this Zone was taken from software called "NASAPOWER" for Koraput and Nawarangpur district. Mean monthly temperature along with extreme temperature were computed and accordingly the observations were made.

Mean monthly temperature

The climate of Koraput and Nawarangpur district which is in the North -Eastern corner of the Deccan plateau is in many respects similar to that of main Deccan plateau, but due to elevation and its location, the climate is milder than that of the main Deccan plateau. Mean monthly maximum temperature of Eastern Ghat Highland Zone was 31.4 ºC and minimum temperature was 17.4 ˚C. Hottest month in the Zone is May reaching as high as (40.2 ˚C) in Nawarangpur followed by April (38.6 ˚C). Mean monthly maximum temperature of the Zone varied from 28-30 ºC during monsoon and post-monsoon whereas, it was nearer to 27 ºC during winter season

(Table 3). Thereafter temperatures decrease with the onset of the monsoon. During the monsoon, weather is cool and pleasant with day temperatures nearly the same as those in the cold season. Spatial distribution of temperature varies widely. On the 2,000 feet plateau the maximum in summer may go up to 42 ˚C degree although the temperature at Koraput may not be over 39.6 ˚C. December is the coldest part of the year with the mean daily minimum temperature at 11.2 ˚C. Both day and night temperatures progressively increase after January till May which is the hottest month.

Table 3: Mean monthly maximum and minimum temperatures (°C)

Koraput			Nawarangpur		
Month	**Tmax(°C)**	**Tmin(°C)**	**Month**	**Tmax(°C)**	**Tmin(°C)**
January	27.4	12.5	January	27.1	12.4
February	30.7	12.6	February	31.4	15.5
March	32.6	16.3	March	35.8	19.7
April	32.7	19.0	April	38.6	23.3
May	35.2	21.0	May	40.2	25.3
June	31.7	20.8	June	39.6	24.0
July	28.5	19.7	July	31.7	22.5
August	27.9	19.6	August	30.6	22.3
September	28.3	19.1	September	30.9	21.9
October	28.5	17.5	October	31.3	19.3
November	27.5	13.7	November	30.8	15.1
December	27.3	10.1	December	28.2	12.2
Mean	29.8	16.4	Mean	33.0	19.4

Extreme temperature frequency

Table 4 presents the number of days with Tmax above 40 ºC and Tmin below 10 ºC and the highest & lowest temperature recorded during respective years (2000-2020). In Koraput district Extreme temperature frequency of hot days (≥40 ºC) varied from 3 days (2014) to 44 days (2003) and frequency of cold days (≤10 ºC) varied between 6 days in 2009 to 25days in 2004. The district experienced increased no. of hotter days in the first five years and last five years of the study period. In Nawarangpur district extreme temperature frequency (≥40 ºC) varied from 2 days (2018) to 54 days (2003) and frequency of cold days (≤10 ºC) varied between 2 days in 2009 to 20 days in 2004.

Table 4: Extreme temperature frequency (days)

Year	**Koraput**		**Nawarangpur**	
	Hot days (≥40 ºC)	**Cold Days (≤10 ºC)**	**Hot days (≥40 ºC)**	**Cold Days (≤10 ºC)**
2000	23	11	26	16
2001	13	11	15	10
2002	38	6	36	5
2003	44	17	54	11
2004	23	25	21	20
2005	18	26	19	14
2006	12	7	9	14
2007	27	9	30	7
2008	27	12	29	6
2009	30	6	25	2
2010	35	18	40	13
2011	9	22	6	18
2012	17	19	19	10
2013	25	10	22	6
2014	18	17	9	12
2015	12	19	8	16
2016	36	8	26	11
2017	39	23	39	17
2018	4	16	2	11
2019	33	18	27	15
2020	12	21	5	11

Trend of temperature variation over year

District level temperature data of 21 years (2000-2020) of Koraput and Nawarangpur district were subjected to Mann-Kendall test for detecting trend in annual temperature at 95% significance level. Plot of annual temperature with time (year) has been presented graphically in figure by running the Mann-Kendall Test annual temp. In both the district, it was observed that the district was showing decreasing trend over the years which is non-significant in both the Koraput and Nawarangpur district (Fig 6).

