

## **Original Research Article**

### **Mapping a climate change vulnerability index: An assessment in agricultural, geological and demographic sectors across the districts of Karnataka state (India)**

#### **Abstract**

Climate change is a continuous phenomenon and over hundreds of years, the atmosphere has changed considerably around the world. Karnataka has the second largest drought prone area in the country next only to Rajasthan. Assessment of vulnerability index could play a major role in designing appropriate mitigation and adaptation policies to overcome the impacts of climate change. The vulnerability assessment is an exhaustive procedure determined by a large number of indicators. This study attempted to capture a picture of composite vulnerability index of different districts of Karnataka by considering agronomic, climatic and demographic indicators. The secondary data on climatic, agronomic and demographic factors were collected from various sources for the year 2017-18. The findings of the study as shown that the average vulnerability index for 30 districts is 0.577 and 16 districts placed above the average composite vulnerability index level. Bidar (0.655) is the most vulnerable district followed by Kolar (0.658) and Yadgir (0.638) districts. Shivamogga (0.440), Davanagere (0.486) and Udupi (0.486) districts exhibit the least vulnerability to changing climate. The results suggest that agricultural and climatic indicators are the major factors which influence vulnerability. So special attention should be given to agricultural and climatic sectors to minimize the impacts of climatic change in the most vulnerable districts.

**Key words:** Vulnerability index, Climate change, Per capita income, Sensitivity, Exposure and Adaptability

**Introduction:** Agricultural economy in Karnataka is largely influenced by agro-climatic factors, water and other resource contributed by farmers, technology, infrastructure, tradition and social capital as also the market forces of demand and supply. Karnataka has the second largest drought

30 prone area in the country next only to Rajasthan and water availability is one of the major  
31 concerns in the state. Karnataka's annual rainfall is 1,151 mm on an average, of which 80 per  
32 cent is received during the southwest monsoon, 12 per cent in the post monsoon period, 7 per  
33 cent during summer and 1 percent in rabi season. Groundwater potential of the area depends on  
34 rainfall and efforts to recharge. Change in climatic conditions directly affects the hydrological  
35 cycle and gradually the groundwater table. Obviously the economic impact of climate change  
36 will severely affect the food security as well as livelihood security including health security of  
37 farmers (Chandrakanth, M. G., 2015).

38 Climate change is a continuous phenomenon and over hundreds of years, the atmosphere  
39 has changed considerably around the world. However, the pace and pattern of changes in  
40 climatic factors in recent decades have turned into a matter of concern. Especially, since it is  
41 very hard to comprehend the effect of change in climatic factors at the small scale level even,  
42 say, at block or district levels (Raju *et al.*, 2017). The Intergovernmental Panel on Climate  
43 Change (IPCC), in its second evaluation report (Anonymous, 1996), characterizes vulnerability  
44 as the degree to which environmental change may harm or damage a system. It infers that  
45 vulnerability not only depends on a system of sensitivity, but also in addition, on its capacity to  
46 adjust to new climatic conditions, the level of economic development and institutions.

47 It is well known that poor people in the least developed nations are the most vulnerable  
48 against the effects of anthropogenic environmental change (Stern *et al.*, 2006). The poor are  
49 antagonistically affected by the environmental change since they live in vigorously affected  
50 nations and areas inside those nations, rely upon natural resource-based livelihood that are  
51 lopsidedly influenced by climate change.

52 People who live in the semi-arid and arid region, in low-lying seaside regions, in water-  
53 restricted or flood-inclined zones or on little islands are especially vulnerable to environmental  
54 change (Watson *et al.*, 1996). Obviously climate change will, in many parts of the world,  
55 antagonistically influence socio-economic status, including water resources, farming, forestry,  
56 fisheries and human settlements, natural resources and human wellbeing with creating nations  
57 being the most vulnerable (IPCC, 2001).

58 There is a huge demand to create indicators of vulnerability and of adaptive capacity to  
59 decide the robustness of methodologies over time (Adger *et al.*, 2004). At the district level,  
60 vulnerability appraisals add to setting development needs and monitoring progress. Sectoral  
61 evaluations give details and focus to key improvement plans. In Karnataka, farmers and  
62 agriculture workers constitute 56 per cent of the aggregate workforce (Government of Karnataka,  
63 2005) and this is viewed as one of the main thrusts in deciding the vulnerabilities of farming  
64 families in Karnataka.

