Assignment 1

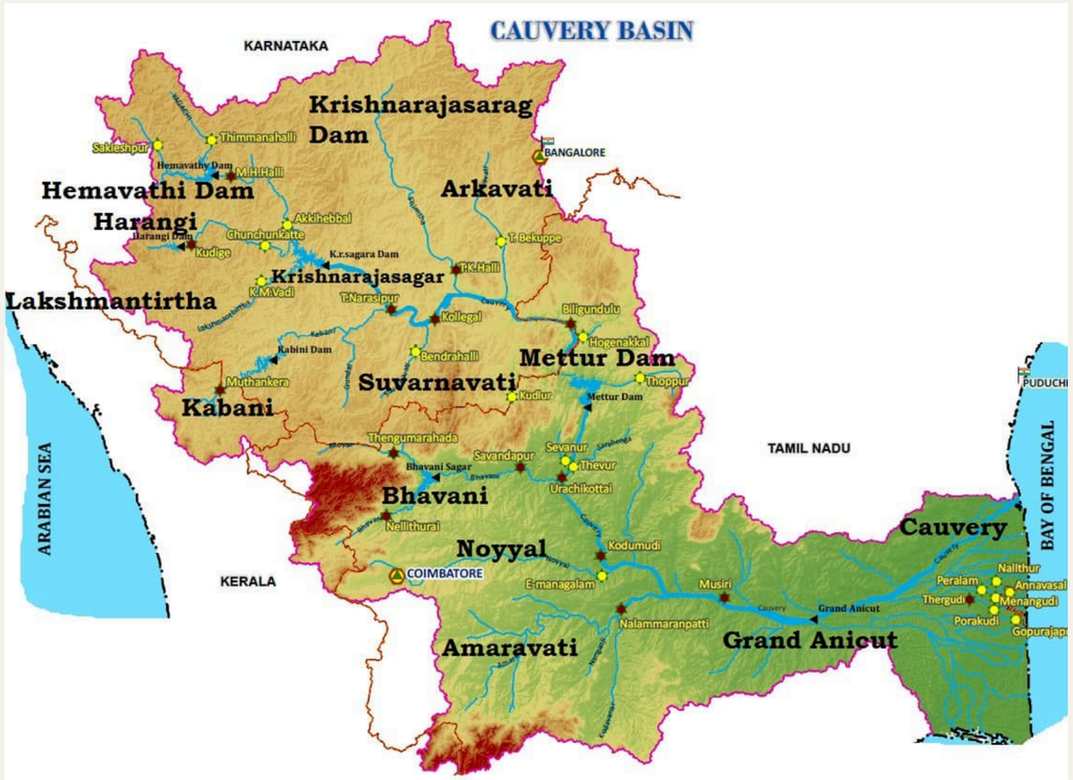
Drought characterization, Remote sensing and mapping

Geospatial Technology for Disaster Risk Modelling
Monsoon'24

Presented by
Sajja Patel & Aishani Pandey

Region of interest

Kaveri Basin



- The Kaveri River Basin, spanning parts of Karnataka and Tamil Nadu in southern India, is one of the most significant river systems in the region.
- The river originates in the Western Ghats and flows eastward into the Bay of Bengal.
- the basin is also prone to varying climatic conditions, leading to periods of drought that can severely impact agricultural productivity and water availability.

What is Drought ?

A drought is a prolonged period of abnormally low precipitation that leads to a shortage of water, affecting ecosystems, agriculture, and human activities.

