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Spatio-Temporal Assessment of Drought using Effective Drought Index (EDI) and Standardized Precipitation Index (SPI) During Monsoon Months in Cuttack District, Odisha, India

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***Abstract*: *Various parts of the World is experiencing frequent droughts due to climatic uncertainties. Drought is the most difficult and least understood natural hazard which can occur virtually in all types of climatic regions. Therefore, improved scientific analysis for forecasting, monitoring and management of drought is required. Effective drought index (EDI) and Standardized Precipitation Index (SPI) is used for drought analysis in this study, as both indices gained popularity as important drought indicators in recent years across space and time. Therefore, EDI 3 Aug (June, July and August), SPI 3 Aug, EDI 3 Sep (July, August and September) and SPI 3 Sep are estimated by utilizing the monthly rainfall data for 30 (1988-2017) years in thirteen blocks of Cuttack District, Odisha, India for characterising drought during monsoon months. The analysis inferred that, highest number of total drought (moderate+severe+extreme) events occurred in Narasighpur block based on EDI 3 Aug and Tangi-Choudwar and Tigiria blocks based on both SPI 3 Aug. Similarly, maximum number of total droughts experienced by Salepur block based on EDI 3 Sep and Cuttack Sadar, Nischintakoili and Tangi-Choudwar blocks as per SPI 3 Sep. Drought maps prepared for the years in decades (1995, 2005 and 2015) to study the variation of drought spatially as well as temporally during monsoon months based on the computed value of drought using EDI and SPI. In the year 1995, no drought events are observed from the drought map based on the drought value of EDI and SPI. Two rainfall threshold values were also estimated for agricultural drought during monsoon months in this study. The threshold limit for agricultural drought varied from 553.9 to 706.3, 516.2 to 722.8, 614.1 to 687.4 and 586.0 to 702.0 mm based on EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep value respectively. This drought analysis will be helpful for implementing various strategies of water management and crop planning for different blocks of Cutttack District.*

Keywords* : *Drought, Effective Drought Index, Standardized Precipitation Index, Agricultural Drought

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I. INTRODUCTION

Demand for water increased over the years because of the expansion in agricultural, industrial and energy sectors and also due to rise in population. Most part of the World also facing scarcity of water in almost every year [1]. Water scarcity further worsen due to climatic change and water supplies contamination. Droughts and floods occurred with higher peaks as well as severity over recent years. Droughts took place because of decrease in amount of rainfall occurred over a large time period in a year or season [2]. Decrease in the supply of water, failure of crop, deterioration of quality of water, reduction in the generation of power, diminished range productivity, disturbed riparian habits and suspension of recreation activities resulted due to the impact of drought on both surface as well as groundwater resources [3].

Water resources management and planning needs the understanding of historical droughts as well as their impact in the region [1]. In order to tackle the adverse impacts of drought, planning will be required for the areal extent, severity and duration of drought information [4]. The drought indices can be used for the forecasting as well as monitoring of the drought as a result of which quantitative information about the characteristics of drought provided to the policy makers, which will be helpful for the management as well as planning of water resources [5]. Surface Water Supply Index [6], Palmer Drought Severity Index [7], China-Z index (CZI) [8], SPI [9], Decile index [10] and EDI [11] are the various drought indices used for the interpretation of drought. For monitoring of the drought in a particular area, selection of drought indices as per the availability of climatic data and also on the drought index's ability for detecting the spatial as well as temporal variation of drought consistently [2].

SPI is a probability index having many advantages [12]. SPI index is commonly used for drought analysis in the areas, where the information on other climatic data except precipitation is unavailable/difficult to access. It is also suitable for characterizing various types of droughts and unaffected by topography [13], [14].

The severity duration frequency curves developed for Australia by using partial duration series technique from the computed value of SPI [15]. Authors have used the threshold limit of rainfall instead of using the SPI value for the characterizing the drought severity.

Interpretation of meteorological drought using SPI was performed in Brazil by developing severity- duration-frequency curves for 1, 3, 6, 9 and 12 months duration [16]. [17] Assessment of the drought study undertaken in the fourteen blocks of Balangir District, India through interpretation of various drought indices based on SPI three, six and twelve months' time scale.

In the computation of EDI, an innovative concept of effective precipitation is used [11]. Originally, EDI is computed using the daily rainfall value but EDI can also be calculated based on month wise precipitation data [18] - [21]. Effective drought index used for the KBK Districts of Odisha for characterizing the drought [21]. The meteorological drought events quantified using EDI in Australia [22].

Most of the research works based on the analysis of drought using SPI and EDI based on various time scales such as 3, 6 and 12 months. But very few studies were carried out for interpretation of the drought by considering monsoon months only in a drought prone area of Odisha, India [17]. Therefore, this study carried out for characterizing the variation of drought spatially as well as temporally for the thirteen blocks of Cuttack District using SPI and EDI in monsoon months and also to estimate the threshold limit for agricultural drought.

