Mapping a Climate Change Vulnerability Index: An Assessment in Agricultural, Geological and Demographic Sectors across the Districts of Karnataka (India)

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Authors’ contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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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.

**Keywords:** Vulnerability index; climate change; per capita income; sensitivity; exposure and adaptability.

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

Climate change is a continuous phenomenon and over hundreds of years, the atmosphere has changed considerably around the world. However, the pace and pattern of changes in climatic factors in recent decades have turned into a matter of concern. Especially, since it is very hard to comprehend the effect of change in climatic factors at the small scale level even, say, at block or district levels [2]. The Intergovernmental Panel on Climate Change (IPCC), in its second evaluation report [3], characterizes vulnerability as the degree to which environmental change may harm or damage a system. It infers that vulnerability not only depends on a system of sensitivity, but also in addition, on its capacity to adjust to new climatic conditions, the level of economic development and institutions.

It is well known that poor people in the least developed nations are the most vulnerable against the effects of anthropogenic environmental change [4]. The poor are antagonistically affected by the environmental change since they live in vigorously affected nations and areas inside those nations, rely upon natural resource-based livelihood that are lopsidedly influenced by climate change.

People who live in the semi-arid and arid region, in low-lying seaside regions, in water-restricted or flood-inclined zones or on little islands are especially vulnerable to environmental change [5]. Obviously climate change will, in many parts of the world, antagonistically influence socio-economic status, including water resources, farming, forestry, fisheries and human settlements, natural resources and human wellbeing with creating nations being the most vulnerable [6].

There is a huge demand to create indicators of vulnerability and of adaptive capacity to decide the robustness of methodologies over time [7]. At the district level, vulnerability appraisals add to setting development needs and monitoring progress. Sectoral evaluations give details and focus to key improvement plans. In Karnataka, farmers and agriculture workers constitute 56 per cent of the aggregate workforce [8] and this is viewed as one of the main thrusts in deciding the vulnerabilities of farming families in Karnataka.

### 2. METHODOLOGY

The key target of this assessment is to analyse the climate vulnerability of different sectors across the districts of Karnataka (Fig. 1). Keeping in view of this appraisal the information relating to different indicators pertaining to agriculture year 2013-14 to 2017-18 were collected from various sources such as Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Directorate of Economics and Statistics (DES) and Central Groundwater Board (CGB).
The vulnerability assessment is an exhaustive procedure influenced by a large number of indicators. However only the most significant and appropriate indicators were chosen for calculation of vulnerability index based on exposure, sensitivity and adaptability to varied climate. Parameters used in this study include:

Climatic components: Variance of annual rainfall (mm$^2$), Variance of South-West monsoon (mm$^2$), Variance of maximum temperature, Variance of minimum temperature and Variance of average temperature.

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

Demographic components: Density of male population (Persons per sq. ha of GA), Density of female population (Persons per sq. ha of GA), Literacy rate of male (%) and Literacy rate of female (%).
Composite Vulnerability Index (CVI) is assessed for each district by using Iyenger and Sudarshan [9] technique for unequal weight. The assessed CVI is a total of three sub-sectors specifically Climatic Vulnerability, Agriculture Vulnerability and Demographic Vulnerability. Development of vulnerability index and Composite Vulnerability Index comprises of several steps.

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

**Step 2:** Since every one of the sub-component is measured using different units and scale, they need to normalized first. The procedure developed by Anand and Sen [10] for construction of the Human Development Index (HDI) is used to normalize indicators. In any case, before doing normalization, it is imperative to distinguish the functional relationship between the indicators and vulnerability. Two kinds of practical relationships, vulnerability increases with the increase (decrease) in the value of indicators are conceivable.

For direct relationship:

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

For indirect relationship:

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

Where,

- \( Y_{ij} \) is the normalized value
- \( X_{ij} \) is the actual value of the indicator
- \( \text{Min}(X_{ij}) \) and \( \text{Max}(X_{ij}) \) are the minimum and maximum actual values

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

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

Where \( w_j \)'s are weights and are determined by

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

Where \( c \) is the normalizing constant

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

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

| Components     | Indicators                        | Functional relationship | Reference                      |
|---------------|-----------------------------------|-------------------------|--------------------------------|
| Demographic   | Density of population             | Direct (↑)              | Palanisami et al. [11]         |
|               | Literacy rate                     | Inverse (↓)             | Palanisami et al. 2009         |
| Climatic      | Variance of rainfall              | Direct (↑)              | Ravindranath et al. [12]       |
|               | Variance of Temperature           | Direct (↑)              | Ravindranath et al. 2011       |
| Agricultural  | Productivity of major crops       | Inverse (↓)             | Hiremath and Shiyani, 2011     |
|               | 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 et al. 2009         |
|               | Depth of Groundwater              | Direct (↑)              | Suresh et al. [14]             |
|               | Per capita income                 | Inverse (↓)             | Suresh et al. 2016             |
3. RESULTS AND DISCUSSION

The Sector wise vulnerability indices and composite index were constructed for all the 30 districts of Karnataka. The districts were ranked based on extent of vulnerability index.