There are 4 types of drought:

- Meteorological drought
- Hydrological drought
- Socio economic drought
- Agricultural drought

The following are factors by which droughts are charcterised-

- Intensity
- Areal extent
- Duration/severity
- Frequency

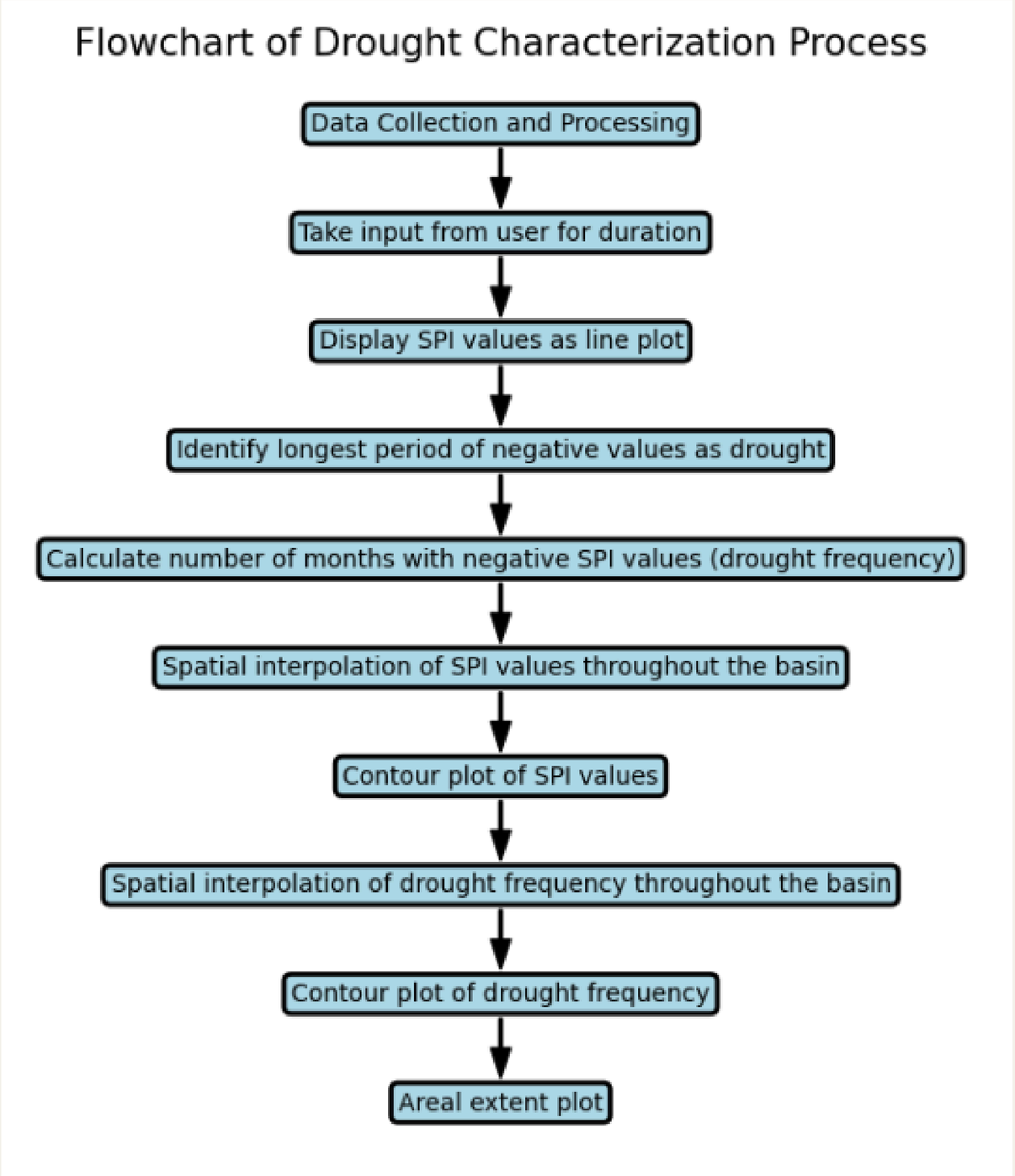
Introduction to SPI

- The Standardized Precipitation Index (SPI) is a widely used statistical measure that quantifies precipitation deficits over varying time scales.
- SPI values are standardized to have a mean of zero and a standard deviation of one for a specific location and time period- allowing comparisons.
- Used to measure Intensity and severity.

