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Forecasting Meteorological Parameters to Identify Categories of Droughts in Amreli Using Downscaling Approach

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***Abstract:** The rising incidence of natural disasters as a result of climate change has become a major concern for the entire world in recent years. The majority of people in India who work in agriculture or near coastal areas rely on natural resources for their sustenance and income. Droughts, floods, cyclones and other natural calamities are linked to uncertainty in meteorological parameters. Hence, this research is crucial for such analysis. As a result, the primary goal of this research is to investigate the uncertainty of numerous meteorological parameters in Amreli. In the previous decade, there has been a considerable increase in the uncertainty of meteorological data in this region. Statistical downscaling uses GCM data, while dynamic downscaling techniques use RCM data. The statistical downscaling technique was used in this work to accurately forecast meteorological characteristics. To anticipate meteorological characteristics, the RCP 8.5 (A2) scenario is used in this study. SPI values are used for the analysis and forecasting of drought categories. The predicted meteorological parameters will be extremely helpful in the future development of various tools and ways of dealing with various natural disasters. Flood vulnerability maps and famine response planning can be prepared using these data. For example, Assistance can be provided topology developers to prepare policy based on the severity of the forecasted meteorological data.*
***Keywords:** GCM, RCP, SPI, Statistical Downscaling, Temperature, Precipitation.*

I. INTRODUCTION

The climate is evolving at its own rate. The average weather in a certain place over a lengthy period of time, often 30 years [18], is referred to as climate [13]. The current atmospheric condition in a specific location is referred to as weather. Climate is the cumulative representation of weather events that occur throughout time [20]. Temperature, humidity, air pressure, wind, and precipitation all have a direct relationship with climate [7], [21]. Solar radiations are also linked to changes in these factors [3], [4]. Climate is categorised by the average and typical ranges of various variables, the most popular of which are temperature and precipitation [7], [24], [25]. Variations in the mean state and other climate characteristics are referred to as climate variability [5]. The phenomenon of global warming is currently being actively explored and debated [13], [24].

Climate change has become a reality on a worldwide scale. Climate change is already influencing every populated location on the planet, with human-caused changes in weather and climate extremes contributing to many of the documented changes [10]. Climate circumstances such as excessive heat, drought, and flooding are causing uncertainty in some parts of the world [6]. Human activity has played a significant impact in the recent rapid rise in world average temperatures [24]. According to the IPCC's AR6 report, the last four decades have been warmer than any decade before them since 1850 [11], [18].People who labour near the coast rely on natural resources for their sustenance and livelihood [19], [9].Droughts, floods, cyclones, and other natural disasters all have a direct link to uncertainty in meteorological parameters [6], [23].According to the Intergovernmental Panel on Climate Change, the global mean temperature has risen by 1.5° C in the last 20 years, with predictions of a 2.7° C rise by the end of the century [1].

To combat disasters caused by climate change, it is necessary to use GCM and RCM to study variations in metrological parameters such as rainfall, temperature, humidity, wind speed, etc. We can calculate meteorological parameters related to climate change, its effects, and climate change forecasting. GCM is used on a global scale to cover large areas and grid cells [2] [22], [12], [14]. Because GCM data is required for statistical downscaling [2], [15], [18], [22], we must first analyse data using GCM [12].

The IPCC's Representative Concentration Pathway (RCP) is a greenhouse gas concentration (rather than emissions) trajectory. For the IPCC's Fifth Assessment Report (AR5) in 2014, four pathways were used for climate modelling and research. The different climate futures described in the pathways are all considered possible depending on the number of greenhouse gases (GHG) emitted in the coming years [10], [14], [22]. The RCPs are named after a possible range of radioactive forcing values in the year 2100 (2.6, 4.5, 6.0, and 8.5 W/m^2, respectively). Since AR5, original pathways have been considered alongside Shared Socioeconomic

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Pathways, as well as new RCPs such as RCP-1.9, RCP-3.4, and RCP-7.0, with RCP 8.5 A2a emissions showing the worst state of climate change at a specific place and time [10], [14], [16].
RCP8.5 is the carbon concentration that causes global warming of 8.5 watts per square metre on average across the globe [17]. Amreli region of Gujarat was chosen for this study because it is severely impacted by climate change. To study climate change in that area and prepare for future catastrophic events [8], a statistical downscaling technique was used to analyse and forecast various methodological parameters of that area [12], [21].

II. STUDY AREA

Gujrat is a state on India's western coast with a coastline of nearly 1,600 kilometres (990 miles).It has the longest coastline of country; with a population of 60.4 million people. It is the fifth-largest state in terms of land and the ninth-largest in terms of population in India. For this study, Amreli district of Gujarat is taken as study area. It is located in Saurashtra region of Gujarat. The map of study area is as shown in Figure 2.1. This map can be prepared by using Q-GIS software.

