Hydro Informatics
SPRING SEMESTER 2021

Drought Analysis Tool - Report

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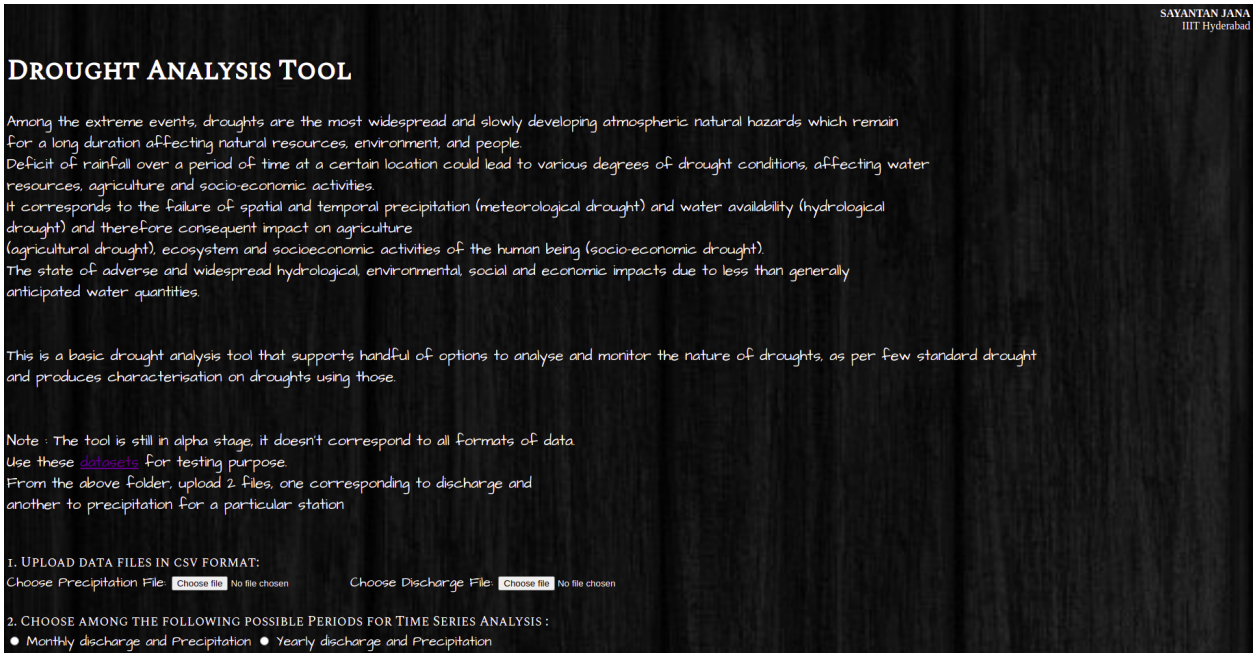


Among the extreme events, droughts are the most widespread and slowly developing atmospheric natural hazards which remain for a long duration affecting natural resources, environment, and people.

Deficit of rainfall over a period of time at a certain location could lead to various degrees of drought conditions, affecting water resources, agriculture and socio-economic activities.

It corresponds to the failure of spatial and temporal precipitation (meteorological drought) and water availability (hydrological drought) and therefore consequent impact on

agriculture (agricultural drought), ecosystem and socioeconomic activities of the human being (socio-economic drought).

The state of adverse and widespread hydrological, environmental, social and economic impacts due to less than generally anticipated water quantities.

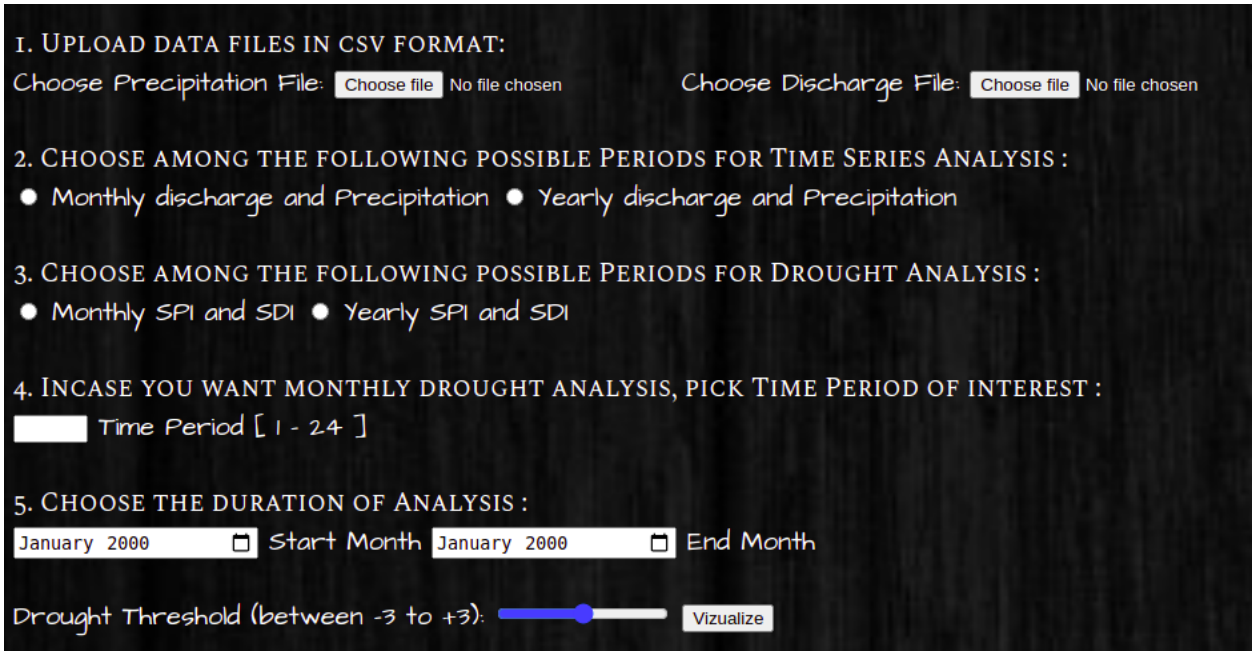
This is a basic drought analysis tool that supports handful of options to analyse and monitor the nature of droughts, as per few standard drought and produces characterisation on droughts using those. The app has been built using Python, Flask, Jinja2 and HTML.

Note : The tool is still in alpha stage, it doesn't correspond to all formats of data. Use these datasets for testing purpose.

From the above folder, upload 2 files, one corresponding to discharge and another to precipitation for a particular station.

Features :

Following options are allowed in the tool for analysis :



Tried Distributions, Goodness tests and Drought Indices and Characterizations used:

Distributions :

We have used the following distributions :

- The probability density function for **gamma** is:

$$f(x, a) = \frac{x^{a-1} e^{-x}}{\Gamma(a)}$$

for x≥0, a>0. Here Γ(a) refers to the gamma function.

gamma takes a as a shape parameter for a. When a is an integer, **gamma** reduces to the Erlang distribution, and when a=1to the exponential distribution. Gamma distributions are sometimes parameterized with two variables, with a probability density function of:

$$f(x, \alpha, \beta) = \frac{\beta^{\alpha} x^{\alpha-1} e^{-\beta x}}{\Gamma(\alpha)}$$

Note that this parameterization is equivalent to the above, with scale = 1 / beta.

The probability density above is defined in the "standardized" form. To shift and/or scale the distribution use the loc and scale parameters. Specifically, gamma.pdf(x, a, loc, scale) is identically equivalent to gamma.pdf(y, a) / scale with y = (x - loc) / scale. Note that shifting the location of a distribution does not make it a "noncentral" distribution; noncentral generalizations of some distributions are available in separate classes.

- The probability density function for **pearson3** is:

$$f(x, \kappa) = \frac{|\beta|}{\Gamma(\alpha)} (\beta(x - \zeta))^{\alpha-1} \exp(-\beta(x - \zeta))$$

Where:

$$\beta = \frac{2}{\kappa}$$
$$\alpha = \beta^2 = \frac{4}{\kappa^2}$$
$$\zeta = -\frac{\alpha}{\beta} = -\beta$$

Γ is the gamma function (**scipy.special.gamma**). Pass the skew κ into **pearson3** as the shape parameter skew.

The probability density above is defined in the "standardized" form. To shift and/or scale the distribution use the loc and scale parameters. Specifically, pearson3.pdf(x, skew, loc, scale) is identically equivalent to pearson3.pdf(y, skew) / scale with y = (x - loc) / scale. Note that shifting the location of a distribution does not make it a "noncentral" distribution; noncentral generalizations of some distributions are available in separate classes.

- The probability density function for **logistic** is:

$$f(x) = \frac{\exp(-x)}{(1+\exp(-x))^2}$$

logistic is a special case of **genlogistic** with c=1.

The probability density above is defined in the "standardized" form. To shift and/or scale the distribution use the loc and scale parameters. Specifically, logistic.pdf(x, loc, scale) is identically equivalent to logistic.pdf(y) / scale with y = (x - loc) / scale. Note that shifting the location of a distribution does not make it a "noncentral" distribution; noncentral generalizations of some distributions are available in separate classes.

Goodness Test :

KOLMOGOROV–SMIRNOV TEST

We could have opted for T-test even but there is an issue with it, samples must be normal (shaped in a normal distribution). Since we don't exactly know, how the data looks like, this would be an unnecessary burden associated with T-test.

The Kolmogorov–Smirnov statistic quantifies a distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution, or between the empirical distribution functions of two samples.