SPI	Drought category
$SPI \geq 2.00$	Extreme wet
$2.00 > SPI \geq 1.50$	Very wet
$1.50 > SPI \geq 1.00$	Moderate wet
$1.00 > SPI \geq -1.00$	Normal
$-1.00 \geq SPI > -1.50$	Moderate drought
$-1.50 \geq SPI > -2.00$	Severe drought
$-2.00 \geq SPI$	Extreme drought

Drought Characterisation

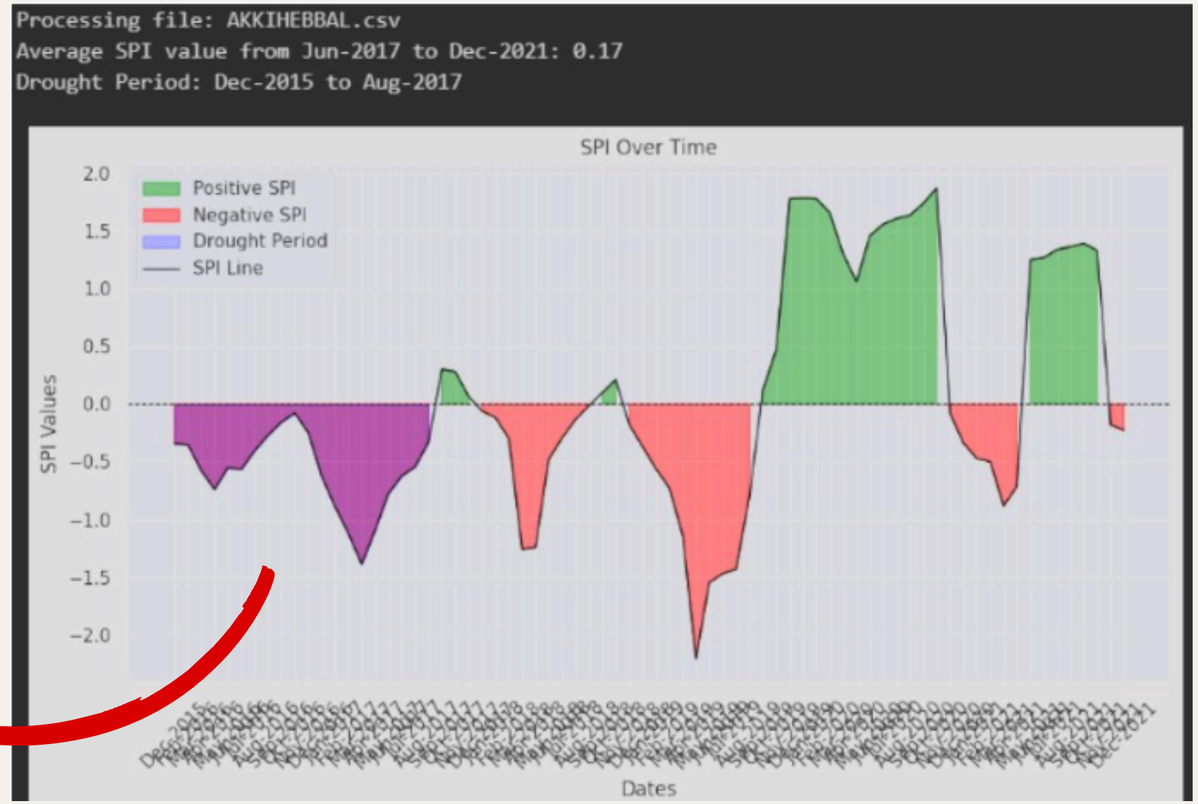
Drought characterization refers to the process of identifying and describing the various aspects and dimensions of a drought event. It involves analyzing the severity, duration, frequency, spatial extent, and impacts of droughts using different indicators and methods.



