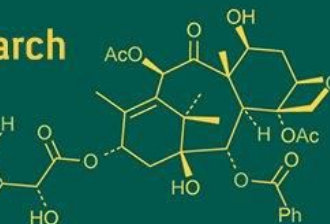


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To assess and compare the districts wise vulnerability index of Chhattisgarh state of Chhattisgarh plain Zone-II

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Abstract

The present study entitled “Studies on impact of rainfall on production and productivity of oilseed crops and vulnerability assessment in different districts of Chhattisgarh plain zone-II” was carried out to find the vulnerability assessment with different districts of Chhattisgarh plain zone-II (Balod, Bemetara, Bilaspur, Janjgir Champa, Kabirdham, Korba, Mungeli and Raigarh). Data on rainfall and crops was obtained from the Department of Department of Agrometeorology, COA, IGKV, Raipur and Government of India, Ministry of Agriculture and Farmers welfare, Department of Agriculture, Cooperation and Farmers Welfare Directorate of Economics and Statistics. With respect to all geographic, climatic, agricultural, occupational and demographic data features, time series data was obtained from various sources (Economics and Statistics) during a 20 year period from 2000 to 2020. The vulnerability assessment and Garrett ranking showed that Mungeli district was the most vulnerable and Korba district was the least vulnerable among all the selected districts. The ranking of the vulnerability index for each district was as follows: Mungeli, Bemetara, Kabirdham, Janjgir-Champa, Raigarh, Bilaspur, Balod and Korba.

Keywords: Climate change, vulnerability assessment, dimension index

Introduction

It is expected that climate change will influence the nature of the climatic hazards. People and ecosystems are exposed to and also contribute to deterioration or improvement of coping and adaptive capacities of those exposed to these changes. Consequently, many studies carried out by researchers (Wisner *et al.*, 2004; Cardona, 2010; Birkmann *et al.*, 2011a) ^[1], 2, 1] focus with a priority on the vulnerability of humans and societies as a central feature, rather than solely on the level of climatic change and respective hazards.

Climate change vulnerability is defined as the propensity to be adversely affected by climate change (IPCC 2014) ^[6]. It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope with and adapt to future changes (IPCC 2014) ^[6]. There are three key elements of vulnerability: (i) exposure (ii) sensitivity (iii) adaptive capacity. Vulnerability assessment has become a pivotal component of risk analysis associated with climate hazards, climate change and climate variability (UNDRR, 2019) ^[10]. Vulnerability assessment can be sectoral or regional but involves social and ecological indicators. This section presents examples of vulnerability assessment to climatic hazards and social vulnerabilities.

Vulnerability is dynamic and context specific, determined by human behavior and societal organization which influences the susceptibility of people (e.g., by marginalization) and their coping and adaptive capacities to hazards (IPCC, 2012a) ^[7]. A geographically disaggregated map of vulnerability to climate change is helpful for planning adaptation strategies. The IPCC working definition of vulnerability as a function of exposure, sensitivity and adaptive capacity (IPCC, 2001) ^[5] is used as measure to derive the district vulnerability to climate change.

Chhattisgarh too faces the threat of climate change and its impacts. Available evidence shows that there is high probability of increase in the frequency and intensity of climate related natural hazards due to climate change and hence increase in potential threat due to climate change related natural disasters. Earlier climate change study was carried out to assess the regional climate changes in Chhattisgarh state in central India and their impact 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 other places, the rainfall decreased by 0-5 percent only. With the changes in rainfall, the general climate changes have influenced the agriculture in the state (Sastri, 2010) ^[9].