II. MATERIALS AND METHODS

A. Study Area

This case study was attempted in thirteen blocks (Athgarh, Badamba, Banki-Dampada, Barang, Cuttack Sadar, Kantapada, Mahanga, Narasinghpur, Niali, Nischintakoili, Salepur, Tangi-Choudwar and Tigiria) of Cuttack District, Odisha, India (Latitude of 21.580 N and Longitude of 85.730 E) having a geographical area of 3932 km^2 (Fig. 1.). Cuttack District experiencing East and South Eastern plateau and Mid Central Table land agro-climatic zones of Odisha having hot, humid and dry sub humid climate. The normal annual rainfall of the District was 1424.3 mm.

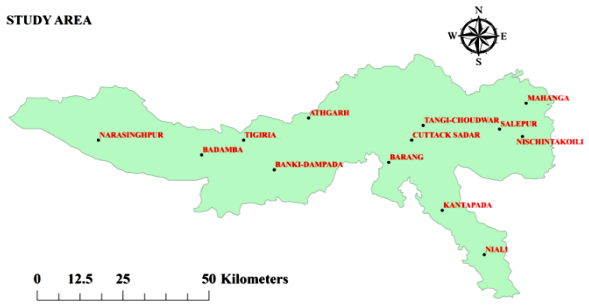


Fig. 1. The study site, Cuttack District of Odisha, India

B. Methodology

Collection of monthly rainfall data for 30 years (1988-2017) were obtained from the Water Resources Department, Govt. of Odisha, India for thirteen blocks of Cuttack District, Odisha, India. In order to interpret the characteristics of drought during monsoon months, effective drought index (EDI) and standardized precipitation index (SPI) calculated by utilising the monthly rainfall data.

C. Drought Indices

Effective Drought Index (EDI)

Based on EDI value, droughts classified into extreme (EDI ≤ −2.0), severe (−1.5 > EDI > −1.99) and moderate (−1.0 > EDI > −1.49) dry, normal (−0.99 < EDI < 0.99), moderate wet (1.0 < EDI < 1.49), very wet (1.5 < EDI < 1.99) and extreme wet (EDI ≥ 2.0). The method of calculation of EDI is given below:

$$EP_j = \sum_{m=1}^{N} \left[\left(\sum_{i=1}^{m} P_i \right) / m \right] \quad (1)$$

where, EPj is the effective precipitation, Pi is the rainfall 'm-1' months previous to the current month and N is the preceding period duration. If N = 3, then EP = P1 + (P1+P2)/2 + (P1+P2+P3)/3, where P1, P2 and P3 are rainfall value during current month (j), previous month and 2 months before respectively. After the calculation of EP, DEP(deviation of effective precipitation) is computed as:

$$DEPj = EPj - \overline{EPJ} \quad (2)$$

Then, PRN (precipitation amount required for returning to normal condition) is calculated by:

$$PRNj = \frac{DEPj}{\sum_{i=1}^{N} (\frac{1}{i})} \quad (3)$$

Effective drought index (EDI) is finally computed as:

$$EDI = PRN/\sigma_{PRN} \quad (4)$$

where, σPRN is the standard deviation of the corresponding month's PRN values. In this study, EDI is computed as EDI 3 Aug and EDI 3 Sep over three month's time scale. EDI 3 Aug is calculated by taking the precipitation data for August as current month, July as previous month and June as previous to previous month. On the same principle, EDI 3 Sep is computed.

Standardized Precipitation Index (SPI)

SPI was developed for quantifying the deficit or surplus of precipitation for various time scales [9]. Firstly, the fitting of precipitation data was done to gamma distribution and after that changed to the normal distribution for the calculation of SPI. Based on SPI value, droughts can be categorized into extreme (SPI ≤ −2.0), severe (−1.5 > SPI > −1.99) and moderate (−1.0 > SPI > −1.49) dry, near normal (−0.99 < SPI < 0.99), moderate wet (1.0 < SPI < 1.49), very wet (1.5 < SPI < 1.99) and extreme wet (SPI ≥ 2.0) [9]. In this study, SPI computed for SPI 3 Aug and SPI 3 Sept over 3 months time scale for all the years in monsoon months.

SPI 3 Aug means, cumulative rainfall over June, July and August were considered. Similarly, in case of SPI 3 Sep, cumulative rainfall for July, August and September were considered.

D. Threshold limit for calculation of Agricultural Drought

Prediction of agricultural drought can be replicated best by calculating the SPI value based on 2-3 months time scale [23] - [25]. In this study, two threshold limits for Agricultural drought were estimated, one by considering the cumulative rainfall for June to August (SPI 3 Aug) and another by taking the cumulative rainfall of July to September (SPI 3 Sep). Based on the same principle, two threshold limits for agricultural drought computed as per the drought value of EDI 3 Aug and EDI 3 Sep. In India, mostly agriculture depends on rainfall, therefore two threshold limits for agricultural drought was computed by considering the monsoon period.