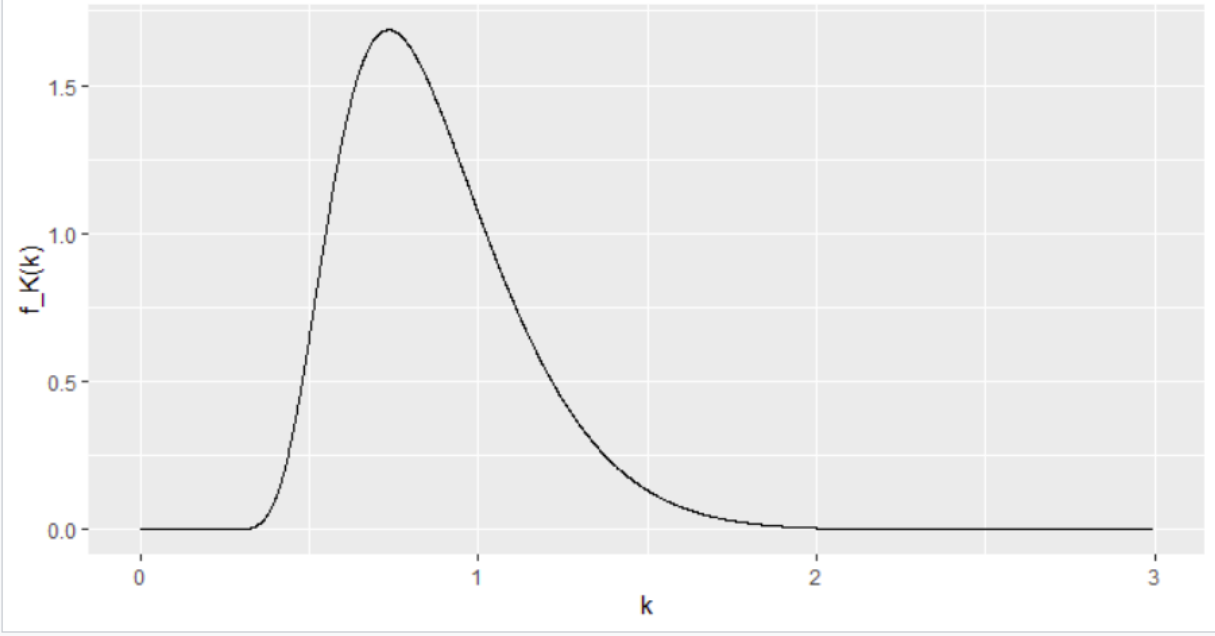


Illustration of the Kolmogorov distribution's PDF.

Drought Indices used :

Standardized Precipitation Index (SPI) and Standardized Discharge Index(SDI)

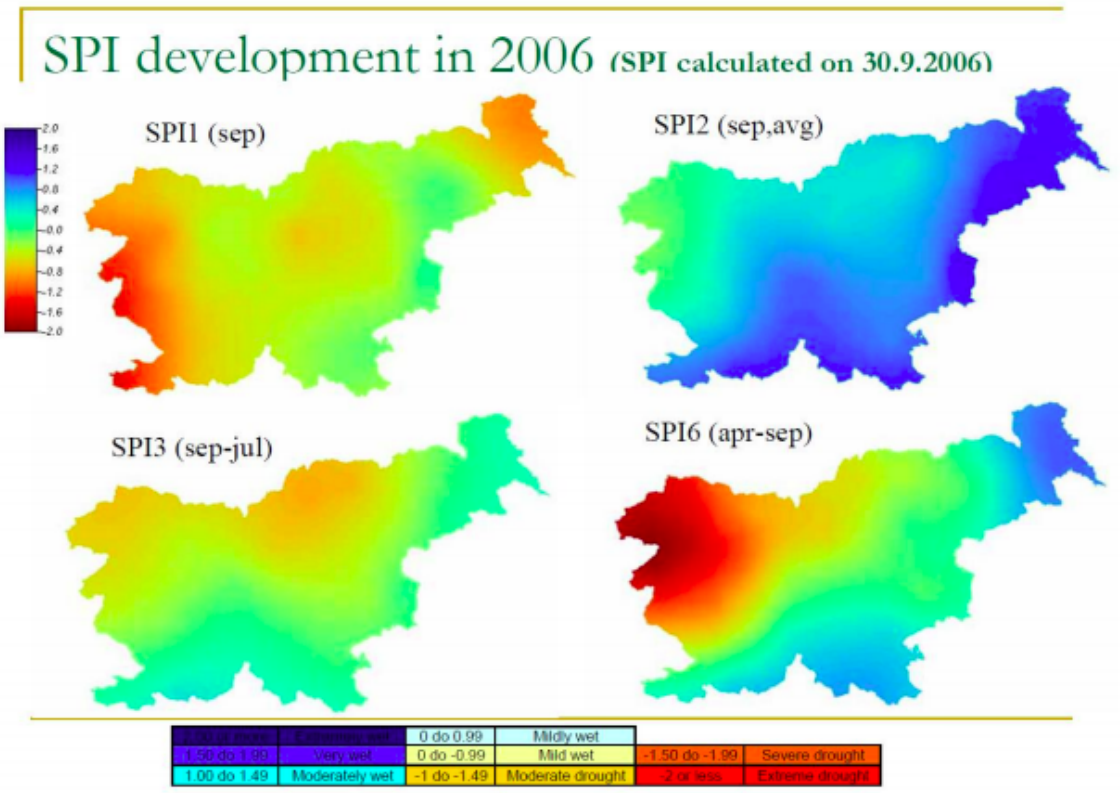
- To calculate the SPI, a long-term precipitation record at the desired station is first fitted to a probability distribution (e.g. gamma distribution), which is then transformed into a normal distribution so that the mean SPI is zero. The SPI may be computed with different time steps (e.g. 1 month, 3 months, 24 months).
- World Meteorological Organization (WMO) recommends :
- The standard normal distribution transformation:

  • It can transfer the mean and standard deviation adjusted to zero and one

  • Skewness of the existing rainfall data can be adjusted to zero

  • Transformation help in having SPI values can be interpreted as mean zero and standard deviation as one

- We tend to use the same function support for Standard Discharge Index, sole, difference being we apply the function on Discharge data rather than Precipitation data.



Note that the tool provides support for analysis on various time periods of interest, from 1 to 24 months, i.e., SPI3, SPI6, etc can also be computed as per the user choice.

Drought Characterizations :

- <u>Intensity of Drought :</u>

  Calculated according to the following table :

Table 1 Drought classifications based on SPI

Probability (%)	SPI	Drought category
2.30	SPI ≥ 2.00	Extreme wet
4.40	2.00 > SPI ≥ 1.50	Very wet
9.20	1.50 > SPI ≥ 1.00	Moderate wet
68.20	1.00 > SPI ≥ −1.00	Normal
9.20	− 1.00 ≥ SPI > −1.50	Moderate drought
4.40	− 1.50 ≥ SPI > −2.00	Severe drought
2.30	− 2.00 ≥ SPI	Extreme drought

- <u>Frequency of draught:</u>

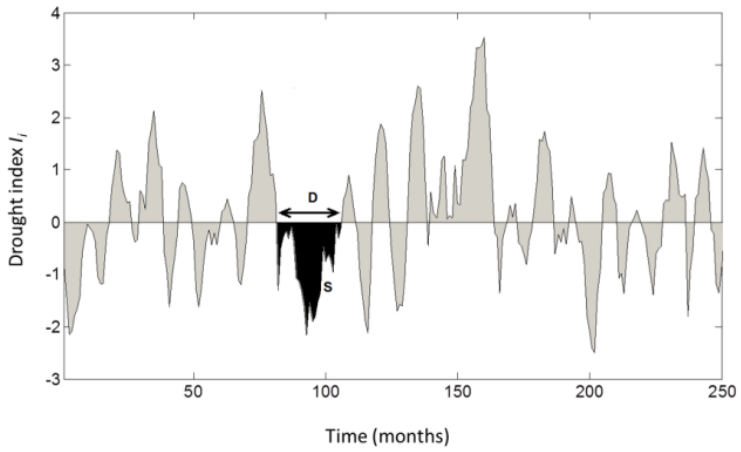
  Calculated as per :

  • Moderate Drought Frequency: −1.5< SPI/SPEI/SRI/SSI ≤ -1.0

  • Severe Drought Frequency: −2.0< SPI/SPEI/SRI/SSI ≤ -1.5

  • Extreme Drought Frequency: SPI/SPEI/SRI/SSI ≤ -2.0

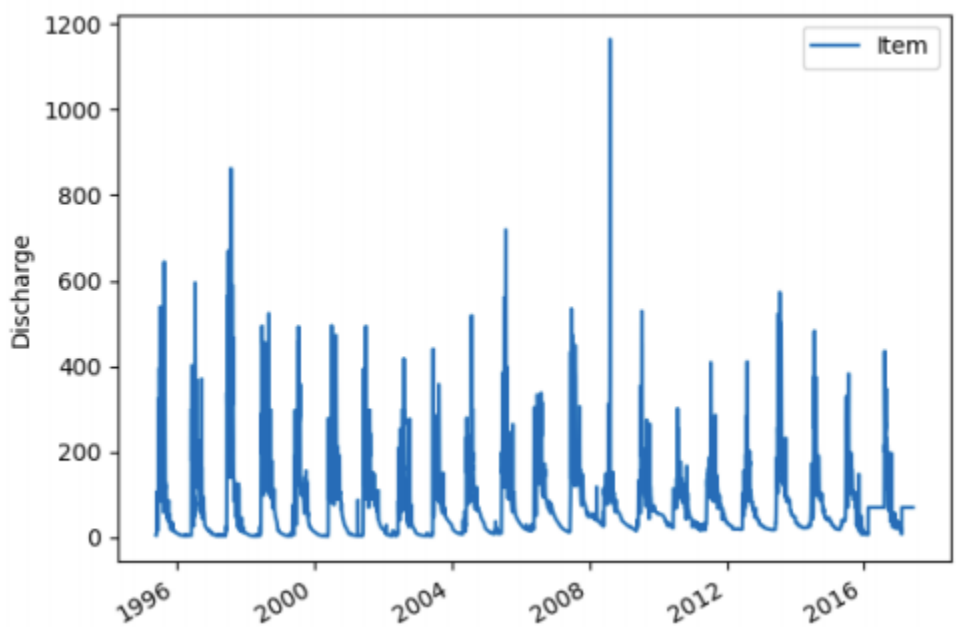
- <u>Duration and Severity of Drought:</u>

