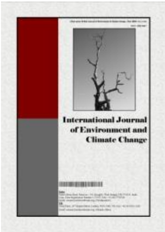

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Assessment of Vulnerability in Different Districts of Chhattisgarh with Reference to Climate Change

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted at department of Agrometeorology, IGKV Raipur (C.G.) during 2019-2021, to assess the district level vulnerability in different districts of Chhattisgarh with reference to climate change. The data on various components was collected from the Census department of Chhattisgarh (2001 and 2011), department of Agrometeorology, Raipur and the report of Directorate of Economics & Statistics Raipur, C.G. for the period 2000 to 2018 and divided into three different periods 2000-2005, 2006-2010 and 2011-2018 as districts increased. We have used the Hiremath and Shiyani methodology to prepare vulnerability index. The outcome of study indicates that the agricultural sector played major role and contributing significantly to quantify the vulnerability followed by climatic and demographic indicators during all most three periods which was considered for the study. During the period 2000-2005, the results indicates that district Dantewada ranked 1st followed by korba and Mahasamund district. While, district Surguja falls under least vulnerable followed by Durg and Raipur district. During the study period 2006-2010, district Bijapur observed in 1st position followed by Dantewada and korba districts. Whereas, district Durg was supposed to be least vulnerable followed by Surguja and Bilaspur district. During the period 2011-2018, district Sukma ranked 1st rank followed by Dantewada and Narayanpur districts. While, district Dhamtari belongs to least vulnerable followed by Balrampur and Janjgir-champa.

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On the basis of degree of vulnerability during year 2000-2005, out of 16 districts the 2 and 12 districts were falls under very highly vulnerable and highly vulnerable category, respectively. While, only 2 districts were belong to vulnerable category. During year 2006-2010, out of 18 districts the 5, 11 and 2 districts were supposed to be very highly vulnerable, highly vulnerable category and vulnerable category, respectively. During year 2011-18, out of 27 districts the 9 and 18 districts were belongs to very highly vulnerable and highly vulnerable category. We have not found less and moderately vulnerable districts during the period 2000-2005 and 2006-2010, while only two viz., highly vulnerable and very highly vulnerable districts found during the period 2011-2018.

Keywords: Vulnerability; agricultural; climatic; demographic and indicators.

1. INTRODUCTION

The climate variability and climate change has been identified as most dangerous man made activities in the world, which has a negative impact on human health and livelihood security. The rural people are mostly vulnerable to climate variability and changes owing to their dependence on agriculture for food and livelihood. Vulnerability assessment indicators are used to measure and characterize the vulnerability of a system. Indicator based assessment is one of the main approaches in vulnerability research. According to the Intergovernmental Panel on Climate Change [1] definition of vulnerability in the context of climate change is “the degree to which a system is susceptible to and copes with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity”. As per climate change the vulnerability may be regarded as a possibility of “future damage” [2]. There is a consensus that vulnerability is a complex and dynamic phenomena that several characteristics of a given social-ecological system contribute to make people and territories more or less vulnerable [3].

Chhattisgarh, too, realizes the effect of climate change. Available evidence suggests that there is high probability of increase in the frequency of extreme events and there may be increase in the number of natural disasters. The state is facing problem with respect to planning and implementation of activities in changing climate scenario. Early climate change study was carried out to assess the regional climate changes in Chhattisgarh state in central India and their impacts on agriculture. It was found that the scale of variability is not the same in the entire state. In some place, the rainfall decreased by 30-35 percent while in some others places, the rainfall deceased from 0-5 percent only. With the changes in rainfall the general climate change have influenced the agriculture in the state [4].

2. METHODOLOGY AND ANALYTICAL FRAMEWORK

The data on various components was collected from the Census department of Chhattisgarh (2001 and 2011), department of Agrometeorology, Raipur and the report of Directorate of Economics & Statistics Raipur, (C.G.) for the period of 2000 to 2018 and divided into three different periods viz., 2000 to 2005, 2006 to 2010 and 2011 to 2018 as districts increased. A new state was established in Chhattisgarh in 2000, with 16 districts at that time and 18 districts in 2007 and 28 districts at present. We therefore have data according to the formation of the respective districts and workout accordingly. The Decadal demographic data *i.e.* population density and literacy rate for the period 2001 and 2011 were collected for different districts of Chhattisgarh from the Census department of Chhattisgarh. The long term Annual and seasonal Rainfall data (mm), annual maximum and minimum temperature (°C) data for the period 2000-2018 were collected from the Department of Agrometeorology, I.G.K.V. Raipur, C.G. and agricultural data for the period from 2000 to 2018, Crop data (Rice, Maize, Pigeon Pea, Wheat and Chickpea), Cropping intensity, area under cultivation and Irrigation intensity were collected from the report of Directorate of Economics & Statistics, Raipur C.G. (Year 2000-18). All these data were used to calculate a vulnerability index.

