SJIF Impact Factor (2025): 8.539 |Journal DOI: 10.36713/epra0212 ISSN: 2277–3142
International Journal of Indian Economic Light (JIEL) - Peer-Reviewed Journal
Volume: 13 | Issue: 6 | August 2025

DROUGHT VULNERABILITY ASSESSMENT IN KARNATAKA

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Article DOI: https://doi.org/10.36713/epra23624
DOI No: 10.36713/epra23624

ABSTRACT

Karnataka is a frequent drought hit state, which has the largest drought prone area after Rajasthan. Karnataka has four natural regions and ten agro climatic zones, which have different climatic conditions. Along with different weather conditions the livelihood patterns also differ. Climate change in terms of droughts and increase in mean temperature are the most effectful elements to environment-based activities in dryland rural communities. Most of rural livelihoods rely on natural resources, which are rendered less productive by prolonged droughts and increased temperature. Although rural communities adopted few coping up strategies to deal with these weather-related stresses. These strategies provide them short term relief, but they pose the risk of pushing them into deeper vulnerability. Vulnerability of a system indicate easy susceptibility to the changes in the external environment. Weak asset base and poor resilience power are the major reasons for the households to become vulnerable. In Karnataka, North Interior Karnataka (NIK) and South Interior Karnataka (SIK) regions are affected by recuring droughts and are categories as very highly vulnerable regions compared to Malnad and coastal regions.

The present study assesses drought vulnerability in Karnataka with across the natural regions. This study uses secondary data and employed average, percentage, index method and GIS software for mapping. Rainfall pattern and temperature trends in Karnataka show NIK and SIK regions are highly drought prone and majority of the taluks in these two regions recorded more than 40^0 temperatures Three fourths of taluks of Karnataka fall under high and very high vulnerability category and majority of these taluks fall in NIK and SIK regions. The study suggests that region specific policy measures are required to improve the resilience capacity of people in vulnerable regions.

KEYWORDS: *Drought vulnerability, Livelihood Assessment, Karnataka.*

1. INTRODUCTION

Karnataka is India's eighth largest state in terms of geographical area (19.1 M sq. km) and home to 6.11 crore people (2011 census), accounting for 5.05 percent of India's population (KSNDMC, 2017). It is the second largest drought prone state after Rajasthan. Karnataka has four natural regions namely, North Interior Karnataka (NIK), South Interior Karnataka (SIK), Malnad and coastal. The state has different climatic conditions caused by distribution of precipitation, different topography and soil type. According to Srinivasareddy *et al* (2019) Karnataka state has humid to sub-humid monsoonal climate on the west coast and western ghats; and semi-arid to arid (very warm) climate in central and northern districts of plateau region. Consecutive droughts situation directly effect on dryland communities by disrupting their means of livelihoods. Although these communities taken coping up methods to maintain their life such as, distress sell of their assets, reduce consumption, fall in debt, migration etc., which lead them to fall in deep vulnerability.

Vulnerability is a situation of a system easily susceptible to the changes. Intergovernmental Penal on Climate Change (IPCC) defined vulnerability as a function of sensitivity (response of a system towards the changes either positively or negatively), exposure (degree of a system's exposer) and adaptive capacity (ability of adjustment) (Rao, 2017). Weak asset base and poor resilience capacity are major reasons for the household to fall in vulnerability. Aassetless people in dry lands rely on natural resources for their livelihoods. Agriculture and allied activities, agricultural labouring, livestock rearing, non-agricultural labour, sale miner forest produce, artisanal works etc. are the main occupations in dry areas. But irregular precipitation and drought destabilize their income source. In Karnataka, many taluks of NIK and SIK regions have dryland topography and are highly susceptible to droughts. Therefore, NIK and SIK are highly vulnerable to weather variability compared to malnad and coastal regions (Kumar *et al*, 2016; KSNDMC, 2017; Srinivasareddy *et al*, 2019).

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2. REVIEW OF LITERATURE

Drought vulnerability in Karnataka has been researched extensively. **Srinivasareddy** (2017) assesses the drought vulnerability using composite climatic index, indicating that 97 percent of north interior Karnataka and 87 percent of south interior Karnataka are susceptible to drought. Whereas, this is 36 percent in malnad region and barely 5 percent in coastal region. That is why NIK and SIK are categorised as highly and very highly drought vulnerable regions. This study recommends for immediate planned measures improving resilience capacity in these highly vulnerable regions. **Reshma** *et al* (2017) attempted drought conditions assessment for Koppal district of Karnataka by using GIS and remote sensing. Consecutive droughts cause economic loss, water stress and these conditions aggravate socio-economic problems. In the vulnerable regions decreased annual rainfall, less irrigation facilities, weak adaptive capacity of the people are most impacted factors **(Rao** *et al,* 2013).

Kumar *et al* (2016) measure the vulnerability of Karnataka state to climate change. Bidar (rank first) and Kalaburgi (rank second) districts are very highly vulnerable to climate change but Dakshina Kannada district is the least vulnerable. The study suggested allocation of funds and resources to these high drought prone districts to address the vulnerability. **Shivakumara** and **Murthy** (2019) mapped a climate change vulnerability index and suggested agriculture and climatic indicators are the major factors influencing vulnerability, therefore, these two- need special attention.

Most of the studies assess the drought vulnerability and measure it at the district level, but very few articles assess region wise analysis. However, the present study assesses drought vulnerability in Karnataka with across the natural regions.