## 65 2. Methodology:

66 The key target of this assessment is to analyse the climate vulnerability of different  
67 sectors across the districts of Karnataka (Fig 1). Keeping in view of this appraisal the  
68 information relating to different indicators pertaining to agriculture year 2013-14 to 2017-18  
69 were collected from various sources such as Karnataka State Natural Disaster Monitoring Centre  
70 (KSNDMC), Directorate of Economics and Statistics (DES) and Central Groundwater Board  
71 (CGB).

72 The vulnerability assesment is an exhaustive procedure influenced by a large number of  
73 indicators. However only the most significant and appropriate indicators were chosen for  
74 calculation of vulnerability index based on exposure, sensitivity and adaptability to varied  
75 climate. Parameters used in this study include

76 **Climatic components:** Variance of annual rainfall ( $\text{mm}^2$ ), Variance of South-West monsoon  
77 ( $\text{mm}^2$ ), Variance of maximum temperature, Variance of minimum temperature and Variance of  
78 average temperature.

79 **Agricultural Components:** Geographical area (GA) (ha), Forest area (% of GA), Area under  
80 food crops (% of Gross Cropped Area(GCA)), Net sown area (% of GA), Livestock population  
81 (No. per ha of GCA), Irrigated area (% of GCA), Cropping intensity (%), Productivity of major  
82 crops (Paddy, Ragi, Jowar, Sugarcane, Maize, Groundnut, Sunflower, Cotton, Arecanut,  
83 Coconut, Redgram, Cowpea, Chilli), Depth of Groundwater (meter below ground level), Per  
84 capita income (Rs per person).

85 **Demographic components:** Density of male population (Persons per sq. ha of GA), Density of  
 86 female population (Persons per sq. ha of GA), Literacy rate of male (%) and Literacy rate of  
 87 female (%).

88 Composite Vulnerability Index (CVI) is assessed for each district by using Iyenger and  
 89 Sudarshan (1982) technique for unequal weight. The assessed CVI is a total of three sub-sectors  
 90 specifically Climatic Vulnerability, Agriculture Vulnerability and Demographic Vulnerability.  
 91 Development of vulnerability index and Composite Vulnerability Index comprises of several  
 92 steps.

93 **Step 1:** The information compiled pertaining to three components was transformed into suitable  
 94 estimation units and arranged in a rectangular matrix with rows representing districts and  
 95 columns representing indicators.

96 **Step 2:** Since every one of the sub-component is measured using different units and scale, they  
 97 need to normalized first. The procedure developed by Anand and Sen (1994) for construction of  
 98 the Human Development Index (HDI) is used to normalize indicators. In any case, before doing  
 99 normalization, it is imperative to distinguish the functional relationship between the indicators  
 100 and vulnerability. Two kinds of practical relationships, vulnerability increases with the increase  
 101 (decrease) in the value of indicators are conceivable.

102 **Table 1: List of indicators and their functional relationship with vulnerability**

Components	Indicators	Functional relationship	Reference
Demographic	Density of population	Direct (↑)	Palanisami <i>et al.</i> , 2009
	Literacy rate	Inverse (↓)	Palanisami <i>et al.</i> , 2009
Climatic	Variance of rainfall	Direct (↑)	Ravindranath <i>et al.</i> , 2011
	Variance of Temperature	Direct (↑)	Ravindranath <i>et al.</i> , 2011
Agricultural	Productivity of major crops	Inverse (↓)	Hiremath and Shiyani, 2013
	Cropping intensity	Inverse (↓)	Hiremath and Shiyani, 2013
	Irrigated area	Inverse (↓)	Hiremath and Shiyani, 2013
	Forest area	Inverse (↓)	Hiremath and Shiyani, 2013
	Net sown area	Inverse (↓)	Hiremath and Shiyani, 2013
	Livestock population	Inverse (↓)	Hiremath and Shiyani, 2013

	Geographical area	Inverse (↓)	Palanisami <i>et al.</i> , 2009
	Depth of Groundwater	Direct (↑)	Suresh <i>et al.</i> , 2016
	Per capita income	Inverse (↓)	Suresh <i>et al.</i> , 2016