Table 1. Functional relationship of indicators and sub-indicators with vulnerability to climate change

S. NO.	Indicators	Sub-Indicators	Functional Relationship
1.	**Demographic Indicators**	i. Density of population (persons per square kilometre)	↑
		ii. Literacy rate (percentage)	↓
2.	**Climatic Indicators**	i. Annual rainfall (mm)	↑
		ii. Seasonal rainfall (mm)	↑
		iii. Annual maximum temperature (°C)	↑
		iv. Annual minimum temperature (°C)	↑
3.	**Agricultural Indicators**	i. Production of Rice crop (Q/ hectare)	↓
		ii. Productivity of Rice crop (Q/ hectare)	↓
		iii. Production of Maize crop (Q/ hectare)	↓
		iv. Production of Maize crop (Q/ hectare)	↓
		v. Production of Pigeon Pea crop (Q/ hectare)	↓
		vi. Productivity of Pigeon Pea crop (Q/ hectare)	↓
		vii. Production of Wheat crop (Q/ hectare)	↓
		viii. Productivity of Wheat crop (Q/ hectare)	↓
		ix. Production of Chick Pea crop (Q/ hectare)	↓
		x. Productivity of Chick Pea crop (Q/ hectare)	↓
		xi. Cropping intensity (percentage)	↓
		xii. Irrigation intensity (percentage)	↓
		xiii. Aera under Cultivation (hec.)	↓

2.1 Methodology for Calculation of the Vulnerability Index

2.1.1 Normalization of indicators using functional relationship

We calculated the geometric mean of demographic, climatic and agricultural indicators through the dimension index. The dimension index was categorized in two types of possible functional relationship *i.e.* positive functional relationship and negative functional relationship shown in the Table 1. Dimension index scores should be between 0 and 1. The value 1 was corresponding to that district with maximum value and 0 was corresponding to the district with minimum value [5].

All climatic and population density sub-indicator has positive functional relationship with vulnerability, then the index was calculated as-

Dimension index = (Actual X_i – Minimum X_i) / (Maximum X_i – Minimum X_i) …(1)

Where,

Actual X_i = Actual value of Current Year

Minimum X_i = Minimum value of Current Year

Maximum X_i = Maximum value of Current Year

Whenever, all agricultural and literacy rate sub-indicator has negative functional relationship with vulnerability then the index is calculated as-

Dimension index= (Maximum X_i – Actual X_i) / (Maximum X_i – Minimum X_i) ...(2)

This method of dimension index that takes into account the functional relationship between the variable and vulnerability was important in the calculation of the indices. If the functional relation was ignored and if the variables were normalized simply by applying formula (1), the resulting index was misleading [5].

2.1.2 Iyenger and Sudershan's method (unequal weight method) for construction of vulnerability index

The method of simple averages gives equal importance for all the indicators which were not necessarily correct. Hence many authors prefer

to give weights to the indicators. Iyengar and Sudarshan [6] developed a method to work-out a composite index from multivariate data and it was used to rank the districts in terms of their economic performance. This methodology was well suited for the development of composite index of vulnerability to climate change.
A brief discussion about the methodology was given below.

It was assumed that there are M districts, K sub-indicators of indicators vulnerability and xij, i= 1, 2, ….M ; j=1, 2, ….k are the normalized scores. The level or stage of development of i^t district, $\bar{y}_t$ was assumed to be a linear sum xij as

$$\bar{y}_t = \sum_{j=1}^{k} WjXij \quad \ldots(3)$$

Where, w's (0<w<1 and $\sum_{j=1}^{k} W$ j=1) were the weights. In Iyenger and Sudarshan's method, the weights were assumed to vary inversely as the variance over the district in the respective sub-indicators of indicators vulnerability. That was, the weight wj was determined by

$$W_j = c/\sqrt{var\ xij}$$

Where, c was a normalizing constant such that

$$C= \left\|\sum_{j=1}^{k} 1/\sqrt{\mathrm{varxij}}\right\|^{-1}$$

The determination of the weights in this manner would ensure that large variation in any one of the indicators would not unduly dominate the contribution of the rest of the indicators and distort inter-district comparisons. The vulnerability index so computed lies between 0 and 1, with 1 indicating maximum vulnerability and 0 indicating no vulnerability at all.