Materials and Methods

The key target of the assessment was to analyze the vulnerability in Balod, Bemetara, Bilaspur, Janjgir-Champa, Kabirdham, Korba, Mungeli and Raigarh districts of Chhattisgarh plain zone-II. The study was carried out at the Department of Agrometeorology, College of Agriculture, I.G.K.V., and Raipur. The data of various socio-economic indicators were collected and compiled from different sources. Agricultural data (2000-2020) i.e., area, production & productivity of oil seed crops grown in different districts of Chhattisgarh were the published record of the Government of India, Ministry of Agriculture and Farmers welfare, Department of Agriculture, Cooperation and Farmers Welfare Directorate of Economics and Statistics. Groundnut, soybean, linseed and mustard etc. are the crops which are chosen for this study. Decadal demographic data i.e., population density and literacy rate,

occupational data of agriculture workers and geographic data regarding forest area for 2001 and 2011 were collected for respecting district of Chhattisgarh Plain Zone-II from the Census department of Madhya Pradesh and Chhattisgarh (Census India).

Analytical Techniques for Construction of Vulnerability Index

Five indicators (demographic, climatic, agricultural, occupational and geographic) have been applied to conduct a district wise vulnerability analysis. The standard methodology proposed by Patnaik and Narayanan (2005) [8] and later used by Hiremanth and Shiyani (2013) [4] has been followed. After calculating the average vulnerability index, the Garret ranking was used to determine the issues, preferences and new positions for the most vulnerable sectors in the analysis. The functional relationship of indicators to vulnerability has been shown in Table 1.

Table 1: Functional relationship of indicators with vulnerability to climate change

S. No. Component Indicator			Functional
Relationship			
1	Demographic (2)	a) Population Density (person per sq. km)	↑
		b) Literacy rate (%)	↓
2	Climatic (2)	a) Annual rainfall (mm)	↑
		b) Seasonal rainfall	↑
3	Agriculture (3)	a) Area, production and productivity of selected crop	↓
		b) Cropping intensity (%)	↓
		c) Irrigation intensity (%)	↓
4	Occupational (4)	a) Total main workers (no. per ha of net area sown)	↓
		b) Agricultural labourers (no. per ha of net area sown)	↓
		c) Non workers (no. per ha of net area sown)	↑
		d) Manufacturing labourers	↓
5	Geographic (1)	a) Forest area	↓

Steps for calculation of the Vulnerability Index

Step-I: All climatic indicators and one demographic indicator like population density are calculated through this formula. In this case we can say that the variables having increasing (↑) functional relationship with vulnerability and the normalization is done using the formula:-

$$\text{Dimension index} = \frac{(\text{Actual } X_i - \text{Minimum } X_i)}{(\text{Maximum } X_i - \text{Minimum } X_i)} \quad (1)$$

Where,

Actual X_i = Actual value of respective indicator

Minimum X_i = Minimum value of respective indicator

Maximum X_i = Maximum value of respective indicator

All agricultural indicators and one demographic indicator viz. literacy rate are calculated through this formula. In this case we say that the variables' having decreasing (↓) functional relationship with vulnerability and the normalization is done using the formula-

$$\text{Dimension index} = \frac{(\text{Maximum } X_i - \text{Actual } X_i)}{(\text{Maximum } X_i - \text{Minimum } X_i)} \quad (2)$$

Where,

Actual X_i = Actual value of respective indicator

Minimum X_i = Minimum value of respective indicator

Maximum X_i = Maximum value of respective indicator

Step-II: The value of geometric mean of demographic, climatic and agricultural indicators obtained from step1 was calculated through the average index.

$$\text{Average Index } i = [\text{Indicator}_1 + \dots + \text{Indicator}_J] / J$$

Where,

Indicator 1 = Geometric mean of Indicator

Indicator J = Geometric mean of Indicator J

J = number of indicators in each source of vulnerability

Step-III: After calculation of average index (AI) for demographic, climatic, occupational, geographic and agricultural indicators, we have to work out climate vulnerability index which is computed with the help of following formula:

$$\text{Vulnerability Index} = \left[\sum_{i=1}^n (AI_i)^\alpha \right]^{\frac{1}{\alpha}} / n$$

Where,

AI = Average index

N = number of source of vulnerability

$\alpha = n$

Step-IV: Garrett's Ranking Technique

Outcome of step three was ranked as per degree of vulnerability. The assigned rank was converted in to percentage position which was subsequently transferred into Garrett score using Garrett's table. For each constraint, scores of individual respondents were added together and then divided by total number of respondents. Thus, mean score for each constraint was ranked by arranging them in descending order.

$$\text{Percentage position} = \frac{100 (R_{ij} - 0.50)}{N_j}$$

Where,

R = Rank given for the i item by the j individual

N = Number of items ranked by the j individual.