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104 For direct relationship:

$$Y_{ij} = \frac{X_{ij} - \text{Min}(X_{ij})}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})}$$

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106 For indirect relationship:

$$Y_{ij} = \frac{\text{Max}(X_{ij}) - X_{ij}}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})}$$

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108 Where,

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110  $Y_{ij}$  is the normalized value

111  $X_{ij}$  is the actual value of the indicator

112  $\text{Min}(X_{ij})$  and  $\text{Max}(X_{ij})$  are the minimum and maximum actual values

113 **Step 3:** The degree of vulnerability ( $\bar{y}_i$ ) is assumed to be the linear sum of  $X_{ij}$  as

$$\bar{y}_i = \sum_{j=1}^k w_j Y_{ij}$$

114 Where  $w_j$ 's are weights and are determined by

$$w_j = \frac{c}{\sqrt{\text{var}(Y_{ij})}}$$

115 Where  $c$  is the normalizing constant

$$c = \left[ \sum_{j=1}^k \frac{1}{\sqrt{\text{var}(Y_{ij})}} \right]^{-1}$$

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117 The vulnerability index lies in the range of 0 and 1. A value of 1 indicates greatest vulnerability

118 and 0 shows absence of vulnerability.

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### 120 3. Results and Discussion:

121 The Sector wise vulnerability indices and composite index were constructed for all the 30

122 districts of Karnataka. The districts were ranked based on extent of vulnerability index.

#### 123 3.1 Component wise vulnerability index

### 124 **3.1.1 Climatic Vulnerability index**

125 To construct district level vulnerability index five climatic variables were used and the  
126 results are presented in the Table 2. The results show that the Kalaburagi district has the highest  
127 climate vulnerability index of 0.747 followed by Kolar (0.720), Bidar (0.720), Raichur (0.712)  
128 and Yadgir (0.711) districts. The districts of Kodagu and Udupi have only 0.278 and 0.215  
129 vulnerability index respectively, the least in Karnataka state. We can observe highest  
130 vulnerability index values in northern districts of Karnataka which is due to large variations in  
131 rainfall and temperature during the year. These are the key determinant indicators which explain  
132 high climatic fluctuations among districts.

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134 For instance, Prevalence of a high degree of anticipated change in mean precipitation and  
135 high inconsistency in minimum and maximum temperatures drove Kalaburagi district to the top  
136 of the chart.

### 137 **3.1.2 Agriculture Vulnerability index**

138 Based on functional relationship of the indicators, Vulnerability index for agricultural parameters  
139 were calculated for each district and is presented in Table 3.

140 Kodagu district secures first place with a total vulnerability index value of 0.787 followed  
141 by Bidar (0.761), Kolar (0.741) and Chitradurga (0.732) districts. Whereas Davanagere has been  
142 rated as least vulnerable district (0.524). Lower productivity, declined forest area, high  
143 groundwater table level, lower cropping intensity and low per capita income are the major  
144 factors which influence the high level of sensitivity leading to higher vulnerability index.

145 In general Kodagu, Bidar, Kolar and Chitradurga districts are most sensitive districts and  
146 highly vulnerable to climate change. On the contrary, Davanagere, Shivamogga, Bellary and  
147 Bengaluru Urban districts are less sensitive and least vulnerable to changing climate.

### 148 **3.1.3 Demographic vulnerability index**

149 The districts having high population density coupled with a lower rate of literacy were  
150 identified as vulnerable districts with respect to demographic features.

151 Bengaluru Urban (0.579) district occupied the first place whereas Dakshina Kannada  
152 (0.039) district is placed in the last position with respect to demographic vulnerability (Table 4).  
153 Yadgir (0.449), Raichur (0.353), Chamarajnaraga (0.335) and Kalaburagi (0.294) are the districts

154 having higher degree of vulnerability index next to Bengaluru Urban district. The coastal  
155 districts of Dakshina Kannada, Udupi (0.051) and Uttara Kannada (0.055) are having lower  
156 vulnerability index and higher adaptive capacity to changing climate because of high literacy rate  
157 and lower population density.