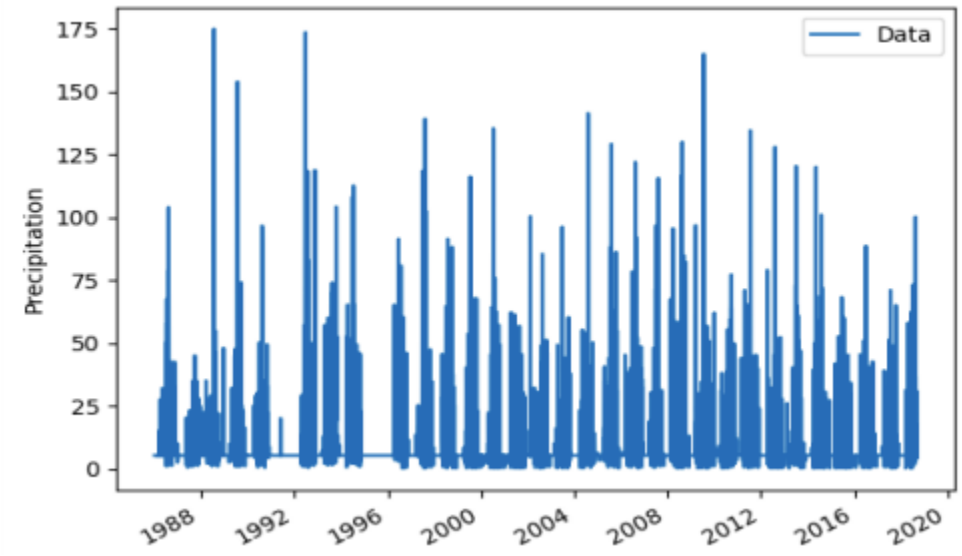


A similar account of analysis is to be performed for the drought indices we obtain.

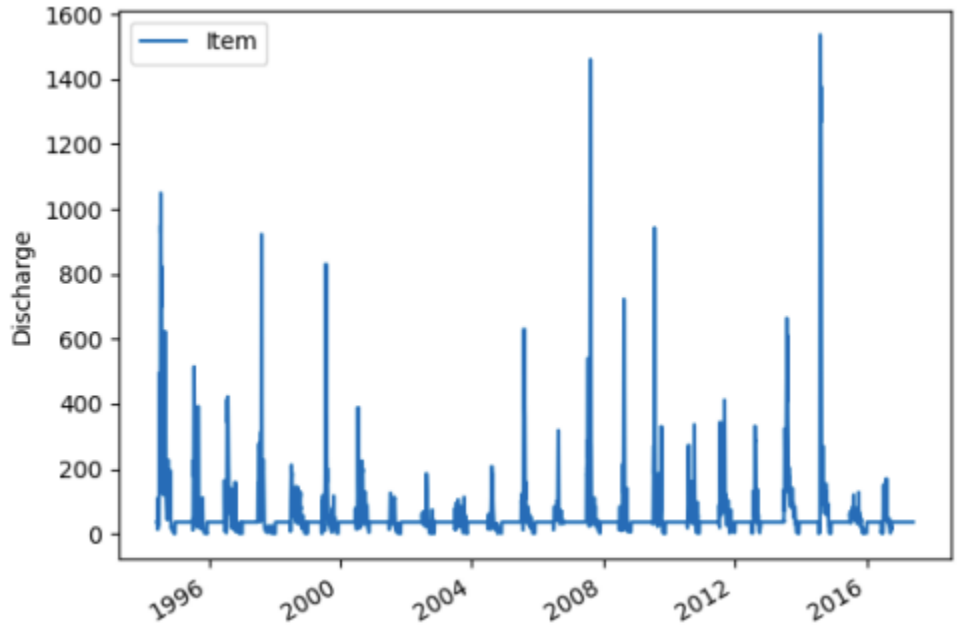
Discharge and Precipitation Variation at the stations under Study

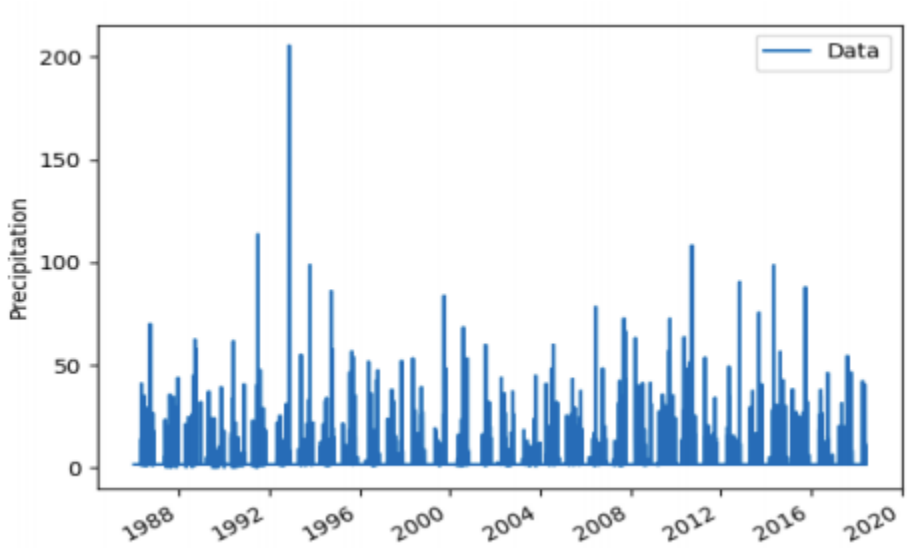
Balehonnur :



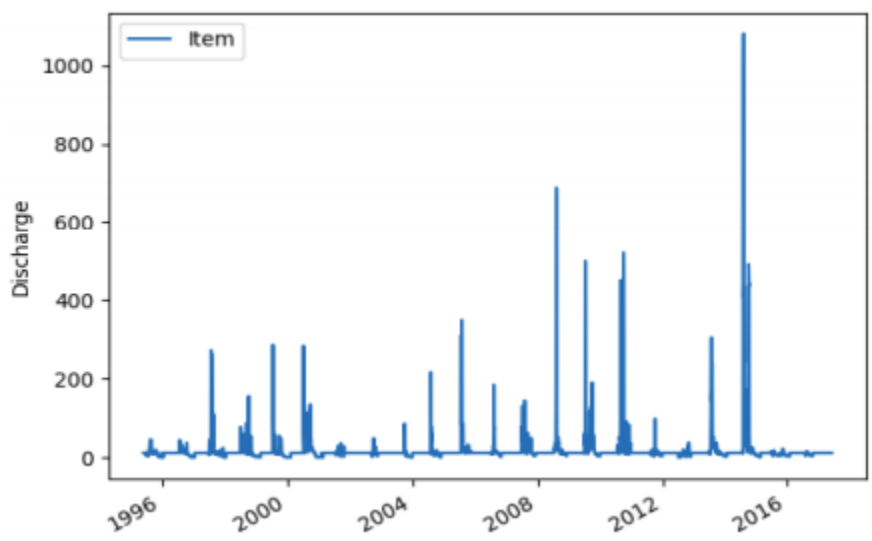


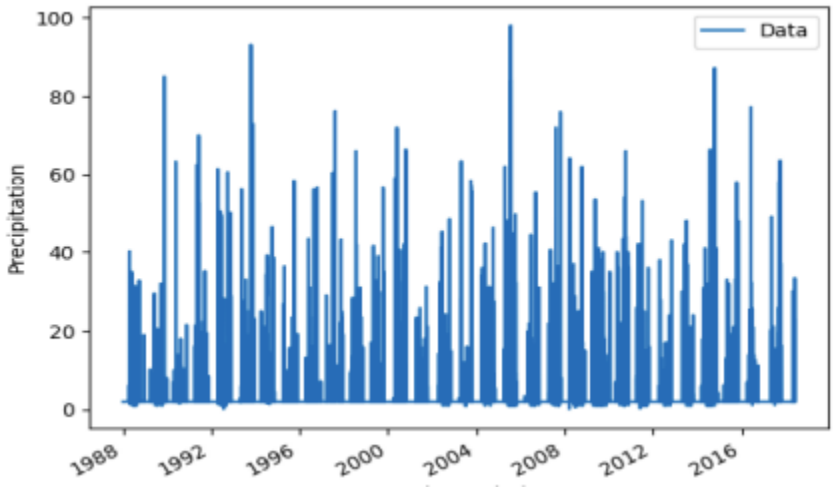
Hosaritti :


Item
Discharge
1600
1400
1200
1000
800
600
400
200
0
1996
2000
2004
2008
2012
2016


Data
Precipitation
200
150
100
50
0
1988
1992
1996
2000
2004
2008
2012
2016
2020

Rattihalli:





Cases Studies :

Since here, we will be choosing a combination of options to try out an analysis on any of the three chosen stations.