SPI over the time

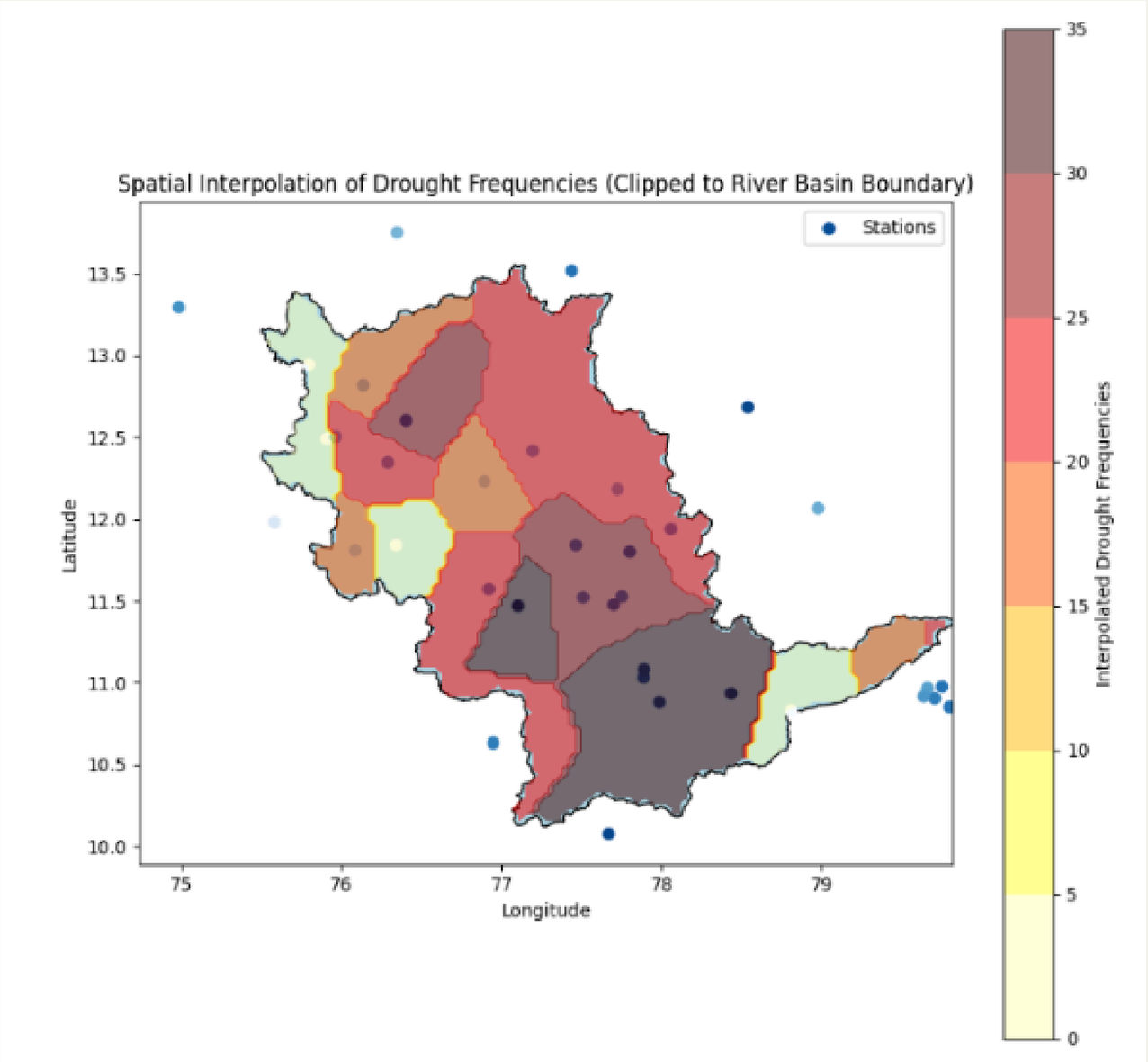
- This plot will show the temporal variations in SPI across different locations in a user specified time frame.
- Within this, for drought identification we have used the longest period of negative SPI of every station.

This is the **longest period of negative SPI values** for this specific station and we will term this as the drought period for this station in the kaveri basin.