### 158 **3.2 Composite vulnerability index**

159 Agricultural indicators, climatic indicators and demographic indicators were used to  
160 construct composite vulnerability index. Table 5 shows district wise composite vulnerability  
161 index which is calculated using all the three sub-components (Agricultural, Climatic and  
162 Demographic). Average composite vulnerability index for 30 districts is 0.584 and 17 districts  
163 placed above the average composite vulnerability index level. Districts having high composite  
164 vulnerability index will be highly vulnerable to climate change. Bidar (0.577) district is having  
165 the highest composite vulnerability index followed by Kolar (0.658) and Yadgir (0.638). These  
166 districts are most vulnerable districts and the results are inline with the report submitted by  
167 Anonymous (2011) which used composite vulnerability index. They reported that Kalaburagi  
168 and Dakshina Kannada districts were the most and the least vulnerable districts, respectively.  
169 Higher composite index is observed mainly due to higher sensitivity of agricultural sector and  
170 larger exposure to climate change. Composite vulnerability index is lower for Shivamogga  
171 (0.440), Davanagere (0.486) and Udupi (0.486) districts because these districts are showing less  
172 vulnerability in terms of agriculture and climatic indicators. In addition also demographic  
173 variables such as population density and literacy rate have contributed to lowering of composite  
174 vulnerability index . At district level, contribution of each sub-component to composite index is  
175 not uniform. In general agricultural indicators contributed foremost, followed by climatic and  
176 demographic indicators. A study conducted by Hiremath and Shiyani (2013) reported that  
177 agriculture and occupation sector were the major sectors which have contributed most to  
178 composite vulnerability index in Saurashtra.

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### 180 **4. Conclusion:**

181 Karnataka is the second most drought prone state after Rajasthan. District wise  
182 vulnerability mapping was carried out to calculate the vulnerability index of each district. Sector  
183 wise indicators were selected based on exposure, sensitivity and adaptive capacity to climate  
184 change. All the indicators were considered to calculate composite vulnerability index. Findings

185 of the analysis shows that Bidar is the most vulnerable district and Shivamogga is the least  
186 vulnerable. Major component which is contributing to composite index is the Agricultural  
187 vulnerability. The results of agricultural vulnerability index analysis has highlighted the  
188 indicators such as productivity of the major crops, cropping intensity and per capita income are  
189 the major drivers in determining the vulnerability of districts. Therefore, it is suggested that  
190 Bidar, Kolar, Yadgir, Koppal and Chtradurga districts should be considered under on priority to  
191 minimize degree of vulnerability. There is a need to take up adaptive practices such as varietal  
192 selection according to prevailing weather, contingent cropping, soil and water conservation  
193 measures, in-situ moisture conservation, rainwater harvesting and augmenting recharging of  
194 groundwater for supplementary irrigation. In addition, better education and infrastructure  
195 development in rural areas will also play a catalytic role in enhancing adaptive capacity of these  
196 districts.

## 197 **5. References:**

198 Adger, W., Neil., Brooks, Nick, Bentham, Graham, Agnew, Maureen, and Eriksen, S., 2004.  
199 New indicators of vulnerability and adaptive capacity (Technical Report 7). Norwich,  
200 UK: Tyndall Centre for Climate Change Research.

201 Anand, S. and Sen, A., 1994, Human development index : Methodology and measurement.  
202 United Nations Development Programme, New York : Human Development Report  
203 Office.

204 Anonymous, 1996, Climate change second assessment report (1995). Intergovernmental panel on  
205 climate change. Geneva, Switzerland.

206 Anonymous, 2011, Karnataka Climate Change Action Plan, Bangalore Climate Change  
207 Initiative–Karnataka, Bengaluru (India) Final Report, Government of Karnataka.

208 Chandrakanth, M. G., 2015, *Water resource economics: Towards sustainable use of water for*  
209 *irrigation in India*, Springer, Switzerland.