Monthly Analysis on Rattihali station :

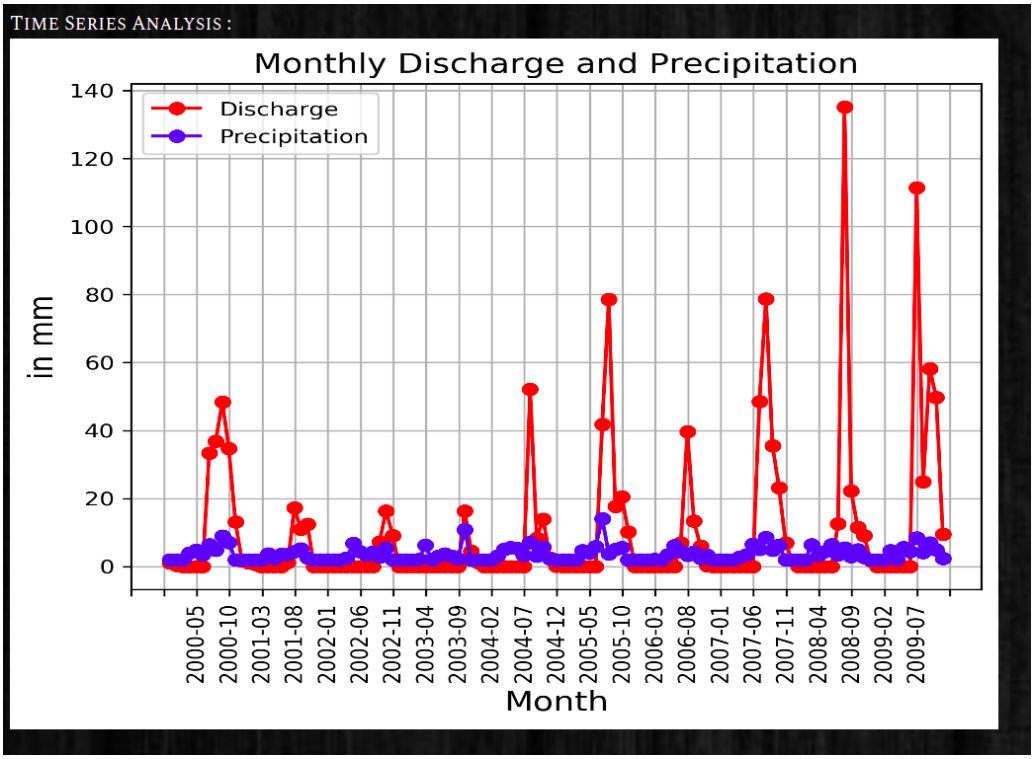
- Period Chosen for Analysis : January 2000 - December 2009
- Monthly Time Series analysis preferred.
- Monthly SPI and SDI analysis preferred wrt to Drought.

The goodness tests results are :

	STATISTIC FOR DISCHARGE	PVALUE FOR DISCHARGE	STATISTIC FOR PRECIPITATION	PVALUE FOR PRECIPITATION
GAMMA DISTRIBUTION	0.55	1.2870733597715016E-34	0.5909	1.858821640595756E-40
PEARSON3 DISTRIBUTION	0.5519	7.078306535752723E-35	0.35	1.2039168330069041E-13
LOGISTIC DISTRIBUTION	0.3431	4.079121547816376 4E-13	0.214	2.6452158058918256E-05

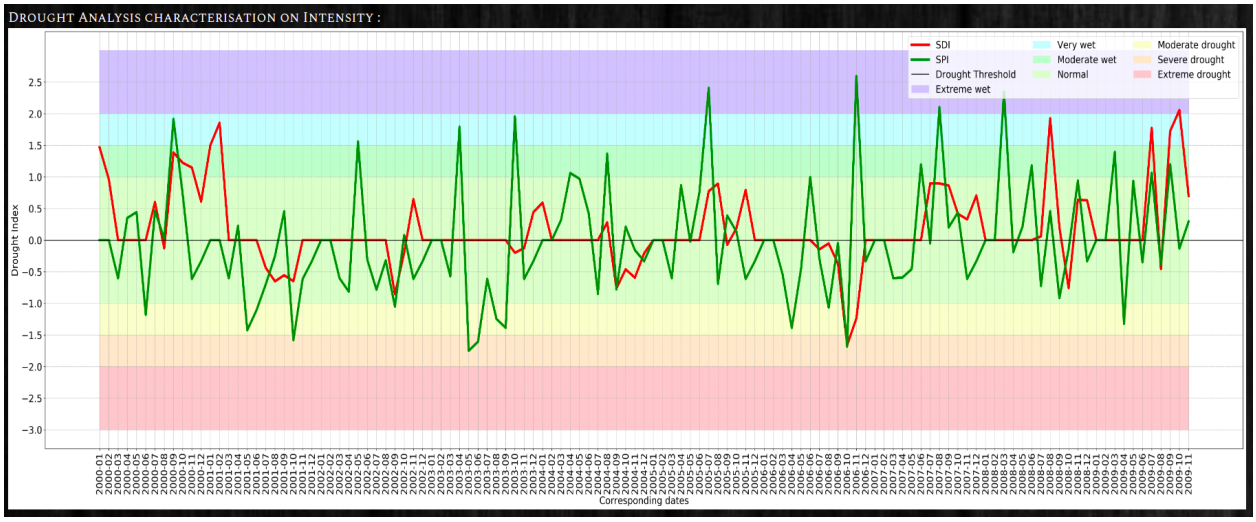
The time series analysis for discharge and precipitation can be found for the Rattihali station in the following image :

TIME SERIES ANALYSIS :



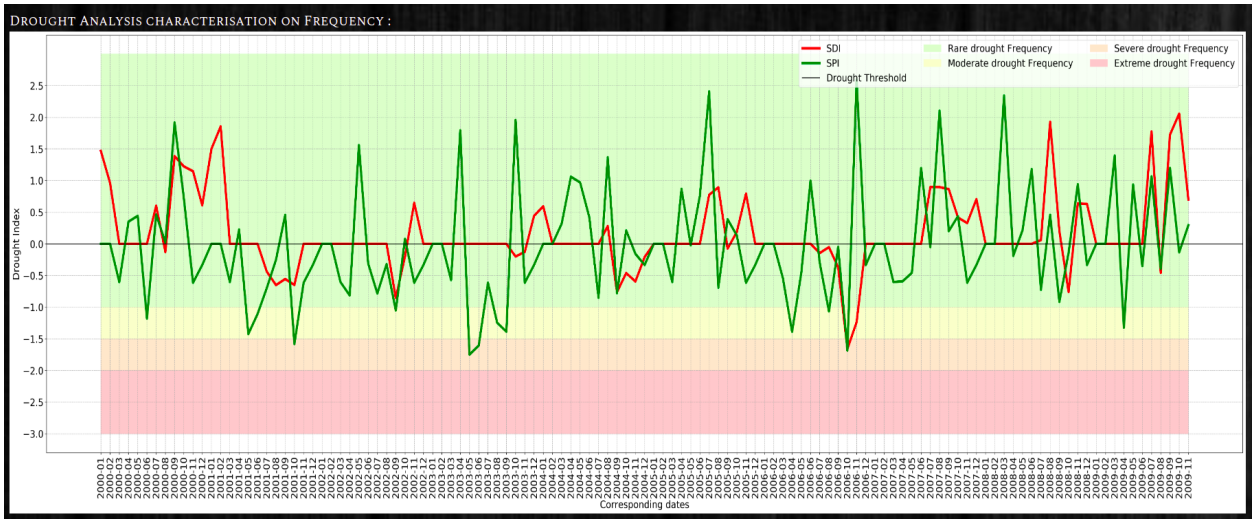
Drought Indices found and Characterised as per Intensity :

Color codes can help understand the characterizations.

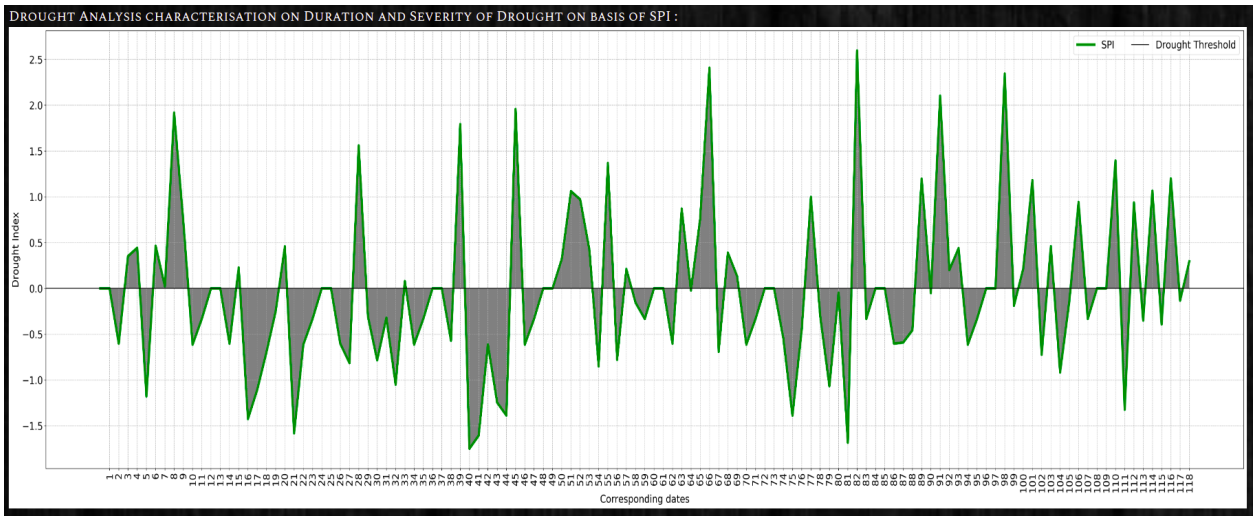


Drought Indices found and Characterised as per Frequency :