III. RESULTS AND DISCUSSION

Average monsoon rainfall of 1421, 1018, 1346, 1216, 1205, 1260, 1301, 1063, 1191, 1074, 1043, 1046 and 1294 mm are observed in Athgarh, Badamba, Banki-Dampada, Barang, Cuttack Sadar, Kantapada, Mahanga, Narasinghpur, Niali, Nischintakoili, Salepur, Tangi-Choudwar and Tigiria blocks respectively. Amongst all the blocks, the maximum and minimum monsoon rainfall occurred in Banki-Dampada and Kantapada blocks respectively.

A. Drought characterization based on EDI 3 and SPI 3 Aug

Moderate, Severe and Extreme categories of drought based on the computed value of EDI 3 and SPI 3 Aug are presented in Table 1. Highest number of moderate droughts experienced by Narasinghpur and Tigiria blocks based on EDI 3 and SPI 3 Aug respectively. Banki-Dampada block did not experience any type of drought based on EDI 3 Aug. No extreme drought found in case of Athgarh, Badamba, Banki-Dampada, Barang, Cuttack Sadar, kantapada, Mahanga, Narasinghpur and Tigiria blocks based on EDI 3 Aug and Athgarh, Banki-Dampada, Barang, Narasinghpur and Niali blocks as per SPI 3 Aug. Drought pattern was not similar among the thirteen blocks of Cuttack District as per EDI and SPI 3 Aug.

Table 1. Moderate, Severe and Extreme categories of drought for different blocks of Cuttack District as per EDI 3 and SPI 3 Aug

BLOCKS	EDI 3 Aug			SPI 3 Aug		
	Mod	Sev	Ext	Mod	Sev	Ext
Athgarh	4	0	0	3	2	0
Badamba	2	2	0	0	3	1
Banki- Dampada	0	0	0	2	1	0
Barang	3	1	0	2	2	0
Cuttack Sadar	4	1	0	2	2	1
Kantapada	4	0	0	1	0	2
Mahanga	2	2	0	2	1	1
Narasinghpur	8	0	0	3	2	0
Niali	1	1	1	0	3	0
Nischintakoili	6	0	1	3	1	1
Salepur	1	2	1	1	1	2
Tangi-Choudwar	2	2	1	2	2	2
Tigiria	5	1	0	4	1	1

Total (moderate+severe+extreme) droughts based on the calculation of EDI 3 and SPI 3 Aug presented in Fig. 2. Narasinghpur block detected with maximum number of total droughts based on EDI 3 Aug whereas Tangi-Choudwar and Tigiria blocks experienced highest number of total droughts as per SPI 3 Aug. More number of droughts experienced in Narasinghpur and Nischintakoili blocks based on EDI in comparison to SPI where as Athgarh, Banki-Dampada and Tangi-Choudwar blocks detected with more number of droughts based on SPI compared to EDI.

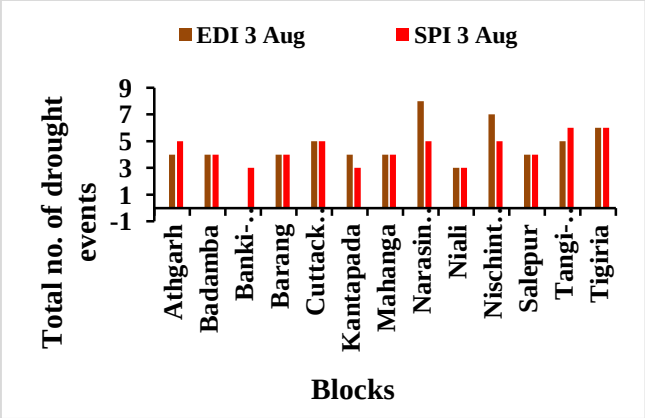


Fig. 2. Total droughts (moderate+severe+extreme) for thirteen blocks of Cuttack District based on EDI 3 Aug and SPI 3 Aug

B. Drought characterization based on EDI 3 and SPI 3 Sep

Highest number of moderate, severe and extreme droughts were experienced in Salepur, Nischintakoili and Tangi-Choudwar blocks and Badamba and Niali blocks based on EDI 3 Sep (Table 2). Maximum number of severe droughts detected in case of Cuttack Sadar and extreme droughts by Badamba, Barang and Tigiria blocks as per SPI 3 Sep. It can be observed from Fig. 3 that, maximum(i.e. 6) number of total (moderate+severe+extreme) droughts observed in Cuttack Sadar, Nischintakoili and Tangi-Choudwar blocks based on SPI 3 Sep where as highest (i.e. 6) number of total droughts occurred only in case of Salepur block as per EDI 3 Sep. More number of total droughts experienced in six blocks based on SPI 3 Sep as compared to EDI 3 Sep. Different drought patterns observed among the thirteen blocks of Cuttack based on the interpretation of drought by EDI and SPI. Blocks experiencing maximum number of total droughts should be given more importance from water resources management point of view.