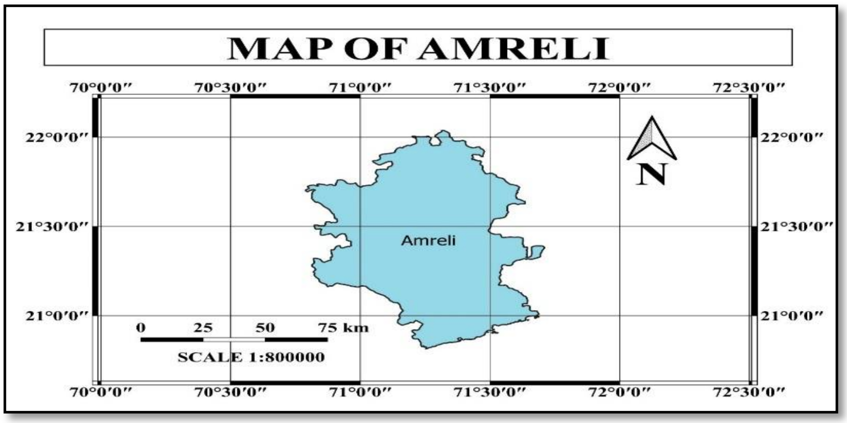

Figure 2.1: Map of Study Area (Amreli)

Increased rainfall in the Saurashtra region could be due to changes in rainfall patterns, changes in east-west temperature patterns and an increase in cyclonic activity in the Arabian Sea in coastal areas. Water levels in rivers will rise in the Saurashtra region, resulting in more submerged and flooded places. The location of Amreli is 21.4445° N latitude and 71.2874° E longitude, at a height of 128 metres above MSL. It has a total size of 6,760km^2. It has a population of 1,514,190 people and a growth rate of 8.63%. The maximum temperature of Amreli is 47.47 °C and minimum temperature is 6.49 °C and average precipitation is585 mm. Difference between maximum and minimum temperature is very wide.

III. DATA COLLECTION

Precipitation and temperature data for the Amreli district are obtained from the NASA Power Data Access View Portal website for the past time 39 years i.e. 1982-2020. Monthly precipitation and temperature data were discovered, and the historical pattern for the previous 39 years was noted. Amreli GCM data for the period were obtained from the Climate and Scenarios website of Canada for years1961-2099 for RCP 8.5A2 scenario. This data are in daily format. So, it should be converted in monthly format using suitable PHP coding. In this study "Nested FOR Loop html code" is used.

IV. METHODOLOGY

The flowchart of methodology is described in Figure 4.1. In very first step, observed precipitation, minimum temperature data and maximum temperature data are collected. Enter monthly meteorological data for 1982-2020,i.e.precipitation and temperature into Excel spreadsheet. In this study, GCM data is used as Predictant data. This data can be collected from Climate and Scenarios website of Canada for years1961-2099 for RCP 8.5A2 scenario. GCM data for 1961-2099 is also entered into same MS Excel sheet. The time scale for the observed data in the study is monthly. As a result, GCM data must be converted into monthly scale using PHP programming. So, daily data should be converted in monthly format using suitable PHP coding. In this study "Nested FOR Loop html code" is used. These observed data and the GCM data are now correlated, to find out maximum correlated parameter with observed data. Select first three parameters for regression model. Now, the multi-linear regression model can be prepared using Microsoft Excel. After regression analysis, one can get values of intercept (regression constant) and regression coefficients for preparation of equation. The model should be properly calibrated and validated with observed meteorological parameters. Now, the regression model is ready to run. The equation of multi-linear regression model is as given below. Results of this method are represented graphically.

$$\mathbf{y_i = f(x_i, \beta_j) + e_i}$$

$$\mathbf{f(x_i, \beta_j) = \sum_{i,j=1}^{n} (x_i * \beta_j)}$$

Where,
y_i = Dependent parameters (modelled parameters)
e_i = Intercept (Regression constant)
x_i = Independent Variables
β_j =Regression Coefficient

The results of modelled data is analysed in time series graph. The rainfall data was divided into three-time series cycles from 1982 to 2020, 2021 to 2060, and 2061 to 2099. Then prepare the Excel sheet for SPI analysis using R-Studios. Determine the Standardized precipitation Index (SPI) value using proper R script. Using SPI values, droughts can be classified in different categories. These categories will give the severity of drought for that particular study area.

