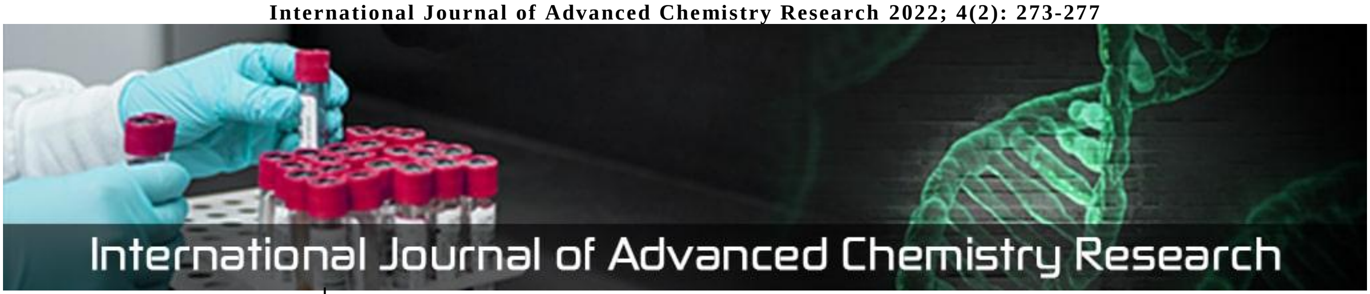

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Study on vulnerability assessment in different districts of Chhattisgarh plains Zone-II

Chandrika Seth, Dr. GK Das and JL Chaudhary

Abstract
The present research work entitled "Study on vulnerability assessment in different districts of Chhattisgarh Plains Zone-II" was conducted at Department of Agrometeorology, Raipur during 2021-22. Climate change vulnerability is a complex, multidimensional process influenced by indicators. The data of agricultural, Climatic, Demographic, Geographic and occupational indicator of respective districts for period 2004-2020 were collected and analysed for the study and their Garrett's ranking was done. The composite vulnerability index and Garrett ranking was observed high in Bilaspur district and lowest index for vulnerability was found in Kabirdham district.

Keywords: Vulnerability, climate change, garret's ranking, dimension index, Chhattisgarh

Introduction

Agriculture is one of the sectors most vulnerable to changes in the climate. At the global level the Intergovernmental Panel on Climate Change (IPCC) note that yields are generally expected to decline most severely in countries at lower latitudes. The IPCC Report described vulnerability as "a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity". It defined vulnerability as "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes". The IPCC has declared that climate change has played a key role in intensifying and triggering extreme events, such as floods, droughts, heatwaves, and tropical cyclones, which are all likely to increase in the future (IPCC 2012) [4].

Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings. The field of climate vulnerability assessment has emerged to address the need to quantify how communities will adapt to changing environmental conditions. Therefore, assessment of vulnerability is necessary to identify locations that will be in need for adaptation measures to cope up with impacts of climate change. It comprises an assessment of the region's or sector's ability to adapt. Similar work was also done by Jeganathan *et al.* (2021) [5] and they investigated the socio-economic vulnerability based on sustainable development goals (SDG) in the state of Tamil Nadu in the context of climate risks. Their result showed that Ariyalur was the most vulnerable district due to its high sensitivity and low adaptive capacity to climate risks. The other top vulnerable districts were Nagapattinam, Ramanathapuram, Thiruvarur, Thiruvallur, Thanjavur, Perambalur, Pudukottai, and Thiruvannamalai. Hiremath and Shiyani (2013) [3] also reported the vulnerability in various agro-climatic zone of Gujarat and they revealed that Amreli area (North Solastra agro climatic area) was the most vulnerable and Panchmahals area was least vulnerable to climate change.

The assessment of vulnerability will give a comprehensive picture of current and future climate change risks with more stress factors to be anticipated. It will help identify opportunities arising from climate change, and provide information on how to assess adaptive capacity and cope with uncertainty. Keeping this fact, the present research "study on Vulnerability assessment in different districts of Chhattisgarh Plains Zone-II" was carried out.

Material & 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 Plains 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 (2004-2020) i.e., area, production & productivity of horticultural crops was collected from Directorate Horticulture and Farm Forestry, Chhattisgarh. Decadal demographic data (population density and literacy rate), occupational data of agricultural workers and geographical data regarding forest area for the period 2001 and 2011 were collected from the Census department of Madhya Pradesh and Chhattisgarh (Census India).