3. DATA AND METHODS

The major sources of data are Karnataka State Natural Disaster Monitoring Centres' (KSNDMC) reports and published secondary data like Karnataka at a Glance by Directorate of Economics and Statistics, Heat Wave Action Plan etc. Data are analysed by descriptive statistical methods, relative index method and GIS software for mapping are employed for analyse the data. The relative index method is borrowed from HDI (Human Development Index) methodology adopted by the United Nations Development Programme (UNDP).

$$\text{Index}_i = \frac{Actual_i - Minimum_i}{Maximum_i - Minimum_i}$$

In which, the index value is in between 0 to 1. If the value is near to 0, then the performance of the parameter or Index value is poor. If the value is near to 1, then its performance is good.

4. DISCUSSION

Geographically Karnataka has different types of topographies and atmosphere. North interior Karnataka (12 districts) and south interior Karnataka (11 districts) have semi-arid and arid land. Malnad region (4 districts) belongs to Western Ghats and coastal region (3 districts) is located in between Western Ghats and Arabian sea. Due to geo-spatial conditions, Karnataka receives varied precipitation across the regions and seasons. The state receives almost 80 percent of its rainfall in southwest monsoon (June to September) and the level of temperature also differs from region to region. Based on this atmospheric distribution, communities adjust their livelihood pattern. In this way climatic conditions determine their socio-economic condition by externally. On the other side, various indicators like, condition of agriculture and farmers, size of land holdings, literacy rate, population density, non-working population are determined socio-economic condition of the region, internally.

4.1. Climatic Condition

Variability in weather condition called climate change severely effects communities whose means of life are linked to climate. Uneven rainfall, reduced number of rainy days, increase in mean temperature (especially, winter temperature), increase in consecutive droughts are the symptoms of changes in climate. KSNDMC (2020) report notes that, changes in climate in smaller timeframe is called climatic variability, if it is continuing in decades is called climate change and this phenomenon is dynamic in nature and directly impacts on socio-economic changes of the region through loss of livelihood because of vulnerability to cope up the new climatic condition. Almost three fourths of rural communities depend on agriculture, allied activities and agricultural labour for their livelihood and few others engaged in non-agriculture activities. These people have few assets, and hence, their resilience power is weak. Resilience is capacity of a household to withstand changes in assets (capital) endowment.

Climate variability is reflected in changes in rainfall, temperature, humidity etc. Rainfall in Karnataka shows variation across time and space. Figure 1 shows average rainfall in districts of Karnataka between 2010 and 2020.

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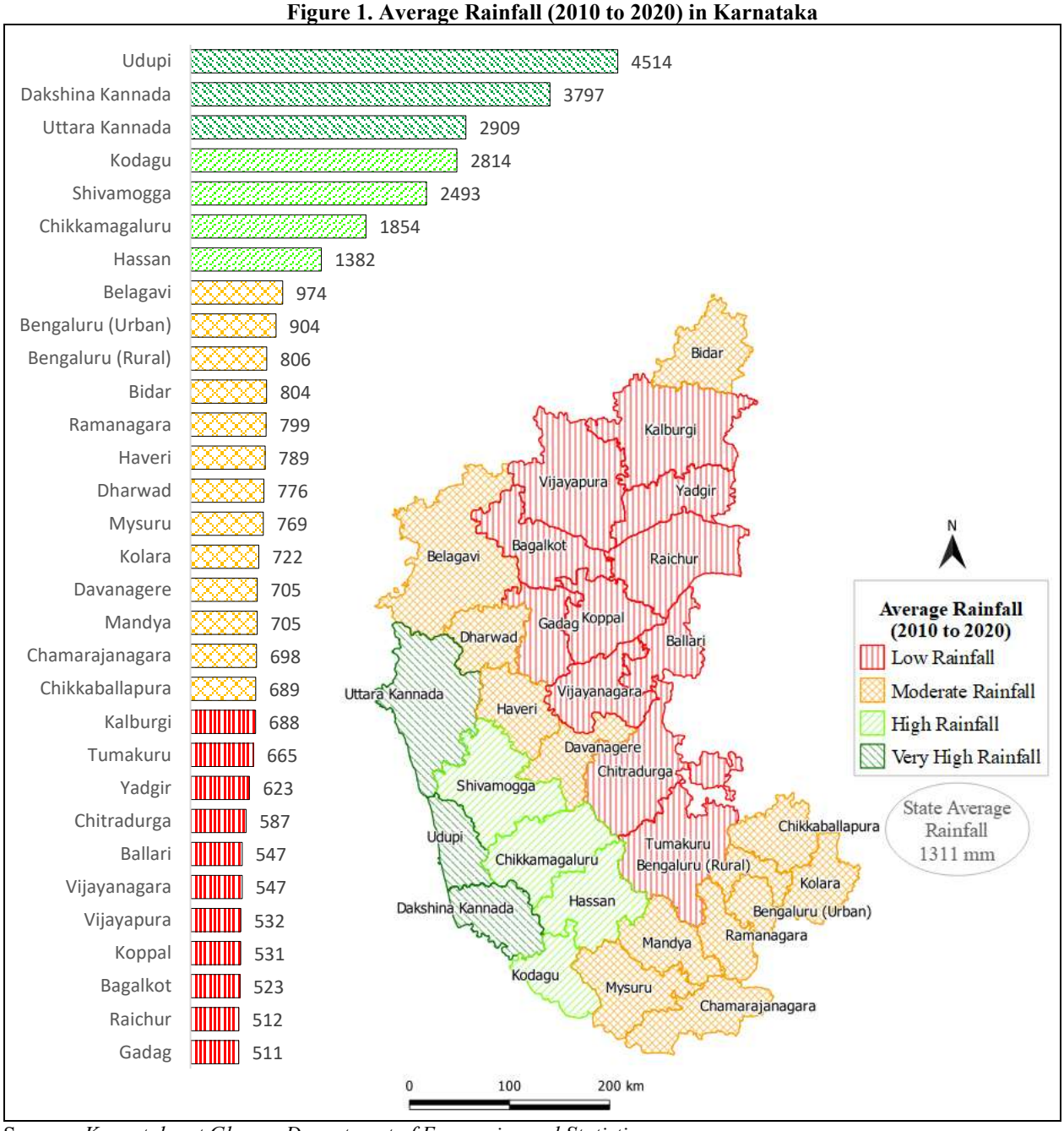
More than three fourth of districts in NIK region received less amount of precipitation followed by SIK. Both regions received less amount of rain during the decade. NIK and SIK are more prone to severe drought compared to Malnad and Coastal regions and frequency of occurrence of drought has increased in recent years (KSNDMC, 2020). This situation exacerbates socio-economic problems to the dwellers in various dimensions. Reduce sources of drinking water negatively impact on women: fetching water far from their habitat is stressful work and results in reduced productivity and livelihood opportunities. Drinking unclean water causes severe health issues. In addition, dropout children from school education to helping in fetching water and earning extra income by engaging work with their parents result in loss the future human capital permanently.

