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Drought Vulnerability Assesment of Vadakarapathy

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Abstract: Drought is a recurring natural hazard that significantly impacts water resources, agriculture, ecosystems, and socio-economic stability. This study focuses on the analysis of drought characteristics using meteorological indices to evaluate temporal and spatial variations. Standardized indices such as the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) were applied to long-term rainfall and climatic data to assess drought intensity, duration, and frequency. The results reveal distinct seasonal and inter-annual fluctuations, with severe droughts occurring predominantly during monsoon deficits. Spatial mapping highlights vulnerable zones that are consistently prone to water stress. The findings provide valuable insights for drought monitoring and management, emphasizing the need for effective early warning systems and adaptive water resource planning. This analysis contributes to strengthening regional drought resilience and supporting sustainable development strategies.

Keywords: Drought Analysis, Standardized Precipitation Index (SPI), Water Resource Management, Meteorological Drought, Drought Intensity, Drought Frequency, Drought Vulnerability.

I. INTRODUCTION

Drought is often called a “silent disaster” because it doesn’t announce itself like a flood or storm, yet it can disrupt lives for months or even years. It starts quietly—with less rainfall than usual, drying soil, and shrinking water sources—but soon its effects spread across every aspect of daily life. For communities that rely on farming and local water resources, drought can mean crop failure, water shortages, reduced income, and increased hardship for families.

In India, drought has always been a challenge because so much of the population depends on rainfall for agriculture. Even with modern irrigation and farming methods, when the monsoon fails or is uneven, millions of people feel the impact. Crops fail, farmers face economic stress, and sometimes families have no choice but to migrate temporarily in search of work.

Kerala is often thought of as a state blessed with plenty of water, thanks to its rivers, backwaters, and high rainfall. Yet, the reality is more complex. Rainfall is not always evenly distributed, population and water demand are increasing, and groundwater is being used faster than it can recharge. This means that even here, certain areas can face serious water stress.

Palakkad district, located on the eastern side of Kerala, is one such area. It lies in the rain shadow of the Western Ghats, which makes it drier than the rest of the state. Even though it is called the “rice bowl of Kerala,” its agriculture is highly vulnerable to rainfall shortages. Farmers depend on monsoon rains and groundwater, and when these fail, crops and livelihoods are at risk.

Vadakarapathy, a village in Chittur Taluk of Palakkad, is a clear example of these challenges. Most families here rely on agriculture and use wells or borewells for both irrigation and daily water needs. In years of good rainfall, life runs smooth ly. But when rains are weak or delayed, water shortages, crop losses, and livelihood struggles quickly become apparent. Over time, repeated drought events make the community more vulnerable and less able to cope with the next dry season.

Understanding drought in a place like Vadakarapathy is not just an academic exercise—it has real implications for the people who live there. By studying the causes and impacts, we can identify who is most at risk, what resources or strategies can help them cope, and how to plan better for the future. This knowledge can guide farmers, local authorities, and the community to take practical steps to reduce the impacts of drought and make the village more resilient

II. CAUSES AND CONSEQUENCES

A. *Casuses*

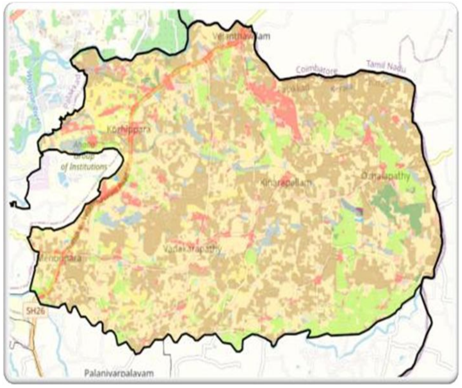
1) Unpredictable Rainfall: One of the main causes is the village’s location in the rain shadow region of the Western Ghats. This means that Vadakarapathy receives less rainfall than the western parts of Kerala. Even when the monsoon arrives, rainfall is often uneven and irregular, with long dry spells in between. Such unpredictability makes it difficult for farmers to plan their sowing and harvesting schedules, directly affecting crop health and yields.

