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

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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 Janjigar-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:

\[ \text{Dimension index} = \frac{(\text{Actual } X_i - \text{Minimum } X_i)}{(\text{Maximum } X_i - \text{Minimum } X_i)} \]  

Where,

\[ \text{Actual } X_i = \text{Actual value of Current Year} \]

\[ \text{Minimum } X_i = \text{Minimum value of Current Year} \]

\[ \text{Maximum } X_i = \text{Maximum value of Current Year} \]

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

\[ \text{Dimension index} = \frac{(\text{Actual } X_i - \text{Actual } X_i)}{(\text{Maximum } X_i - \text{Minimum } X_i)} \]

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 Sudarshana [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 $x_{ij}$, i = 1, 2, ..., M; j = 1, 2, ..., k are the normalized scores. The level or stage of development of ith district, $y_i$ was assumed to be a linear sum $x_{ij}$ as

$$y_i = \sum_{j=1}^{k} w_j x_{ij} \ldots (3)$$

Where, w’s (0<w<1 and $\sum_{j=1}^{k} w_j = 1$) were the weights. In Iyengar and Sudarshana’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 $w_j$ was determined by

$$w_j = c/\sqrt{\text{var} x_{ij}}$$

Where, c was a normalizing constant such that

$$C = ||\sum_{j=1}^{k} 1/\sqrt{\text{var} x_{ij}}||^{-1}$$

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., $y_i$ 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:

$$f(z) = (z^{a-1}(1-z)^{b-1}) / (B(a,b)), \quad 0 < z < 1$$

and $a, b > 0$

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

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

The two parameters $a$ and $b$ of the distribution can be estimated by using the method by Iyengar and Sudarshan (1982). The beta distribution was skewed. Let $(0, z_1), (z_1, z_2), (z_2, z_3)$ and $(z_3, 1)$ 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 $0 < y_i < z_1$
2. Moderately vulnerable if $z_1 < y_i < z_2$
3. Vulnerable if $z_2 < y_i < z_3$
4. Highly vulnerable if $z_3 < y_i < z_4$
5. Very highly vulnerable if $z_4 < y_i < 1$

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 indicators. 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).
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 Janjir-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    | 0.968                             | 10   | 0.596                         | 6    |
| 2      | Bilaspur       | 0.0453                          | 4    | 0.0804                        | 10   | 0.357                             | 11   | 0.403                         | 13   |
| 3      | Dantewada      | 0.0493                          | 2    | 0.1870                        | 1    | 0.476                             | 2    | 0.513                         | 1    |
| 4      | Dhamtari       | 0.0283                          | 12   | 0.1034                        | 7    | 0.381                             | 9    | 0.513                         | 11   |
| 5      | Durg           | 0.0460                          | 3    | 0.0736                        | 11   | 0.516                             | 15   | 0.436                         | 13   |
| 6      | Janjgir-Champa | 0.0582                          | 1    | 0.1335                        | 5    | 0.539                             | 14   | 0.531                         | 8    |
| 7      | Jashpur        | 0.0273                          | 13   | 0.0653                        | 13   | 0.594                             | 8    | 0.486                         | 12   |
| 8      | Kanker         | 0.0380                          | 7    | 0.0611                        | 16   | 0.473                             | 3    | 0.572                         | 5    |
| 9      | Korba          | 0.0335                          | 9    | 0.1143                        | 6    | 0.490                             | 1    | 0.638                         | 2    |
| 10     | Korea          | 0.0222                          | 14   | 0.0639                        | 14   | 0.460                             | 4    | 0.546                         | 7    |
| 11     | Mahasamund     | 0.0321                          | 10   | 0.1004                        | 8    | 0.449                             | 5    | 0.562                         | 3    |
| 12     | Raigarh        | 0.0266                          | 11   | 0.0986                        | 9    | 0.401                             | 6    | 0.526                         | 9    |
| 13     | Raipur         | 0.0384                          | 6    | 0.0722                        | 12   | 0.352                             | 12   | 0.466                         | 14   |
| 14     | Rajnandgaon    | 0.0182                          | 15   | 0.1584                        | 2    | 0.398                             | 7    | 0.574                         | 4    |
| 15     | Surguja        | 0.0364                          | 8    | 0.0623                        | 15   | 0.254                             | 16   | 0.383                         | 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      | Kanker         | 6.64                            | 10.68                         | 82.68                            | 100   |
| 9      | Korba          | 2.64                            | 30.59                         | 66.77                            | 100   |
| 10     | Korea          | 5.25                            | 17.93                         | 76.82                            | 100   |
| 11     | Mahasamund     | 4.06                            | 11.72                         | 84.22                            | 100   |
| 12     | Raigarh        | 5.52                            | 17.25                         | 77.23                            | 100   |
| 13     | Raipur         | 5.42                            | 18.69                         | 75.90                            | 100   |
| 14     | Rajnandgaon    | 8.29                            | 15.60                         | 76.11                            | 100   |
| 15     | Surguja        | 3.16                            | 27.60                         | 69.24                            | 100   |
| 16     |                 | 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
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         | 0.0416                          | 0.1680                       | 0.353                           |       |
| 2      | Bijapur        | 0.0450                          | 0.1670                       | 0.4680                          |       |
| 3      | Bilaspur       | 0.0440                          | 0.0530                       | 0.2943                          |       |
| 4      | Dantewada      | 0.0429                          | 0.1551                       | 0.4507                          |       |
| 5      | Dhamtari       | 0.0300                          | 0.1317                       | 0.3150                          |       |
| 6      | Durg           | 0.0471                          | 0.0817                       | 0.2162                          |       |
| 7      | Janjgir-Champa | 0.0568                          | 0.1040                       | 0.2688                          |       |
| 8      | Jashpur        | 0.0269                          | 0.0762                       | 0.3974                          |       |
| 9      | Kabirdham      | 0.0354                          | 0.1040                       | 0.4110                          |       |
| 10     | Kanker         | 0.0156                          | 0.1230                       | 0.3666                          |       |
| 11     | Kotea          | 0.0240                          | 0.0747                       | 0.4781                          |       |
| 12     | Korea          | 0.0219                          | 0.0328                       | 0.4699                          |       |
| 13     | Mahasamund     | 0.0331                          | 0.1143                       | 0.4822                          |       |
| 14     | Narayanpur     | 0.0383                          | 0.1379                       | 0.3621                          |       |
| 15     | Raigarh        | 0.0294                          | 0.1157                       | 0.3621                          |       |
| 16     | Raipur         | 0.0384                          | 0.1015                       | 0.3099                          |       |
| 17     | Rajnandgaon    | 0.0399                          | 0.1051                       | 0.3813                          |       |
| 18     | Surguja        | 0.0338                          | 0.0411                       | 0.3104                          |       |

