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CLIMATE CHANGE VULNERABILITY INDEX FOR KARNATAKA: ADAPTIVE CAPACITY, EXPOSURE AND SENSITIVITY FOR THE DISTRICTS OF KARNATAKA

Karnika A* and Krishna Raj**

Abstract

Climate change is a global phenomenon that will have a long-lasting effect. These effects, however, differ according to the regions and sectors. The objective of this paper is to study the intensity of climate vulnerability across the districts in different climatic zones in Karnataka through the construction of a climate change vulnerability index, and to analyse the climate vulnerability among socio-economic groups in the districts of Karnataka. The focus of the study has been on the region of Karnataka and its districts for analysing their level of vulnerability and studying their socio-economic backgrounds that explain this vulnerability to climate change. Data was collected from several state and central government reports, various census reports, ICRISAT, IMD reports, etc. Principal Component Analysis and Factor Analysis have been done to arrive at conclusions. A choropleth map has also been designed to indicate the scale of vulnerability of the districts. It was found that the vulnerability of a district is influenced not just by its location but also by its demographic and socio-economic background. The computation for the vulnerability index has been done by estimating the exposure, sensitivity and adaptive capacity indexes, a framework suggested by the Intergovernmental Panel on Climate Change (IPCC), 2007. The districts having very high vulnerability index to climate change have been observed on average to have high sensitivity, high exposure, and low adaptive capacity and the districts with low vulnerability index are found to have high adaptive capacity with low exposure or low sensitivity. The index levels are studied in the background of various socioeconomic, demographic and agricultural indicators for the districts hence, the level of intensity of climate change in the districts may differ from one another. Ballari, Raichur, Gulbarga, and Yadgir are found to have climate vulnerability compared to other districts and are also observed to have high levels of poverty, female-male sex ratios, and scheduled caste and scheduled tribe populations.

Key words: Climate Change, Vulnerability Assessment, Adaptability, Exposure, Sensitivity, Principal Component Analysis

Introduction

Global climate change has now been understood as the most pressing issue affecting the survival of humans. It is considered the most complicated environmental problem and could endanger global food security and agriculture. India has been the nation most severely impacted by heat waves over the previous few years, according to the Global Climate Risk Indices. Global warming-induced meteorological and hydrological changes can severely affect the society and economy of India. Also, because it's a developing country, there are higher chances for the nation to leave the poor and underprivileged in the chains of financial and economic losses due to calamities. According to the Council of Energy, Environment and Water Report (Wadhawan, 2021), more than 80% of the population of India is highly vulnerable to hydro-met disasters and the southern part of India is exposed

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to extreme climate events. The vulnerability of the states of this region is followed by those in the east, west, northeast, north and central. The Indian subcontinent has seen several natural disasters throughout recorded history. According to (Sinha, 2003), the Indian landmass is susceptible to cyclones, droughts, floods, and earthquakes by 57%.

Natural resource systems are at danger of being disrupted by climate changelrading to a negative effect on populations reliant on these ecosystems. The vulnerable areas are worse off since they cannot effectively reduce the effects of climate change, and the poor are the section of society, most affected by anthropogenic climate change. A study by the Karnataka State Natural Disaster Monitoring Center states that the northern and coastal areas of Karnataka have been facing a declining trend in rainfall, in addition to high fluctuation in rainfall patterns. The state has faced 11 years of drought and two years of floods since 2000, and in 2018, the state dealt with both flood and drought. This reveals the importance of studying this region. It also emphasises the importance of studying the region of Karnataka. Hence, we assess the vulnerability index for districts of Karnataka in this present study.

A crucial component of integrating assessments of the effects of climate change into current development planning is a vulnerability assessment. Assessing vulnerability to climate change is important for developing countries, especially India. Over the past few decades, techniques to estimate vulnerability have been developed in domains connected to natural hazards, food security, poverty analysis, sustainable livelihoods, etc. There is a growing body of literature that studies the climate vulnerability and adaptation mechanisms taken by various states and countries around the globe for climate change. (Patwardhan, 2002)

Relationship of Climate Vulnerability: Exposure, Sensitivity and Adaptive Capacity

Earlier studies focused on the physical aspects of vulnerability like the spatial distribution of population, the nature of infrastructure in the region of hazard, now the studies tend to have a greater focus on social aspects of vulnerability. The level of susceptibility of people to a hazard will depend on the social, economic and political patterns in which people are. While vulnerability research on natural hazards developed an integral knowledge of environmental risks with human response drawing on geographical and psychological perspectives as well as social parameters of risk, entitlements-based explanations of vulnerability focused almost exclusively on the social realm of institutions, well-being, and class, social status, and gender as important variables (Suresh Kumar, 2016). Vulnerability is the combination of attributes like physical, social and environmental factors that impact a system at times of hazard.

The most widely used definition of vulnerability, developed in the IPCC's third and fourth assessment reports (2014), is the degree to which a system is susceptible to or unable to deal with the negative effects of climate change, climate variability, and extremes. This study will follow the framework according to (Intergovernmental Panel on Climate Change (IPCC), 2007), which states that the source of vulnerability depends on exposure, sensitivity, and adaptive capacity. While sensitivity refers to how much the system is impacted by climate-related stress or severe events, exposure in the fourth assessment report refers to the size and duration of the stress, such as a drought or a change in precipitation. The system's capacity to endure or recover from extreme events or damage is called adaptive capacity in the fourth assessment report. The Special Report on Extreme Events and Disasters (2012) of the IPCC warned that climate change will cause a rise in the intensity, frequency, length, and geographic scope of weather-related events, posing increasing future public health issues. Although these hazards are likely to occur more frequently and with greater intensity, the population's vulnerability risk factors and associated health impacts depend on the interaction of the following factors: hazard exposures, such as floods or extreme heat events that are expected to rise with climate change, a community's pre-existing sensitivities or the inherent characteristics and conditions that make people more likely to be impacted by the exposures like age, and adaptive capacities which are individual and collective resources that are sufficient to adjust to the actual or expected climate and its effects. Vulnerability is a multidimensional and dynamic process and helps build resilience to a region's external risks. Assessment of vulnerability fluctuates between biophysical, which is outcome-based vulnerability, and social environment, which is contextual vulnerability, and the concepts behind them differ with the researcher's interpretation of vulnerability.

In this study, we will be following an integrated approach involving both the biophysical and social environment, that is, using adaptive capacity (socioeconomic) and sensitivity and exposure (biophysical) components for computing the climate change vulnerability index, as suggested by the IPCC framework. (Balasubramanian M. , 2020)

Literature review

The concept of 'vulnerability' can be analysed and studied at different scales or levels like regional or country level, sub-national level, community level, household level or even at the individual level, and there is a growing body of literature on climate change vulnerability, livelihood vulnerability, socioeconomic vulnerability. There have also been different approaches to vulnerability used in literature.

Adger (2006) mentions two major types of traditions in the early works on the predecessors of the concept of vulnerability where its analysis in terms of lack of entitlements and analysis of vulnerability to natural hazards. The successors and the current research on vulnerability try to understand it holistically and try merge the research that is systems-oriented with the advances in methods.