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

S. No.	Component	Indicator	Functional Relationship
1.	Demographical	a. Population Density (Persons on per sq. km)	↑
		b. Literacy rate (%)	↓
2.	Climatic	a. Annual rainfall (mm)	↑
		b. Seasonal rainfall	↑
3.	Agricultural	a. Area, production productivity of selected crop	↑
		b. Cropping intensity (%)	↓
		c. Irrigation intensity (%)	↓
4.	Occupational	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.	Geographical	a. Forest area	↓

Analytical Techniques for Construction of Vulnerability Index

Vulnerability index for different districts will be carried out with the help of Iyengar and Sudarshan technique (1882) for Composite Vulnerability Index and Hiremath and Shiyani formula (2013) [3] for Dimension Index and Average Index. Garrett's Ranking Technique will be used for arranging districts as per their degree of vulnerability. The functional relationship of indicators to vulnerability was shown in table 1.

Step 1: All climatic indicators and one demographic indicator i.e., population density was calculated through this Increasing functional relationship formula,

$$\text{Dimension index} = \frac{(\text{Actual } X_I - \text{Minimum } X_I)}{(\text{Maximum } X_I - \text{Minimum } X_I)}$$

Where

Actual X_I =Actual value of respected Year

Minimum X_I =Minimum value of respected Year

Maximum X_I =Maximum value of respected Year.

Step 2: All agricultural indicators and one demographic indicator i.e., literacy rate both are calculated through this Decreasing functional relationship formula,

$$\text{Dimension index} = \frac{(\text{Maximum } X_I - \text{Actual } X_I)}{(\text{Maximum } X_I - \text{Minimum } X_I)}$$

Where

Actual X_I =Actual value of respected Year

Minimum X_I =Minimum value of respected Year

Maximum X_I =Maximum value of respected Year.

Step 3: The Average Index of all five indicators was calculated by using this formula,

$$\text{Average Index (AI)} = [\text{Indicator}_1 + \ldots\ldots\ldots + \text{Indicator}_J] / J$$

Where

Indicator $_1$ = Geometric mean of Indicator $_1$

Indicator $_J$ = Geometric mean of Indicator $_J$

J = number of indicators in each source of vulnerability.

Step 4: The Composite Vulnerability Index was calculated by using Iyengar and Sudarshan technique (1882),

$$\text{Vulnerability Index} = [\textstyle\sum_{i=1}^{n} (\text{AI } i)\alpha]^{1/\alpha} / n$$

Where

AI = Average index

n = number of sources of Vulnerability

α = n.

Step 5: The Garrett's Score was calculated by following formula given below and Garrett's ranking conversion table was used for the ranking of selected districts accordingly.

$$\text{Percentage position} = \frac{100(Rij - 0.50)}{Nj}$$

Where

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

N = Number of items ranked by the j individual.

Result and Discussion

The indicator wise vulnerability and composite vulnerability index was calculated and ranked based on their extent of vulnerability index. Ranking of the respective districts were also done by garret's score.

Table 2: Indicator wise Vulnerability Index for selected districts of Chhattisgarh Plains Zone-II

District	Agricultural Vulnerability	Climatic Vulnerability	Demographic Vulnerability	Geographical Vulnerability	Occupational Vulnerability
Balod	1.27	0.60	1.00	0.16	0.42
Bemetara	1.88	0.18	0.46	-	0.36
Bilaspur	1.94	0.60	0.28	0.54	1.99

Janjgir-Champa	1.55	0.67	0.31	0.00	1.40
Kabirdham	0.99	0.40	0.50	0.43	0.16
Korba	0.64	0.73	0.47	1.00	0.72
Mungeli	1.34	0.33	0.19	0.14	0.29
Raigarh	1.45	0.61	0.20	0.72	1.22

Indicator wise Vulnerability Index for selected districts of Chhattisgarh Plains Zone-II

There are number of indicators which can be used to assess the vulnerability in any sector. In agriculture and allied sectors these five indicators i.e., agricultural, climatic, demographic, geographic and occupational were comparatively more useful. Therefore, we have combined these indicators to assess the Vulnerability for Chhattisgarh Plains Zone-II.

Agricultural Vulnerability Index

Agricultural vulnerability was analysed with the help of cropping intensity, irrigation intensity, area under cultivation, production, productivity and area of respective districts. It is quite clear from the table 2 and Figure 1 that district Bilaspur was reported highest value of Agricultural Vulnerability (1.94), this district was most vulnerable with respect to agricultural indicator in changing scenarios and the lowest value was reported in the district Korba (0.64), indicates that this district was less vulnerable to agriculture and allied sectors. Less vulnerable districts need to give proper trainings to Farmers for adaptation of new techniques.