2) Dependence on Groundwater: Most households and agricultural fields in Vadakarapathy rely on wells and borewells for water. During years of low rainfall, these sources fail to recharge, leading to declining water tables. Over time, continuous extraction without adequate recharge structures increases the village's exposure to drought.
3) Agricultural Practices: The local economy is heavily agrarian, with crops like paddy, banana, and coconut dominating the landscape. These crops require consistent water supply, and reliance on rainfed cultivation makes farming highly sensitive to rainfall variability. The lack of alternative irrigation techniques, such as drip systems or rainwater harvesting, further limits the community's ability to cope with water shortages.
4) Socio-economic Constraints: Many farmers in Vadakarapathy are smallholders with limited financial resources. They often lack access to modern technology, credit, or government support to invest in water-saving measures. Additionally, limited awareness about drought-resilient crops or sustainable farming practices reduces their adaptive capacity.
5) Infrastructure Limitations: The village has few large-scale water storage or irrigation structures. Ponds, check dams, and canals are insufficient to meet the needs during dry periods, which increases both exposure and sensitivity to drought events.

B. Consequences

1) Agricultural Losses: Reduced rainfall and limited water availability often result in partial or total crop failure. Farmers lose income, and the shortage of local produce can affect food security in the village. Repeated losses may push families into debt and reduce their capacity to invest in future crops.
2) Water Scarcity: Wells, ponds, and other water sources dry up during prolonged dry periods, creating shortages not only for irrigation but also for drinking and daily use. Families may need to travel long distances or depend on water tankers, which adds financial and physical strain.
3) Livelihood Impacts: Agriculture provides employment for both farmers and laborers. When crops fail, many lose their primary source of income. Some families may be forced to migrate temporarily for work, which disrupts community life and social stability.
4) Environmental Stress: Repeated droughts lead to soil degradation, reduced vegetation cover, and declining groundwater levels. These changes reduce the natural resilience of the environment, making the village more prone to future droughts and other climate- related stresses.
5) Social Challenges: Water scarcity and economic stress can lead to conflicts over shared resources. Vulnerable groups, including women, children, and landless laborers, are disproportionately affected. Health and sanitation may also decline due to lack of adequate water, further impacting quality of life.

C. Area Of Studty



III. DROUGHT VULNERABILITY CALCULATION

Drought Vulnerability=f(Exposure, Sensitivity, Adaptive Capacity)

A. Exposure

The degree to which a region, population, or system is exposed to drought-related climatic conditions, mainly how often, how long, and how severe drought occurs in that area.

Exposure = w1(normal rainfall deviation)+w2(normal standard precipitation index)

Exposure value	Exposure level
0 to 0.33	Low exposure
0.34 to 0.66	Moderate expose
0.67 to 1	High exposure

- Rainfall Deviation (%)=Actual Rainfall−Normal Rainfall×100
  Normal rainfall

Rainfall deviation	Condition
≥ 40%	Extremely wet
20% to 39%	Very wet
10% to 19%	Moderately wet
-9% to +9%	Near normal
-10% to -19%	Moderate drought
-20% to -39%	Severe drought
≤ -40%	Extreme drought

- Standard precipitation index (SPI)=(Yearly Rainfall-Mean rainfall)/Standerd deviation
  SPI expresses how much the observed precipitation deviates from the long-term mean, in units of standard deviation.

SPI	Condition
≥ 2.0	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to +0.99	Near normal
-1.0 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
≤ -2.0	Extreme drought

	january	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1994	5.6	11.94	0.94	129.89	46.3	318.55	530.85	140.65	152.5	280.74	95.06	0
1995	7.25	1.52	1.66	44.25	106.26	147.46	347.12	121.87	305.81	96.97	107.43	0
1996	0.01	0.11	5.36	137.35	50.48	239.58	409.45	127.89	162.95	301.59	49.88	86.45
1997	0	0	48.48	5.55	96.94	121.51	516.25	330.15	42.03	256.32	367.56	43.76
1998	0	0	0.84	35.1	71.25	350.53	465.63	166.34	125.41	107.18	170.73	107.05
1999	0	4.77	0.09	28.23	123.44	269.63	397.47	153.87	11.53	216.59	55.34	3
2000	2.59	28.68	8.2	55.31	15.6	227.72	177.49	390.19	81.41	41.49	76.12	16.78
2001	0.28	9.59	1.24	44.82	42.69	283.11	192.83	151.37	34.01	121.69	228.57	13.17
2002	0	0	17.62	4.23	51.34	219.12	88.26	236.51	75.74	125.61	91.3	2.28
2003	0	25.53	101.17	47.56	6.37	133.87	188.37	99.09	13.6	259.74	27.92	12.44
2004	6.66	2.3	13.75	55.59	256.12	435.85	245.33	268.37	82.15	146.76	39.82	0
2005	9.05	0.49	2.8	124.77	79.92	232.4	697.13	215.94	243.16	95.74	85.83	98.67
2006	30.19	0	150.72	42.41	215.24	254.26	350.44	140.52	133.52	56.31	185.63	0
2007	0.82	0.4	0	79.82	54.37	437.4	469.04	228.41	259.88	258.32	28.91	49.47
2008	3.44	25.24	113.03	20.96	29.31	150.01	168.16	101.07	136.37	333.9	9.61	1.55
2009	0	0	41.79	2.37	45.85	98.85	519.05	114.16	137.75	164.77	233.78	0.34
2010	0.68	0	3.36	53.07	44.16	163.53	208.54	174.6	124.89	155.16	223.9	27.7