Agriculture production is reduced, sometimes nil. The entire rainfed agricultural area is drought prone and which covers almost 80 percent of taluks in the state (Srinivasareddy *et al*, 2019), which affect farmers and agriculture labours, forced them to either migrate towards cities for means of livelihood or adapt some emergency strategies such as; distress selling of assets like, livestock, land and other holdings, take loan by unorganised sectors. These strategies push them into deep vulnerability.

Figure 1. Average Rainfall (2010 to 2020) in Karnataka



Source: *Karnataka at Glance, Department of Economics and Statistics.*

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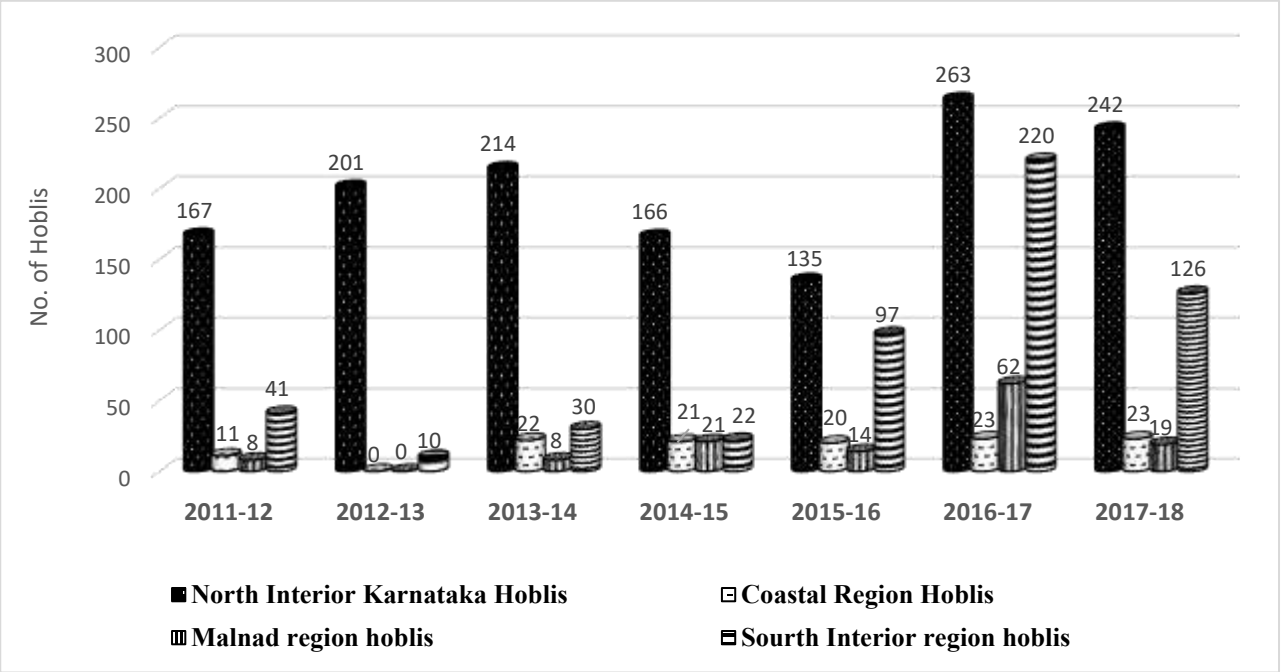
Less amount of precipitation reduces water availability and groundwater level to over extraction and reduced seepage. On the other hand, increase in temperature reduces humidity in atmosphere, which is a major issue in global warming. For instance, increasing in global temperature by increases greenhouse gases (GHGs) exacerbate environmental problems globally. Increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level and an increase in carbon dioxide (CO_2) in atmosphere have increased from the pre-industrial levels of 280 to 379 ppm (parts per million) in 2005 and to around 392.5 ppm during 2012 (Rao *et al,* 2013). Cities situated in coastal region fall in stress by increase in sea level by inundation of agriculture land and increase salinity in potable water. Forecasting by KSNDMC (2020) shows that global mean surface temperature in next 100 year may rise between 1.4^0 c and 5.6^0 c.