Climatic Vulnerability Index

Climatic vulnerability index was workout with annual and seasonal rainfall of the selected districts. Result of the analysis indicates that district the Korba was more vulnerable with highest value (0.73) of climatic vulnerability and district Bemetara was less vulnerable with lowest value (0.18) of climatic vulnerability. This indicates that there is urgent need to address the issue of climatic change.

Demographic Vulnerability Index

Population density and literacy rate was used to find out demographic vulnerability index for respected districts. Our findings indicates that the district Balod observed maximum (1.00) and district Mungeli observed minimum (0.19) value of vulnerability index. Maximum value in the district Balod indicates that this district needs to improve the quality of education and capacity building to control population density.

Geographical Vulnerability Index

Geographical vulnerability was calculated with the help of forest cover in the respective districts. Our study indicates that the geographical vulnerability index was highest in the district Korba (1.00) and lowest value was in the district Mungeli (0.14). This result provides information to address the forest related issue in the Korba district.

Occupational Vulnerability Index

We have worked out the occupational vulnerability index with the help of agricultural labour, Industrial worker, non-workers and total workers of respected districts. It was found that Bilaspur district was most vulnerable with highest occupational vulnerability index (1.99) followed by Janjgir-Champa (1.40) and Raigarh (1.22) and the lowest occupational vulnerability index reported in the Kabirdham district (0.16). Therefore, it is suggested that there are more vulnerable districts to keep in mind to address the occupational status of population to overcome present status.

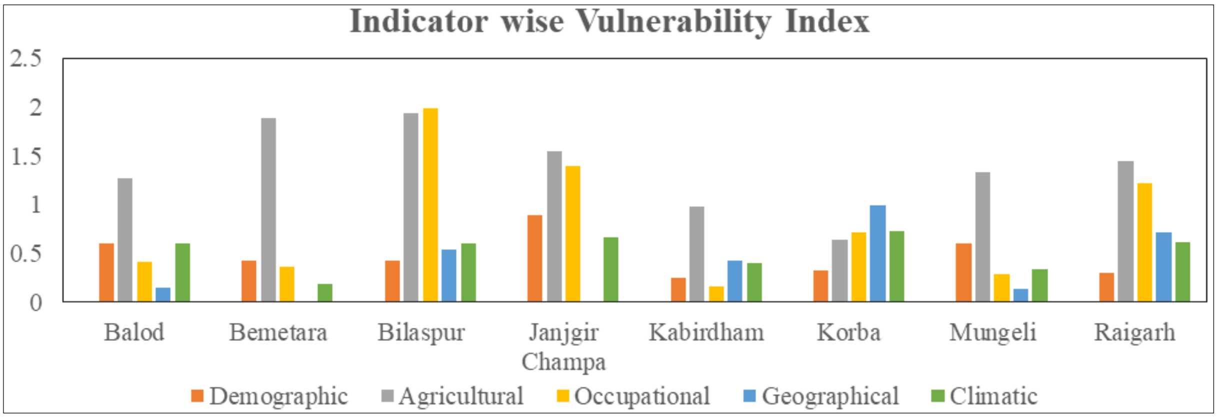

Fig. 1: Indicator wise vulnerability assessment in selected districts of Chhattisgarh Plains Zone-II

Table 3: Composite Vulnerability Index with their Ranks for selected districts of Chhattisgarh Plains Zone-II

S.N.	District	Composite Vulnerability Index (CVI)	Rank by CVI
1.	Balod	0.61	6
2.	Bemetara	0.71	4
3.	Bilaspur	1.10	1
4.	Janjgir-Champa	0.90	2
5.	Kabirdham	0.45	8
6.	Korba	0.68	5
7.	Mungeli	0.54	7
8.	Raigarh	0.86	3

Composite Vulnerability Index

Composite Vulnerability Index was carried out with the help of given formula. Using all the five indicators (Agricultural, Climatic, Demographic, Geographical and occupational), all the districts were ranked on the basis of their composite vulnerability index. The outcome was shown in the table 2. District Bilaspur was reported most vulnerable with highest CVI value (1.10) among all the eight districts in Plains zone-II of Chhattisgarh followed by district Mungeli and Balod. The district Kabirdham obtained CVI value 0.45 falls under least vulnerable districts among all. Shanabhoga and Krishnamurthy (2020) [6] investigated the Vulnerability and Adaptation Strategies for Climate Change among the Farmers of Hyderabad Karnataka Region during 2018-19. They reported that among the six districts, Yadagiri (0.64) belonged to very high degree of vulnerability to climate change whereas, Raichur (0.25) belonged to low vulnerability category.