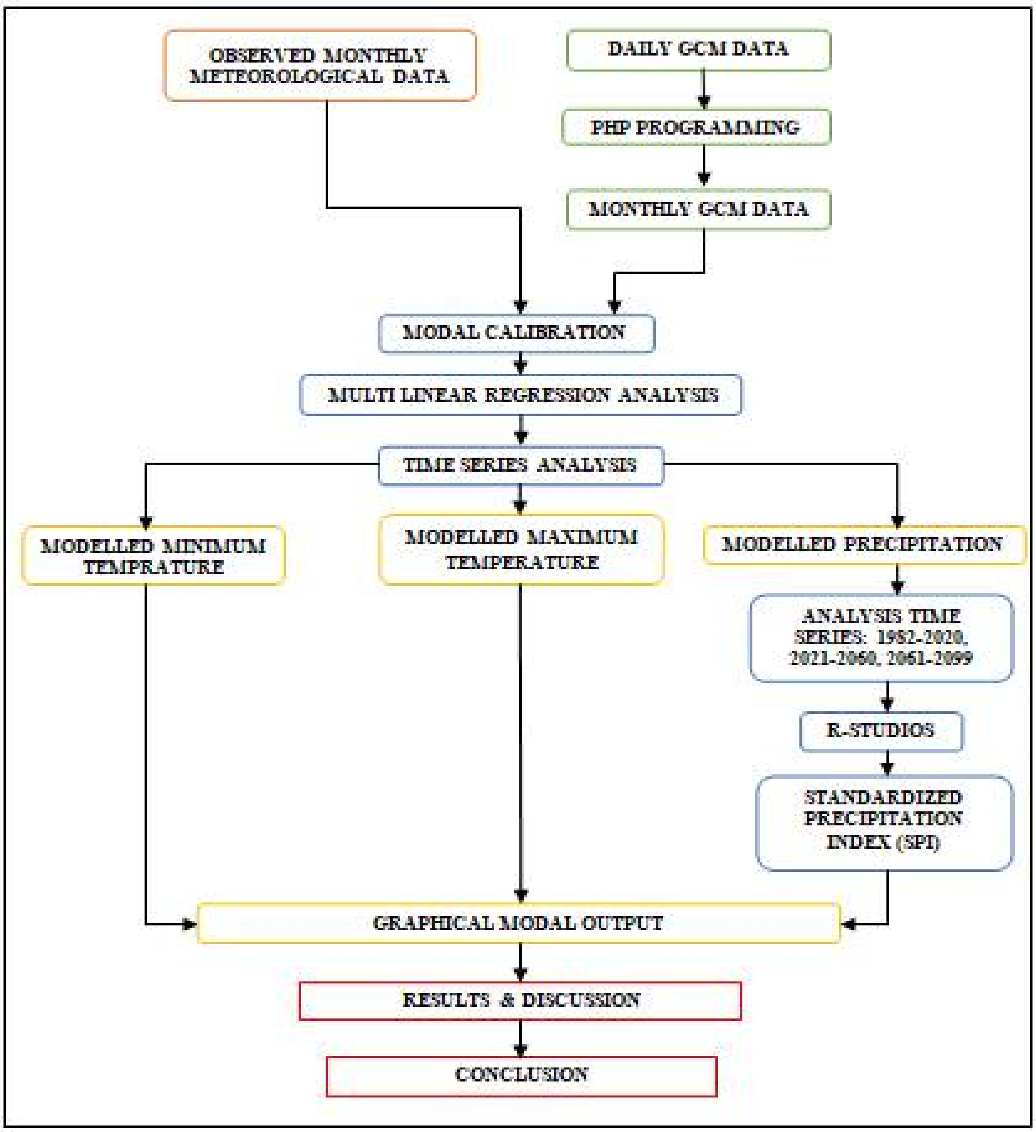

Figure 4.1: Flowchart of Methodology

V. RESULTS AND DISCUSSION

Figure 5.1 indicates the graphical outcome of minimum temperature for calibration-validation process. Using that model, forecasting of minimum temperature is done up to December-2099. This is represented in Figure 5.2.

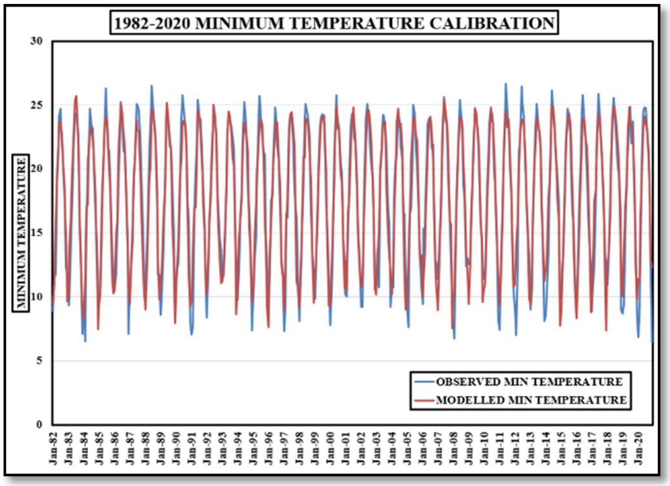

Figure 5.1: Statistical Downscaling of MinimumTemperature for Year 1982-2020 (Amreli)