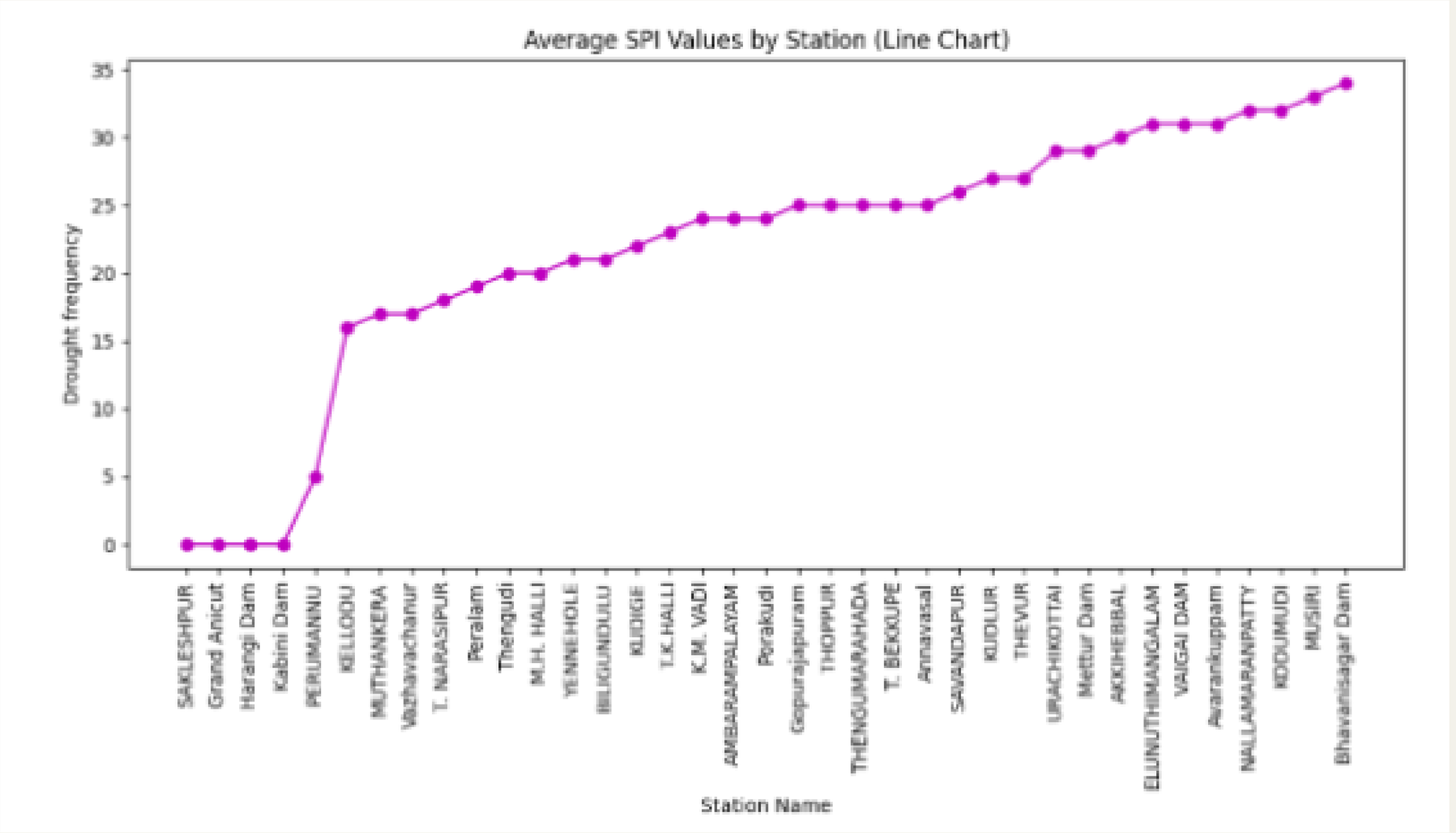


Drought Frequency

- Drought frequency is the number of months with negative frequency in the user specified time frame.
- The code performs spatial interpolation using griddata to estimate drought frequencies over a grid of points across the river basin