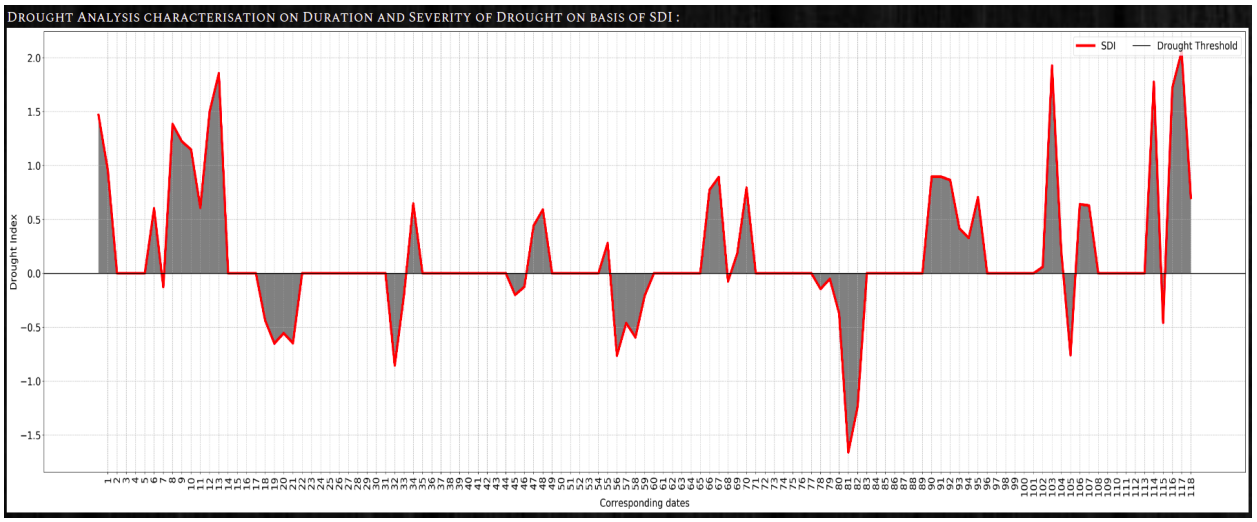
Color codes can help understand the characterizations.



Drought Indices found and Characterised as per Duration on basis of SPI :



Drought Indices found and Characterised as per Duration on basis of SDI :



Yearly Analysis on Rattihali station :

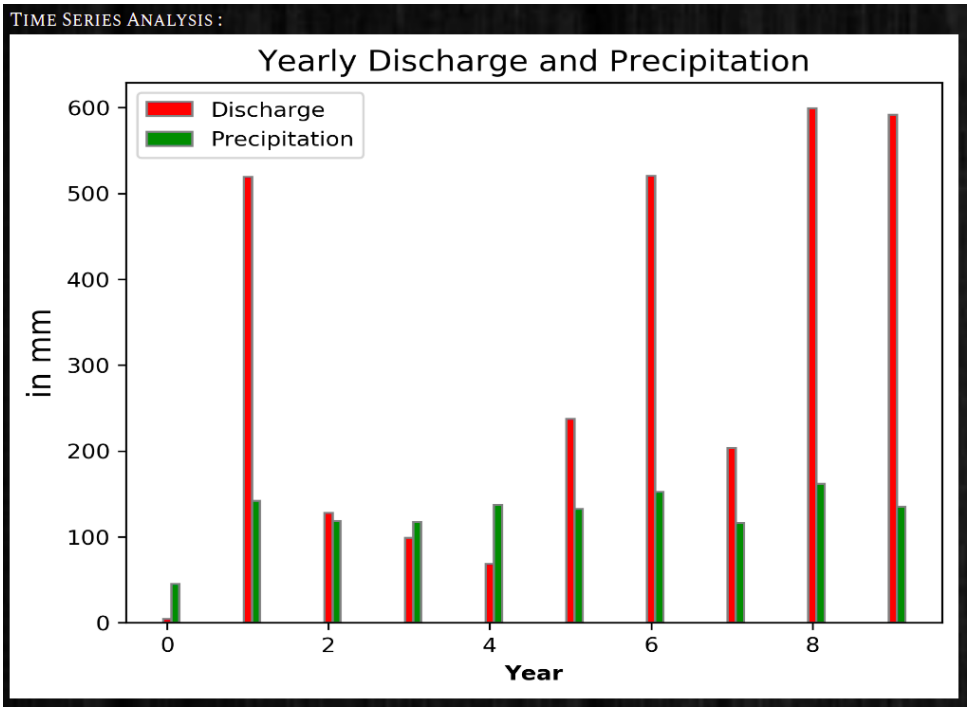
- Period Chosen for Analysis : January 2000 - December 2009
- Yearly Time Series analysis preferred.
- Yearly SPI and SDI analysis preferred wrt to Drought.

The goodness tests results are :

	Statistic for Discharge	Pvalue for Discharge	Statistic for Precipitation	Pvalue for Precipitation
Gamma Distribution	0.55	1.2870733597715016E-34	0.5909	1.858821640595756E-40
Pearson3 Distribution	0.5519	7.078306535752723E-35	0.35	1.2039168330069041E-13
Logistic Distribution	0.3431	4.079121547816376 4E-13	0.214	2.6452158058918256E-05

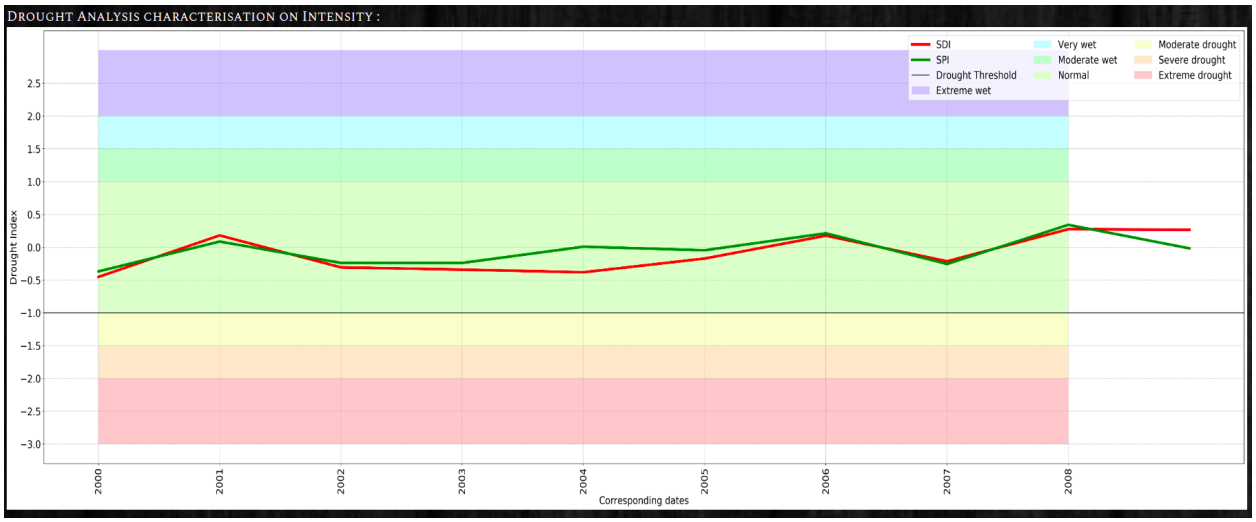
The time series analysis for discharge and precipitation can be found for the Rattihali station in the following image :

Time Series Analysis :



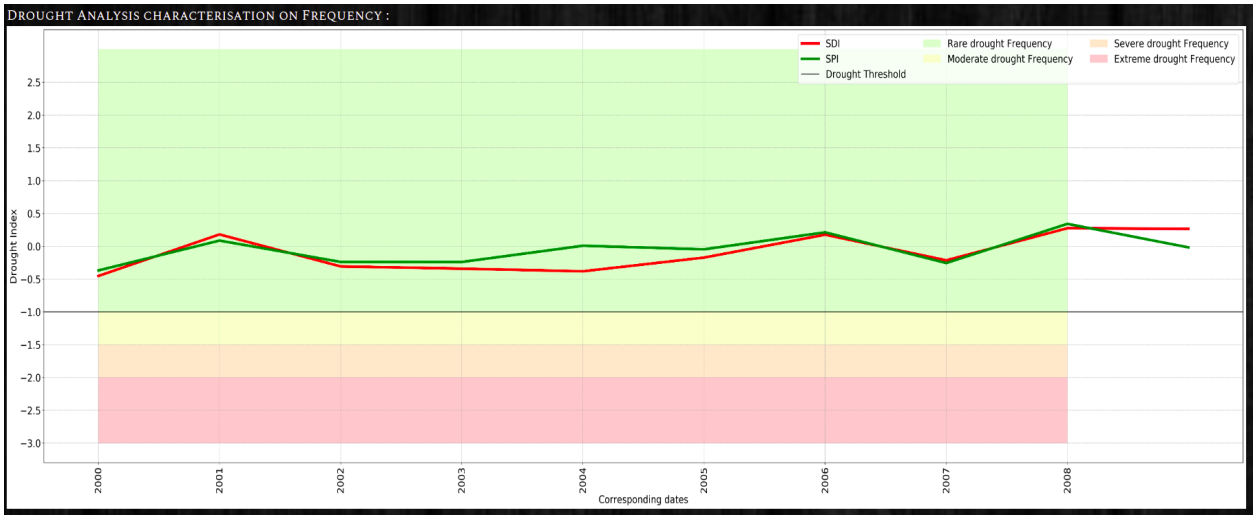
Drought Indices found and Characterised as per Intensity :

Color codes can help understand the characterizations.