Terry Cannon (1994) used the 'Pressure and Release Model' where they proposed that one pressure of vulnerability is physical and biological hazards and an additional pressure is the cumulative progression of it, which emerges from the locality and builds up to the social differentiation. This paper points to class inequality while citing the example of the Guatemala earthquake in 1976, terming it as the 'class quake' where the people living in the slums were the most affected. They claim that for the less fortunate segment of the population, hazardous regions are typically cheaper and easier to access for accommodation. Therefore, those in difficult economic conditions are forced to live in disaster-prone areas and locales.

The strategy put out by Turner (2003) in his seminal paper, aims to study the components of vulnerability (its exposure, sensitivity, and resilience) of a bounded system at a specific geographical scale rather than concentrating on numerous consequences from a single physical stress. Additionally, it aims to quantify and clarify the connections to other scales and the effects of responsibility and action on other system components (such as the degree of exposure of ecological components or communities).

Senapati (2017) in his study examined the socioeconomic effects of climate change and the susceptibility of Mumbai, India's "Koli" fishing villages. Due to their inability to use effective mechanised boats and cutting-edge fishing equipment, such as fish finders and GPS, it has been discovered that fishermen from the villages of Madh and Worli are more sensitive and less adaptive and were identified as being extremely vulnerable based on the vulnerability scores. Large-scale fishermen who use mechanised equipment are less vulnerable than small-scale fishers.

Cutter (2003) used the Social Susceptibility Index (SoVI), a measure of social susceptibility to environmental hazards, in the United States based on 1990 data. It was created using county-level socioeconomic and demographic data. With the help of a factor analysis method, 42 variables were condensed into 11 independent components that explained almost 76% of the variance. To create a summary score called the Social Vulnerability Index, these variables were added together in an additive model. The most vulnerable countries were concentrated in metropolitan counties in the east, south Texas, and the Mississippi Delta region. The study discovered some notable spatial trends in the SoVI.

The study by Akukwe (2005), used an integrated vulnerability assessment approach in a spatial pattern, where the indicators of adaptive capacity, sensitivity and exposure were used as per the definition of the Intergovernmental Panel on Climate Change. The objectives of the study was to review the socio-economic characteristics and adaptability of locals for the 13 zones in the Port Harcourt metropolis. The study developed a vulnerability map showing the spatial pattern of different levels of flood vulnerability. They found that the spatial pattern decreased as it moved towards the centre of Port Hart mouth and increased towards the northwest, southwest and northeast parts of the Port.

Rathi (2022) in a study aim to assess the multi-dimensional heat vulnerability index for four cities with different socio-economic and cultural backgrounds in India. According to the study, such a heat vulnerability index helps classify the vulnerable population and helps to advance adaptive practices. For this analysis, a composite index for household vulnerability is followed by a multidimensional approach. The study results show that a large proportion of households across the districts, fell under the category of moderate to high vulnerability levels. Further, it was also found that there was a higher significant relationship of household vulnerability to adaptive capacity than to sensitivity and exposure.

Balaganesh (2020) studies one of the most vulnerable states to drought which has impacted agriculture and allied activities. They have attempted to develop a composite drought vulnerability index that captures both crop and dairy indicators for the 30 districts of Tamil Nadu, India. The selection and computation of the index was based on the approach defined by the IPCC which includes the use of exposure, sensitivity and adaptive capacity. Findings from the index observed Tamil Nadu’s Erode as the least vulnerable to drought and Kanchipuram as highly vulnerable. They identified about 12districts to be highly vulnerable, eight to be moderately vulnerable and 10to be less vulnerable from the district-level mapping they did. A majority of Tamil Nadu's districts in the northwestern, western, and high rainfall zones were less vulnerable than the districts in the north eastern, southern, and Cauvery delta agro-climatic zones, as well as a few other districts.

Brien (2004) in the paper 'Mapping Vulnerability to multiple stressors: climate change and globalisation in India' considers a process with four key phases (1) creating a national vulnerability profile at the district level for climate change; (2) creating a national vulnerability profile at the district level for another stressor; (3) superimposing the profiles to identify "double exposed" districts in India; and (4) conducting case studies in the chosen districts. The outcomes of these case studies confirm the macro-profiles' predictions that sensitivity to climate change and economic transformation will coexist. The case study results also indicated that, in the context of trade liberalisation, state-level agriculture policies, which differ throughout India, may be crucial in enhancing local resilience to climatic variability and change.

In the evaluation of the vulnerability assessment for Georgia, done by Binita (2015) both biophysical and socio-demographic indices of susceptibility are considered. They propose a vulnerability score for biophysical measurements that considers both longer-term variations in precipitation and temperature as well as sporadic occurrences like floods, heat waves, and drought episodes. The index considers relevant socio-demographic and topographical factors that show how well humans can absorb or tolerate the biophysical effects of climate change. The study also discovered that social vulnerability, combined with environmental exposures like anomalies in temperature, precipitation, and severe events, led to a high level of climate change vulnerability in the most recent 10years.

In the study conducted by Ravindranath (2011), a collection of indicators representing important areas of vulnerability (agriculture, forests, and water) was chosen using the Statistical Method Principal Component Analysis in an index-based approach. The objective of using this method was to: (i) identify and prioritise the most susceptible districts and sectors; (ii) determine adaptation activities; and (iii) mainstream adaptation in development programmes. Impact assessment models were used to calculate the impacts of climate change on important sectors as indicated by changes in the indicators. According to the findings, the bulk of the districts in North East India are now, and in the near future, vulnerable to climate change. This groundbreaking study ranks the districts in North East India according to the values of the vulnerability index.

The authors of the study "A Climate Change Vulnerability Index and Case Study in a Brazilian Coastal City" by Zanetti (2016) noted that while several coastal vulnerability indices have been constructed to assess coastal vulnerability, these indexes are still not sufficiently developed to simultaneously consider inland and ocean hazards. The authors of this paper have created the Socio-Environmental Vulnerability Index for Coastal Areas to help close this knowledge gap. The score demonstrated that the bulk of the city is located in regions extremely vulnerable to flooding caused by heavy rainfall events and sea-level rise, according to IPCC criteria.

Uniqueness of the current study

There have been concerns identified in the previous vulnerability studies that have been addressed in this study (ford 2018)

Firstly, the study investigates a longitudinal data set for climate-related factors to know about the pattern of climate vulnerability over a period and cross-section data for other variables. This will help us give a meta-analysis of the impacts and changes in climate-related factors over time on the income, education, and occupation of people from different social and economic backgrounds. Secondly, the study focuses on socio-economic factors being impacted and influenced by climate change and not just climate-related indicators. By considering the major non-climatic indicators of sensitivity, adaptive capacity and exposure that affect vulnerability, we make sure they are not being overlooked. Thirdly, we investigate the socio-economic and demographic background of the society for factors like land holding, access to basic needs, and education. This is done to specifically assess the impacts faced by the less privileged communities in the highly vulnerable districts.