210 Government of Karnataka. 2005, Human development report, Karnataka. Bangalore:Government  
211 of Karnataka.



- 212 Hiremath, D. B. and Shiyani, R. L., 2013, Analysis of vulnerability indices in various agro-  
213 climatic zones of Gujarat. *Indian Journal of Agricultural Economics*, **68**(1):122-137.
- 214 IPCC, 2001. Climate change 2001: The scientific basis—Contribution of working group I to the  
215 third assessment report of the intergovernmental panel on climate change. Cambridge,  
216 UK: Cambridge University Press.
- 217 Iyengar, N. S. and Sudharshan, P., 1982, A method of classifying regions from multivariate data,  
218 *Economic and Political Weekly, Special Article* : 2048-1052.
- 219 Palanisami, K., Paramasivam, P., Ranganathan, C.R., Aggarwal, P.K., and Senthilnathan, S.  
220 (2009). Quantifying vulnerability and impact of climate change on production of major  
221 crops in Tamil Nadu, India. In: Taniuchi, M., Burnett, W.C., Fukushima, Y., Haigh, M.,  
222 and Y. Umezawa, From headwaters to the ocean: Hydrological changes and watershed  
223 management. London: Taylor and Francis Group.pp.509-521.
- 224 Raju, K. V., Deshpande, R. S. and Satyasiba Bedamatta, 2017, Vulnerability to Climate Change:  
225 A Sub-regional Analysis of Socio-economic and Agriculture Sectors in Karnataka, India,  
226 *Journal of Development Policy and Practice*, **2**(1):24–55.
- 227 Ravindranath, N.H., Rao, S., Sharma, N., Nair, M., Gopalakrishnan, Rao, A.S. and Baka, G.,  
228 2011, Climate change and vulnerability profiles for north-east India. *Current Science*,  
229 **101**(3): 384-394.
- 230 Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S. and Dietz, S., 2006,  
231 *Stern review: The economics of climate change*. Oxford, UK: OUP.
- 232 Suresh, K., Biswas, H., Raizada, A. and Srinivas, S., 2016, Assesment of vulnerability to climate  
233 change:A case study of Karnataka, *Journal of Soil and Water Conservation*, Vol. 44, No.  
234 **3**, pp 314-320.
- 235 Watson, R.T., Zinyoera, M.C. and Moss, R.H., 1996, The regional impact of climate change: An  
236 assessment of vulnerability (A Special Report of IPCC Working Group II).Cambridge,  
237 UK: Cambridge University Press.

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239 **Tables**240 **Table 2: Index of climate vulnerability across the various districts of Karnataka**

Sl. No	Districts	Annual rainfall	S-W monsoon	Max Temp	Min Temp	Avg Temp	Index total
1	KALABURAGI	0.177	0.174	0.102	0.169	0.125	0.747
2	KOLAR	0.170	0.183	0.189	0.107	0.073	0.720
3	BIDAR	0.173	0.169	0.120	0.189	0.069	0.720
4	RAICHUR	0.183	0.183	0.082	0.127	0.138	0.712
5	YADGIR	0.181	0.177	0.088	0.130	0.135	0.711
6	VIJAYAPURA	0.185	0.182	0.087	0.147	0.100	0.701
7	RAMANAGARA	0.163	0.178	0.165	0.085	0.103	0.693
8	BALLARI	0.186	0.187	0.100	0.054	0.154	0.681
9	KOPPALA	0.183	0.184	0.063	0.096	0.141	0.667
10	BAGALKOTE	0.188	0.185	0.078	0.109	0.095	0.656
11	DHARWAD	0.181	0.179	0.118	0.094	0.070	0.643
12	DAVANAGERE	0.178	0.179	0.066	0.046	0.125	0.593
13	GADAG	0.189	0.186	0.061	0.075	0.082	0.593
14	CHITRADURGA	0.183	0.185	0.060	0.044	0.119	0.591
15	CHIKKABALLAPURA	0.176	0.183	0.055	0.077	0.094	0.585
16	BELAGAVI	0.174	0.166	0.058	0.103	0.083	0.584
17	TUMAKURU	0.176	0.181	0.044	0.055	0.105	0.561
18	HAVERI	0.179	0.174	0.072	0.051	0.082	0.559
19	MANDYA	0.172	0.185	0.038	0.026	0.116	0.537
20	MYSURU	0.173	0.182	0.023	0.036	0.101	0.514
21	CHAMARAJANAGARA	0.172	0.189	0.000	0.028	0.086	0.475
22	UTTARA KANNADA	0.078	0.074	0.139	0.077	0.106	0.474
23	BENGALURU RURAL	0.164	0.175	0.023	0.052	0.056	0.470
24	BENGALURU URBAN	0.157	0.168	0.015	0.038	0.055	0.431
25	HASSAN	0.152	0.149	0.024	0.043	0.052	0.421
26	CHIKKAMAGALURU	0.128	0.126	0.076	0.039	0.042	0.412
27	SHIVAMOGGA	0.103	0.082	0.053	0.058	0.076	0.372
28	DAKSHINA KANNADA	0.031	0.030	0.045	0.000	0.189	0.294
29	KODAGU	0.080	0.082	0.094	0.022	0.000	0.278
30	UDUPI	0.000	0.000	0.024	0.022	0.170	0.215