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 | 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     | Kotea          | 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. (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      | Baloda Bazar   | 0.0144                         | 0.0360                      | 0.4374                          | 0.5150 |
| 2      | Bilaspur       | 0.0230                         | 0.1646                      | 0.4243                          | 0.5376 |
| 3      | Bemetara       | 0.0257                         | 0.0901                      | 0.5662                          | 0.6905 |
| 4      | Bijapur        | 0.0411                         | 0.1411                      | 0.4611                          | 0.5591 |
| 5      | Bilaspur       | 0.0375                         | 0.0706                      | 0.3979                          | 0.5083 |
| 6      | Dhamtari       | 0.0253                         | 0.1411                      | 0.3504                          | 0.4262 |
| 7      | Durg           | 0.0511                         | 0.0706                      | 0.4410                          | 0.5037 |
| 8      | Garhwa         | 0.0265                         | 0.0901                      | 0.3972                          | 0.5444 |
| 9      | Janjgir-Champa | 0.0333                         | 0.0872                      | 0.3226                          | 0.4431 |
| 10     | Jalpur         | 0.0185                         | 0.0803                      | 0.3043                          | 0.4262 |
| 11     | Kanker         | 0.0199                         | 0.1133                      | 0.4162                          | 0.5570 |
| 12     | Korba          | 0.0314                         | 0.0798                      | 0.3486                          | 0.5591 |
| 13     | Korwa          | 0.0422                         | 0.0543                      | 0.2307                          | 0.4162 |
| 14     | Mahasamund     | 0.0216                         | 0.0908                      | 0.4068                          | 0.5777 |
| 15     | Mungeli        | 0.0413                         | 0.0557                      | 0.4099                          | 0.5505 |
| 16     | Narayanpur     | 0.0279                         | 0.1409                      | 0.3711                          | 0.4908 |
| 17     | Raigad         | 0.0232                         | 0.0908                      | 0.3935                          | 0.4252 |
| 18     | Raipur         | 0.0453                         | 0.0809                      | 0.4133                          | 0.5572 |
| 19     | Raipur         | 0.0230                         | 0.0908                      | 0.3935                          | 0.4252 |
| 20     | Raipur         | 0.0453                         | 0.0809                      | 0.4133                          | 0.5572 |
| 21     | Raipur         | 0.0255                         | 0.0973                      | 0.3425                          | 0.4908 |
| 22     | Raipur         | 0.0453                         | 0.0809                      | 0.4133                          | 0.5572 |
| 23     | Raipur         | 0.0255                         | 0.0973                      | 0.3425                          | 0.4908 |
| 24     | Raipur         | 0.0453                         | 0.0809                      | 0.4133                          | 0.5572 |
| 25     | Raipur         | 0.0255                         | 0.0973                      | 0.3425                          | 0.4908 |
| 26     | Raipur         | 0.0453                         | 0.0809                      | 0.4133                          | 0.5572 |
| 27     | Raipur         | 0.0255                         | 0.0973                      | 0.3425                          | 0.4908 |