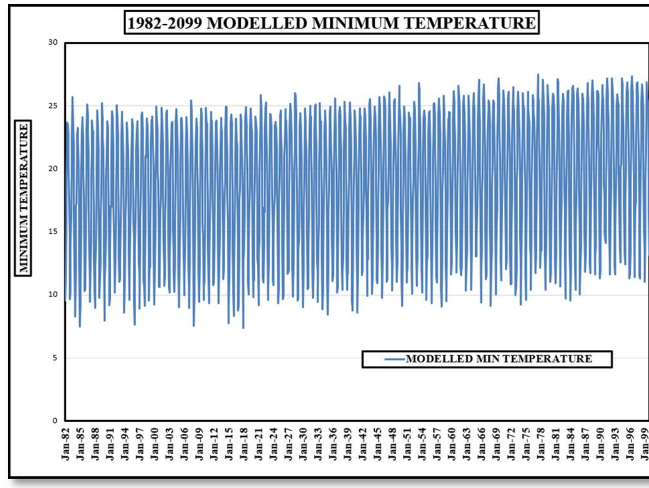

Figure 5.2: Statistical Downscaling of Minimum Temperature for Year 1982-2099 (Amreli)

Table 5.1 indicates results of minimum temperature of Amreli.The term highest-min in the table refers to the highest minimum temperature value. Similarly, the lowest-min refers to lowest minimum temperature value.Similarly, Table 5.2 shows results of maximum temperature of Amreli. The term highest-max in the table refers to the highest maximum temperature values. Similarly, the lowest-max refers to lowest maximum temperature values.

Table 5.1: Results of the Minimum Temperature Downscaling in Amreli

Amreli				
Minimum Temperature (°C)				
Time Series	Min Temp (°C)	Year	Observed	Modelled
1982-2020	Highest-min	Jun-11	26.65	24.51
	Lowest-min	Feb-84	6.53	8.29
2021-2060	Highest-min	Jun- 53	-	26.81
	Lowest-min	Jan-35	-	8.44
2061-2099	Lowest-min	Jun-77	-	27.47
	Lowest-min	Dec-67	-	9.13

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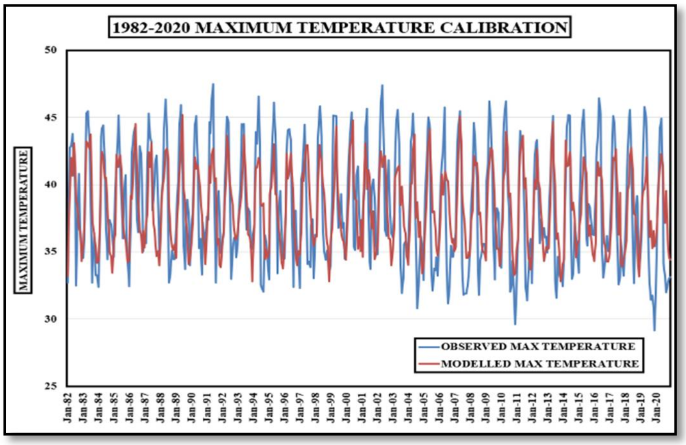

Figure 5.3: Statistical Downscaling of Maximum Temperature for Year 1982-2020 (Amreli)

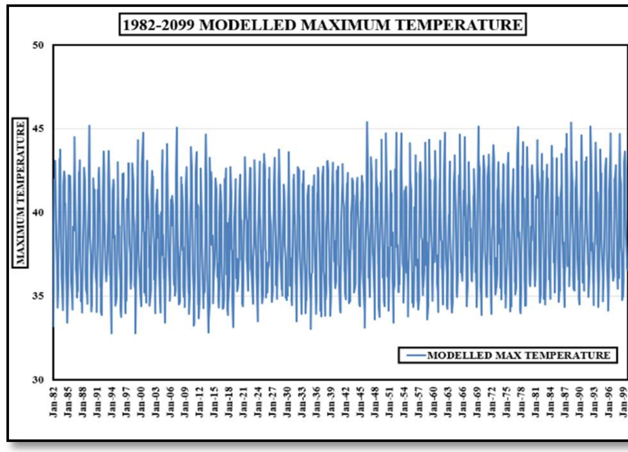

Figure 5.4: Statistical Downscaling of Maximum Temperature for Year 1982-2099 (Amreli)

Table 5.2: Results of the Maximum Temperature Downscaling in Amreli

Amreli				
Maximum Temperature (°C)				
Time Series	Max Temp (°C)	Year	Observed	Modelled
1982-2020	Highest-max	Jun-91	47.47	42.66
	Lowest-max	Dec-19	29.16	35.41
2021-2060	Highest-max	Jun- 46	-	45.41
	Lowest-max	Dec-34	-	33.04
2061-2099	Highest-max	May-88	-	45.38
	Lowest-max	Dec-69	-	33.85