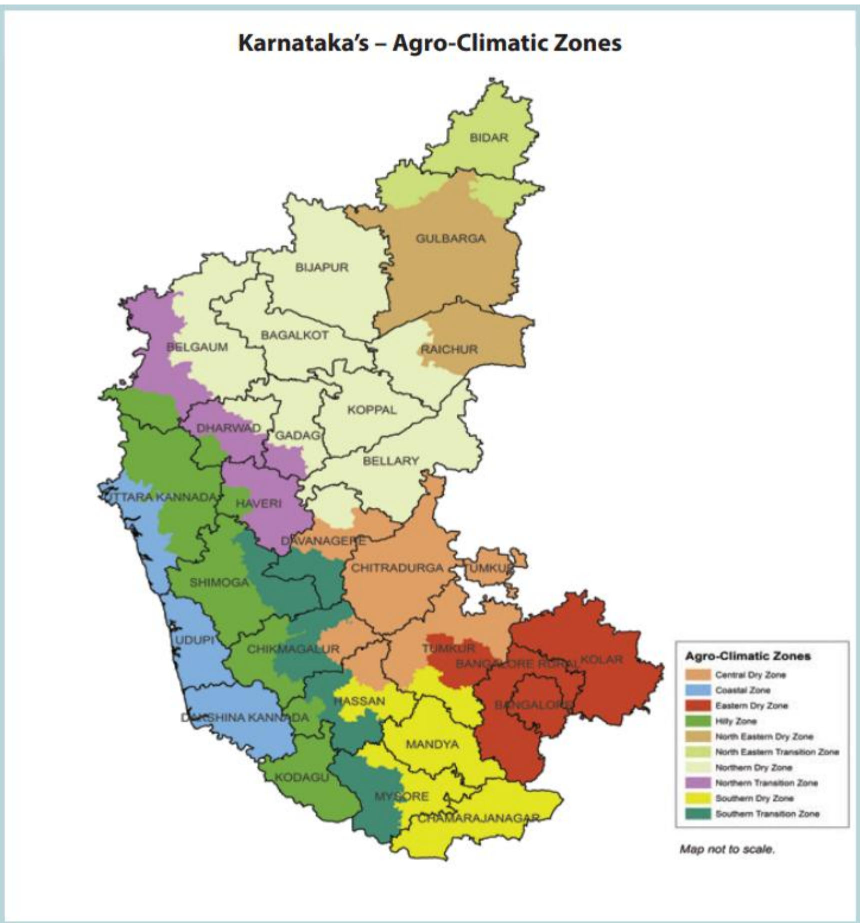
Materials and Methods

Study area

Karnataka falls in zones X and XII, which are the southern plateau, hilly region and west coast plain, ghat region respectively. Based on the state's soil structure, humidity, rainfall, vegetation and topography, Karnataka has been divided into 10 agro climatic zones. Some districts in the zones located in the hilly region receive lesser rainfall and are more arid compared to those zones that lie in the coastal and Malnad regions. From earlier studies, it can be known that Karnataka has the second largest arid and semi-arid lands after Rajasthan and is hence, very dependent on rainfall. The state has more than 80% of farming communities as small and marginal farmers having lesser access to food and water resources when a disaster like drought hits. The state has gone through several episodes of intense droughts and substantial variations in the rainfall patterns across the districts. The eastern regions of Chitradurga district receive the least rainfall (477 mm) each year, while the Western Ghats receive the most (4,747 mm). For over two-thirds of the state, the annual precipitation is less than 750 mm. The south and north interior Karnataka regions' central districts receive less rainfall on average. The southwest monsoon season brings in 250–500 mm of seasonal precipitation and 500–1000 mm of yearly precipitation—less than 750 mm—to this part of the state. There has been a decrease in the yearly rainfall in the districts of Kodagu, Kalaburagi, Yadgir, Dakshina Kannada, and Uttara Kannada, whereas Shivamogga and Hassan have experienced an increase in rainfall. Rainfall variability is said to be higher between years in some areas of Vijayapura, Bagalkote, Raichur, Koppal, Ballari, Gadag, Dharwad, Belagavi, Haveri, Davanagere, Chitradurga, Chikkamagaluru, Bengaluru, and Ramanagara districts. In addition, during the past 20 years, there has been a rise in the frequency of droughts and an increase in extreme rainfall events in various parts of the state. (Environmental Management and Policy Research Institute, 2021)

Parts of the Deccan Plateau, the Coastal Plains, and the Western Ghats Mountain Range make up Karnataka. The Northern Karnataka Plateau, Central Karnataka Plateau, Southern Karnataka Plateau, and Coastal Karnataka Region are the four physiographic landforms that make up the state. The districts of Yadgir, Kalaburagi, Belagavi, Bidar, and Vijayapura are all part of the Northern Karnataka Plateau. The Northern Plateau slopes eastward and is situated between 300 and 600 metres above sea level. The large, treeless plateau is broken up by ridges, river flats, watersheds, and leftover hills. Rivers Bhima, Ghataprabha, Krishna, and Malaprabha stand in for the river plains. The districts of Ballari, Chikkamagaluru, Chitradurga, Davanagere, Dharwad, Gadag, Haveri, Raichur, Koppal, and Shivamogga are all part of the Central Karnataka Plateau.

The districts of Ballari, Chikkamagaluru, Chitradurga, Davanagere, Dharwad, Gadag, Haveri, Raichur, Koppal and Shivamogga are all part of the Central Karnataka Plateau. The Central Plateau slopes eastward and varies in elevation between 450 and 700 metres. This area contains the basin of the Tungabhadra River. Bengaluru Urban, Bengaluru Rural, Tumakuru, Ramanagara, Hassan, Kodagu, Kolar, Chikballapur, Mandya, Mysuru, and Chamarajanagar districts are all part of the Southern Karnataka Plateau. The steeply sloping Western Ghats surround this area on both the west and south sides. The Western Ghats in the west and the edge of the Karnataka Plateau in the east mark the beginning and end of the Coastal Karnataka region. The districts of Uttar Kannada, Udupi, and Dakshin Kannada are all part of the coastal area. This area is covered in hill ranges and peaks, rivers, creeks, and waterfalls.



Source: National Dairy Development Board, Karnataka

Objective of the study

1. To study the intensity of climate vulnerability across the districts in different climatic zones in Karnataka through the construction of climate change vulnerability index.
2. Studying the climate vulnerability among socio-economic groups in the districts of Karnataka.

Data Sources

Data for the various indicators of vulnerability was taken from secondary sources. Information regarding GDP, PCI, No. of schools, No. of livestock, irrigated land, etc. were taken from Karnataka at a Glance. Demographic information like sex ratio, population above 60 and below 14, SC ST population, literacy rate, untreated drinking water etc. are taken from Census 2011 reports, and information relating to yield, no. of agricultural holdings, share of agriculture labourers etc. from the agricultural census 2015-16. Other required data was sourced from government portals like Karnataka State reports, Karnataka Health Dossier, Karnataka State Natural Disaster Management reports, ICRISAT, and IMD reports.

Vulnerability Assessment

As defined earlier, the vulnerability index is arrived at by estimating the index figures of the three components: adaptive capacity, exposure and sensitivity according to the framework provided by IPCC 2004.

Vulnerability = (Exposure + Sensitivity) – Adaptive Capacity

The combined effect of Exposure and Sensitivity is called the potential impact. Both these indices on average have a positive relationship with climate change vulnerability and adaptive capacity has a negative relationship with the vulnerability to climate change. Hence, the vulnerability level of a particular region is measured over the adaptive capacity of that region.