Figure 2 show that the hoblis belongs to four regions recorded temperature (greater than 40^0 C.) from 2011 to 2018. In these four regions. The temperature will be impacted large number of hoblis which belongs to NIK and SIK regions in the year of 2016-17 and 2017-18. Deforestation, forest encroachment and human habitation, various development activities and increasing GHGs emission etc. are major contributors to increase in surface temperature.

Figure 2. No. of Hoblis Recorded Temperature (more than 40^0 C.) in Karnataka from 2011-18
Source: *Heat Wave Action Plan, 2018.*



Due to increase in temperature, humidity of the atmosphere reduced, which impact on agriculture yield, livestock production and productivity of labour. These are main sources of income of rural communities. Rise in winter temperature influences precipitation in next monsoon. People used some temperature tolerance seeds, extraction ground water for irrigation as well as domestic using purpose, reduce working hours especially in summer etc. But over extracting of ground water reduces future use of it and reduced grassing land and decrease in common property resources (CPR) for livestock rearing and forced selling of their livestock at low prices. Generally, in summer season labour income, productivity and health low compared to other seasons. Heat wave caused 2,042 deaths in 1998 and more than 1,200 deaths in 2002 in southern India (NDMA, 2016).

Analysis of drought effected taluks in the geographical regions of Karnataka made by Karnataka state natural disaster monitoring centre (2017) shows that total 59 percent of taluks in 2001 to 2010 have categorised as drought affected taluks. While in 2011 to 2015, total 65 percent of taluks affected drought (table 1) and in the same way in 2016, 75 percent of taluks in kharif and 91 percent of taluks in rabi season are prone to the drought. Compared to other two regions, a large number of taluks belongs to SIK and NIK regions categorised drought prone at 76 percent and 78 percent in 2011 to 2015 respectively. In 2016, all taluks of SIK region affected by drought in both season, followed by NIK region. This shows that both of these regions suffering from consecutive droughts, which makes people highly vulnerable to very highly vulnerable. About 80 percent of taluks were drought prone taluks spread in Karnataka (KSNDMC, 2017; Srinivasareddy *et al*, 2020).

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Table 1. Drought affected taluks in different regions in Karnataka (2001-2016)

Region (Total Taluks)	% of Drought Affected Taluks (2001-2010)	% of Drought Affected Taluks (2011-2015)	% of Drought Affected Taluks (2016)	
			Kharif	Rabi
SIK (63)	61	76	100	100
NIK (69)	78	78	75	94
Malnad (25)	42	43	68	72
Coastal (19)	12	14	36	74
Total (176)	59	65	75	91

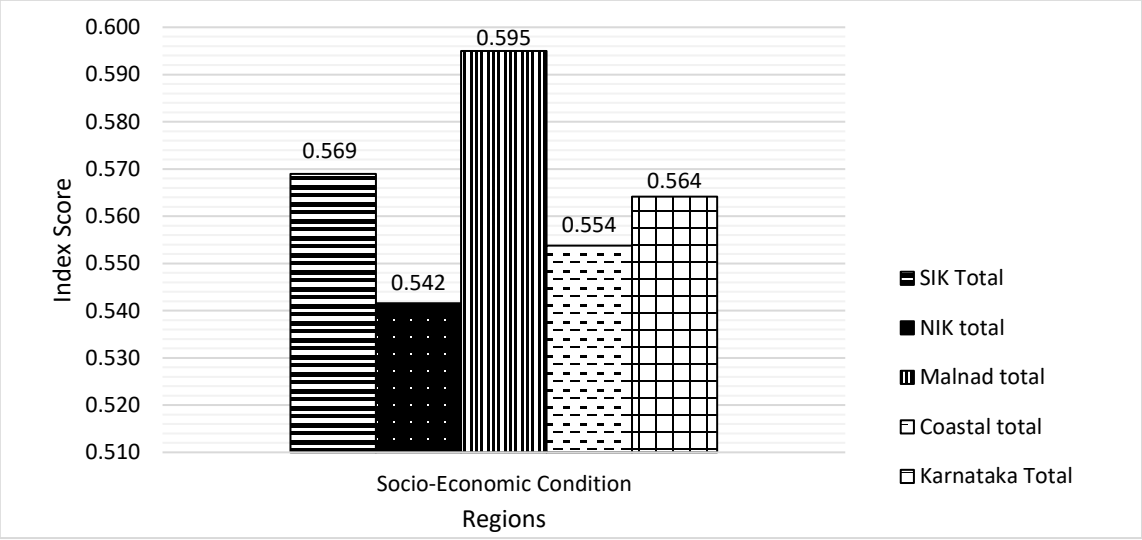
Source**:** *Karnataka State Natural Disaster Monitoring Centre, 2017.*

4.2. Socio-Economic Condition

Karnataka is characterized by diverse socio-economic conditions. The agriculture sector plays a significant role in the state, with a mix of large and small land holdings across different regions. The literacy rate in Karnataka has seen improvements, but can vary across different areas. Population density varies with urban areas like Bengaluru having higher densities compared to rural regions. The livestock possession is also varied across these regions. The non-working population like aged, people suffering from illness are the people whose contribution to the economy is very less or even zero. In this background, these parameters proxies for socio-economic conditions of region.