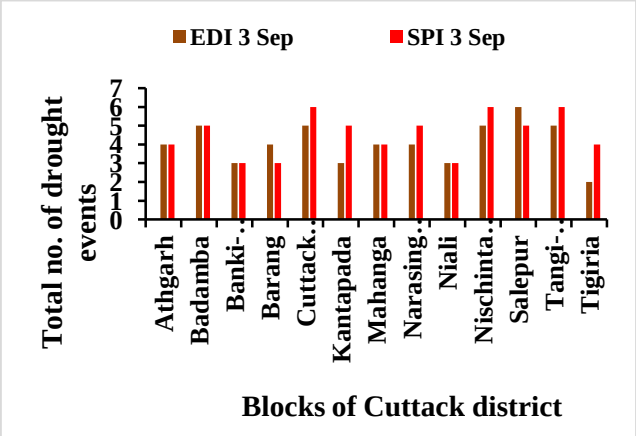


Fig. 3. Total droughts (mod+sev+ext) for thirteen blocks of Cuttack District based on EDI 3 Sep and SPI 3 Sep

Table 2. Moderate, Severe and Extreme categories of drought for different blocks of Cuttack District as per EDI 3 and SPI 3 Sep

BLOCKS	EDI 3 Sep			SPI 3 Sep		
	Mod	Sev	Ext	Mod	Sev	Ext
Athgarh	3	1	0	3	0	1
Badamba	3	0	2	3	0	2
Banki- Dampada	3	0	0	2	1	0
Barang	2	1	1	1	0	2
Cuttack Sadar	3	2	0	2	4	0
Kantapada	3	0	0	3	1	1
Mahanga	4	0	0	2	2	0
Narasinghpur	4	0	0	3	1	1
Niali	0	1	2	1	2	0
Nischintakoili	2	3	0	2	3	1
Salepur	5	1	0	2	2	1
Tangi-Choudwar	2	3	0	2	3	1
Tigiria	1	1	0	2	0	2

Similarly moderate, extreme and very wet events found from the computed value based on EDI 3 Aug , EDI 3 Sep and SPI 3 Aug and SPI 3 Sep. Maximum number (i.e. 7) of total wet events occurred in Barang and Banki-Dampada block based on EDI 3 Aug and EDI 3 Sep respectively. Badamba block detected with highest number (i.e. 8) of total wet events as per SPI 3 Aug and in Athgarh and Barang blocks based on SPI 3 Sep.

C. Spatio-Temporal characterization of drought as per EDI 3 and SPI 3Aug, EDI 3 and SPI 3 Sep

Spatial and temporal variation map of EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep was prepared for thirteen blocks of Cuttack District covering the period from 1988 to2017, using Inverse Distance Weighted method. Figs. 4, 5, 6 and 7 presented the variation of drought both spatially as well as temporally as per EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep respectively in 1995, 2005 and 2015 for thirteen blocks of Cuttack District.

It can be seen from Fig. 4 that, EDI 3 Aug varies from -1.6 to 0.7 (Severe dry to normal condition), -0.7 to 1.3 (Normal to moderate wet condition) and -1.3 to 0.5 (Moderate dry to normal condition) for the years 1995, 2005 and 2015 respectively. Similarly, the SPI 3 Aug varies from -2.2 to 0.4 (Extreme dry to normal condition), -0.3 to 1.5 (Normal to moderate wet condition) and -1.3 to 0.7 (Moderate dry to normal condition) for the years1995, 2005 and 2015 respectively (Fig. 5). Drought value varied from -2.0 to 0.2 (Severe dry to normal condition), 0.2 to 2.4 (Normal to extreme wet condition) and -1.5 to 0.5 (Severe dry to normal condition) based on EDI 3 Sep (Fig. 6) and -2.1 to 0.0 (Extreme dry to normal), -0.6 to 2.2 (Normal to Extreme wet condition) and -1.5 to 0.6 (Moderate dry to normal condition) as per SPI 3 Sep (Fig. 7) in 1995, 2005 and 2015 respectively. It can be concluded that, there was temporal as well as spatial variation of drought among the thirteen blocks of Cuttack based on EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep. In 2015, no drought detected among thirteen blocks of Cuttack District based on EDI 3 Aug, EDI 3 Sep, SPI 3 Aug and SPI 3 Sep.