Results and Discussion

District wise vulnerability analysis for eight districts of Chhattisgarh plain zone II and status of degree of vulnerability for the period 2000-20.

Based on their extent of vulnerability indicators, indicator wise

vulnerability and composite vulnerability indices were calculated and ranked. Garret's score was also used to rank the various districts.

Indicator wise vulnerability Index for different districts of Chhattisgarh Plain zone-II

Demographic Vulnerability (DV Index)

The results of the vulnerability assessment for the chosen Chhattisgarh district are Shown in Table 2 and Fig.1. Population density and literacy rate was used to analyse demographic vulnerability index. Our results indicate that the district Mungeli

observed maximum (0.90) and district Balod observed minimum (0.15) value of vulnerability index. According to the demographic vulnerability index, district Mungeli is more vulnerable whilst district Balod is less vulnerable. It means that efforts to improve the literacy rate in that area Mungeli district are required. Enhancing literacy rates can have multiple benefits, including better access to information, improved understanding of climate change risks and increased capacity to adapt to and mitigate those risks. Efforts to improve literacy can be accompanied by targeted interventions and awareness campaigns related to climate change resilience, sustainable practices and adaptive measures.

Table 2: Indicator wise vulnerability index for eight districts of Chhattisgarh plain zone- II

District	Demographic Vulnerability	Climatic vulnerability	Agricultural vulnerability	Occupational vulnerability	Geographic vulnerability
Bilaspur	0.65	0.58	0.41	0.28	0.43
Janjgir-Champa	0.59	0.37	0.35	0.31	1.00
Kabirdham	0.75	0.15	0.67	0.74	0.57
Korba	0.21	0.68	0.69	0.52	0.00
Raigarh	0.39	0.93	0.40	0.41	0.28
Balod	0.15	0.29	0.20	0.68	0.84
Bemetara	0.76	0.45	0.55	0.69	-
Mungeli	0.90	0.43	0.33	0.72	0.85

Climatic vulnerability (CV Index)

The climate vulnerability index was calculated using the district's annual and seasonal rainfall. The results of the analysis reveal that Raigarh was more vulnerable with a highest score (0.93) of climatic vulnerability and district Balod (0.29) was less vulnerable with the lowest score of climatic vulnerability. Given the high vulnerability in Raigarh district, it is important to respond to the issue of climate change promptly. This response could involve implementing adaptation measures such as improved drainage systems, flood management strategies, watershed management practices or agricultural practices that account for changing rainfall patterns.

Agricultural vulnerability (AV Index)

The results of the vulnerability assessment for a selected Chhattisgarh districts are provided in Table 2. Cropping intensity, irrigation intensity, area under cultivation, production, productivity and area of respective crops in different districts were used to analyse agricultural vulnerability. According to our findings, the vulnerability index was found with a high value in the Korba district (0.69) and a minimum value in the Balod district (0.20). District Korba is more vulnerable than district Balod, according to the demographic vulnerability index. It means that to enhance area, production, and productivity in Korba district, efforts should focus on promoting climate-smart agricultural practices. Providing access to information, training and resources to farmers can support the adoption of these practices.

Occupational vulnerability (OV Index)

Applying the agricultural labour, industrial labour, non-workers and total workers of various districts, we calculated the occupational vulnerability index. Kabirdham district revealed the highest occupational vulnerability index value of 0.74 followed by Mungeli (0.72), Bemetara (0.69), Balod (0.68), Korba (0.52), Raigarh (0.41), Janjgir-Champa (0.31), while Bilaspur district found the lowest occupational vulnerability index value of 0.28. According to the occupational vulnerability index, Bilaspur is less vulnerable than Kabirdham. This implied that in order to reduce vulnerability, action must be done to enhance source of income in that area. This suggests that Bilaspur district may have relatively better income sources, job opportunities or economic diversification compared to Kabirdham district. However, it is important to note that vulnerability is a complex concept and is influenced by various factors beyond occupational vulnerabilities alone.