3.1 Component Wise Vulnerability Index

3.1.1 Climatic vulnerability index

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

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

3.1.2 Agriculture vulnerability index

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

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

Table 3. Agricultural vulnerability index across the districts of Karnataka

| District          | Geographical area (Ha) | Forest area (% to GA) | Total food crops (% to GCA) | Net sown area (% to GA) | Livestock pon (No. per Ha of GCA) |
|-------------------|------------------------|-----------------------|----------------------------|------------------------|-----------------------------------|
| 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                             |
| Chikballapur      | 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                             |
| Tumkur            | 0.035                  | 0.051                 | 0.037                      | 0.024                  | 0.059                             |
| Mysuru            | 0.017                  | 0.047                 | 0.021                      | 0.016                  | 0.062                             |
| Chamrajnaragona   | 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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| Irrigated area (% to GCA) | Cropping intensity (%) | Productivity | Per capita income | Depth of groundwater (mbgl) | Index total |
|---------------------------|------------------------|--------------|-------------------|---------------------------|------------|
| 0.049                     | 0.045                  | 0.443        | 0.046             | 0.018                     | 0.787      |
| 0.041                     | 0.034                  | 0.438        | 0.051             | 0.030                     | 0.761      |
| 0.038                     | 0.056                  | 0.442        | 0.045             | 0.006                     | 0.741      |
| 0.032                     | 0.037                  | 0.410        | 0.048             | 0.017                     | 0.732      |
| 0.027                     | 0.040                  | 0.426        | 0.050             | 0.012                     | 0.708      |
| 0.032                     | 0.037                  | 0.378        | 0.042             | 0.038                     | 0.697      |
| 0.035                     | 0.029                  | 0.402        | 0.046             | 0.038                     | 0.694      |
| 0.012                     | 0.041                  | 0.449        | 0.014             | 0.011                     | 0.684      |
| 0.041                     | 0.000                  | 0.429        | 0.041             | 0.024                     | 0.683      |
| 0.028                     | 0.039                  | 0.394        | 0.048             | 0.020                     | 0.677      |
| 0.029                     | 0.048                  | 0.381        | 0.046             | 0.012                     | 0.669      |
Table 4. Demographic vulnerability index across the districts of Karnataka

| District               | Density of male population | Density of female population | Literacy rate of male (%) | Literacy rate of female (%) | Index total |
|------------------------|---------------------------|------------------------------|---------------------------|----------------------------|-------------|
| 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       |
| Chikkballapura         | 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       |
In general Kodagu, Bidar, Kolar and Chitradurga districts are most sensitive districts and highly vulnerable to climate change. On the contrary, Davanagere, Shivamogga, Bellary and Bengaluru Urban districts are less sensitive and least vulnerable to changing climate.

3.1.3 Demographic vulnerability index

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

Bengaluru Urban (0.579) district occupied the first place whereas Dakshina Kannada (0.039) district is placed in the last position with respect to demographic vulnerability (Table 4). Yadgir (0.449), Raichur (0.353), Chamarajnagara (0.335) and Kalaburagi (0.294) are the districts having higher degree of vulnerability index next to Bengaluru Urban district. The coastal districts of Dakshina Kannada, Udupi (0.051) and Uttara Kannada (0.055) are having lower vulnerability index and higher adaptive capacity to changing climate because of high literacy rate and lower population density.

3.2 Composite Vulnerability Index

Agricultural indicators, climatic indicators and demographic indicators were used to construct composite vulnerability index. Table 5 shows district wise composite vulnerability index which is calculated using all the three sub-components (Agricultural, Climatic and Demographic). Average composite vulnerability index for 30 districts is 0.584 and 17 districts placed above the average composite vulnerability index level. Districts having high composite vulnerability index will be highly vulnerable to climate change. Bidar (0.577) district is having the highest composite vulnerability index followed by Kolar (0.658) and Yadgir (0.638). These districts are most vulnerable districts and the results are in line with the report submitted by Anonymous [15] which used composite vulnerability index. They reported that Kalaburagi and Dakshina Kannada districts were the most and the least vulnerable districts, respectively. Higher composite index is observed mainly due to higher sensitivity of agricultural sector and larger exposure to climate change. Composite vulnerability index is lower for Shivamogga (0.440), Davanagere (0.486) and Udupi (0.486) districts because these districts are showing less vulnerability in terms of agriculture and climatic indicators. In addition also demographic variables such as population density and literacy rate have contributed to lowering of composite vulnerability index. At district level, contribution of each sub-component to composite index is not uniform. In general agricultural indicators contributed foremost, followed by climatic and demographic indicators. A study conducted by Hiremath and Shiyani (2013) reported that agriculture and occupation sector were the major sectors which have contributed most to composite vulnerability index in Saurashtra.

| 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    | Kodaqui   | 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           |

Average=0.577
Fig. 2. Climate vulnerability of different districts of Karnataka (India)

4. CONCLUSION

Karnataka is the second most drought prone state after Rajasthan. District wise vulnerability mapping was carried out to calculate the vulnerability index of each district. Sector wise indicators were selected based on exposure, sensitivity and adaptive capacity to climate change. All the indicators were considered to calculate composite vulnerability index. Findings of the analysis shows that Bidar is the most vulnerable district and Shivamogga is the least vulnerable. Major component which is contributing to composite index is the Agricultural vulnerability. The results of agricultural vulnerability index analysis has highlighted the indicators such as productivity of the major crops, cropping intensity and per capita income are the major drivers in determining the vulnerability of districts. Therefore, it is suggested that Bidar, Kolar, Yadgir, Koppal and Chtradurga districts should be considered under on priority to minimize degree of vulnerability. There is a need to take up adaptive practices such as varietal selection according to prevailing weather, contingent cropping, soil and water conservation measures, in-situ moisture conservation, rainwater harvesting and augmenting recharging of groundwater for supplementary irrigation. In addition, better education and infrastructure development in rural areas will also play a catalytic role in enhancing adaptive capacity of these districts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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