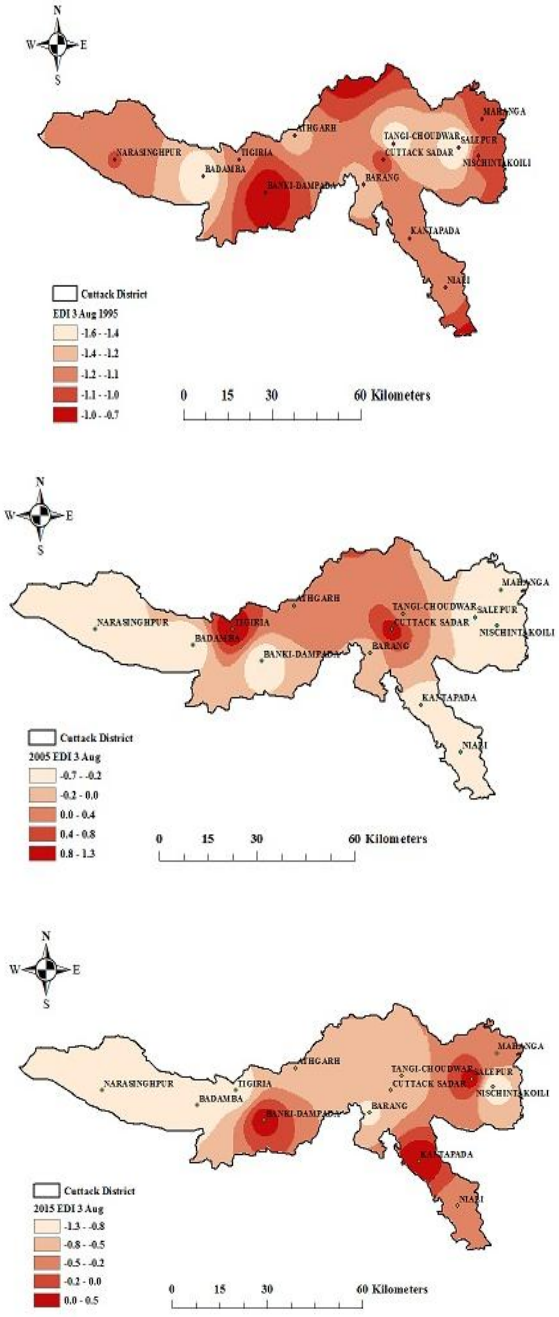


Fig. 4. Spatial and temporal variation of drought based on EDI 3 Aug in 1995, 2005 and 2015

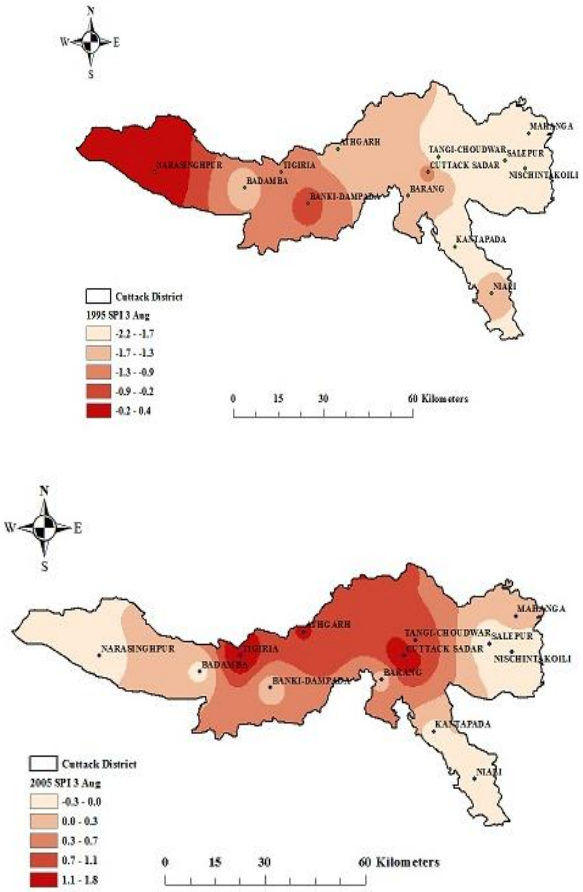
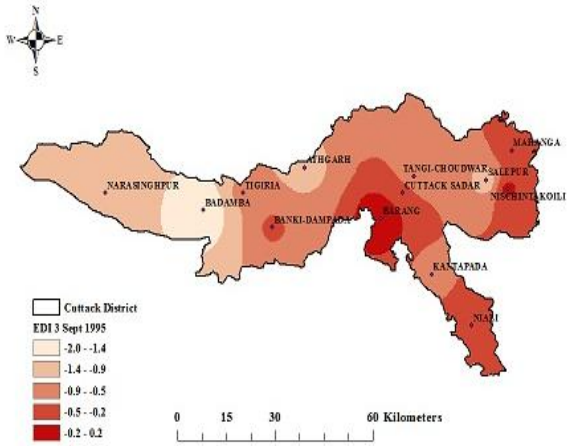


Fig. 5. Spatial and temporal variation of drought based on SPI 3 Aug in 1995, 2005 and 2015