Steps in the assessment of vulnerability

Identification of suitable indicators

Indicators that are selected for the study have been chosen from a thorough review of literature and consultation from experts. Indicators used for the estimation of each index with their functional relationships to respective indices

Adaptive Capacity	Exposure	Sensitivity
GDP (Karnataka Economic Survey) (+)	RAINFALL (Karnataka at a Glance) (+)	FOOD SECURITY – Yield (Karnataka At a Glance) (-)
PCI (Karnataka Economic Survey) (+)	TEMPERATURE (MIN, MAX) (+) (ICRISAT)	%MARGINAL AND SMALL FARMERS TO TOTAL (Agriculture census 2015-16) (+)
LITERACY ABOVE SECONDARY EDUCATION (HDR 2022) (+)		%FOREST AREA TO TOTAL AGRI LAND (Karnataka Economic Survey) (-)
NO. OF SCHOOLS (Karnataka at a Glance) (+)		GROUNDWATER DRAFT (+)
LFPR (HDR 2022) (+)		POPULATION OF AGES BELOW 0-14 AND ABOVE 60 (Karnataka at a Glance)(+)
NO. OF LIVESTOCK (Karnataka at a glance) (+)		UNPROTECTED WATER SOURCE (Census 2011) (+)
NET AREA SOWN(Agriculture Census) (-)		PERCENT OF SC ST POPULATION (+)
INFRASTRUCTURE INDEX- CONNECTIVITY TO ROADS (Karnataka at a Glance) (+)		
%AGRICULTURAL LABOURERS TO TOTAL LABOURERS (Karnataka at a Glance) (-)		
IRRIGATED LAND (Karnataka at a Glance 2021)(+)		
SGDP FROM AGRICULTURE (+)		
%CROPPING INTENSITY (Karnataka at a Glance) (-)		

Indicators of exposure and their functional relationship

According to IPCC (2014), Exposure is the presence of individuals, means of subsistence, species, or ecosystems, as well as infrastructure and economic, social, or cultural assets in areas that may be negatively impacted by climate change. The average of minimum and maximum temperature, actual annual rainfall, and the districts affected due to extreme events like drought or floods are the indicators that are taken to measure the exposure index. All these indicators will influence food yield and production and will affect the people who are dependent on them. It can indirectly affect those from the other sectors as well. In regions that are arid, a slight rise in temperature will make them even more vulnerable and prone to sickness, reduced access to water sources, food insecurity, etc.

The **average of the maximum and minimum temperatures** over 35 years (1980-2015) have a positive functional relationship with exposure to climate change vulnerability since when the percentage change in temperature rises above the maximum or falls below the minimum temperature, the effect of vulnerability also rises or falls respectively. The variability in the temperatures is calculated from the monthly estimates for the 30 years of the districts of Karnataka.

Average annual rainfall (mm) over 35 years (1980-2015) is taken for the study and it has been observed to have a positive functional relationship with exposure to climate change vulnerability. When it's over or below the average can cause disturbances in agriculture and production. (Rajesh Kalli, 2021)

Indicators of sensitivity and their functional relationship

Sensitivity has a positive functional relationship with climate vulnerability. Sensitivity is defined as the degree of effect or modification in a region caused by a disturbance caused by climate change. In this study, the indicators taken for sensitivity include domains that are economic and social. From the variables taken under this index,

Population density for ages above 60 and below 14, represented as the number of persons per square kilometre, has a positive functional relationship with climate vulnerability, as when the number of persons per sq.km increases, their vulnerability to climate change also increases. It reveals the density of vulnerable populations in the region.

Percent of the **SC and ST population** has a positive functional relationship with sensitivity. When the proportion of SC and ST in a particular region increases, their sensitivity to climate change also increases.

Percent of the **SC and ST population** with **unprotected water sources** has a positive functional relationship with the index sensitivity to climate vulnerability. As the proportion of people's access to unprotected water sources increases, their vulnerability also increases.

Percent of **small and marginal farmers to total farmers** has a positive functional relationship concerning sensitivity to climate vulnerability since when the proportion of the susceptible class of farmers increases the impact of climate change endured by them will also be higher.

Percent of **forest area** to the total geographical area has a negative functional relationship with vulnerability.

Food grain yield per hectare is taken as a proxy for food security available in the districts of Karnataka. It has a negative functional relationship with the sensitivity of the vulnerable population since the higher the yield, the less vulnerable people would be.

The percentage **of annual groundwater draft** or groundwater extraction has a positive functional relationship with sensitivity to climate vulnerability since the higher the extraction,the more affected will people be in case of climate change.

Multi-Dimensional Poverty Index measures the overall poverty levels of the individuals deprived of education, monetary welfare, basic infrastructural facilities, etc.

Indicators for adaptive capacity and their functional relationship

IPCC defines adaptive capacity as the 'potential of a system to adapt to climate change, variability or any extremes to moderate the challenges, cope with the consequences, and to take advantage of the opportunities. Adaptive capacity has a negative functional relationship with climate vulnerability. Various biophysical, socioeconomic, and technological factors make up the adaptive capacity. The following are the determinants taken for finding the adaptive capacity index. Income in **per capita income**, education in **secondary education of males and female**s, **no. of schools** and employment in **labour force participation rate of males and females** are key determinants for adaptation since they reflect the wellbeing of the society. They have a positive functional relationship with vulnerability. Since higher the mortality rate, the lesser will there be the adaptable facilities and capabilities of the infants and mothers.

The percentage of **agricultural labourers to total labourers** has a negative functional relationship to vulnerability. Considering agricultural labourers are more averse to climate vulnerability, as their share among the total labourers increases, their adaptive capacity falls.

Percent of **cropping intensity** has a negative functional relationship with adaptability to climate change vulnerability. High cropping intensity means that there is more crop raised from the same land during a particular agriculture year, and this would lead to more climate change vulnerability as the resource from it will all be lost when there is a flood or drought.

The percentage **share of agriculture and allied sector in the gross domestic district product** has a positive functional relationship with the adaptive capacity to climate change. Agriculture and allied sectors are highly vulnerable to climate change, and when its share in the total GDDP increases, the level of vulnerability also rises.

Irrigated land is also represented as per 1000 hectares has a positive functional relationship with the adaptable capacity concerning climate vulnerability. As the proportion of increase in irrigated land reflects an improved agricultural technology and thereby a higher adaptive capacity in response to a climate change vulnerability.

The **net sown area** in hectares and the **number of livestock** per agricultural holding have a positive relationship with adaptive capacity to climate vulnerability. The percentage of **habitations connected to all-weather roads** that is taken as a proxy for infrastructure index, also has a positive functional relationship with the adaptability to climate change vulnerability because it increases their adaptive capacity. Infrastructure index is a technological factor and a higher on the rate of infrastructure index reflects a higher adaptive capacity. (Karen O Brien, 2004)

Normalisation of the variables

Since we have chosen multiple variables and each have different units of measurement, it is important to normalise these variables to bring it to a common unit of analysis and measurement. There are various methods for normalising. The most widely used method for normalising variables in vulnerability assessments is the min-maxmethod. We use the following general formula in general and in case of a positive functional relationship of the indicators with the index. For this study, normalisation was done with the help of Python using the *pandas package*.