For classificatory purposes, a simple ranking of the districts based on the indices viz., $\bar{y}_t$ would be enough. However, a meaningful characterization of the different stages of vulnerability, suitable fractile classification from an assumed probability distribution was needed.

A probability distribution which was suitable for this purpose was the Beta distribution, which was generally skewed and takes values in the interval (0, 1). This distribution has the probability density given by:

$$f(z) = (Z^{a-1} (1-z)^{b-1} dx) / (B (a,b)),\ 0 < z < 1 \text{ and } a, b > 0$$

Where, B (a, b) was the beta function defined by

$$B (a, b) = \int_0^1 x^{a-1} (1-x)^{b-1} dx$$

The two parameters *a* and *b* of the distribution can be estimated by using the method by Iyenger and Sudarshan (1982). The beta distribution was skewed. Let $(0,z_1)$, (z_1,z_2), (z_2,z_2), (z_3,z_4) and $(z_4,1)$ be the linear intervals such that each interval has the same probability weight of 20 per cent.

These fractile intervals were used to characterize the various stages of vulnerability as shown below:

1. Less vulnerable if $0<\bar{y}_t < z_1$;
2. Moderately vulnerable if $z_1<\bar{y}_t < z_2$;
3. Vulnerable if $z_2< \bar{y}_t < z_3$;
4. Highly vulnerable if $z_3< \bar{y}_t < z_4$; and
5. Very highly vulnerable if $z_4< \bar{y}_t < 1$.

3. RESULTS AND DISCUSSION

3.1 District WISE SHARE to the Vulnerability to Climate Change for the Year 2000-2005, 2006-2010 and 2011-2018

During 2000-2005, 2006-2010 and 2011-2018, district-wise vulnerability Indices of Chhattisgarh have been worked out for demographic, climatic and agricultural indictors. The districts have been ranked on the basis of vulnerability indices.

The results were given in the Table 2. (a and b), during the period 2000-05, the result of vulnerability indices indicates that district Dantewada reported in 1st rank followed by korba and Mahasamund districts where it was noticed that agricultural sector contributes 66.85 percent followed by climatic sector 26.23 percent and demographic sector 6.92 percent. The district Surguja was least vulnerable followed by Durg and Raipur districts where the contribution of agricultural sector was 72.01 percent followed by climatic sector 17.66 percent and demographic sector 10.32 percent.

During the study period 2006-2010, the district Bijapur was ranked 1st rank followed by Dantewada and korba districts where it was indicated that agricultural sector contributes 68.67 percent followed by climatic sector 24.70 percent and demographic sector 6.63 percent shown in the Table 2. (c and d). The district Durg was least vulnerable followed by Surguja and Bilaspur where it was noticed that contribution of agricultural sector, climatic sector and demographic sector was 62.67 percent, 23.68 percent and 13.65 percent, respectively.

It is clear from the Table 2. (e and f), during the study period 2011-2018, the Sukma district observed in 1st position followed by Dantewada and Narayanpur districts where it was also reported that agricultural sector contributes 69.23 percent followed by climatic sector 24.93 percent and demographic sector 5.84 percent. The district Dhamtari was least vulnerable followed by Balrampur and Janjgir-champa where it was noticed that contribution of agricultural sector was 80.85 percent followed by climatic sector 15.99 percent and demographic sector 3.15 percent.