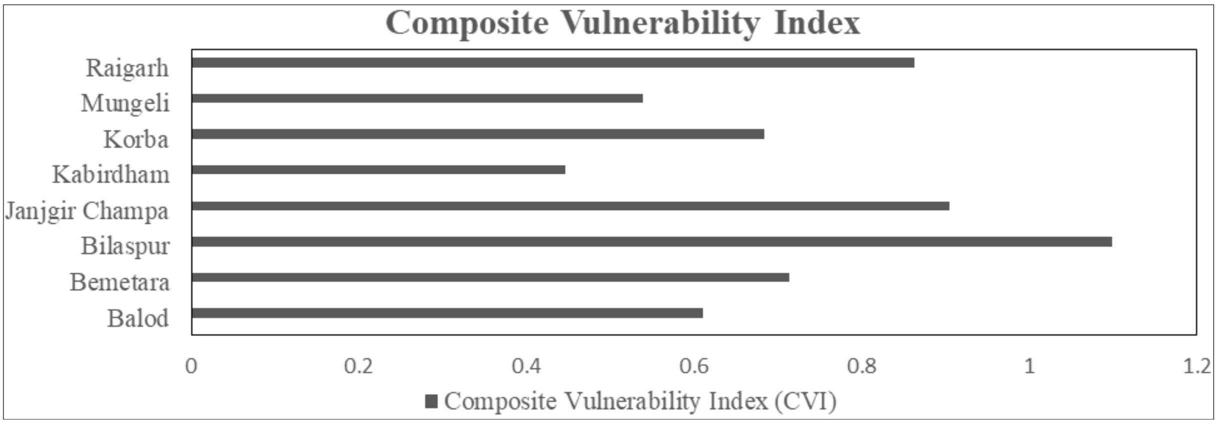

Fig 2: Composite Vulnerability Index of different districts of Chhattisgarh Plains Zone-II

Table 4: Garett's ranking score of Composite Vulnerability Index (CVI) for selected districts of Chhattisgarh Plains Zone-II

S. N.	District	CVI Rank	Garett's Percentage	Garett's Ranking
1.	Balod	6	68.75	41
2.	Bemetara	4	43.75	53
3.	Bilaspur	1	6.25	80
4.	Janjgir-Champa	2	18.75	68
5.	Kabirdham	8	93.75	21
6.	Korba	5	56.25	47
7.	Mungeli	7	81.25	32
8.	Raigarh	3	31.25	60

Garrett's ranking

The outcome of our analysis presented in table 3, reported that District Bilaspur was ranked 80 with 6.25 Garett's Percentage value hence, found most vulnerable district among all the selected districts of Chhattisgarh Plains Zone-II. District Kabir dham was given 21st Garett's rank with 93.75 Garett's Percentage showing less vulnerable district among all the selected districts. S. Shanabhoga *et al*. (2019) [7] worked on the vulnerability to climate change among the districts of Hyderabad and Karnataka region for the period of 2018-19. Various indicators are selected under three dimensions i.e., exposure, sensitivity and adaptive capacity. Results indicated that district Yadagir (0.64) belonged to very high degree of vulnerability to climate change whereas districts Ballari (0.58) and Bidar (0.50) were belonged to high and medium level of vulnerability respectively. It is also depicting that districts Kalburagi (0.45), Koppal (0.19) and Raichur (0.25) belonged to low vulnerability category.

Conclusion

To determine each district's vulnerability index, a district-level vulnerability assessment was conducted. Based on exposure, sensitivity, and potential for adaptation to climate change, specific indicators were chosen. The composite vulnerability index was calculated by taking into account all the selected indicators. Findings of the analysis shows that Bilaspur was the most vulnerable district and Kabirdham was the least vulnerable district among all the eight selected districts. To reduce the degree of susceptibility, it is recommended that Bilaspur, Janjgir-Champa, Raigarh and Bemetara districts need to be more prioritize. To improve the adaptive ability in rural and internal areas, it is necessary to take advanced and adaptive measures including water conservation, rainwater harvesting, better education and infrastructure development in these vulnerable districts.

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