Gross irrigated area, net area sown, fallow land, cropping intensity and farmers and land holdings, having livestock gives information on agriculture condition. With this, literacy rate, population density and non-working population gives socio-economic condition of the region. Figure 3 shows region wise socio-economic condition by constructed relative index. Overall, in Karnataka, index score is 0.564, which means that socio-economic condition of rural people in Karnataka is good at around 50 percent. Region wise index explained that compared to other three regions, NIK scored least resulted in low literacy rate, having non-working population, low per capita livestock and relatively high population density, followed by coastal and SIK regions.

Figure 3. Region wise Socio-Economic Index



Source: *Various Government Reports*

Hence, due to low level of rainfall, relatively high temperature, consecutive droughts, less natural resources and at the same time, poor socio-economic conditions including asset possession makes NIK region became more vulnerable than other regions. In the same way, figure 4 explained region wise performance in per-capita income and Human Development Index (HDI). Considering the overall state of Karnataka, it becomes apparent that it has an HDI score of 0.644 and a per-capita income of 1,68,647 rupees. While this indicates a decent level of development on average, it also highlights the disparities between regions within the state.

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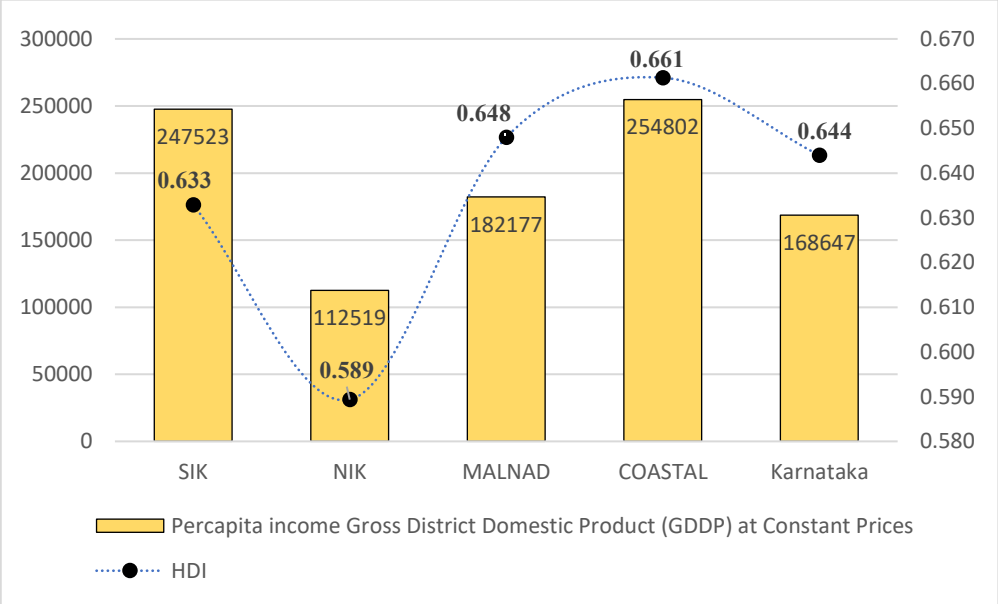
Figure 4. Karnataka Region wise Per-capita Income and HDI



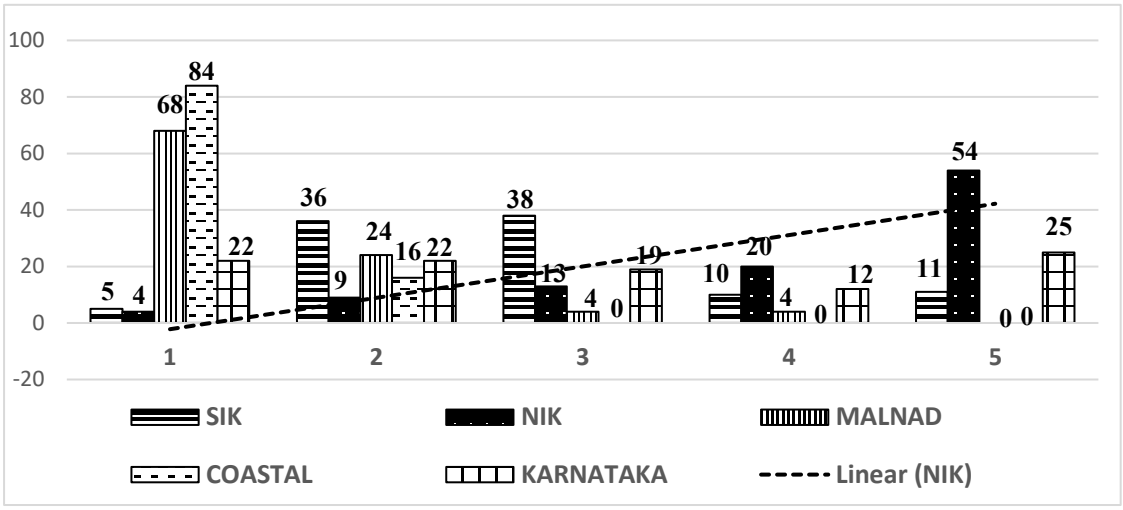
Source: *Planning Department, CODR 2021 and Human Development Index Across Districts 2019*

It is evident that the coastal region has the highest HDI score of 0.661, indicating relatively better overall development compared to other regions in Karnataka. This is likely a result of better access to education, healthcare facilities, and higher per-capita income, which contributes to improved living standards and a higher quality of life for the people in this area. But in the case of the NIK region, which seems to have the lowest HDI score of 0.589 and the lowest per-capita income of 1,12,519 rupees. This suggests that the NIK region may face some development challenges, such as limited access to essential services and economic opportunities, potentially impacting the well-being of its residents.