Table 2. (a) District wise share to the vulnerability and composite vulnerability to climate change for the year 2000-2005

S. No.	Districts Name	Demographic Vulnerability Index	Rank	Climatic Vulnerability Index	Rank	Agricultural Vulnerability Index	Rank	Composite Vulnerability Index	Rank
1	Bastar	0.0420	5	0.1555	4	0.368	10	0.566	6
2	Bilaspur	0.0453	4	0.0804	10	0.357	11	0.483	13
3	Dantewada	0.0493	2	0.1870	1	0.476	2	0.713	1
4	Dhamtari	0.0283	12	0.1034	7	0.381	9	0.513	11
5	Durg	0.0460	3	0.0736	11	0.316	15	0.436	15
6	Janjgir-Champa	0.0582	1	0.1335	5	0.339	14	0.531	8
7	Jashpur	0.0273	13	0.0653	13	0.394	8	0.486	12
8	Kabirdham	0.0380	7	0.0611	16	0.473	3	0.572	5
9	Kanker	0.0136	16	0.1577	3	0.344	13	0.515	10
10	Korba	0.0335	9	0.1143	6	0.490	1	0.638	2
11	Korea	0.0222	14	0.0639	14	0.460	4	0.546	7
12	Mahasamund	0.0321	10	0.1004	8	0.449	5	0.582	3
13	Raigarh	0.0286	11	0.0986	9	0.401	6	0.528	9
14	Raipur	0.0384	6	0.0722	12	0.352	12	0.463	14
15	Rajnandgaon	0.0182	15	0.1584	2	0.398	7	0.574	4
16	Surguja	0.0364	8	0.0623	15	0.254	16	0.353	16

Table 2. (b) Indicator-wise contributions to the composite vulnerability to climate change for the Year 2000-2005 (*In percent*)

S. No.	Districts Name	Demographic Vulnerability Index	Climatic Vulnerability Index	Agricultural Vulnerability Index	Total
1	Bastar	7.42	27.48	65.10	100
2	Bilaspur	9.38	16.65	73.96	100
3	Dantewada	6.92	26.23	66.85	100
4	Dhamtari	5.52	20.18	74.31	100
5	Durg	10.56	16.90	72.54	100
6	Janjgir-Champa	10.96	25.15	63.89	100
7	Jashpur	5.61	13.42	80.97	100
8	Kabirdham	6.64	10.68	82.68	100
9	Kanker	2.64	30.59	66.77	100
10	Korba	5.25	17.93	76.82	100
11	Korea	4.06	11.72	84.22	100
12	Mahasamund	5.52	17.25	77.23	100
13	Raigarh	5.42	18.69	75.90	100
14	Raipur	8.29	15.60	76.11	100
15	Rajnandgaon	3.16	27.60	69.24	100
16	Surguja	10.32	17.66	72.01	100

Table 2. (c) District wise Share to the vulnerability and composite vulnerability to climate change for the Year 2006-2010

S. No.	Districts Name	Demographic Vulnerability Index	Rank	Climatic Vulnerability Index	Rank	Agricultural Vulnerability Index	Rank	Composite Vulnerability Index	Rank
1	Bastar	0.0416	6	0.1680	1	0.353	12	0.5630	5
2	Bijapur	0.0450	3	0.1670	2	0.4660	3	0.6786	1
3	Bilaspur	0.0440	4	0.0530	15	0.2943	16	0.3913	16
4	Dantewada	0.0429	5	0.1551	3	0.4507	4	0.6487	2
5	Dhamtari	0.0300	13	0.1317	5	0.3150	13	0.4768	13
6	Durg	0.0471	2	0.0817	12	0.2162	18	0.3450	18
7	Janjgir-Champa	0.0568	1	0.1040	10	0.2868	17	0.4475	15
8	Jashpur	0.0269	15	0.0762	13	0.3974	8	0.5005	11
9	Kabirdham	0.0354	9	0.0317	18	0.4110	5	0.4781	12
10	Kanker	0.0156	18	0.1230	6	0.3686	10	0.5072	10
11	Korba	0.0324	11	0.0747	14	0.4781	1	0.5852	3
12	Korea	0.0219	16	0.0328	17	0.4699	2	0.5245	7
13	Mahasamund	0.0321	12	0.1143	8	0.4062	6	0.5526	6
14	Narayanpur	0.0383	8	0.1379	4	0.3980	7	0.5742	4
15	Raigarh	0.0294	14	0.1167	7	0.3621	11	0.5082	8
16	Raipur	0.0384	7	0.1015	11	0.3099	15	0.4498	14
17	Rajnandgaon	0.0209	17	0.1051	9	0.3813	9	0.5073	9
18	Surguja	0.0338	10	0.0411	16	0.3104	14	0.3853	17