Assigning weights to the variables

Post the normalisation of the indicators, the next step in the process is to assign weights to them according to their level of impact of the vulnerability to that region. Assigning equal weights, asking opinions from experts and stakeholders, inverse of variance and Principal Component Analysis are the commonly used methods for the purpose of attaching weights. In this study we have used the Principal Component Analysis (PCA) with the help of the software STATA.

The functional equation of PCA is represented as follows:

$$Xt = \wedge t F t + e t$$

where,

- Xt indicates the *N*-dimensional vector of variables influencing vulnerability.
- $\wedge t$ represents the $r \times 1$ common factor.
- Ft represents the factor loading.
- et represents the associated idiosyncratic error term of order $N \times 1$.

The weights are then calculated from the following equation:

$$Wi = \Sigma\ |Lij| Ej$$

where, Wi represents the weight of the ith variable, Ej represents the Eigen value of the jth factor, and Lij represents the loading value of the ith variable on jth factor.

The composite vulnerability index is then calculated by the following:

After individual estimations, weights are assigned to the exposure, sensitivity, and adaptive capacity indices. After the weights are assigned, we use them in the following formula to find the index vulnerability. (G. Balaganesh, 2020) (R. Sendhil, 2018) (Chaitanya Ashok Adhav, 2021)

$$Index\ (Districts) \frac{\Sigma XiWi}{\Sigma Wi}$$

where, Xi represents the normalised value of ith variable, and Wi is the weight of ith variable.

The districts are then ranked by categorising them into quartiles. The four categories in which the districts are divided are: Very high, high, moderate and low.

Results and Discussion

Karnataka is divided into 10 agr-climatic zones. Each district is divided based on the homogeneity in the variables of weather, soil, environmental conditions, etc. which have a great influence on the crop yield of the districts in these zones. We will look into detail the background of the districts that have high and low values of indices from the results obtained through Principal Component Analysis (PCA).

Results

Adaptive capacity Index

For analysing the adaptive capacity index, several economic, health, education-related indicators are taken. From the results obtained, we infer the following districts havevery high adaptive capacity index alongside their index scores, Bengaluru Urban (0.255), Belagavi (0.238), Yadgir (0.195), Vijayanagara (0.194), Bagalkot (0.189), Tumakuru (0.174), andChitradurga (0.172). According to the results, the index figures obtained for these districts have a high adaptive capacity as they have a higher ability to resist climate-related hazards. These districts are usually ranked higher on the list of indicators that have a positive functional relationship and are lower on the list of indicators that have a negative functional relationship with adaptive capacity in response to climate change. Bengaluru Urban is ranked first in our estimation of the adaptive capacity index. It also happens to be ranked the highest in GDP, PCI, male and female literacy above secondary education, and net area irrigated and stands the least in indicators like cropping intensity and percentage of agricultural labourers to total labourers. Since these indicators have a negative relationship with adaptive capacity in response to climate change, the less the district constitutes them makes them have a greater capacity to adapt to the changes resulting from climate change adversities. Taking the same example of Bengaluru Urban, we can see that they have only 2.31% of agricultural labourers to total labourers, which is the least out of all the 30 districts making their adaptive capacity higher. Similar reasonable results can be obtained for the other seven districts that are found to have a very high adaptive capacity index. Districts that are ranked moderate in the adaptive capacity index like Kalaburagi, Raichur, Bellari, Mandya, Shivamogga, Gadag, Davanagere, and Mysore, have their indicators reflecting neither too high nor too low results. Most of these districts have their indicators ranked on the average scale as well. For instance, taking the example of Mysore, although it has a high GDP of Rs. 68,29,719 as per the 2021-22 Karnataka Census report,itsper capita income is ranked at the 16^{th} position compared to the other 30 districts of Karnataka. Similarly, for female and male literacy above secondary education, it is ranked at an average of around 40% compared to the other districts. Under cropping intensity as well, Mysore stands at the 16^{th} rank with an intensity of 0.17457 which constitutes 48.5% compared to the other districts of the state.

The districts that have resulted in having low adaptive capacity index alongside their index scores are Dharwad (0.138), Ramnagar (0.129), Chamarajanagar (0.127), Bengaluru Rural (0.126), Haveri (0.125), Uttar Kannada (0.122), and Kodagu (0.110). These districts are found to be having the least of the abilities to overcome or adapt to any calamity that has been a result of climate change and are seen to have been ranked lower for those indicators that are likely to have a positive functional relationship of adaptive capacity to climate change and are highly under those indicators that have a negative functional relationship. For instance, if we take the example of Chamarajanagar, the district has a very low GDP of Rs. 2276867 and is ranked at the 27th place among the other districts. The district’s per capita income is also below average, constituting Rs. 1,79,338, which is ranked at the 15^{th} level compared to the other districts. The male and female literacy rates above the secondary level are also very low with just 25% and 22.8% being ranked 29^{th} and 20^{th} respectively, compared to the other districts. Although the male labour force participation rate is slightly higher with 79.1%, the female labour force participation is only 30.5%. For the percentage of agricultural labourers to total laborers, Chamarajanagar stands at the highest with 44.49% agricultural labourers revealing its higher vulnerability and lesser adaptive capacity considering an incompetent economic background for the district. In the indicator category of net sown area which has a negative functional relationship with adaptive capacity to climate vulnerability, Haveri has 385136 hectares and Chamarajanagar has 178623 hectares.

Sensitivity Index

From the results of the Principal Component Analysis, we can decipher the index values of sensitivity for the districts of Karnataka. We then categorised the districts into quartiles, namely very high, high, moderate, and low indexes based on their rankings. Very highly sensitive districts to climate change alongside their index scores are Mandya (0.200), Chamarajnagar (0.190), Chikkabalapur (0.188), Ballari (0.1869), Davanagere (0.1865), Chitradurga (0.181), and Tumakuru (0.179). These districts have higher rates for the indicators that relate positively with sensitivity and comparatively lower rates for the indicators that relate negatively with sensitivity in response to climate change than those districts with lower sensitivity index. The indicators having a positive relationship with sensitivity in response to climate change are population above 60 years and below 14 years of age, percentage of marginal and small farmers to total farmers, untreated drinking water, percentage of SC/ST population, annual groundwater draft, and the indicators with a negative relationship with sensitivity in response to climate change are yield to food grains, and percentage of forest area. A positive functional relationship indicates a rise in the level of sensitivity of the districts corresponding to an increase in the rates of indicators and a negative functional relationship indicates a rise in the level of sensitivity of the districts corresponding to a fall in the rates of such indicators. Mandya with the highest sensitivity index of 0.200, for instance, has a density of 2,11,857 people aged 60 and a population of 8,23,640 below 14 years of age. Mandya has 43.85% of marginal farmers to total farmers and 28.96% of small farmers to total farmers. It also has a large percentage of ST and SC population exposed to unclean drinking water with 37.5% and 37.6% respectively. The percentage of SC and ST population is also considerably high in the district, with 21.1% and 18.4%, respectively, showcasing that the higher the vulnerable section of people, the higher their sensitivity towards climate change. Concerning the indicators that have a negative relationship with sensitivity in response to climate change, Mandya has only 4.9% of the forest cover to the total geographical land. But we can observe that Mandya has comparatively low groundwater extraction and high level of yield from foodgrains, this could either be part of an anomaly or we could say that the sensitivity from the social and demographic factors have a higher impact on the district.