5. DROUGHT VULNERABILITY IN KARNATAKA

KSNDMC (2017) report assess the drought vulnerability in Karnataka state by using Composite Drought Vulnerability Index (DVI) to analyse region wise taluks fall in various vulnerability classes namely; very slightly vulnerable (class 1), slightly vulnerable (class 2), moderately vulnerable (class 3), highly vulnerable (class 4) and very highly vulnerable (class 5) by constructing index values of sub components. Figure 5 depict that the taluks under DVI classes in deferent regions in Karnataka.

Figure 5. Percent of Taluks under DVI classes in different regions of Karnataka



Source**:** *Karnataka State Natural Disaster Monitoring Centre, 2017.*

Overall, 37 percent of taluks (12+25) in Karnataka fall under highly vulnerable and very highly vulnerable classes. The trend line for taluks of NIK fall in various DVI classes show few taluks fall in slightly vulnerable class and 54 percent (more) taluks are very highly vulnerable. Poor natural resource base, continuous variability in climatic

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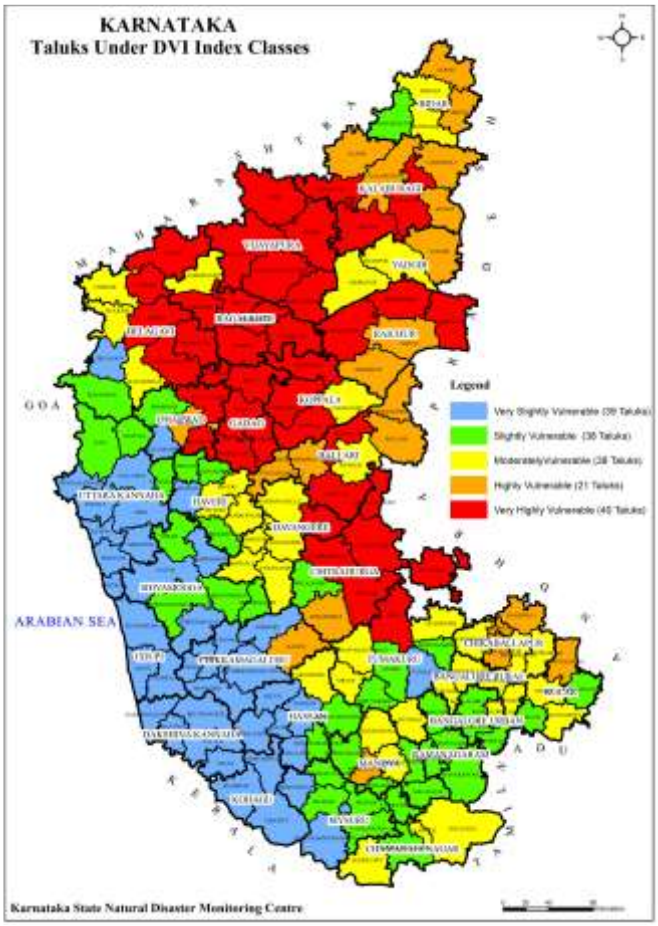
elements and weak socio-economic conditions of poor are the major reasons for the higher number of taluks in NIK region fall in very highly vulnerable to drought.

Taluks of south interior Karnataka are in moderately vulnerable at 38 percent and slightly vulnerable at 36 percent. Malnad and coastal regions have ample of natural resources compared to NIK and SIK regions. Therefore, almost all taluks of these both regions fall under the class of very slightly vulnerable (68 percent of malnad taluks and 84 percent of coastal taluks).

We can see in the map 1 to understand the different classes and different regions of the taluks fall in vulnerability to drought. The scale of blue coloured taluks depicts very slightly vulnerable and red coloured are very highly vulnerable. Three fourths of the taluks fall in very highly vulnerable to drought (Kumar *et al,* 2016; Radhika *et al,* 2017). More than three fourths of the taluks under malnad and coastal regions categorised very slightly vulnerable.

Map1. Taluks under DVI Index classes in Karnataka



Source**:** *Karnataka State Natural Disaster Monitoring Centre, 2017.*

Bangalore, Mysore besides taluks are slightly vulnerably because of Bangalore is the capital city, so naturally livelihood opportunities are high compared to other areas. And Chitradurga district fall in very highly vulnerable to drought in SIK region.

Based on atlas on vulnerability of Indian agriculture to climate change, Table 2 shows relative rankings of Karnataka's districts at national level based on exposure, sensitivity, adaptive capacity and vulnerability indices. For instance, vulnerability rank for Vijayapura district is 7, which means among all the districts in India Vijayapura district is placed 7 in vulnerability, or Vijayapura district is classified as highly vulnerable district in India. It applied to all three components, where this district placed 4th in terms of exposure, 91st for sensitivity and 424th in the case of adaptive capacity among all the districts in India. Here, Vijayapura district fall in poor adaptive capacity as it is far from the first rank in it.