Table 2. (d) Indicator-wise contributions to the composite vulnerability to climate change for the Year 2006-2010 (*In Percent*)

S. No.	Districts Name	Demographic Vulnerability Index	Climatic Vulnerability Index	Agricultural Vulnerability Index	Total
1	Bastar	7.39	29.85	62.76	100
2	Bijapur	6.63	24.70	68.67	100
3	Bilaspur	11.25	13.55	75.21	100
4	Dantewada	6.61	23.91	69.48	100
5	Dhamtari	6.30	27.63	66.07	100
6	Durg	13.65	23.68	62.67	100
7	Janjgir-Champa	12.68	23.24	64.07	100
8	Jashpur	5.37	15.22	79.41	100
9	Kabirdham	7.40	6.64	85.96	100
10	Kanker	3.08	24.25	72.66	100
11	Korba	5.53	12.76	81.71	100
12	Korea	4.17	6.25	89.58	100
13	Mahasamund	5.81	20.69	73.50	100
14	Narayanpur	6.67	24.01	69.31	100
15	Raigarh	5.78	22.96	71.26	100
16	Raipur	8.53	22.56	68.91	100
17	Rajnandgaon	4.11	20.72	75.17	100
18	Surguja	8.77	10.67	80.56	100

Table 2. (e) District wise Share to the vulnerability and composite vulnerability to climate change for the Year 2011-2018

S. No.	Districts Name	Demographic Vulnerability Index	Rank	Climatic Vulnerability Index	Rank	Agricultural Vulnerability Index	Rank	Composite Vulnerability Index	Rank
1	Balod	0.0143	25	0.0868	13	0.4584	9	0.5595	12
2	Baloda Bazar	0.0228	18	0.0724	19	0.4505	11	0.5458	14
3	Balrampur	0.0268	16	0.0460	25	0.3701	23	0.4430	26
4	Bastar	0.0320	12	0.1648	3	0.4143	18	0.6110	6
5	Bemetara	0.0267	17	0.0801	15	0.3662	24	0.4730	23
6	Bijapur	0.0431	6	0.1651	2	0.4611	7	0.6693	4
7	Bilaspur	0.0375	10	0.0728	18	0.3979	21	0.5083	21
8	Dantewada	0.0447	3	0.1596	4	0.5187	4	0.7230	2
9	Dhamtari	0.0137	27	0.0693	21	0.3504	25	0.4334	27
10	Durg	0.0551	1	0.0776	17	0.4410	14	0.5737	11
11	Gariaband	0.0165	22	0.0903	11	0.4972	6	0.6040	7
12	Janjgir-Champa	0.0333	11	0.0872	12	0.3226	27	0.4431	25
13	Jashpur	0.0188	20	0.0840	14	0.4487	12	0.5515	13
14	Kabirdham	0.0447	4	0.0407	27	0.4355	15	0.5208	19
15	Kanker	0.0149	24	0.1133	7	0.4162	17	0.5444	15
16	Kondagaon	0.0389	9	0.1261	6	0.4321	16	0.5970	8
17	Korba	0.0181	21	0.0786	16	0.5468	1	0.6435	5
18	Korea	0.0142	26	0.0543	24	0.5207	3	0.5893	9
19	Mahasamund	0.0210	19	0.0958	9	0.4608	8	0.5777	10
20	Mungeli	0.0413	8	0.0557	23	0.4039	20	0.5009	22
21	Narayanpur	0.0279	14	0.1408	5	0.5218	2	0.6905	3
22	Raigarh	0.0283	13	0.0904	10	0.3935	22	0.5122	20
23	Raipur	0.0450	2	0.0689	22	0.4133	19	0.5272	18
24	Rajnandgaon	0.0155	23	0.0973	8	0.3425	26	0.4553	24
25	Sukma	0.0428	7	0.1828	1	0.5076	5	0.7332	1
26	Surajpur	0.0440	5	0.0420	26	0.4513	10	0.5373	17
27	Surguja	0.0271	15	0.0697	20	0.4420	13	0.5388	16

Table 2. (f) Indicator-wise contributions to the composite vulnerability to climate change for the year 2011-2018 (*In Percent*)