2011	0	75.36	10.25	103.58	22.02	428.34	297.21	269.89	161.66	156.51	222.41	14.02
2012	0	0	0	85	17.02	195.94	211.77	216.69	100.47	172.77	51.19	1.1
2013	0	61.58	10.17	75.39	23.68	443.99	539.95	248.69	154.82	140.74	82.22	13.69
2014	0.12	0	11.38	7.95	148.23	176.15	506.96	332.21	175.04	216.81	8.79	7.35
2015	0	0.08	4.89	148.26	234.16	413.44	144.36	127.73	114.69	125.3	127.66	8.02
2016	0	0	0	0.61	108.33	242.37	201.81	119.39	38.68	80.68	21.53	27.75
2017	3.2	0	32.23	22.5	81.9	214.98	192.5	227.07	253.06	41.18	34.96	20.93
2018	0	18.27	36.8	70.97	274.35	440.41	594.26	614.21	55.3	109.35	29.95	3.17
2019	0	0	2.94	57.62	24.19	118.46	267.28	610.79	246.02	289.46	87.38	5.25
2020	0	0	31.77	79.72	70.08	88.12	236.04	434.99	265.13	216.58	43.79	0
2021	21.02	1.33	51.09	127.62	190.7	159.39	323.97	129.3	185.73	342.49	212.62	23.4
2022	4.02	0.42	25.24	58.14	132.91	700.4	512.67	592.47	198.87	90.83	173.77	121.63
2023	0.26	0.42	0.03	41.16	5	24.96	367.97	21.47	112.01	165.21	179.38	37.19
2024	72.24	0	5.03	13.15	233.79	252.75	640.22	204.16	78.81	151.96	103.23	44.07

This is the 30-year rainfall data collected From this data
Exposure = 0.5361 (Moderate Exposure)

B. *Sensitivity*

In drought vulnerability assessment**,** Sensitivity means how much a system (such as agriculture, water resources, soil, or people) is affected when drought occurs. If a system is highly sensitive, even a small decrease in rainfall can cause large damage (crop failure, water shortage, etc.). If a system is less sensitive, it can tolerate drought better.

Sensitivity = s = (s1+ s2+ s3) / 3 GROUND WATER DATA

year	Pre monsoon	Post monsoon	Fluctuation	avg	GW normal
2015	7.43	4.91	2.52	6.17	0.205835
2016	8.22	5.84	2.38	7.03	0.321988
2017	9.62	6.77	2.85	8.195	0.479335
2018	9.62	5.51	4.11	7.565	0.394246
2019	8.29	4.72	3.57	6.505	0.25108
2020	6.034	5.25	0.874	5.642	0.134522
2021	5.262	4.03	1.232	4.646	0
2022	6.7	5.41	1.29	6.055	0.190303
2023	12.07	12.03	0.04	12.05	1
2024	12.95	10.69	2.26	11.82	0.968936

Mean = 0.394625
Range of ground water depth

Index value	Vulnerability
0-0.25	Low
0.25-0.5	Moderate
0.5-0.75	High
0.75-1	Very high

Moderate vulnerability Soil depth

soil depth class	Area (Ha)	% area	Vulnerability score	Soil sensitivity index
Deep to very deep	2583	53.11536	2	106.2307218
Very deep	2188	44.9928	1	44.9928028
Rock out crops	92	1.891836	4	7.56734526