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246 **Table 3: Agricultural vulnerability index across the districts of Karnataka**

<b>District</b>	<b>Geographical area(Ha)</b>	<b>Forest area(% to GA)</b>	<b>Total food crops(% to GCA)</b>	<b>Net sown area(% to GA)</b>	<b>Livestock pon(No. per Ha of GCA)</b>
Kodagu	0.008	0.032	0.055	0.027	0.065
Bidar	0.013	0.051	0.026	0.016	0.063
Kolar	0.007	0.051	0.012	0.027	0.057
Chitradurga	0.026	0.048	0.031	0.024	0.059
Koppal	0.014	0.051	0.018	0.010	0.062
Hassan	0.019	0.048	0.022	0.021	0.061
Gadag	0.010	0.049	0.020	0.001	0.064
Dakshin Kannada	0.011	0.036	0.013	0.034	0.063
Dharwad	0.008	0.049	0.023	0.003	0.064
Haveri	0.011	0.048	0.021	0.006	0.062
Chikballapura	0.008	0.046	0.016	0.024	0.058
Bengaluru Rural	0.000	0.051	0.026	0.022	0.061
Kalaburagi	0.036	0.052	0.006	0.009	0.064
Raichur	0.026	0.053	0.014	0.018	0.061
Tumkuru	0.035	0.051	0.037	0.024	0.059
Mysuru	0.017	0.047	0.021	0.016	0.062
Chamarajanagara	0.014	0.021	0.017	0.034	0.061
Yadgir	0.013	0.050	0.028	0.014	0.061
Ramanagara	0.005	0.041	0.019	0.024	0.060
Chikkamagaluru	0.021	0.035	0.032	0.027	0.063
Vijayapura	0.034	0.054	0.003	0.000	0.064
Bagalkot	0.018	0.046	0.005	0.010	0.060
Uttar Kannada	0.033	0.000	0.004	0.044	0.059
Udupi	0.006	0.035	0.015	0.035	0.061
Mandya	0.011	0.051	0.010	0.026	0.058
Belagavi	0.046	0.045	0.014	0.016	0.065
Bellari	0.026	0.046	0.019	0.020	0.057
Bengaluru Urban	0.000	0.053	0.017	0.041	0.000
Shivamogga	0.026	0.032	0.000	0.035	0.060
Davanagere	0.015	0.044	0.005	0.013	0.062

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<b>Irrigated area(% to GCA)</b>	<b>Cropping intensity (%)</b>	<b>Productivity</b>	<b>Per capita income</b>	<b>Depth of groundwater (mbgl)</b>	<b>Index total</b>
0.049	0.045	0.443	0.046	0.018	<b>0.787</b>
0.041	0.034	0.438	0.051	0.030	<b>0.761</b>
0.038	0.056	0.442	0.045	0.006	<b>0.741</b>
0.032	0.037	0.410	0.048	0.017	<b>0.732</b>
0.027	0.040	0.426	0.050	0.012	<b>0.708</b>
0.032	0.037	0.378	0.042	0.038	<b>0.697</b>
0.035	0.029	0.402	0.046	0.038	<b>0.694</b>
0.012	0.041	0.449	0.014	0.011	<b>0.684</b>
0.041	0.000	0.429	0.041	0.024	<b>0.683</b>
0.028	0.039	0.394	0.048	0.020	<b>0.677</b>
0.029	0.048	0.381	0.046	0.012	<b>0.669</b>
0.034	0.057	0.358	0.037	0.020	<b>0.667</b>
0.040	0.041	0.332	0.051	0.033	<b>0.663</b>
0.023	0.039	0.379	0.049	0.000	<b>0.663</b>
0.025	0.044	0.345	0.040	0.003	<b>0.662</b>
0.026	0.024	0.371	0.045	0.030	<b>0.661</b>
0.019	0.037	0.392	0.044	0.017	<b>0.657</b>
0.023	0.034	0.379	0.051	0.003	<b>0.655</b>
0.034	0.053	0.352	0.039	0.028	<b>0.654</b>
0.036	0.035	0.353	0.029	0.021	<b>0.651</b>
0.025	0.053	0.348	0.050	0.018	<b>0.649</b>
0.014	0.036	0.378	0.041	0.037	<b>0.646</b>
0.024	0.050	0.364	0.043	0.021	<b>0.644</b>
0.027	0.045	0.386	0.024	0.007	<b>0.641</b>
0.005	0.033	0.356	0.039	0.039	<b>0.628</b>
0.011	0.027	0.325	0.049	0.025	<b>0.623</b>
0.014	0.032	0.297	0.040	0.013	<b>0.564</b>
0.029	0.049	0.361	0.000	0.003	<b>0.552</b>
0.000	0.047	0.266	0.036	0.025	<b>0.527</b>
0.012	0.049	0.267	0.048	0.010	<b>0.524</b>