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Table 2: National Level Relative Rankings of Districts Based on Exposure, Sensitivity, Adaptive Capacity and Vulnerability Indices of Karnataka

District	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Vijayapura	4	91	424	7
Kalburgi	7	203	461	11
Gadag	11	122	389	13
Bagalkot	3	108	244	16
Raichur	28	139	404	17
Chitradurga	88	131	411	24
Haveri	64	181	400	32
Bidar	161	156	435	35
Davanagere	103	140	287	69
Bangalore (Rural)	216	192	327	89
Tumkur	365	183	359	90
Koppal	129	224	319	100
Dharwad	179	248	346	108
Chamarajanagar	78	259	315	112
Kolar	516	180	367	146
Bellary	164	240	296	149
Belgaum	66	219	179	179
Mysore	74	272	224	199
Mandya	62	198	125	227
Bangalore (Urban)	185	273	137	356
Hassan	221	391	241	444
Chikmagalur	276	502	313	519
Uttara Kannada	337	519	352	524
Kodagu	241	533	251	556
Udupi	510	486	194	566
Dakshina Kannada	504	464	116	568
Shimoga	289	526	128	570

Source: Rama Rao *et al* (2013)

Note: *Ranks are given based on the index value. A district with minimum value in vulnerability, has highest vulnerability and the one with maximum value is least vulnerability. Similar interpretation applies to the three components of vulnerability and green colour given to the minimum value and red colour to the maximum value.*

According to these rankings, Vijayapura, Kalburgi, Gadag, Bagalkot and Raichur districts are top most vulnerable districts and on the other hand, Shivamogga, Dakshina Kannada, Udupi, Kodagu and Uttara Kannada districts are least vulnerable in the case of Karnataka state. Further, this table also explained that vulnerability is high in where the sensitivity is high and at the same time less adaptive capacity. For example, we can observe in the table that adaptive capacity ranks are good in which districts ranks for vulnerability are least and sensitivity ranks for them are also least. This indicates that sensitivity and vulnerability are positively and vulnerability and adaptive capacity are negatively correlated.

6. GOVERNMENT BUDGETARY ALLOCATIONS FOR DROUGHT PRONE AREAS

Government budgetary allocations for drought-prone areas are a critical tool in mitigating the adverse effects of drought. By investing in early warning systems, water management, agriculture, social safety nets, and environmental conservation, governments can build resilience and support communities facing water scarcity and agricultural challenges.

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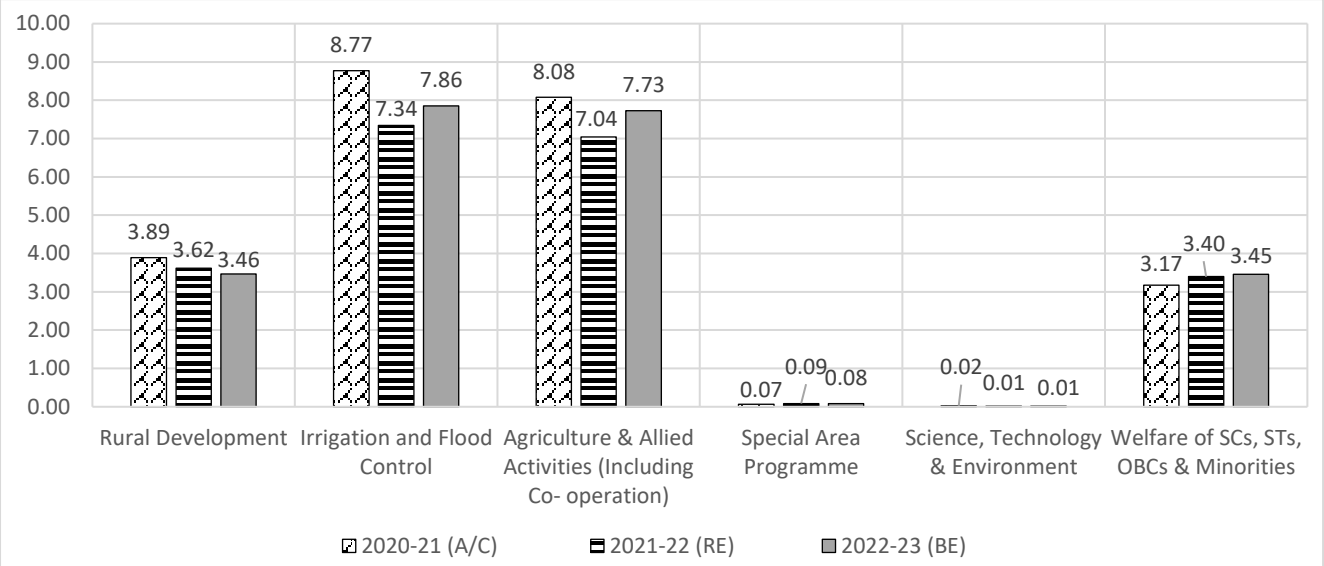
Figure 6. % of Budgetary Expenditure by Departments in Karnataka



Source: *Economic Survey, 2022-23*

Figure 6 illustrate budgetary expenditure by Karnataka state government on drought prone areas, especially in rural development, irrigation and flood control, agriculture, special area programme etc. The share of expenditure on rural development from 2020-21 to 2022-23 is declined continuously. In the same way, compared to 2020-21 budget actual expenditure, outlay on irrigation and flood control and agriculture and allied activities reduced at more or less 1 percent in 2022-23 budget estimate. On the other hand, expenditure on special area programme and science, technology and environment are ignored where the government spend less than 1 percent of its budget.