Districts with low sensitivity to climate change alongside their index values are Kodagu (0.133), Kalaburagi (0.132), Gadag (0.127), Udupi (0.1208), Yadgir (0.1207), Dharwad (0.119), Vijayapura (0.112). Taking the example of Kodagu for analysis, the district has very low density of people aged 60 and above with a population of just 58,096, and the density of children aged below 14 is also very low with just 1,34,007. The percentage of marginal farmers to total farmers is 44.46% and small farmers is just 23.21%. The district has the lowest groundwater draft of just 9817.03. the percentage of the SC population is also less at13.27% and ST population accounts for 10.47% of the total population. The percentage of SCs having untreated drinking water is just 10.1% and the least is for Udupi with 8.2% which is also on the low adaptive capacity index. On the other hand, it has been identified that Kodagu is in the higher ranks under those indicators that have a negative relationship with sensitivity in response to climate change. In terms of yield to food grain production, the district has 2,797 metric tonnes worth of production and is ranked 6th among other districts. Under the percentage cover of forest area, the district constitutes 32.8% and is being ranked the 3rd highest among the other districts. These results prove why the districts are ranked with a low sensitivity index to climate change.

Exposure Index

The exposure index is measured based on indicators like average rainfall, average minimum and maximum temperature for the 30 districts of Karnataka over the past 35 years (1980-2015). From the results of the PCA test, we find we have categorised the districts into quartiles based on their level of exposure and their amount of impact as a result of these indicators. The quartiles are very high exposure, high exposure, moderate, and low exposure. The following are the districts with very high exposure along with their respective index scores. Udupi (0.294), Dakshina Kannada (0.275), Uttar Kannada (0.229), Shivamogga (0.217), Kodagu (0.209), Chikkamagulur (0.177), Yadgir (0.163). We can observe that most of these districts are in part of the narrow coastal zone and the mountainous (Malnad) zone of Karnataka, which is the tropical and coastal zone of the state. These zones receivebulk rainfall, especially during June to September in the southwest monsoon period. The average rainfall in these zones is generally above 4000 mm. For instance, if we take the example of Udupi, which is in the coastal zone, it has an average annual rainfall of 4522.203 mm, an average minimum temperature of 22.279 and an average maximum temperature of 30.60°C Since both rainfall and temperatures have a positive functional relationship with exposure to climate change vulnerability, an increase in the levels of the indicators will lead to higher exposure levels for the districts.

The following are the districts with low exposure levels and their respective index scores. Gadag (0.1473), Davangere (0.1472), Chitradurga (0.1469), Mandya (0.1467), Tumakuru (0.1466), Bengaluru Rural (0.1465), Kolar (0.145). These districts are mostly in the northern and southern plains of Karnataka, where the levels of rainfall decrease from the west to east. Average annual rainfall in these regions is only around 400-1000 mm. taking the example of Gadag, the average annual rainfall in this region is only 566.32 mm, and the average minimum temperature is 20.121 centigrade and average maximum temperature is 31.385 centigrade.

Vulnerability Index

Vulnerability Index = (Exposure Index + Sensitivity Index) – Adaptive Capacity Index

Districts	*VI*	*Rank*
Bagalkot	*0.239375*	*1*
Bengaluru (Urban)	*0.226736*	*2*
Bengaluru (Rural)	*0.223105*	*3*
Belagavi	*0.209565*	*4*
Ballari	*0.206662*	*5*
Bidar	*0.18452*	*6*
Dakshina Kannada	*0.17362*	*7*
Chikkaballapur	*0.171774*	*8*
Chikkamagalur	*0.171542*	*9*
Chamarajanagar	*0.171436*	*10*
Dharwad	*0.171237*	*11*
Davanagere	*0.170115*	*12*
Chitradurga	*0.169978*	*13*
Gadag	*0.169484*	*14*
Hassan	*0.166774*	*15*
Kolar	*0.166404*	*16*
Mandya	*0.163014*	*17*
Koppal	*0.16267*	*18*
Haveri	*0.161559*	*19*
Kalaburagi	*0.160408*	*20*
Kodagu	*0.160026*	*21*
Mysuru	*0.153601*	*22*
Shivamogga	*0.149304*	*23*
Yadgir	*0.14757*	*24*
Tumakuru	*0.147073*	*25*
Raichur	*0.145437*	*26*
Vijayapura	*0.14312*	*27*
Ramanagara	*0.14276*	*28*
Uttara Kannada	*0.142627*	*29*
Udupi	*0.140812*	*30*

Color coding:

(green)	Very high vulnerability
(blue)	High vulnerability
(yellow)	Moderate Vulnerability
(grey)	Low vulnerability

The above is the vulnerability index that was formulated by considering the three indices-adaptive capacity, exposure, exposure and sensitivity. From the Table, we can find that Bagalkot, Bengaluru Urban (0.226), Bengaluru Rural (0.223), Belagavi (0.209), Ballari (0.206), Bidar (0.184) and Dakshina Kannada (0.173) are ranked as *very highly vulnerable* from the estimates generated. Most of these districts are part of the North Interior Karnataka and are usually very vulnerable and prone to climate disasters. While taking Bidar for our analysis, we find that the district comes under the category of moderate adaptive capacity with high exposure levels. The district also has one of the state's highest population of Scheduled Castes and Scheduled Tribes, with 23.5% and 13.5% respectively. In 2018, when Karnataka was severely struck by drought, some of these districts were observed to be the worst hit. Belagavi for instance had almost 10 Taluks affected by drought, Bengaluru rural and urban each had 4 taluks affected by drought, Ballari had 7 affected taluks, Bagalkot had 6 affected taluks and Bidar had 5. Taking the example of Bidar, we find that the district comes under moderate adaptive capacity but has high exposure levels. The district also has one of the state's highest populations of SC/STs, with 23.45% and 13.85%, respectively. Bagalkot has an ST population of 16.9% and an SC population of5.14%. Bengaluru Rural has an ST population of 21.6% and an SC population of 5.34%.

In 2018, when Karnataka was severely struck by drought, some of these districts were observed to be worst hit. Belagavi for instance had almost 10 Taluks affected by drought, Bengaluru rural and urban each had 4 taluks affected by drought, Ballari had 7 affected taluks, Bagalkot had 6 affected taluks and Bidar had 5. Ballari is recorded to have high adaptive capacity but equally recorded to have very high sensitivity and moderate exposure levels. Bengaluru Rural has evidently the least adaptive capacity and moderate levels of sensitivity and exposure. Bengaluru Urban and Dakshin Kannada also have been identified as very highly vulnerable to climate change. Although they have good adaptive capacity, other factors like high groundwater extraction levels, and fewer agricultural capabilities could make them highly vulnerable.