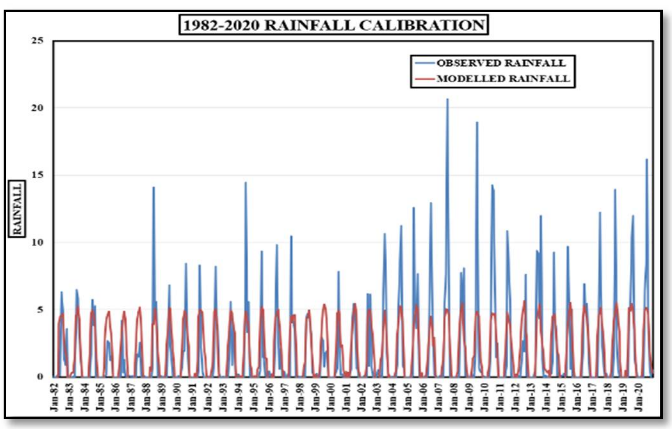

Figure 5.5: Statistical Downscaling of Precipitation for Year 1982-2020 (Amreli)

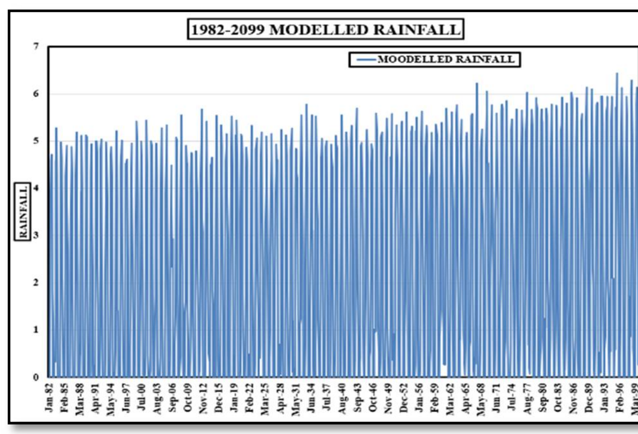

Figure 5.6: Statistical Downscaling of Precipitation for Year 1982-2020 (Amreli)

Table 5.3: Results of the Precipitation Downscaling in Amreli

Amreli		
Precipitation		
Time Series	Year	Modelled (mm/day)
1982-2020	Jul-93	5.56
2021-2060	Aug-33	5.77
2061-2099	Aug-95	6.43

The drought can be identified using R-Studio using SPI software package. It is readily available software package in R-studios. The results of SPI can be generated in graphical and tabular form. The graphical results are as shown in figure below. Figure 5.7 shows

SPI values of 1982-2020 years. Similarly, Figure 5.8 and Figure 5.9 shows future SPI values of year 2021-2060 and 2061-2099 respectively. These results can be used for analysis of severity of future droughts.