Budgetary expenditure on components of rural economy by the central government shows in the table 3. Expenditure on rural economy since 1990-91 shows increased by 25 percent to 28 percent for 2017-18 revised estimated budget. We can observe here that government focused on agriculture and allied activities, power, irrigation and flood control and rural development where more than 50 percent of allocation spent on these three components. But at the same time, very less amount of money spent on soil and water conservation, animal husbandry and dairy development, which also continuously reduced since 1990-91. These components give livelihood to the rural people along with the agriculture.

Table 3. % of Budgetary Expenditure on Components of Rural Economy in Total Expenditure by The Centre

Components of RE	1990-91	2000-01	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17 (B.E.)	2017-18 (R.E.)
Crop husbandry	4.4	4.6	4.9	6.2	5.7	6.3	5.9	7.1	5.1	6.5	8.7
Soil & water conservation	1.1	1.1	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.6	0.6
Animal husbandry	1.9	1.9	1.3	1.4	1.5	1.6	1.6	1.5	1.3	1.2	1.2
Dairy development	1.6	1.2	0.3	0.3	0.3	0.4	0.5	0.4	0.3	0.3	0.3
Food storage & warehousing (excl. food & fert. subsidy)	0.5	0.4	0.3	0.3	0.3	0.3	0.7	0.6	1.2	1.1	1.2
Rural development	13.2	13.3	17.5	18.1	16.7	16.0	16.3	15.7	15.4	18.2	17.2
Others	7.4	5.4	5.1	4.4	4.5	5.3	4.7	5.1	6.3	5.5	5.2
Agriculture & allied services	30.0	27.9	30.0	31.3	29.7	30.5	30.2	30.9	30.1	33.4	34.4
Co-operation	2.8	1.0	1.4	1.1	1.1	1.1	1.6	1.1	1.1	1.0	0.9
Fertiliser subsidy	11.3	12.5	14.5	13.5	13.9	11.5	11.8	10.0	8.6	6.1	5.4
Power, irrigation & flood control	25.9	30.6	24.0	22.8	25.5	26.3	26.1	27.0	30.1	26.1	25.0
% of Total Expenditure on RE to total expenditure	25.0	19.8	23.2	21.8	21.3	21.5	20.3	22.2	23.4	26.8	28.1

Source: *Indian Public Finance Statistics 2017-2018*

Note: Green coloured cell denotes higher percentages of respective components

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Overall, the central government has consistently allocated a significant portion of its budget to support agriculture, rural development and allied services. However, there have been fluctuations in some sectors over the years, reflecting changing priorities and economic conditions. The overall trend suggests an increasing focus on rural development and a recognition of the critical role of the rural economy but concentration on rural environment conservation especially soil and water is crucial to reduce rural livelihood vulnerability and it also true that this measures can achieve sustainability in rural livelihood.

7. CONCLUSION AND IMPLICATIONS

Karnataka has fragile eco-system in various regions, which makes the livelihoods of people highly sensitive. Distribution of rainfall is highly fluctuating within the state. Dakshina Kannada received large amount of rain while Chitradurga received very low amount of it. Large number of taluks belongs to NIK and SIK regions are impacted more than 40^0 C. of temperature, it makes sense that the climate change is severely affect on these regions by reducing resilience capacity of the area by reduce humidity in atmosphere and productivity of the soil. So, there is urgently need drought proofing measures to increase resilience capacity of the communities as well as the regions.

Major findings reveal that the most backward areas are mostly suffering from natural calamities and NIK is highly affected region to the drought, where most of the districts fall under highly to very highly vulnerable fallowed by SIK. Due to topographic condition and less natural resources, sensitivity and vulnerability to drought is very high. Furthermore, socio-economic index reveals that NIK and SIK regions are scored relatively average (moderate). Agriculture activities and livestock rearing, agriculture labour, non-agriculture labour are influencing this poor performance in the index, so these regions, especially, NIK region is highly sensitive to variation in precipitation. Therefore, more number of taluks are fall in highly vulnerable classes compared to other region's taluks. On the other hand, national level relative rankings in vulnerability shows that top five districts in Karnataka belongs to NIK region, followed by SIK. So, there is needed some measures to resolve these crises.

First, government should take region specific plans to concentrate on issue-based actions. Second, give skills to the poor people for creating new livelihood opportunities in their own regions and reduce migration. Third, create the market for small scale industries such as, handicrafts, weavers, artisans etc., because most of the communities of north interior Karnataka especially *Kalyan Karnataka*'s areas rely on these conventional industries for their livelihoods. Fourth, introduce water harvesting system in low precipitation regions to save water for future use and farm ponds for ground water recharge. Fifth, strictly reduce burning fossil fuel, plastic use, over exploitation of ground water and deforestation. Sixth, take regulations on industries to limits emission of pollutants etc. The government release drought vulnerability index for every five years, which will help to the policy makers to concentrate on highly vulnerable places to curb issues.

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SJIF Impact Factor (2025): 8.539 |Journal DOI: 10.36713/epra0212 ISSN: 2277–3142
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