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**Table 4: Demographic vulnerability index across the districts of Karnataka**

<b>District</b>	<b>Density of male population</b>	<b>Density of female population</b>	<b>Literacy rate of male (%)</b>	<b>Literacy rate of female (%)</b>	<b>Index total</b>
Bengaluru Urban	0.281	0.281	0.015	0.001	0.579
Yadgir	0.006	0.006	0.225	0.212	0.449
Raichur	0.006	0.006	0.165	0.176	0.353
Chamarajanagara	0.003	0.003	0.184	0.145	0.335
Kalaburagi	0.007	0.007	0.137	0.144	0.294
Bellari	0.010	0.010	0.120	0.129	0.270
Vijayapura	0.005	0.005	0.116	0.136	0.262
Ramanagara	0.011	0.012	0.119	0.112	0.255
Koppal	0.007	0.008	0.106	0.132	0.253
Bagalkot	0.010	0.010	0.101	0.128	0.249
Mandya	0.015	0.016	0.108	0.107	0.246
Chikkaballapura	0.011	0.011	0.112	0.112	0.245
Bidar	0.012	0.012	0.102	0.112	0.238
Mysuru	0.022	0.023	0.107	0.085	0.237
Belagavi	0.014	0.015	0.080	0.097	0.206
Kolar	0.016	0.017	0.083	0.086	0.202
Chitradurga	0.004	0.004	0.086	0.091	0.184
Davanagere	0.013	0.013	0.078	0.075	0.179
Tumakuru	0.008	0.008	0.075	0.083	0.174
Gadag	0.006	0.006	0.062	0.093	0.167
Bengaluru Rural	0.020	0.020	0.061	0.067	0.167
Hassan	0.008	0.009	0.069	0.077	0.163
Haveri	0.013	0.013	0.067	0.068	0.160
Dharwad	0.019	0.020	0.049	0.053	0.142
Chikkamagaluru	0.001	0.002	0.056	0.054	0.114
Shivamogga	0.005	0.005	0.052	0.046	0.107
Kodagu	0.000	0.000	0.043	0.030	0.073
Uttara Kannada	0.000	0.000	0.026	0.028	0.055
Udupi	0.011	0.014	0.013	0.013	0.051
Dakshina Kannada	0.018	0.021	0.000	0.000	0.039

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269 **Table 5: Composite index of vulnerability**

Sl. No	Districts	Composite index	Sl. No	Districts	Composite index
1	BIDAR	0.677	16	CHAMARAJANAGAR	0.579
2	KOLAR	0.658	17	MYSURU	0.574
3	YADGIR	0.638	18	TUMKUR	0.573
4	KOPPAL	0.636	19	HASSAN	0.571
5	RAICHUR	0.628	20	BENGALURU RURAL	0.558
6	CHITRADURGA	0.628	21	MANDYA	0.557
7	KALABURAGI	0.625	22	BELAGAVI	0.555
8	RAMANAGARA	0.604	23	BALLARI	0.543
9	VIJAYAPURA	0.602	24	BENGALURU URBAN	0.538
10	GADAG	0.599	25	CHIKKKAMAGALURU	0.531
11	DHARWAD	0.596	26	UTTARA KANNADA	0.530
12	KODAGU	0.594	27	DAKSHINA KANNADA	0.528
13	CHIKBALLAPUR	0.593	28	UDUPI	0.486
14	BAGALKOT	0.590	29	DAVANGERE	0.486
15	HAVERI	0.580	30	SHIVAMOGGA	0.440
					<b>Average=0.577</b>