Geographic vulnerability (GV Index)

Janjgir- Champa is the district with the highest geographic vulnerability score (0.85), while Korba has the lowest geographic vulnerability score (0.00). Using the total area of forest in each district, geographic vulnerability was calculated. The assessment highlights the need for Janjgir-Champa district to focus on improving its resilience and coping skills in the face of climate change. Efforts to address deforestation, promote sustainable land management practices, restore ecosystems and conserve forest resources can contribute to enhancing resilience and reducing vulnerability to climate change impacts.

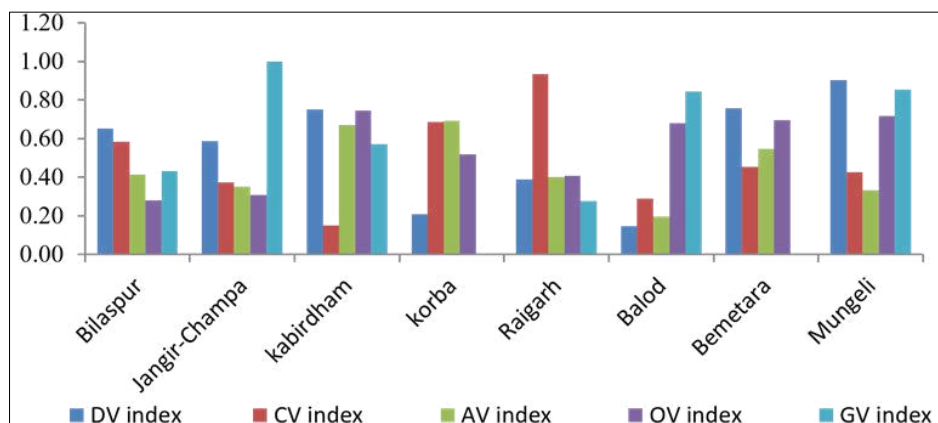


Fig 1: Variation of various vulnerability indices

Average vulnerability index and ranking

It is evident from Table 3 that Mungeli ranked first with average vulnerability index value (AVI) of 0.65 out of all the eight districts of Chhattisgarh plain zone-II when analyzed on the basis of five

indicators (demographic, climatic, agricultural, occupational and geographic) altogether. It is also represented in Fig.2. The least vulnerable district is Korba with average vulnerability index (AVI) value of 0.42.

Table 3: Average vulnerability Index with Rank for different districts of Chhattisgarh plain zone –II

S. No.	District	Average vulnerability index(AVI)	Rank
1	Bilaspur	0.47	6
2	Janjgir-Champa	0.52	4
3	Kabirdham	0.58	3
4	Korba	0.42	8
5	Raigarh	0.48	5
6	Balod	0.43	7
7	Bemetara	0.61	2
8	Mungeli	0.65	1

After calculating the average vulnerability index, the Garret ranking was used to determine the issues, preferences and new positions for the most vulnerable sectors in the analysis. The table

below presents the Garret ranking results for the cumulative vulnerability index.