Chikkaballapur (0.1717), Chikkamaglur(0.1715), Chamarajanagar (0.1714), Dharwad (0.1712), Davanagere (0.170), Chitradurga (0.1699), Gadag (0.1698), Hassan (0.166) are the districts found to be falling under the category of *high vulnerability*. The districts under this bracket are similar to the districts with very high vulnerability but the intensity of the vulnerability is to some extent lesser. Chamarajanagar for instance, comes under the category of having the least adaptive capacity, high sensitivity and moderate exposure levels. To resist the effect of drought, the district is seen to be engaged in the cultivation of millet, which is a popular drought-resistant crop. The district also has a high percentage population of Scheduled Caste and Scheduled Tribes, with 25.4% and 11.5% respectively, which could addto the sensitivity of the region.

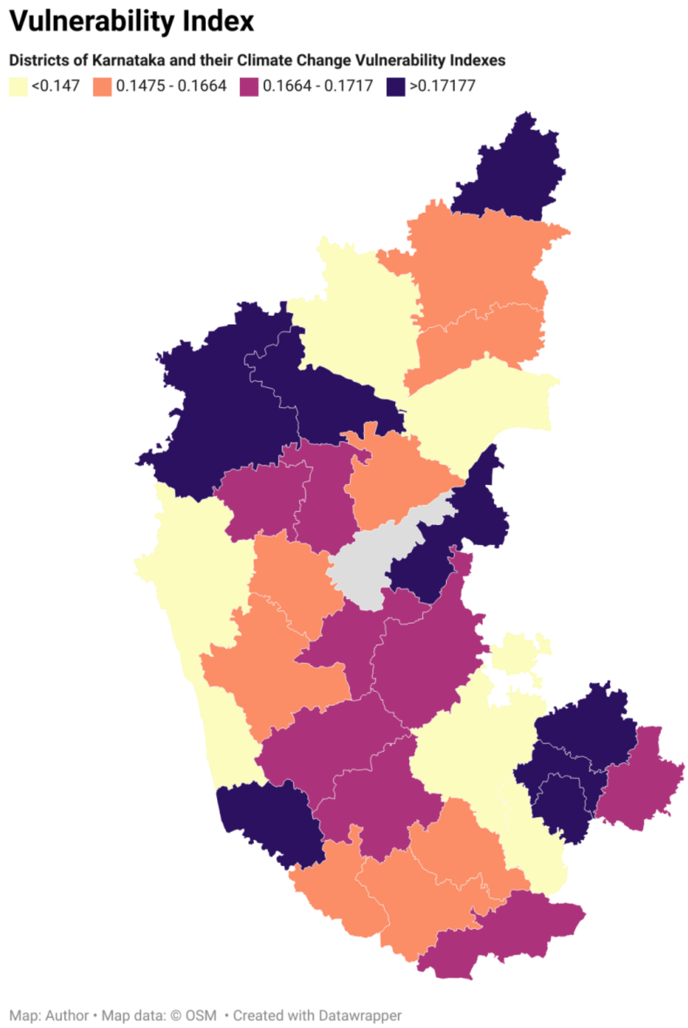
In the index category of *moderately vulnerable* are Kolar (0.166), Mandya (0.163), Koppal (0.162), Haveri (0.161), Kalaburagi (0.1604), Kodagu (0.160), Mysuru (0.153), and Shivamogga (0.1493). These districts are found to be having lesser impacts concerning the vulnerability to climate change compared to the districts mentioned above. Mandya for instance, has a high adaptive capacity index, and sensitivity index, but low exposure index. The population of the Scheduled Castes and Tribes are relatively lesser in this district, with 15% and 1.2% respectively. The multidimensional poverty index of the district is also very low compared to the other districts and is at 0.0086, which reflects their capability to overcome a disaster. The districts under this bracket are like the districts with very high vulnerability but the intensity of the vulnerability is to some extent lesser. Chamarajanagar for instance, comes under the category of having the least adaptive capacity, high sensitivity and moderate exposure levels. To resist the effect of drought the district is seen to be engaged in the cultivation of millets, which is a popular drought-resistant crop.

The district also has a high percentage population of Scheduled Caste and Scheduled Tribes, with 25.4% and 11.78% respectively, which could add to the sensitivity of the region. The other districts having high vulnerability are also observed to have high levels of ST and SC populations. Chikkaballapur, Chikkmanglur, Chitradurga and Davangere have an ST population of 24.9%, 25.4%, 23.5%, and 20.18% respectively and an SC population of 12.47%, 3.95%, 18.2%, 11.9% respectively. Most of these districts have moderate to high adaptive capacity but because of their high sensitivity due to poor social backgrounds can result in them having vulnerability. Among Kolar, Haveri, Kalaburagi, and Kodagu, Kolar has a relatively higher population of SCs and STs at 30.2% and 5.13% respectively. The other districts in the list have SC and ST populations of 13.7% and 8.85%, 25.28% and 2.5%, 13.27% and 10.47%, and 18.6% and 11.82% respectively. Haveri and Kodagu have been recorded to have the least adaptive capacity but are found to have moderate and high exposure indices. Kalaburagi has been found to have high adaptive and exposure index levelsand a low sensitivity index.

The *least vulnerable* districts from the results obtained are Yadgir (0.147), Tumakuru (0.1471), Raichur, Vijayapura (0.145), Ramanagar (0.1427), Uttar Kannada (0.1426), and Udupi (0.140). Although some of these districts are vulnerable in terms of socio-economic factors, they have higher access to all-weather roads, higher revenue generated from agriculture, higher net sown area, and a greater number of livestock. Tumakuru for instance, has a high sensitivity index but a low exposure index from the estimation. It has also been recorded to have a very high adaptive capacity because of the varied indicators we have taken to represent the resilience of a district. Udupi has an ST population of 6.41% and an SC population of 4.49%. Uttar Kannada has an ST population of 8.81% and an SC population of 2.38%. Vijayapura and Yadgir have an ST and SC population of 20.34% and 1.81%, 23.28% and 1.4% respectively. We can see how the proportion of vulnerable social groups drops as vulnerability falls. Vijayapura and Yadgir, although they have very high adaptive capacity, are also found to have very high exposure but are the least sensitive. Hence, they come under the category of low vulnerability.

Hence, efficient infrastructure elements help these districts to sustain any climate-related hazards. Most of the districts that are ranked in the low vulnerability are seen to have moderate to high adaptive capacity which would help them to withstand the effect of the hazard caused by climate change.

A choropleth map has been designed to map the districts according to their vulnerability indexes.