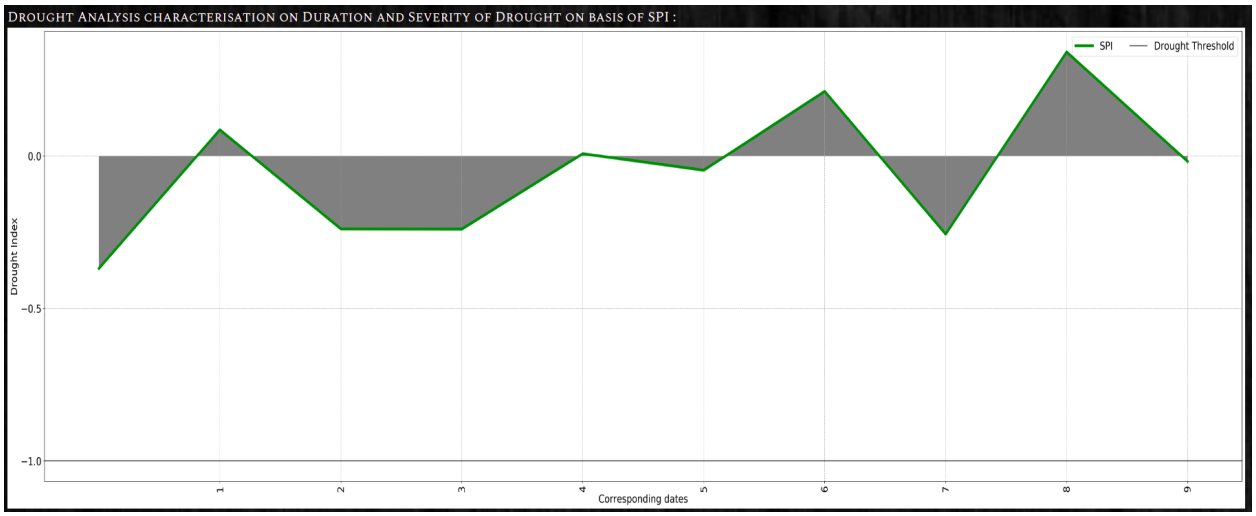


Drought Indices found and Characterised as per Frequency :

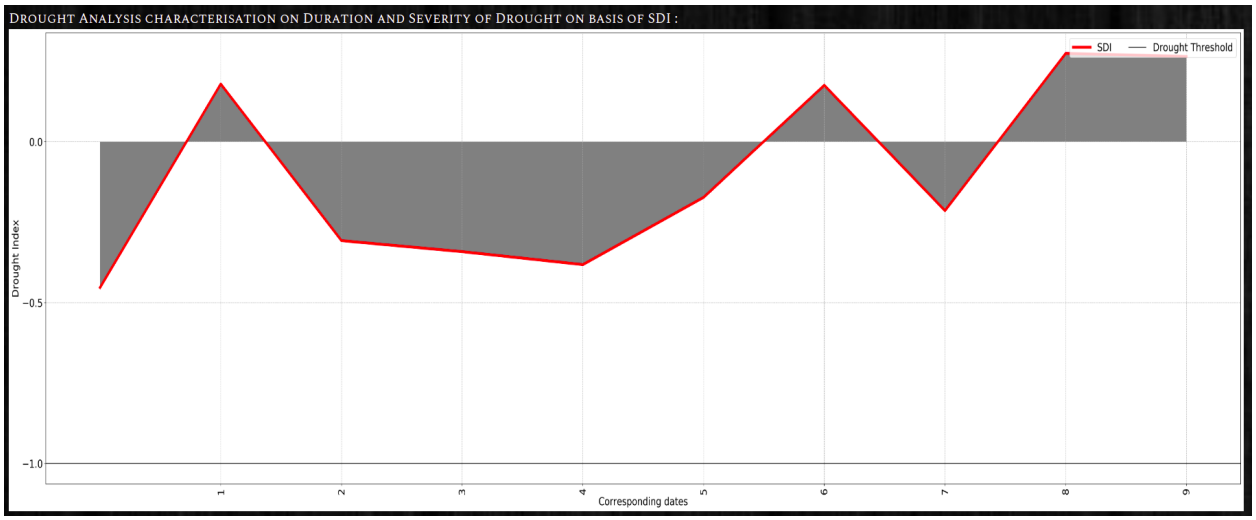
Color codes can help understand the characterizations.



Drought Indices found and Characterised as per Duration on basis of SPI :



Drought Indices found and Characterised as per Duration on basis of SDI :



Quarterly Analysis on station [SPI3, SDI3] :

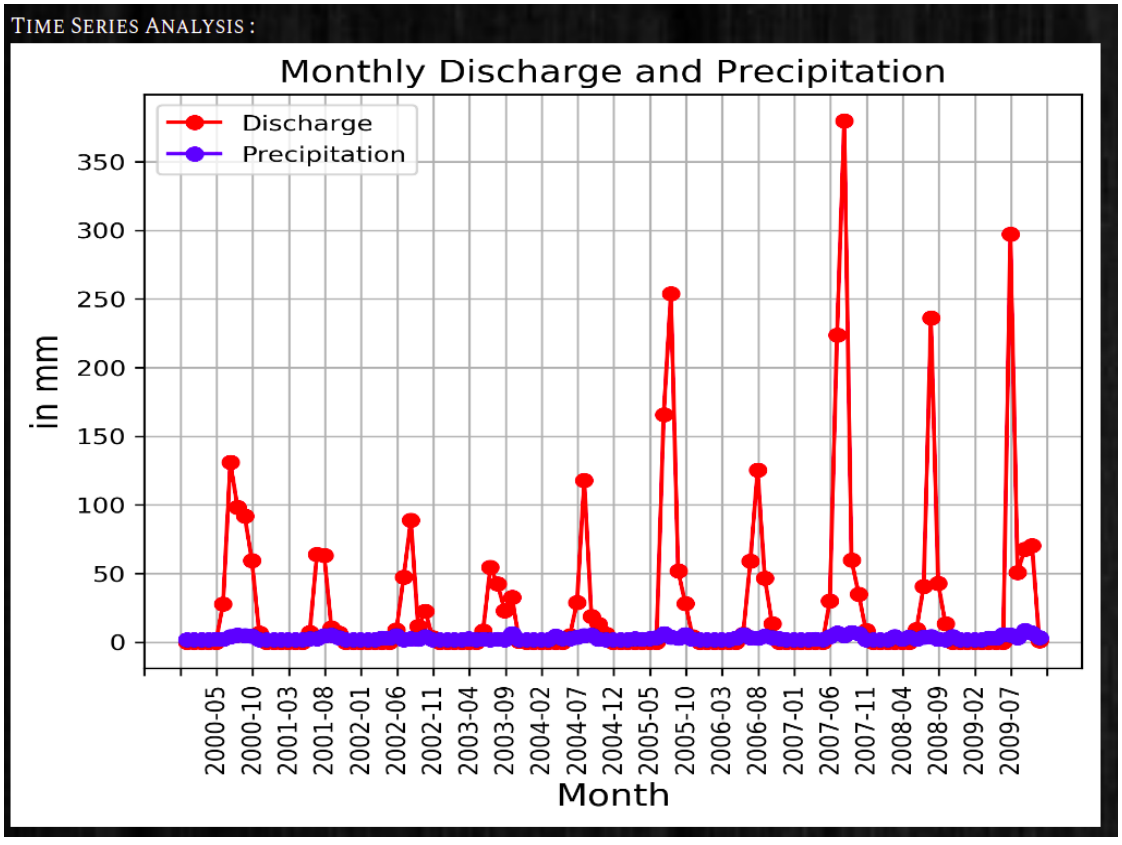
- Period Chosen for Analysis : January 2000 - December 2009
- Monthly Time Series analysis preferred.
- Quarterly SPI and SDI analysis preferred wrt to Drought, i.e., SPI3 and SDI3 .