S. No.	Districts Name	Demographic Vulnerability Index	Climatic Vulnerability Index	Agricultural Vulnerability Index	Total
1	Balod	2.56	15.52	81.92	100
2	Baloda Bazar	4.19	13.26	82.55	100
3	Balrampur	6.06	10.39	83.55	100
4	Bastar	5.23	26.97	67.80	100
5	Bemetara	5.65	16.94	77.42	100
6	Bijapur	6.45	24.66	68.89	100
7	Bilaspur	7.39	14.33	78.28	100
8	Dantewada	6.19	22.07	71.75	100
9	Dhamtari	3.15	15.99	80.85	100
10	Durg	9.61	13.53	76.86	100
11	Gariaband	2.74	14.95	82.31	100
12	Janjgir-Champa	7.50	19.68	72.81	100
13	Jashpur	3.41	15.23	81.36	100
14	Kabirdham	8.58	7.81	83.61	100
15	Kanker	2.74	20.81	76.45	100
16	Kondagaon	6.51	21.12	72.37	100
17	Korba	2.82	12.21	84.97	100
18	Korea	2.42	9.22	88.37	100
19	Mahasamund	3.64	16.59	79.77	100
20	Mungeli	8.24	11.11	80.65	100
21	Narayanpur	4.04	20.39	75.57	100
22	Raigarh	5.52	17.66	76.82	100
23	Raipur	8.53	13.06	78.41	100
24	Rajnandgaon	3.41	21.37	75.22	100
25	Sukma	5.84	24.93	69.23	100
26	Surajpur	8.18	7.82	84.00	100
27	Surguja	5.04	12.94	82.02	100

3.2 Classification of Different Districts under Different Degrees of Vulnerability for the Period of 2000-2005, 2006-2010 and 2011-18

Initially, we have classified the degree of vulnerability for the parental districts 16 of Chhattisgarh during 2000-2005 and then districts restructured and degree of vulnerability calculated for 18 districts during the period 2006-2010. During the study period 2011-2018, it was workout for 27 districts as in existence.

On the basis of degree of vulnerability the districts were categories into 5 groups they are less vulnerable, moderately vulnerable, vulnerable, highly vulnerable and very highly vulnerable category. It is quite clear from the Table 3 (a), that during year 2000-2005, out of 16 districts the Dantewada and Korba districts belongs to under very highly vulnerable category, the districts Mahasamund, Rajnandgaon, Kabirdham, Bastar, Korea, Janjgir-Champa, Raigarh, Kanker, Dhamtari, Jashpur, Bilaspur and Raipur were supposed to be highly vulnerable category, while only two districts i.e. Surguja and Durg were belong to Vulnerable category.

The perusal of Table 3 (b), indicates that out of 18 districts reported the districts Bijapur, Dantewada, Korba, Mahasamund and Narayanpur were supposed to be very highly vulnerable category, the Rajnandgaon, Korea, Bastar, Raigarh, Kabirdham, Jashpur, Kanker, Dhamtari, Raipur, Janjgir-Champa and Bilaspur, districts fell under highly vulnerable category. Only three districts they are Surguja and Durg belongs to vulnerable category during year 2006-2010.

It is clear from the Table 3 (c), that during year 2011-2018, out of 27 districts the districts Sukma, Dantewada, Narayanpur, Bijapur, Korba, Bastar, Gariaband, Kondagaon and Korea belongs to under very highly vulnerable category, while Mahasamund, Durg, Balod, Jashpur, Balodabazar, Kanker, Surguja, Surajpur, Raipur, Kabirdham, Raigarh, Bilaspur, Mugeli, Bemetara, Rajnandgaon, Janjgir-Champa, Balrampur and Dhamtari were supposed to be highly vulnerable category.

We have not found less and moderately vulnerable districts during the study period 2000-2005 and 2006-2010, while only two viz., highly vulnerable and very highly vulnerable districts found during the period 2011-2018.