Total soil sensitivity % = 1.587908698 Range of soil depth

range	Vulnerability
1-1.5	Very Low
1.5-2.5	Low
2.5-3.5	Moderate
3.5-4	High

Low Vulnerability

Crops	Area	%	Sensitivity score	LULC sensitivity index
Coconut	1678.42	34.20921	3	102.6276206
Paddy Land (current Fallow)	1093	22.2773	5	111.3864918
Residential	403	8.213862	2	16.42772413
Seasonal Crop	306	6.236828	4	24.94731307
Paddy Land (Long Fallow)	277	5.645756	5	28.22878154
Virippu	205	4.178267	4	16.71306921
Barren Rocky Land	145	2.95536	1	2.9553598
Other Perinial Crops	122	2.486579	3	7.45973577
River / Stream	29	0.591072	1	0.59107196
Road	24	0.489163	1	0.489163001
Agricultural (Current Fallow)	67	1.36558	4	5.462320182
Agricultural (Long Fallow)	46	0.937562	4	3.750249677
Other Plantaion Crop	70	1.426725	3	4.280176262
Other Built Ups	60	1.222908	2	2.445815007
Mixed Crop	356.92	7.274669	4	29.09867641
Ponds	24	0.489163	1	0.489163001

LULC sensitivity index % = 3.573527314
Range of LULC

range	Vulnerability
1-2	Low
2-3	Moderate
3-4	High
4-5	Very high

High vulnerability

C. Adaptive Capacity

Adaptive Capacity in drought vulnerability refers to the ability of a system, community, or region to adjust, cope with, and recover from drought conditions. It indicates how well an area can reduce the negative impacts of drought through available resources, infrastructure, technology, and management practices. Factors such as irrigation facilities, water storage systems, groundwater availability, socio-economic conditions, and effective water management policies influence adaptive capacity. Areas with better water management and stronger socio-economic support generally have higher adaptive capacity.
ADAPTIVE CAPACITY = (irrigation + population + drainage)/3

1) Irrigation Index

Irrigation index = Irrigated Area / Cultivable Area Total Area = 4951 Ha
Cultivable Area = 2300 Ha Irrigated Area = 2070 Ha
Irrigation Index = 2070/2300 = 0.9

2) Population Density

Total Population = 26459 (2011 Census) Population Density = Total Population / Area
Population Density = 26459 / 49.51 = 534 people/km

3) Drainage Density

Drains	Length
Order 1	8.24 km
Order 2	5.90 km
Order 3	2.46 km
Order 4	5.08 km
Order 5	2.34 km

Total length of drain = 24.02 km
Drainage density = total stream length / Area Drainage density = 24.02 / 49.51 = 0.48 km/km²

4) Normalise These Values

Scoring of irrigation

Irrigation ratio	Score
<0.2	1
0.2-0.4	2
0.4-0.6	3
0.6-0.8	4
>0.8	5

Scoring of drainage density

Drainage density	Score
<1	1
1-2	2
2-3	3
3-4	4
>4	5

Scoring of population density

Population density	Score
<200	1
200-400	2
400-600	3
600-800	4
>800	5

From above

Parameter	Value	Score
Irrigation index	0.90	5
Population density	534 people / km	3
Drainage density	0.48 km/km²	1

Adaptive capacity = (5+3+1)/3 = 3 Range of adaptive capacity

AC Value	Vulnerability
1-2	Low
2-3	Moderate
3-4	High
4-5	Very high

D. Final Drounght Vulnerability Index (DVI)

DVI = (EXPOSURE + SESITIVITY -ADAPTIVE CAPAITY)/3 DVI = (0.5361+1.8520-3)/3
DVI = -0.6199
Vulnerability classification

DVI Value	Vulnerability
0-0.25	Low
0.25-0.5	Moderate
0.5-0.75	High
0.75-1	Very high

DVI = -0.6199 (low vulnerability)

III. CONCLUSIONS

This study evaluated drought vulnerability in the study area by analyzing several environmental and socio-economic factors such as soil characteristics, land use/land cover, groundwater depth, drainage density, irrigation ratio, and population density. These parameters were used to calculate the sensitivity and adaptive capacity of the area, which were then combined to obtain the Drought Vulnerability Index (DVI). The results show that the study area falls under low drought vulnerability. One of the main reasons for this may be the high irrigation of agricultural crops, which helps farmers manage water shortages during dry periods. The availability of irrigati on facilities improves the adaptive capacity of the region and reduces the overall impact of drought conditions. Overall, the study shows that effective water use and irrigation practices play an important role in reducing drought risk. The findings of this study can be useful for planners and local authorities in promoting better water resource management and sustainable agricultural practices in the future.

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