The goodness tests results are :

	Statistic for Discharge	Pvalue for Discharge	Statistic for Precipitation	Pvalue for Precipitation
Gamma Distribution	0.5417	1.6819135017401376E-33	0.762	3.244030242970943E-73
Pearson3 Distribution	0.5417	1.6819135017477154E-33	0.1963	0.0001590814500885335 2
Logistic Distribution	0.3394	7.701943425997798E-13	0.2301	4.5328221739567795E-06

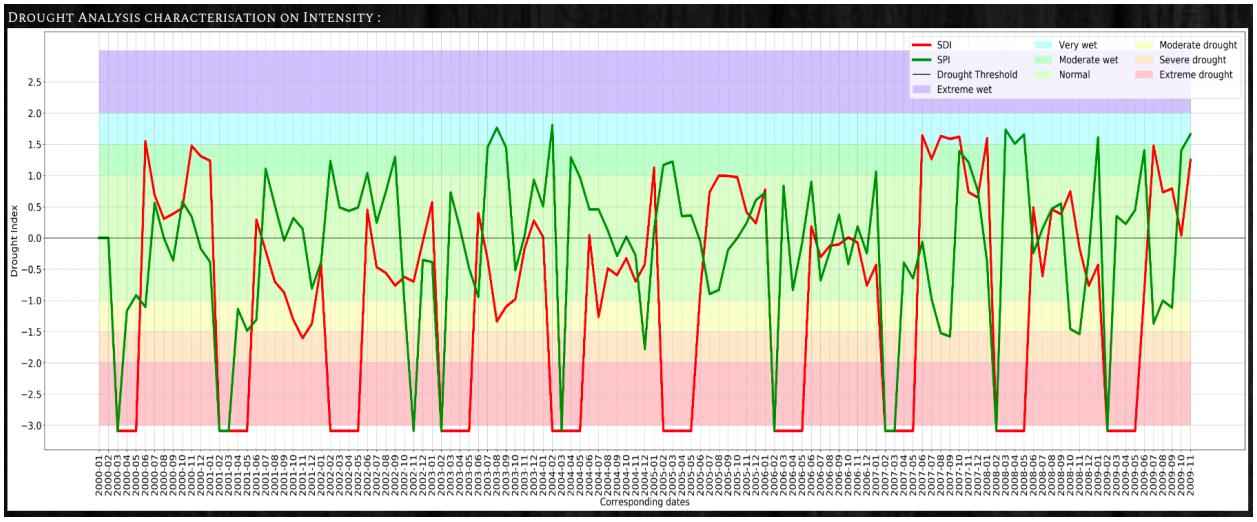
The time series analysis for discharge and precipitation can be found for the Rattihali station in the following image :

Time Series Analysis :



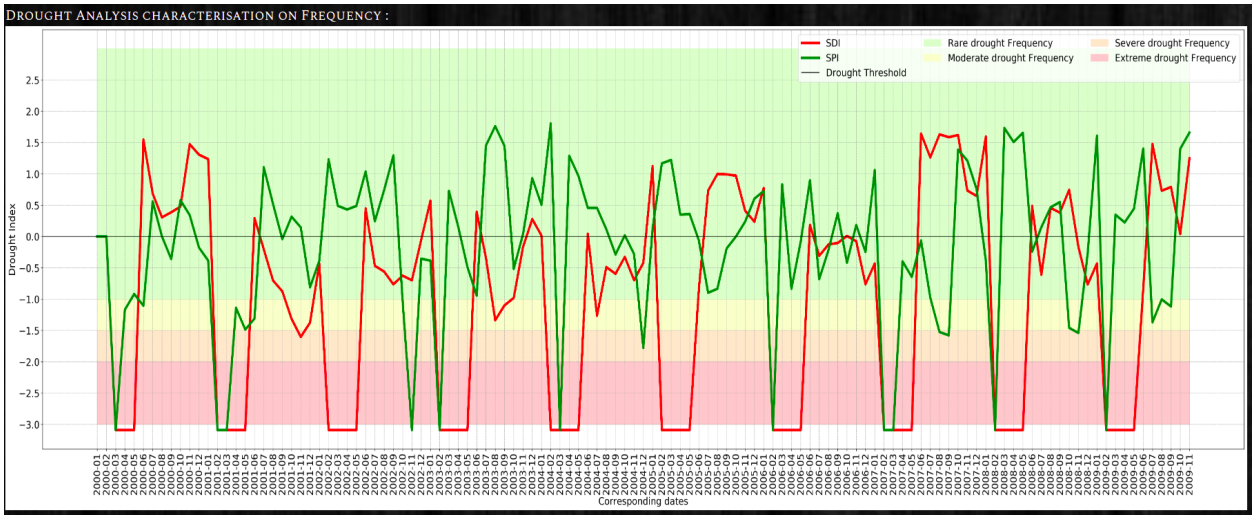
Drought Indices found and Characterised as per Intensity :

Color codes can help understand the characterizations.

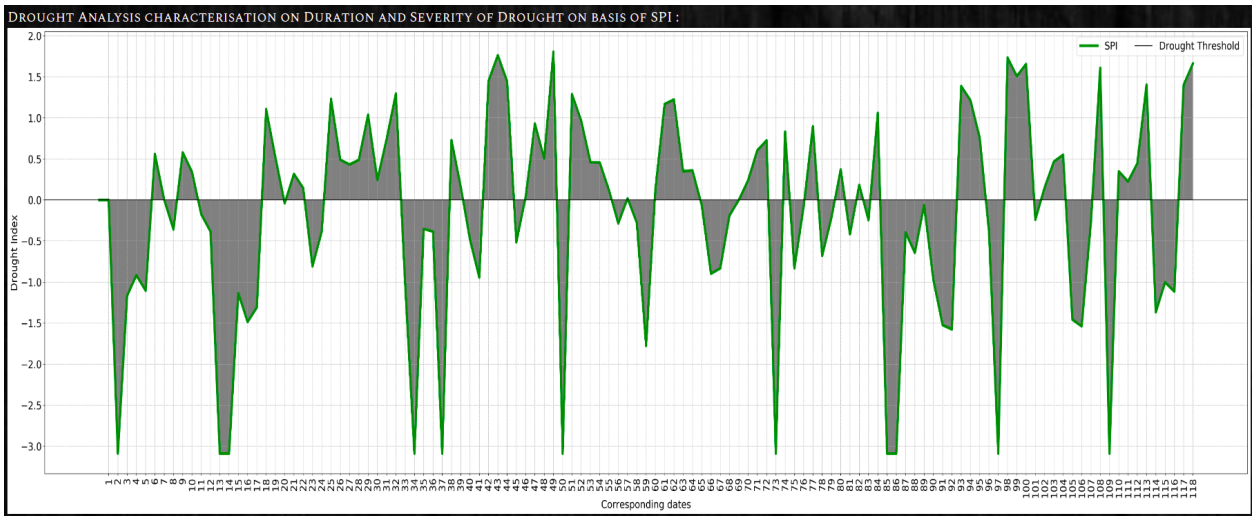


Drought Indices found and Characterised as per Frequency :

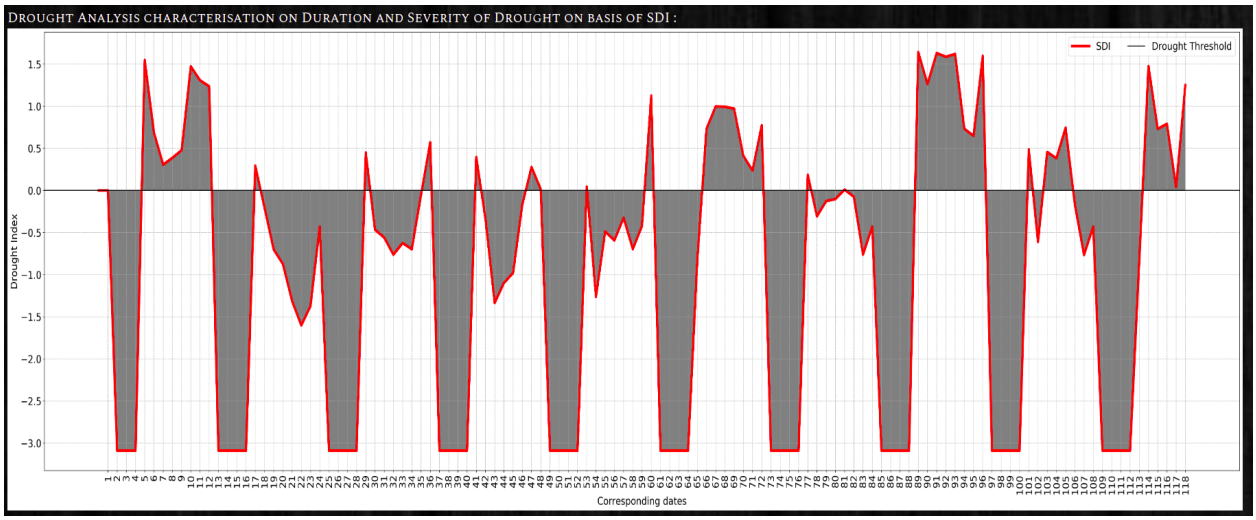
Color codes can help understand the characterizations.