Interactive map link: https://www.datawrapper.de/_/NGChr/

Discussion

The districts that are taken for the study for the climate vulnerability assessment, can also be studied from their backgrounds in social, demographic, economic and health aspects as these are requirements for improving the efficiency of a district to withstand a disaster. Economic indicators are GDP, PCI, labour force participation rate, literacy rates, etc. When these indices are improved; the district has a better chance to overcome challenges caused by any hazard. GDP and PCI are the highest in the districts of Bengaluru Urban and Dakshina Kannada. According to the 2022 Human Development Index, which includes health, education, and income levels of the districts, Bengaluru Urban, Dakshina Kannada, Chikkamagalur, Udupi, and Kodagu have the highest index levels. Higher these index levels, along with other essential factors, will help districts to be less vulnerable to climate change. With higher levels of education and health, the adaptive capacity of these districts improves. The poverty levels are observed from the Multidimensional poverty index, which shows that Bengaluru urban has the lowest MDPI with an index value of 0.003, followed by Ramanagar with 0.0038 and Dakshina Kannada with

0.0049. Districts like Yadgir, Raichur, and Kalburagi have high MDPI values of0.1292, 0.095 and 0.083 respectively.

Demographics like SC, ST, population density, sex ratio etc. will reveal the extent of the vulnerable section in a particular district. Vulnerable groups such as Scheduled Tribes and Scheduled Castes are marginalised and have poor income, few privileges, little influence, and a high level of insecurity placing them at a higher level of risk to climate vulnerability. It is noted that the SC/ST population is higher in the southern districts of Karnataka. Bengaluru Urban and Kalaburagi are observed to be having the highest SC population, with 11.98 % and 6.49%, respectively. Ballari and Raichur are seen to have the highest ST population with 4.51% and 3.67%, respectively. Kodagu and Bengaluru Rural are observed to have the highest sex ratios with 1190 and 1177 respectively.

Ballari, Raichur, Kalburagi, and Yadgir are found to be having higher socio-economic vulnerability than the other districts. The per capita income of a district makes it adaptable to a particular climatic hazard in cases of rehabilitation and displacement. When the per capita income of a district is low it can have a negative impact on their adaptive capacity. Coincidently we can observe that Belagavi, and Bidar, which have low per capita incomes, are also highly vulnerable to climate change. The districts in northern Karnataka like Bagalkot, Bidar and Bellary are more dependent on agriculture and less on service-based sectors making them more exposed and vulnerable to climate disasters like droughts and floods. Belagavi, Bengaluru Urban are some districts that are of the highest geographical area in the state and are thus, exposed to larger risks of climate hazards making them more vulnerable to climate change.

Karnataka currently holds a composite SDG goal ranking in India at about 72 in the year 2021, and it has risen from a score of 66 in 2019. The results from the vulnerability assessment can also help us determine the level of standing the districts of Karnataka have in achieving the SDG goals. The greater the achievement, the higher the capability of the districts to adapt and resist vulnerable situations to climate change. The sustainable development goals which have been listed are no poverty, hunger and nutrition, health and well-being, quality education, gender equality, water and sanitation, clean energy, work and economic growth, industry and innovation, reduced inequality, sustainable cities, responsible production and consumption and last but not the least climate action. The state actively takes measures and improvements which can be seen from the year-wise state and national reports.

Conclusion

Karnataka is one of the fastest growing economies in India, from the agriculture, service, and industrial sectors. Climate change has had its effect on rainfed-Karnataka in the recent past affecting the districts in the state, some more than others. In this paper, a study of all 30 districts of Karnataka has been done, considering several socio-economic, demographic, health, education and agriculture-related indicators that define the three constituents of the climate vulnerability index: adaptive capacity, exposure, and sensitivity. The climate change vulnerability index was constructed using the Principal Component Analysis utilizing the STATA software. Results indicate that socioeconomic factors aren’t the only necessary factor that could determine if a district is highly vulnerable to climate change, other factors like agriculture, livelihood, and infrastructure also compound to determine the vulnerability. Districts in the north-interior Karnataka, like Bagalkot, and Bidar, are found to be highly vulnerable. Bengaluru Urban, Dakshin Kannada also has been identified as highly vulnerable to climate change, and although they have good adaptive capacity, other factors like high groundwater extraction levels, and fewer agricultural capabilities could make them highly vulnerable.

Farmers of the districts, who are highly vulnerable, have chosen mitigation practices like drip irrigation, cultivating drought-prone crops like millets, construction of farm ponds etc. These have been highly preferred to overcome groundwater depletion. Switching to non-farm activities like dairy farming has also been considered a viable option. (Shivakumara, 2020) Climate financing measures have also been taken by the state government. Although adaptation schemes for climate change have been found in agriculture, horticulture, and fisheries, climate change mitigation has been found mainly in forestry, horticulture, and agriculture departments. Long-term state initiatives and policies are necessary for both mitigating and adapting to climate change. (Environmental Management and Policy Research Institute, 2021). Public and private climate finance will aid in the development of coping strategies in the impacted states, sectors, and social and vulnerable groups as well as the reduction of climate-related vulnerabilities.

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Appendix

Colour coding:

(green)	Very high vulnerability
(blue)	High vulnerability
(yellow)	Moderate Vulnerability
(grey)	Low vulnerability

Districts	***Exposure index***
Udupi	0.294427
Dakshina Kannada	0.274671
Uttara Kannada	0.229513
Shivamogga	0.217093
Kodagu	0.209421
Chikkamagaluru	0.177236
Yadgir	0.163411
Hassan	0.162016
Ramanagara	0.159337
Bidar	0.158941
Vijayapura	0.158702
Kalburagi	0.158576
Mysuru	0.158435
Belagavi	0.15835
Raichur	0.156969
Haveri	0.150947
Chamarajanagara	0.150056
Dharwad	0.149707
Ballari	0.14859
Koppal	0.148127
Bengaluru U	0.148047
Chikkabalapura	0.147779
Bagalkot	0.147585
Gadag	0.147318
Davangere	0.147221
Chitradurga	0.146974
Mandya	0.146755
Tumakuru	0.146666
Bengaluru R	0.146581
Kolar	0.145868

Districts	*Senstivity Index*
Mandya	0.200235
Chamarajanagara	0.190269
Chikkabalapura	0.188784
Ballari	0.186936
Davanagere	0.186514
Chitradurga	0.181392
Tumakuru	0.179862
Belagavi	0.178842
Shivamogga	0.174259
Haveri	0.170002
Bengaluru (Urban)	0.169758
Kolar	0.166302
Uttara Kannada	0.166104
Ramanagara	0.161622
Koppal	0.160155
Mysuru	0.160063
Bagalkot	0.159713
Chikkamagaluru	0.159498
Raichur	0.158772
Bengaluru (Rural)	0.155193
Hassan	0.154941
Bidar	0.145194
Dakshin Kannada	0.136391
Kodagu	0.133165
Kalburagi	0.13199
Gadag	0.127157
Udupi	0.120485
Yadgir	0.120474
Dharwad	0.119201
Vijayapura	0.112078

Districts	Adaptive Capacity Index
Bengaluru (Urban)	0.255288
Belagavi	0.238204
Yadgir	0.195192
Vijayapura	0.194464
Bagalkot	0.189273
Tumakur	0.174108
Chitradurga	0.171837
Kalburagi	0.169084
Raichur	0.162054
Ballari	0.158965
Mandya	0.15484
Shivmogga	0.154764
Gadag	0.153302
Davangere	0.150488
Mysuru	0.15035
Koppal	0.149451
Hassan	0.149361
Dakshina Kannada	0.14918
Chikkamagluru	0.140957
Bidar	0.14065
Koppal	0.139974
Chikkabalapur	0.139372
Udupi	0.138538
Dharwad	0.137723
Ramanagar	0.129906
Chamarajanagar	0.127057
Bengaluru R	0.126427
Haveri	0.124513
Uttar Kannada	0.122662
Kodagu	0.110377

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