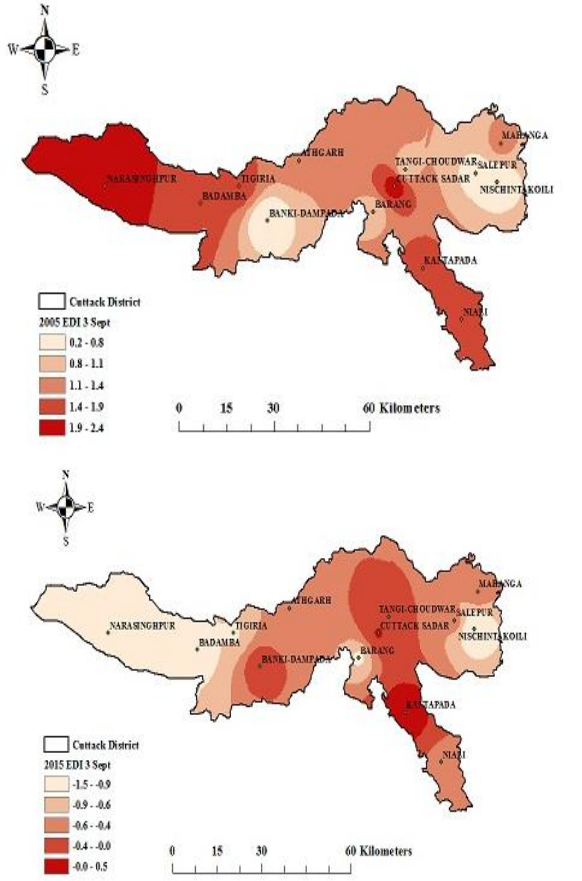
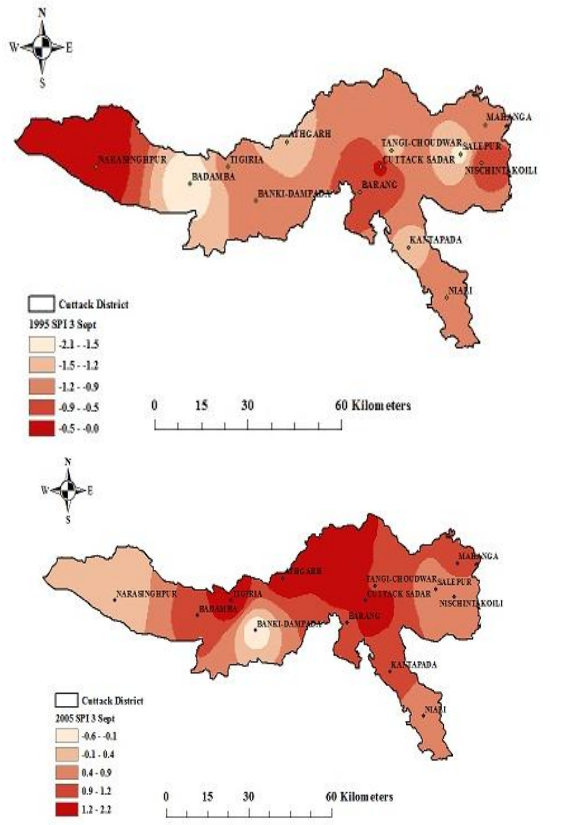


Fig. 6. Spatial and temporal variation of drought based on EDI 3 Sep in 1995, 2005 and 2015



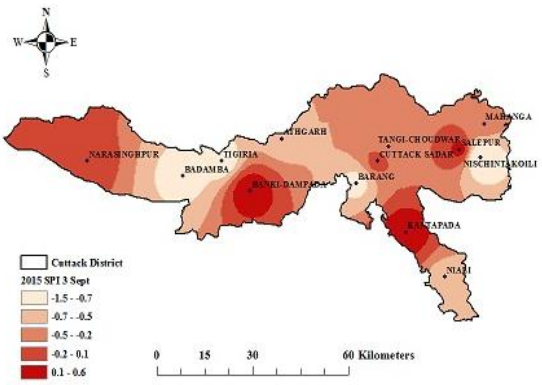


Fig. 7. Spatial and temporal variation of drought based on SPI 3 Sep in 1995, 2005 and 2015

D. Computation of threshold limit for agricultural drought

The threshold rainfall limits for agricultural drought were computed firstly by considering the cumulative rainfall for June, July and August (EDI 3 and SPI 3 Aug), and secondly by taking the cumulative rainfall of July, August and September (EDI 3 and SPI 3 Sep).. For an example, a linear equation (y = 427.7x + 981.6) was fitted between EDI 3 Aug and cumulative rainfall over the period of June to August for Kantapada Block (Fig. 8.). In this equation, x represents the EDI 3 Aug and y represents the cumulative rainfall for the months of June, July and August. Then threshold limit for agricultural drought was calculated by putting the value of x as -1.0 in the linear equation. Similarly in another example, the threshold rainfall limit in Mahanga block for agricultural drought was estimated by developing a linear relationship (y = 329.5x + 987.6) between SPI 3 Aug and cumulative rainfall for the months of July, August and September (Fig. 9.) and by putting the value of x (SPI 3 Aug) as -1.0. By following the same procedure, agricultural drought threshold rainfall limit based on EDI 3 Sep and SPI 3 Sep were computed. Threshold limit for agricultural drought based on EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep calculated for the thirteen blocks of the Cuttack District and presented in Tables 3,4,5 and 6.