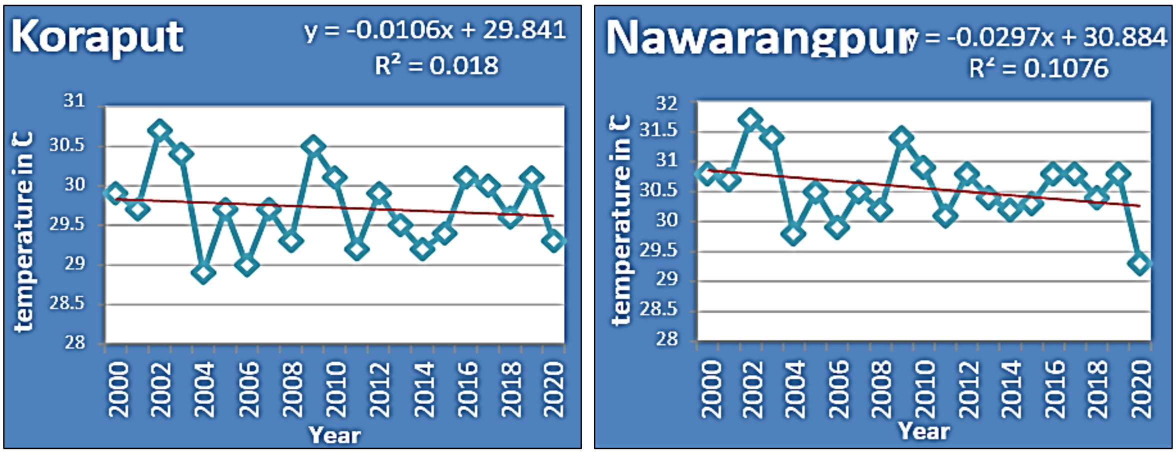

Fig 6: Trend of temperature variation

Calculation of length of growing period

Post-monsoon and winter rainfall covers the period from the day after cessation of monsoon to end of February. Average evaporative demand of the atmosphere from agricultural field in post monsoon and winter period for this Zone was taken as 3.7 mm/day. The total rainy period in a year was computed for all 24 blocks using Sattar *et al*., 2013's LGP formula. The growing season in Koraput district lasted an average of 192 days (Table 5), the most of the blocks have a growth season of >180 days. All the blocks of Nawarangpur have growing season of >200 days (Table 6). The analysis revealed that the monsoon starts effectively from 23 SMW and 24SMW in Koraput Nawarangpur district remain active up to 41 SMW (8th October to 13th October). Therefore, we expected good monsoon shower for about 19 weeks (22 to 41 SMW) in the region.

Table 5: Block wise LGP Calculation (Koraput)

Block	Onset date	Cessation date	Rainy Days	Post monsoon Rainfall (mm) (Oct-Jan)	AWHC (mm)	LGP (DAYS)
Bandhugaon	12 June	12 Oct	123	165	120	200
Boipariguda	13 June	11 Oct	121	161	150	205
Borigumma	13 June	9 Oct	119	120	100	178
Dasmanthpur	14 June	10 Oct	119	128	100	181
Jeypore	13 June	11 Oct	121	143	150	200
Koraput	13 June	10 Oct	120	149	100	187
Kotpad	13 June	8 Oct	118	154	120	192
Kundra	13 June	8 Oct	118	107	100	180
Lamtaput	17 June	9 Oct	115	108	100	171
Laxmipur	12 June	13 Oct	124	154	120	199
Nandapur	13 June	13 Oct	123	163	120	200
Narayanpatna	14 June	13 Oct	122	201	100	203
Pottangi	13 June	13 Oct	123	214	100	208
Semiliguda	14 June	12 Oct	121	156	120	196

Table 6: Block wise LGP Calculation (Nawarangpur)

Block	Onset date	Cessation date	Rainy Days	Post monsoon Rainfall (mm) (Oct-Jan)	ANVHC (mm)	LGP (Days)
Chandahandi	11 June	9 Oct	121	141	120	192
Dabugaon	13 June	8 Oct	118	104	100	173
Jharigaon	10 June	7 Oct	120	147	100	187
Kosagumuda	12 June	6 Oct	119	156	120	194
Nandahandi	13 June	8 Oct	116	86	150	180
Nawaran2pur	11June	7 Oct	119	114	100	177
Papadahandi	13 June	6 Oct	116	107	100	172
Raighar	12 June	9 Oct	120	115	100	183
Tentulikhunti	13 June	7 Oct	117	113	120	180
Umerkote	12 June	7 Oct	118	104	100	173