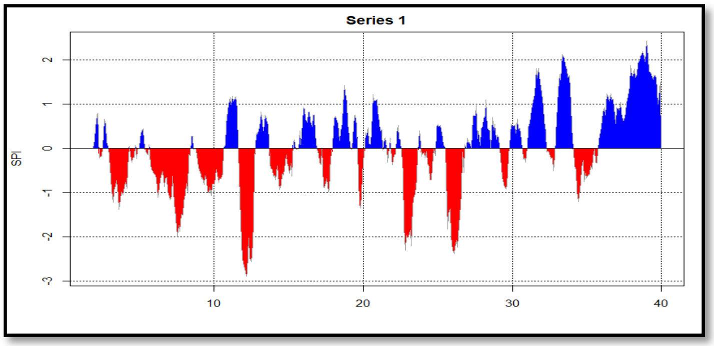

Figure 5.7: SPIAnalysis for Year 1982-2020

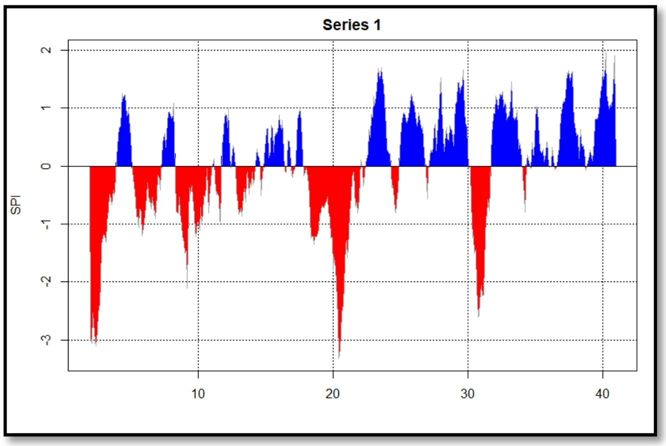

Figure 5.8: SPI Analysis for Future Year 2021-2060

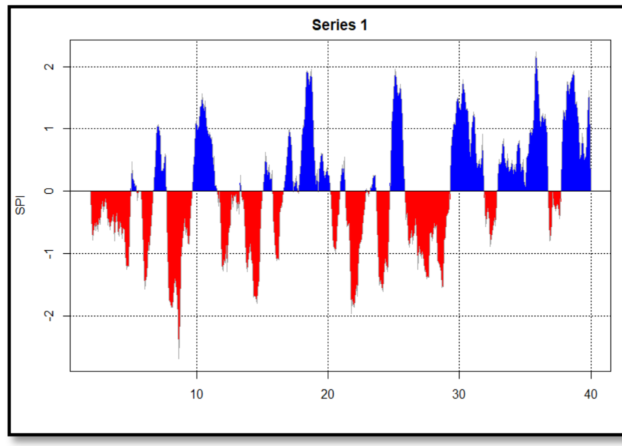

Figure 5.9: SPI Analysis for Future Year 2061-2099

Table 5.4shows classification SPI according to the severity of droughts. This table can be used to identify the severity of different droughts that have occurred in the area. Drought years according to its severity are enlisted in Table 5.5. This can be classified in mild, moderate and severe droughts.

Table 5.4: Classification of Droughts using SPI values

Grade	SPI Values	Drought Categories
1	-0.5 <SPI	No Drought
2	-1.0 <SPI ≤ -0.5	Mild Drought
3	-1.5 <SPI≤ -1.0	Medium Drought
4	-2.0 <SPI≤ -1.5	Severe Drought
5	SPI ≤ -2.0	Special Drought

Table 5.5: Analysis of various drought years in Amreli

Time Series	Drought Categories			
	Mild	Medium	Severe	Special
1982-2020	1984,1987,1990,1995,1998, 2003,2015	1988,2004,2007	1993	
2021-2060	2023,2025,2026,2030,2033,20 38,2039,2041,2051	2029,2050	-	2021,2022,2040
2061-2099	2062,2064,2066,2072,2081,20	2074,2087	2068	-

	82,2084,2086,2088,2092			

VI. CONCLUSION

Coastline of Gujaratis closest to Amreli. The majority of Gujarat's regions are hot and dry in the summer, and cold and damp in the winter; because, the minimum temperature in Amreli has climbed by about 3 degrees Celsius. Number of hot days and cold nights will become more common in Amreli. Here, maximum temperature rises roughly in proportion to the third part of the decrease in minimum temperature, which explains why the number of hottest days is increasing in comparison to the number of coldest days in some areas. The variance in the coldest and hottest days implies global warming, which is the sole cause of climate change uncertainty. At the end of the century, rainfall in Amreli increased by 8 mm. Amreli will experience26 mild droughts, 7 medium drought sand 2 severe droughts during 1981-2099 drought analysis. In the year 2040, a special drought may be experienced in Amreli. In the year 2068, Amreli is experiencing severe drought. These drought years can be used for drought contingency planning.

VII. ACKNOWLEDGEMENT

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REFERENCES

[1] Abbas, A. S., &Abdulateef, T. M. (2020). Generation of rainfall for Mosul city using statistical downscaling method (SDSM). IOP Conference Series: Materials Science and Engineering, 737(1), 012165. https://doi.org/10.1088/1757-899X/737/1/012165.

[2] Arora, H., Ojha, C. S. P., & Kashyap, D. (2016). Effect of Spatial Extent of Atmospheric Variables on Development of Statistical Downscaling Model for Monthly Precipitation in Yamuna-Hindon Interbasin, India. Journal of Hydrologic Engineering, 21(9), 05016019. https://doi.org/10.1061/(asce)he.1943-5584.0001400.

[3] Attribute Selection for Earth's Climate Prediction (2016). International Journal of Science and Research (IJSR), 5(8), 2319-7064 . https://doi.org/ART20161352.

[4] A Study on the Impact of Climate Change on the Productivity and Women Employment in Coffee and Tea Plantations in India(2016). International Journal of Science and Research (IJSR), 5(8), 2319-7064 https://doi.org/ART2016831.

[5] Bartczak, A., Kaczmarek, H., Badocha, M., Krzemiński, M., &Tyszkowski, S. (2021). Measured and predicted freeze-thaw days frequencies in climate change conditions in central Poland. PeerJ, 9, e12153. https://doi.org/10.7717/peerj.12153.

[6] Ben Khalfallah, C., &Saidi, S. (2018). Spatiotemporal floodplain mapping and prediction using HEC-RAS - GIS tools: Case of the Mejerda river, Tunisia. Journal of African Earth Sciences, 142, 44–51. https://doi.org/10.1016/j.jafrearsci.2018.03.004.

[7] Du, P., Xu, M., & Li, R. (2021). Impacts of climate change on water resources in the major countries along the Belt and Road. PeerJ, 9, e12201. https://doi.org/10.7717/peerj.12201.