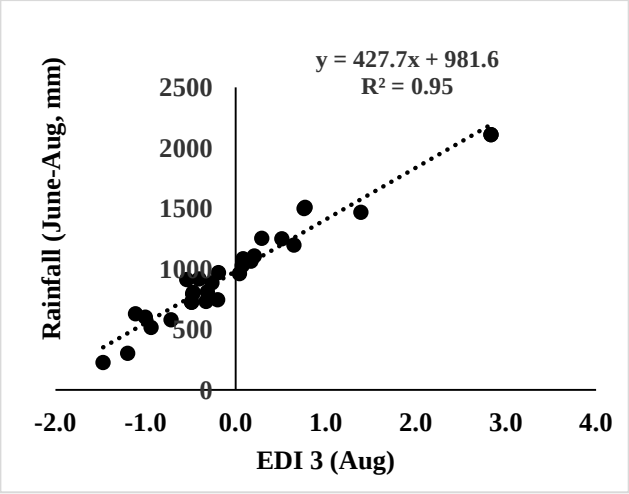


Fig. 8. Relationship between EDI 3 Aug and Rainfall (Jun-Aug, mm) of Kantapada Block

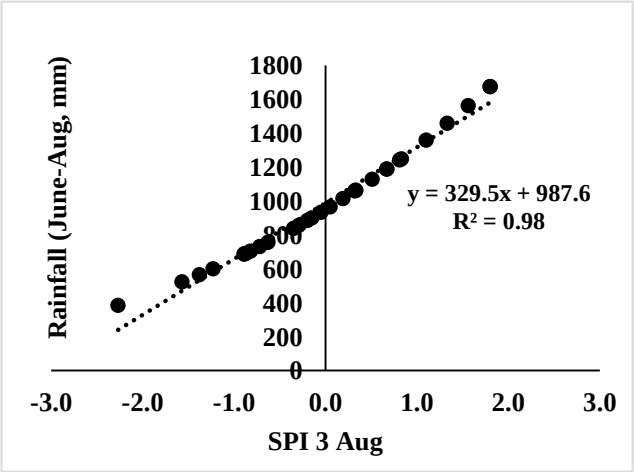


Fig. 9. Relationship between SPI 3 Aug and Rainfall (Jun-Aug, mm) of Mahanga Block

Table 3. Threshold limit of rainfall in thirteen blocks of Cuttack District based on EDI 3 Aug

BLOCKS	EQUATION	R^2	THRESHOLD VALUE
Athgarh	y = 304.9x + 1009.3	0.88	704.3
Badamba	y = 198.3x + 801.6	0.79	603.3
Banki- Dampada	y = 405.8x + 1047.4	0.91	641.6
Barang	y = 254.6x + 960.9	0.85	706.3
Cuttack Sadar	y = 292.7x + 946.6	0.88	653.9
Kantapada	y = 427.7x + 981.6	0.95	553.9
Mahanga	y = 323.2x + 987.4	0.91	664.2
Narasinghpur	y = 163.5x + 842.5	0.79	679.0
Niali	y = 349.1x + 910.1	0.85	561.0
Nischintakoili	y = 202.3x + 813.2	0.91	610.9
Salepur	y = 205.3x + 809.2	0.90	603.9
Tangi-Choudwar	y = 222.4x + 808.5	0.89	586.1
Tigiria	y = 242.4x + 907.1	0.89	664.7

Table 4. Threshold limit of rainfall in thirteen blocks of Cuttack District based on SPI 3 Aug

BLOCKS	EQUATION	R^2	THRESHOLD VALUE
Athgarh	y = 318.4x + 1005.3	0.98	686.9
Badamba	y = 217.0x + 801.4	0.98	584.4
Banki- Dampada	y = 378.9x + 1048.9	0.82	670.0
Barang	y = 269.6x + 960.9	0.98	691.3
Cuttack Sadar	y = 303.1x + 946.4	0.98	643.3
Kantapada	y = 420.4x + 981.0	0.95	560.6
Mahanga	y = 329.5x + 987.6	0.98	658.1
Narasinghpur	y = 153.6x + 876.4	0.87	722.8
Niali	y = 386.7x + 902.9	0.98	516.2
Nischintakoili	y = 207.3x + 812.7	0.99	605.4
Salepur	y = 211.6x + 808.9	0.98	597.3
Tangi-Choudwar	y = 230.2x + 808.0	0.99	577.8
Tigiria	y = 251.5x + 906.8	0.99	655.3

Table 5. Threshold limit of rainfall in thirteen blocks of Cuttack District based on EDI 3 Sep