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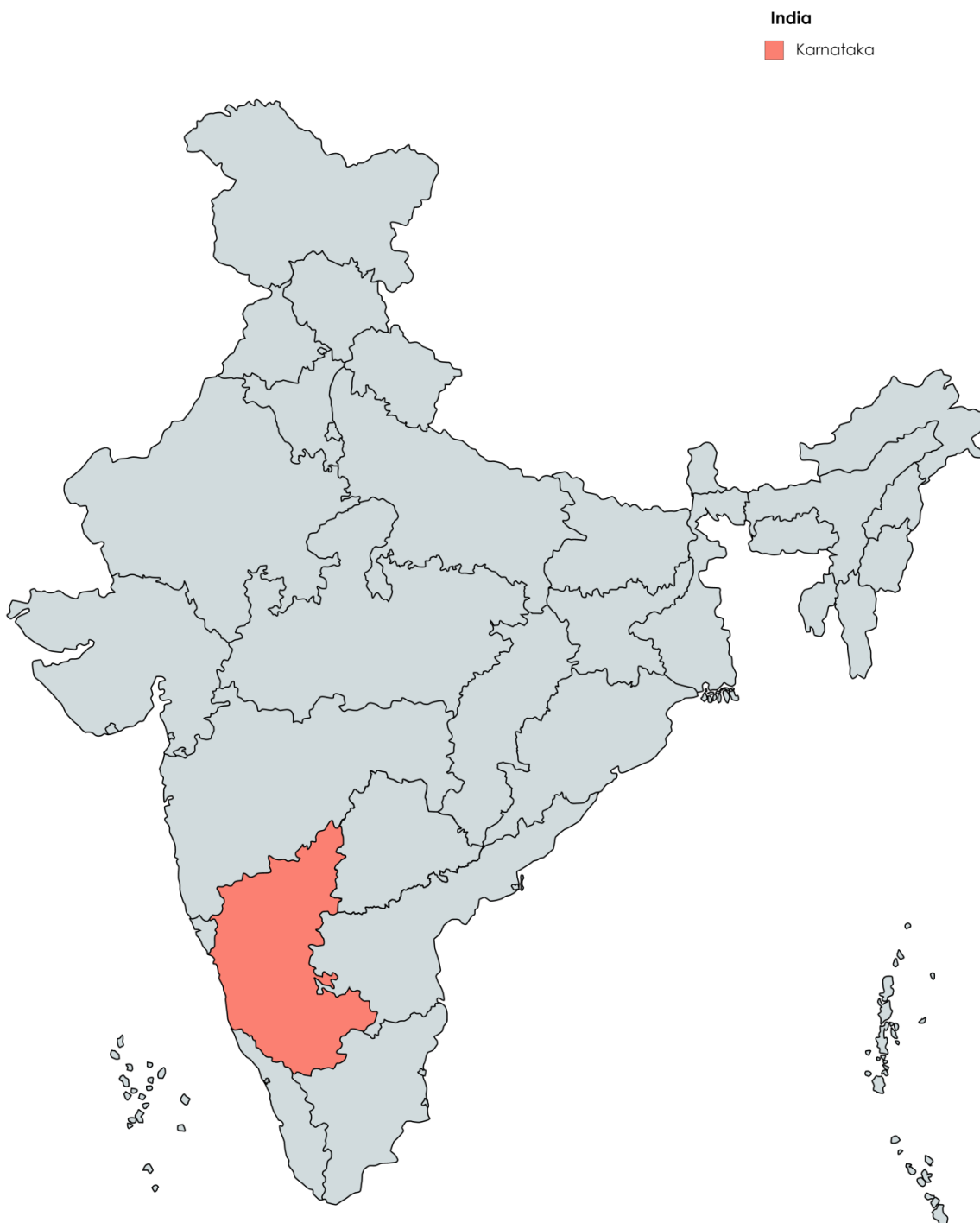
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**Fig 1: Map showing Karnataka state in India**



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284 **Fig:2 Climate Vulnerability of different districts of Karnataka (India)**

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