Drought Indices found and Characterised as per Duration on basis of SPI :



Drought Indices found and Characterised as per Duration on basis of SDI :



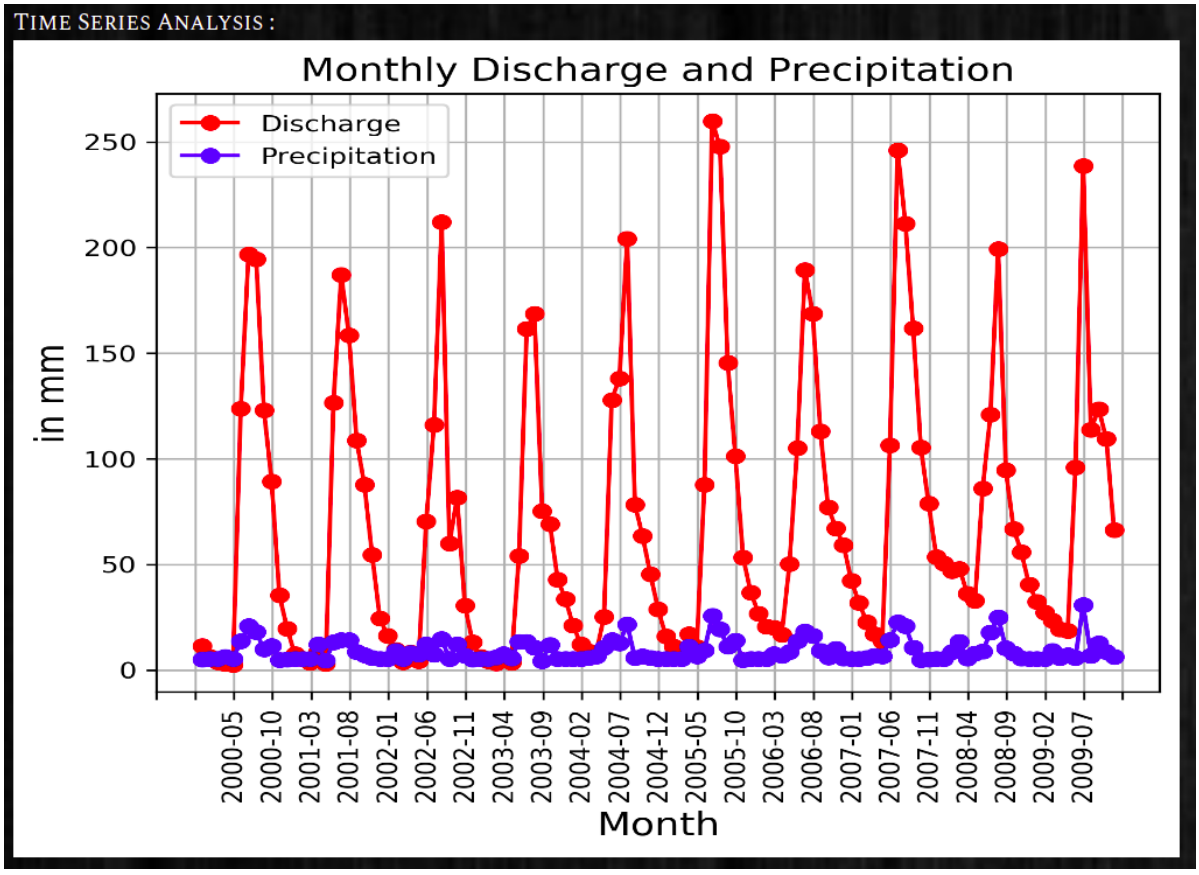
Half-Yearly Analysis on station [SPI6, SDI6] :

- Period Chosen for Analysis : January 2000 - December 2009
- Monthly Time Series analysis preferred.
- Half-Yearly SPI and SDI analysis preferred wrt to Drought, i.e., SPI6 and SDI6 .

The goodness tests results are :

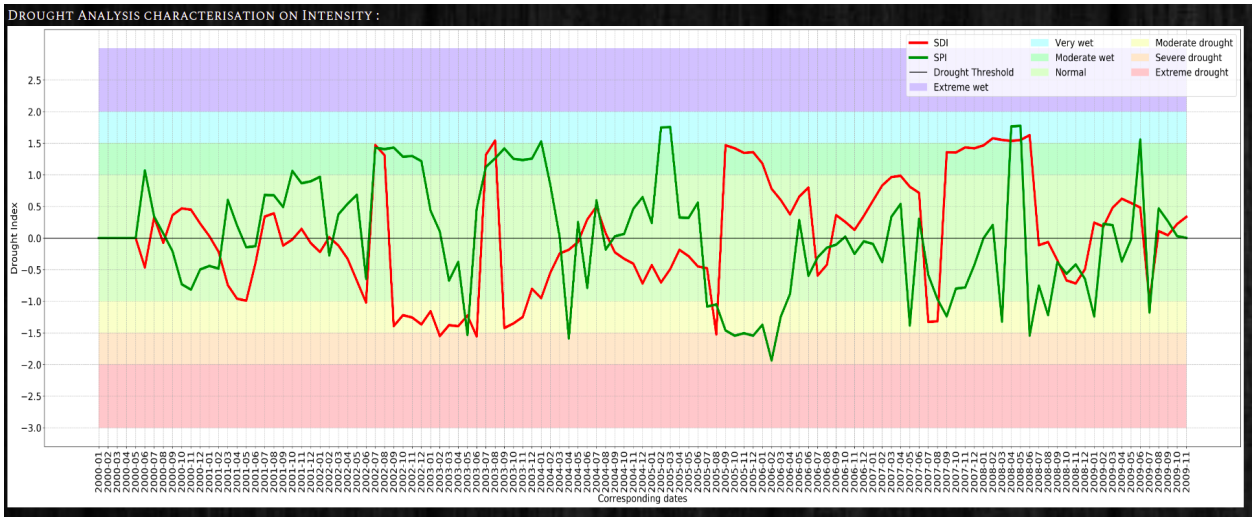
	Statistic for Discharge	Pvalue for Discharge	Statistic for Precipitation	Pvalue for Precipitation
Gamma distribution	0.1357	0.021818414926484415	0.6832	3.733835723835645E-56
Pearson3 distribution	0.061	0.7394I4804752232	0.1178	0.06586080156366778
Logistic distribution	0.1675	0.0020695107389653855	0.1927	0.0002232565157358118

The time series analysis for discharge and precipitation can be found for the Rattihali station in the following image :



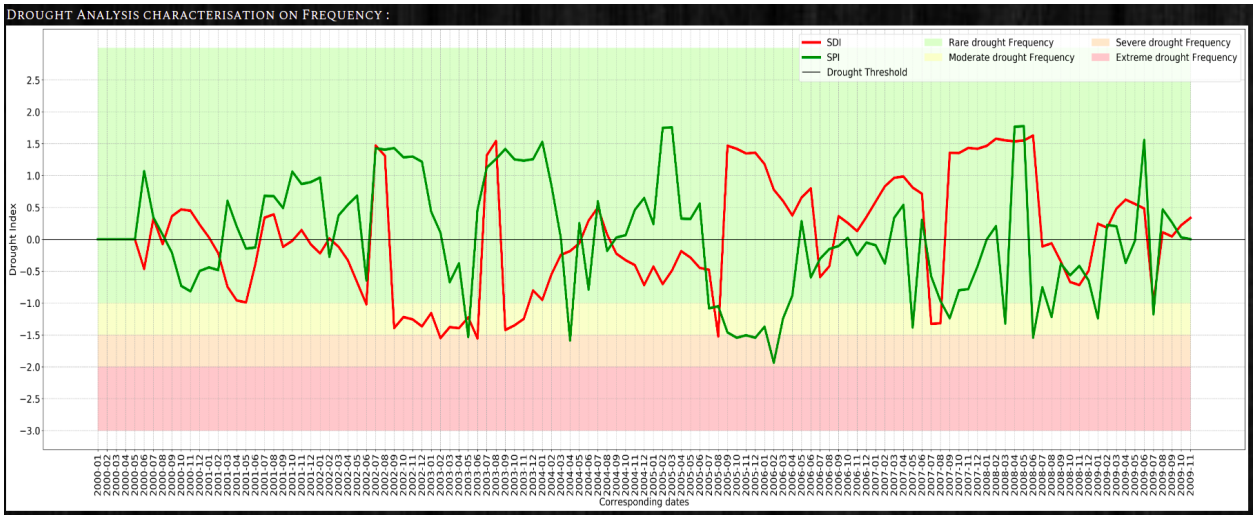
Drought Indices found and Characterised as per Intensity :

Color codes can help understand the characterizations.

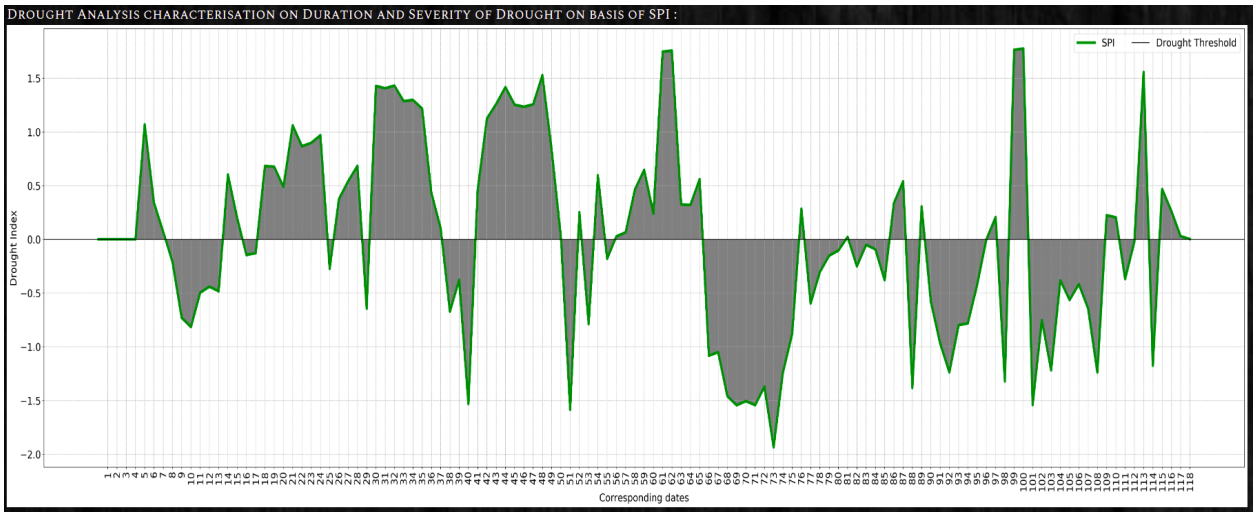


Drought Indices found and Characterised as per Frequency :

Color codes can help understand the characterizations.



Drought Indices found and Characterised as per Duration on basis of SPI :



Drought Indices found and Characterised as per Duration on basis of SDI :