BLOCKS	EQUATION	R^2	THRESHOLD VALUE
Athgarh	y = 378.0x + 1062.0	0.85	684.0
Badamba	y = 213.6x + 858.8	0.81	645.2
Banki- Dampada	y = 486.3x + 1132.0	0.88	645.7
Barang	y = 195.4x + 880.7	0.78	685.3
Cuttack Sadar	y = 334.6x + 1007.3	0.93	672.7
Kantapada	y = 441.3x + 1068.7	0.86	627.4
Mahanga	y = 381.2x + 1063.7	0.85	682.5
Narasinghpur	y = 173.5x + 841.9	0.86	668.4
Niali	y = 305.0x + 992.4	0.76	687.4
Nischintakoili	y = 241.9x + 886.1	0.82	644.2
Salepur	y = 239.1x + 862.7	0.82	623.6
Tangi-Choudwar	y = 251.8x + 865.9	0.82	614.1
Tigiria	y = 290.0x + 976.3	0.77	686.3

Table 6. Threshold limit of rainfall in thirteen blocks of Cuttack District based on SPI 3 Sep

BLOCKS	EQUATION	R^2	THRESHOLD VALUE
Athgarh	y = 399.9x + 1062.4	0.99	662.5
Badamba	y = 224.4x + 849.5	0.99	625.1
Banki- Dampada	y = 467.7x + 1133.5	0.85	665.8
Barang	y = 216.9x + 880.5	0.99	663.6
Cuttack Sadar	y = 337.8x + 1007.5	0.98	669.7
Kantapada	y = 460.1x + 1069	0.97	608.9
Mahanga	y = 400.9x + 1063.7	0.98	662.8
Narasinghpur	y = 158.1x + 861.0	0.77	702.9
Niali	y = 388.7x + 974.7	0.97	586.0
Nischintakoili	y = 261.7x + 886.2	0.99	624.5
Salepur	y = 257.9x + 862.4	0.98	604.5
Tangi-Choudwar	y = 268.1x + 865.3	0.98	597.2
Tigiria	y = 322.6x + 976.2	0.98	653.6

Agricultural drought threshold limit value is found to be 704.3, 603.3, 641.6, 706.3, 653.9, 553.9, 664.2, 679.0, 561.0, 610.9, 603.9, 586.1 and 664.7 mm based on EDI 3 Aug (Table 3), 686.9, 584.4, 670.0, 691.3, 643.3, 560.6, 658.1, 722.8, 516.2, 605.4, 597.3, 577.8, and 655.3 mm based on SPI 3 Aug (Table 4), 684.0, 645.2, 645.7, 685.3, 672.7, 627.4, 682.5, 668.4, 687.4, 644.2, 623.6, 614.1 and 686.3 mm based on EDI 3 Sep (Table 5) and 662.5, 625.1, 665.8, 663.6, 669.7, 608.9, 662.8, 702.9, 586.0, 624.5, 604.5, 597.2 and 653.6 mm (Table 6) based on SPI 3 Sep for Athgarh, Badamba, Banki-Dampada, Barang, Cuttack Sadar, Kantapada, Mahanga, Narasinghpur, Niali, Nischintakoili, Salepur, Tangi-Choudwar and Tigiria blocks respectively.

IV. CONCLUSION

Interpretation of drought was carried out in thirteen blocks of Cuttack District based on EDI and SPI for suggesting the strategy on management of water resources during monsoon months using 30 years of historical rainfall data. Highest number of total drought (moderate+severe+extreme) events occurred in Narasighpur block based on EDI 3 Aug and Tangi-Choudwar and Tigiria blocks based on both SPI 3 Aug. Similarly, maximum number of total droughts experienced by Salepur block based on EDI 3 Sep and Cuttack Sadar, Nischintakoili and Tangi-Choudwar blocks as per SPI 3 Sep. Droughts occur because of the reduction in the amount of mean rainfall over a larger time period during the monsoon season. Therefore, proper utilization of limited water resources should be thought up for the drought prone areas like Cuttack Sadar, Narasinghpur, Nischintakoili, Tangi-Choudwar and Tigiria blocks by constructing water harvesting structures for harvesting the runoff and growing of drought resistant crop varieties.

The existence of spatial and temporal variation of drought among the thirteen blocks of Cuttack District found from the prepared drought maps using EDI and SPI value. Agricultural drought threshold limit was different for different blocks based on the estimated value of EDI 3 Aug, SPI 3 Aug, EDI 3 Sep and SPI 3 Sep. Lowest threshold limit value for agricultural drought identified in case of Kantapada and Niali block based on EDI 3 Aug and EDI 3 Sep value respectively. Niali block detected with minimum threshold limit for agricultural drought based on both SPI 3 Aug and Sep. One of the suggested measure is to go for the modification in the existing cropping pattern by growing low water requirement crops by the farmers. Because thirteen blocks of Cuttack District experiencing different categories of drought, different water management strategies should be adopted to cope with drought situations for the individual blocks. Therefore, interpretation of drought using drought indices is necessary to mitigate the drought by adopting suitable cropping pattern, growing drought resistant crop varieties, harvesting the runoff water and water saving techniques.

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