[8] E. Arnone & Marco Cucchi & Sara Dal Gesso & Marcello Petitta &Sandro Calmanti (2020). Droughts Prediction: A Methodology Based on Climate Seasonal Forecast Water Resources Management https://doi.org/10.1007/s11269-020-02623-3.

[9] Egbebiyi, T. S., Crespo, O., Lennard, C., Zaroug, M., Nikulin, G., Harris, I., Price, J., Forstenhäusler, N., & Warren, R. (2020). Investigating the potential impact of 1.5, 2 and 3 °C global warming levels on crop suitability and planting season over West Africa. PeerJ, 8, e8851. https://doi.org/10.7717/peerj.8851.

[10] Feldman, D. R., Tadić, J. M., Arnold, W., & Schwarz, A. (2021). Establishing a Range of Extreme Precipitation Estimates in California for Planning in the Face of Climate Change. Journal of Water Resources Planning and Management, 147(9), 04021056. https://doi.org/10.1061/(asce)wr.1943-5452.0001410.

[11] Genthon, C., Krinner, G., &Castebrunet, H. (2009). Antarctic precipitation and climate-change predictions: horizontal resolution and margin vs plateau issues. Annals of Glaciology, 50(50), 55–60. https://doi.org/10.3189/172756409787769681.

[12] MassoudGoodarzia, Mohammad HoseinMahdianb and Bagher Ghermezcheshmehc(2019). Assessment of climate change using SDSM downscaling Model (A case study: West of Iran) .Water Harvesting Research ,29-39. https://doi.org/10.22077/jwhr.2019.2720.1029.

[13] Marcinkowski, P., &Mirosław-Świątek, D. (2020). Modelling of climate change impact on flow conditions in the lowland anastomosing river. PeerJ, 8, e9275. https://doi.org/10.7717/peerj.9275.

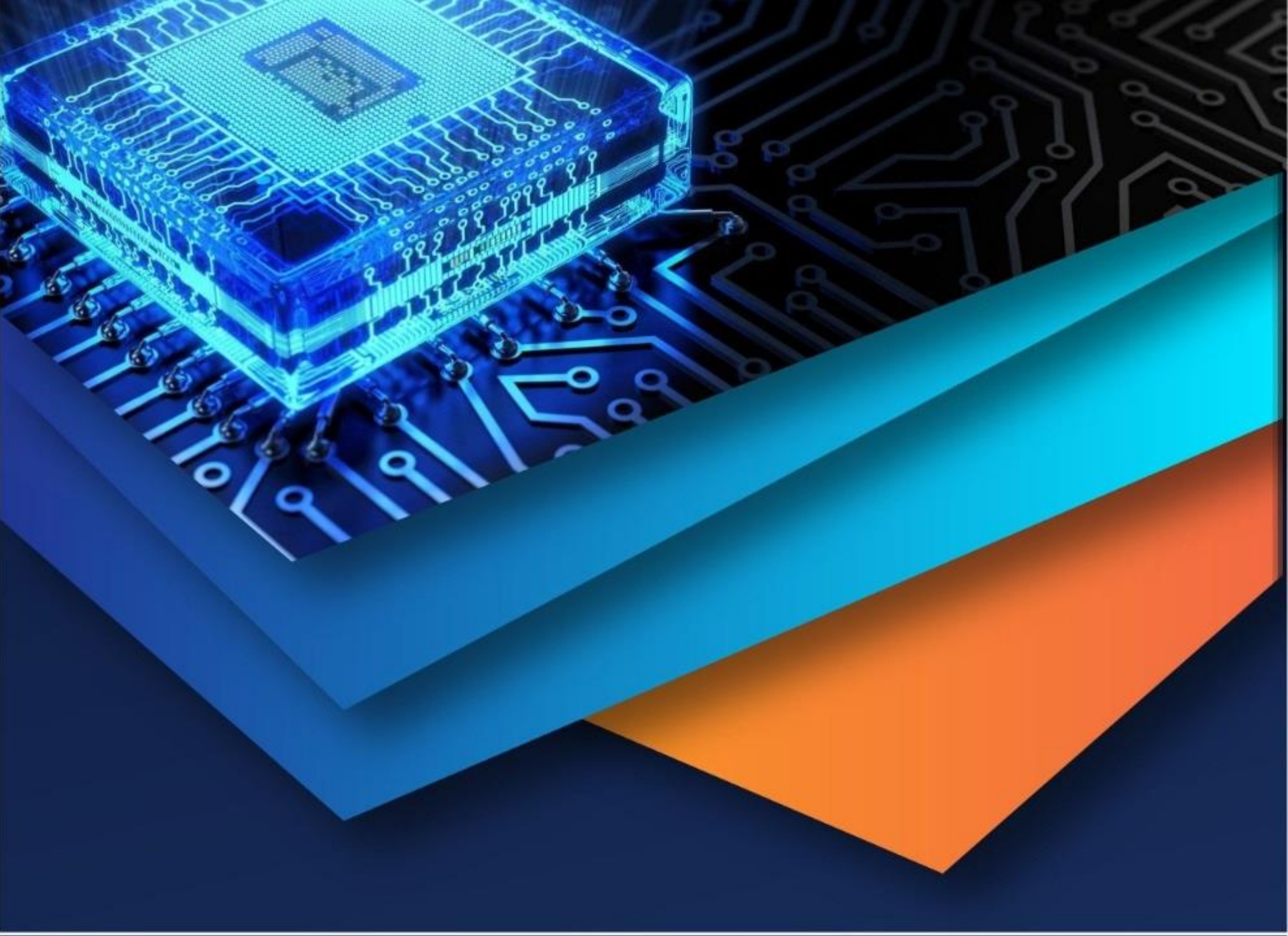
[14] Mo, X. G., Hu, S., Lin, Z. H., Liu, S. X., & Xia, J. (2017). Impacts of climate change on agricultural water resources and adaptation on the North China Plain. Advances in Climate Change Research, 8(2), 93–98. https://doi.org/10.1016/j.accre.2017.05.007.