Many studies on quantitative assessment of vulnerability such as Bharti et al. [7] reported that the agricultural sector played a main role in construction of vulnerability followed by occupational, climatic and demographic indicators during the period 1976-2016. They concluded that the district Kisanganj was considered most vulnerable district where the contribution of agriculture sector was 46.18 percent followed by moderately vulnerable districts like Supaul, Saharsa, Madhepura, Purnea and Khagaria and the Araria districts of Bihar was found least vulnerable to climate change. Similar results was also reported by Hiremath et al. [8] they worked on the date of 1980-1983 and 1988 were the wettest years, while the years 1987, 1993, 1999 and 2000 were the driest year in all the districts of North Saurashtra. In 2007 was the wettest year and 1987 was the driest year in all the district of Saurashtra. The Period-wise vulnerability indices showed that agriculture sector was the principle contributor to the overall vulnerability to climate change. Another study reported by Hiremath and Shiyani [5] revealed that the variables pertaining to agricultural vulnerability were the major contributors in the overall vulnerability to climate change during the period 1991 and 2008. They also found that the district of Amreli (north Saurashtra agro climatic zone) was found to be the most vulnerable district where the contribution of agriculture sector was 52.61 percent and district of Panchmahals was the least vulnerable to climate change in the year 2008.

Table 3. (a) Classification of 16 districts under different degrees of vulnerability for the period 2000-2005

S. No.	Less Vulnerable (Category 1)	Moderately Vulnerable (Category 2)	Vulnerable (Category 3)	Highly Vulnerable (Category 4)	Very Highly Vulnerable (Category 5)
1	-	-	Surguja	Mahasamund	Dantewada
2	-	-	Durg	Rajnandgaon	Korba
3	-	-		Kabirdham	
4	-	-		Bastar	
5	-	-		Korea	
6	-	-		Janjgir-Champa	
7	-	-		Raigarh	
8	-	-		Kanker	
9	-	-		Dhamtari	
10	-	-		Jashpur	
11	-	-		Bilaspur	
12	-	-		Raipur	

Table 3. (b) Classification of 18 districts under different degrees of vulnerability for the year

S. No.	Less Vulnerable (Category 1)	Moderately Vulnerable (Category 2)	Vulnerable (Category 3)	Highly Vulnerable (Category 4)	Very Highly Vulnerable (Category 5)
1	-	-	Surguja	Rajnandgaon	Bijapur
2	-	-	Durg	Korea	Dantewada
3	-	-		Bastar	Korba
4	-	-		Raigarh	Mahasamund
5	-	-		Kabirdham	Narayanpur
6	-	-		Jashpur	
7	-	-		Kanker	
8	-	-		Dhamtari	
9	-	-		Raipur	
10	-	-		Janjgir-Champa	
11	-	-		Bilaspur	

Table 3. (c) Classification of 27 districts under different degrees of vulnerability for the year 2011-2018

S. No.	Less Vulnerable (Category 1)	Moderately Vulnerable (Category 2)	Vulnerable (Category 3)	Highly Vulnerable (Category 4)	Very Highly Vulnerable (Category 5)
1	-	-	-	Mahasamund	Sukma
2	-	-	-	Durg	Dantewada
3	-	-	-	Balod	Narayanpur
4	-	-	-	Jashpur	Bijapur
5	-	-	-	Balodabazar	Korba
6	-	-	-	Kanker	Bastar
7	-	-	-	Surguja	Gariaband
8	-	-	-	Surajpur	Kondagaon
9	-	-	-	Raipur	Korea
10	-	-	-	Kabirdham	
11	-	-	-	Raigarh	
12	-	-	-	Bilaspur	
13	-	-	-	Mungeli	
14	-	-	-	Bemetara	
15	-	-	-	Rajnandgaon	
16	-	-	-	Janjgir-Champa	
17	-	-	-	Balrampur	
18	-	-	-	Dhamtari	

4. CONCLUSION

The results of vulnerability indices analysis for the different districts revealed that the variables pertaining to agricultural vulnerability were the major contributors in the composite vulnerability to climate change during the periods 2000-2005, 2006-2010 and 2011-2018. Since the agricultural sector was found to have the greatest bearing there was a need to shift focus towards investments in adaptation research capacity: particularly, in the development of climate resilient crops (drought, flood resistant and heat tolerant varieties) that can cope with wide range of climatic variability. An improvement in the agronomic practices of different crops such as timely planting dates, plant densities and cropping pattern/sequences can help cope with the delayed rainy seasons, longer dry spells and earlier plant maturity. In order to enhance the resilience of the agriculture sector new strategies must be built around 'green' agricultural technologies, such as adaptive plant breeding, forecasting of pests, rainwater harvesting and fertilizer micro dosing.

Thus, the state of Chhattisgarh requires a development strategy that integrates climate change policies with sustainable development strategies to effectively combat climate change issues.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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