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

![Graph](https://via.placeholder.com/150)
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.

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     |                             | Durg                              |                         | Mahasamund                       | Dantewada                            |
| 2     |                             | booster                            |                         | Rajnandgaon                      | Korba                                |
| 3     |                             | booster                            |                         | Kabirdham                        |                                      |
| 4     |                             | booster                            |                         | Bastar                           |                                      |
| 5     |                             | booster                            |                         | Kanker                           |                                      |
| 6     |                             | booster                            |                         | Janjgir-Champa                   |                                      |
| 7     |                             | booster                            |                         | Raigarh                          |                                      |
| 8     |                             | booster                            |                         | Kanker                           |                                      |
| 9     |                             | booster                            |                         | Dhamtari                         |                                      |
| 10    |                             | booster                            |                         | Jashpur                          |                                      |
| 11    |                             | booster                            |                         | Bilaspur                         |                                      |
| 12    |                             | booster                            |                         | Raipur                           |                                      |

Table 3. (b) Classification of 18 districts under different degrees of vulnerability for the year 2006-2010.
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      | -                           | -                                 | Surguja                | Raipur Korba                 | Bilaspur                            |
| 2      | -                           | -                                 | Durg                   | Korea            | Dantewada                           |
| 3      | -                           | -                                 | Baster                 | Narayanpur        | Korba                               |
| 4      | -                           | -                                 | Raigarh                | Mahasamund        | Mahasamund                          |
| 5      | -                           | -                                 | Kabirdham              | Narayanpur        | Narayanpur                          |
| 6      | -                           | -                                 | Jashpur                | Narayanpur        | Narayanpur                          |
| 7      | -                           | -                                 | Kanker                 | Bastar             | Bastar                              |
| 8      | -                           | -                                 | Surguja                | Gariaband         | Gariaband                           |
| 9      | -                           | -                                 | Dhamtari               | Rajipur           | Rajpur                              |
| 10     | -                           | -                                 | Raipur                 | Narayanpur        | Narayanpur                          |
| 11     | -                           | -                                 | Janjgir-Champa         | Bilaspur           | Bilaspur                            |
| 12     | -                           | -                                 | Mahasamund             | Sukma             | Sukma                               |
| 13     | -                           | -                                 | Durg                   | Dantewada         | Dantewada                           |
| 14     | -                           | -                                 | Balod                  | Narayanpur        | Narayanpur                          |
| 15     | -                           | -                                 | Jashpur                | Bilaspur           | Bilaspur                            |
| 16     | -                           | -                                 | Balodabazar            | Korba             | Korba                               |
| 17     | -                           | -                                 | Surguja                | Gariaband         | Gariaband                           |
| 18     | -                           | -                                 | Rajpur                 | Korea             | Korea                               |
| 19     | -                           | -                                 | Kabirdham              | Raipur            | Raipur                              |
| 20     | -                           | -                                 | Rajgarh                | Mungeli            | Mungeli                             |
| 21     | -                           | -                                 | Bemetara               | Raipur            | Raipur                              |
| 22     | -                           | -                                 | Rajnandgaon            | Surajpur           | Surajpur                            |
| 23     | -                           | -                                 | Jashpur                | Surajpur           | Surajpur                            |
| 24     | -                           | -                                 | Bilaspur               | Kondagaon         | Kondagaon                           |
| 25     | -                           | -                                 | Kanker                 | Bilaspur           | Bilaspur                            |
| 26     | -                           | -                                 | Bilaspur               | Meghalay          | Meghalay                            |
| 27     | -                           | -                                 | Bilaspur               | Raipur            | Raipur                              |

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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