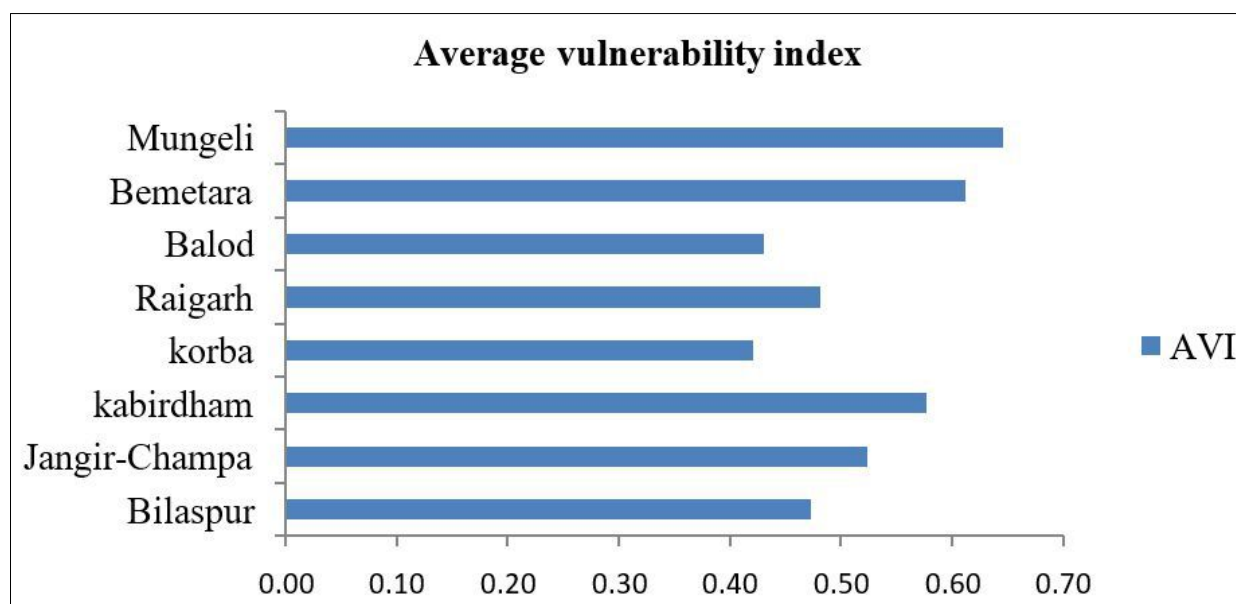


Fig 2: Variation in different districts of average vulnerability index

Garrett's ranking for different districts of Chhattisgarh plain zone -II

The percent position is converted into scores by referring to the table given by Garrett and Woodworth (1969). Then for each factor the scores of the individual respondents were added together and divided by the total number of respondents for whom scores were added (Table 4). It can be used to identify the most significant aspect that affected the respondent's techniques. The district with the highest garret ranking is the most vulnerable among all the districts taken into consideration, according to the average of all values.

Accordingly, district Mungeli is ranked first and presumed to be the most vulnerable district among all those located in Chhattisgarh Plain Zone-II, while district Korba was found to be the least vulnerable district with the lowest average index of all indicators according to the observation. The higher vulnerability index in Mungeli suggests that the district may face greater challenges in terms of demographic vulnerability to climate change impacts. This could be due to factors such as higher population density, lower literacy rates or other socio-economic factors that contribute to increased vulnerability. In contrast, Korba district has demonstrated a lower vulnerability index, indicating a relatively better capacity to cope with and adapt to climate change impacts. This could be attributed to factors such as economic diversity, infrastructure development and access to resources or proactive measures taken to address climate change risks.

Table 4: Garret ranking score of average vulnerability Index for different districts of Chhattisgarh plain zone –II

S. No.	District	AVI Rank	Garret's percentage	Garret's Ranking
1	Bilaspur	6	68.75	41
2	Janjgir-Champa	4	43.75	54
3	Kabirdham	3	31.25	60
4	Korba	8	93.75	20
5	Raigarh	5	56.25	47
6	Balod	7	81.25	33
7	Bemetara	2	18.75	68
8	Mungeli	1	6.25	80

Conclusion

To determine each district's vulnerability index, a district- level vulnerability assessment was conducted. Specific indicators were chosen based on exposure, sensitivity and potential for response to climate change. All of the chosen indicators were used to calculate the composite vulnerability index. The average vulnerability index (AVI) and Garrett's ranking for selected districts of Chhattisgarh Plain zone-II showed that Mungeli district was more vulnerable whereas district Korba observed least vulnerable to climate change. Focus is required on implementing climate change adaptation measures to reduce vulnerability. This may include strategies such

as building resilient infrastructure, implementing early warning systems and promoting sustainable agriculture practices.

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