Crop planning

Off season vegetables based crop planning

When supply is low and prices are high, farmers can make more money and customers have more choices by growing crops outside of the traditional cropping season. The climatic conditions of certain pockets of Koraput offer bright potential for off-season vegetables cultivation under different altitude zones along with milder climates. Detailed agro climatic characterizations such as rainfall variability and trend analysis, temperature, assured weekly rainfall, initial and conditional probability and length of the growing season analyzed under this study were presented for each block of the

Koraput and Nawarangpur districts to make suitable agricultural and meteorological decisions.

A. Farming situation I (600-900m)-Pottangi, Semiliguda, Nandapur, Laxmipur, Narayanpatna, Bandhugaon, Dasmanthpur, Lamtaput, Koraput.
B. Farming situation II (300-600m)-Jeypore, Boipariguda, Borigumma, Kundra.

Farming situation I Includes nine blocks of Koraput district which supports off season cultivation being an area of low temperature, hills and lands at higher altitude, it has ideal conditions for growing off- season vegetables like, cole crops and monsoon potato, tomato. Besides, it has excellent prospects in floriculture. Spices like black pepper, cardamom and potato, sweet potato, tapioca and arrowroot are the major root and tuber crops that are favourable for these regions. It also supports plantation crops like coffee, cashew and mango too.

Crop planning based on LGP

The length of the growing season varies based on the soil type and slope, which impact the soil depth and hence the water holding capacity of the soil. Thus, depending on the soil properties and the availability of secured irrigation facilities, a block can support either intercropping, sequence cropping, or double cropping (short duration second crop) under the same rainfall conditions. Because rainfall in the Eastern Ghat Highland Zone is unimodal and we have roughly 25–32 weeks of LGP, intercropping and sequential cropping can be adopted in most blocks and double cropping can be done in some blocks where irrigation (groundwater or surface) is available. Intercropping will be beneficial taking base crop of longer duration and the companion crop of short duration. The two crops should have different rooting depths and volumes, as well as, if possible, differing water requirements. This will help to reduce competition for water and nutrients, and the crop will produce a high yield.

Conclusion

Analysing 21 years rainfall and temperature data of Eastern Ghat Highland Zone of Odisha using weather cock model reveals that the overall mean rainfall of the Zone was 1597mm with an average of 70 rainy days. Monsoon season contributes the highest quantity to the annual rainfall. The seasonal C.V. was found lowest in Monsoon (18-57%) indicating rainfall was most reliable. During monsoon, probability of consecutive wet for 2 weeks gradually increased and was >50% at 20mm limit during 24 to 37th SMW in different blocks. Hence sufficient rain is available for plant growth during this period. This study further shows that minimal irrigation is required between 1st and 19th SMW and during 38th to 52nd week for growing short duration summer and winter crops. Monsoon starts effectively from 24th SMW (11thJune to 13th June) in both Koraput & Nawarangpur district and remain active up to 41st SMW (9th October to 13th October). The average length of growing season in Koraput district was 192 days and in Nawarangpur district was 181days. The average minimum monthly temperature (20.8 ˚C, 19.7 ˚C, 19.6 ˚C and 19.1 ˚C respectively) of Koraput district during southwest monsoon season is milder compared to remaining part of the Eastern Ghat Highland Zone which supports cole crops, beans, monsoon potato and tomato. The average rainfall of the blocks (Pottangi, Semiliguda, Narayanpatna, Koraput, Nandapur, Dasmanthpur, Lamtaput, Laxmipur and Bandhugaon) is more than 1100 mm and LGP >170days supporting the cultivation of off season vegetables in kharif period.

Hence, it can be concluded that the rainfall and temperature characterization helped in identifying the potential off season vegetable cultivation areas (Pottangi, Semiliguda, Narayanpatna, Koraput, Nandapur, Dasmanthpur, Lamtaput, Laxmipur and Bandhugaon) under Eastern Ghat High Land Zone of Odisha which canprovide a better alternative for diversification of EGHZ agriculture in view of higher returns available from them**.**

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