[15] Jafarzadeh, A., Pourreza-Bilondi, M., KhasheiSiuki, A., &Ramezani Moghadam, J. (2021). Examination of Various Feature Selection Approaches for Daily Precipitation Downscaling in Different Climates. Water Resources Management, 35(2), 407–427. https://doi.org/10.1007/s11269-020-02701-6.

[16] Najafi, R., &HessamiKermani, M. R. (2017). Uncertainty Modeling of Statistical Downscaling to Assess Climate Change Impacts on Temperature and Precipitation. Water Resources Management, 31(6), 1843–1858. https://doi.org/10.1007/s11269-020-02701-6.

[17] Ostad-Ali-Askari, K., GhorbanizadehKharazi, H., Shayannejad, M., &Zareian, M. J. (2020). Effect of Climate Change on Precipitation Patterns in an Arid Region Using GCM Models: Case Study of Isfahan-Borkhar Plain. Natural Hazards Review, 21(2), 04020006. https://doi.org/10.1061/(asce)nh.1527-6996.0000367.

[18] Predicting Future Changes in Temperature and Precipitation in Arid Climate (2015). of Kutch, Gujarat: Analyses Based on LARS-wG Model.Current Science, https://doi.org/10.22077/jwhr.2015.2750.2451.
[19] Peltonen-Sainio, P., Juvonen, J., Korhonen, N., Parkkila, P., Sorvali, J., &Gregow, H. (2021b). Climate change, precipitation shifts and early summer drought: An irrigation tipping point for Finnish farmers?Climate Risk Management, 33, 100334. https://doi.org/10.1016/j.crm.2021.100334.
[20] Roya Quraishi (2020). Impact Assessment of Climate Change and Mitigation and Adaptation Methods on Water Resources in Kabul River Basin. International Journal of Science and Research (IJSR), 9(9), https://doi.org/ 10.21275/SR20916140642.
[21] RifniNuraryssaMohd Patnani1, Nor Maizzaty Abdullah1*, Nur Aini Arish @ Arshad(2021). Prediction of Future Temperature using Statistical Downscaling Model (SDSM) in Accessing Climate Change at Catchment Area Sungai Bekok, Batu, Pahat. Proceeding in Engineering Application and Technology Vol. 2 No. 1 (2021) 409–417 https://doi.org/10.30880/peat.2021.02.01.040.
[22] Shukla, R., Khare, D., & Deo, R. (2015). Statistical Downscaling of Climate Change Scenarios of Rainfall and Temperature over Indira Sagar Canal Command Area in Madhya Pradesh, India. 2015 IEEE 14th International Conference on Machine Learning and Applications (ICMLA). https://doi.org/10.1109/icmla.2015.75.
[23] Shah, N. V., Patel, Y. S., &DBhangaonkar, P. (2021). Assessing Impact of Climate Change on Rainfall Patterns of Vadodara District, Gujarat, India. Journal of Physics: Conference Series, 1714(1), 012046. https://doi.org/10.1088/1742-6596/1714/1/012046.
[24] Trend Analysis of Temperature: A Case Study of Aegean Region, Turkey. (2017). International Journal of Science and Research (IJSR), 6(7), 431–438. https://doi.org/10.21275/art20175255.
[25] Zhou, Z., Guo, B., Su, Y., Chen, Z., & Wang, J. (2020). Multidimensional evaluation of the TRMM 3B43V7 satellite-based precipitation product in mainland China from 1998–2016. PeerJ, 8, e8615. https://doi.org/10.7717/peerj.8615.



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