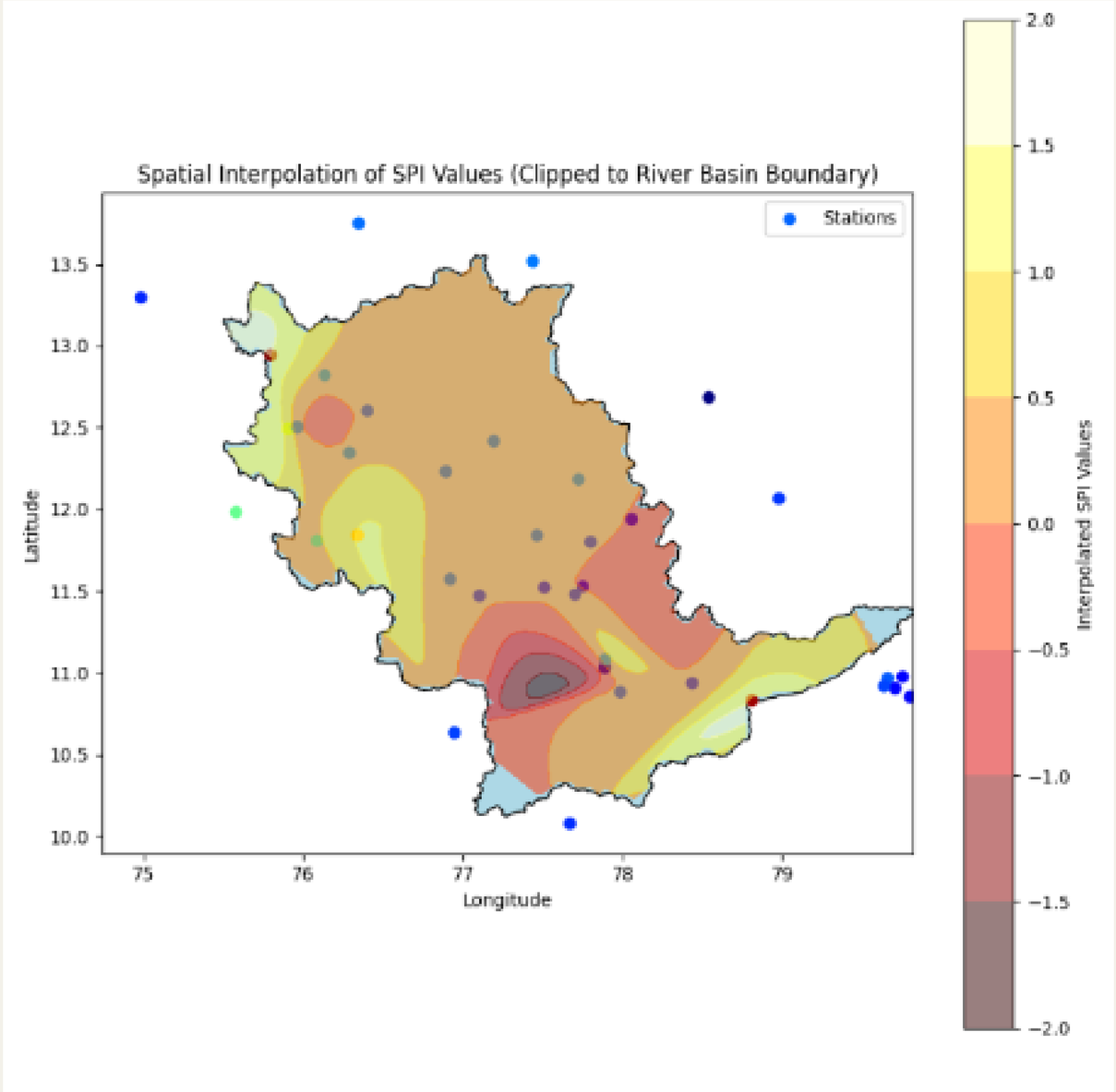


Drought Frequency



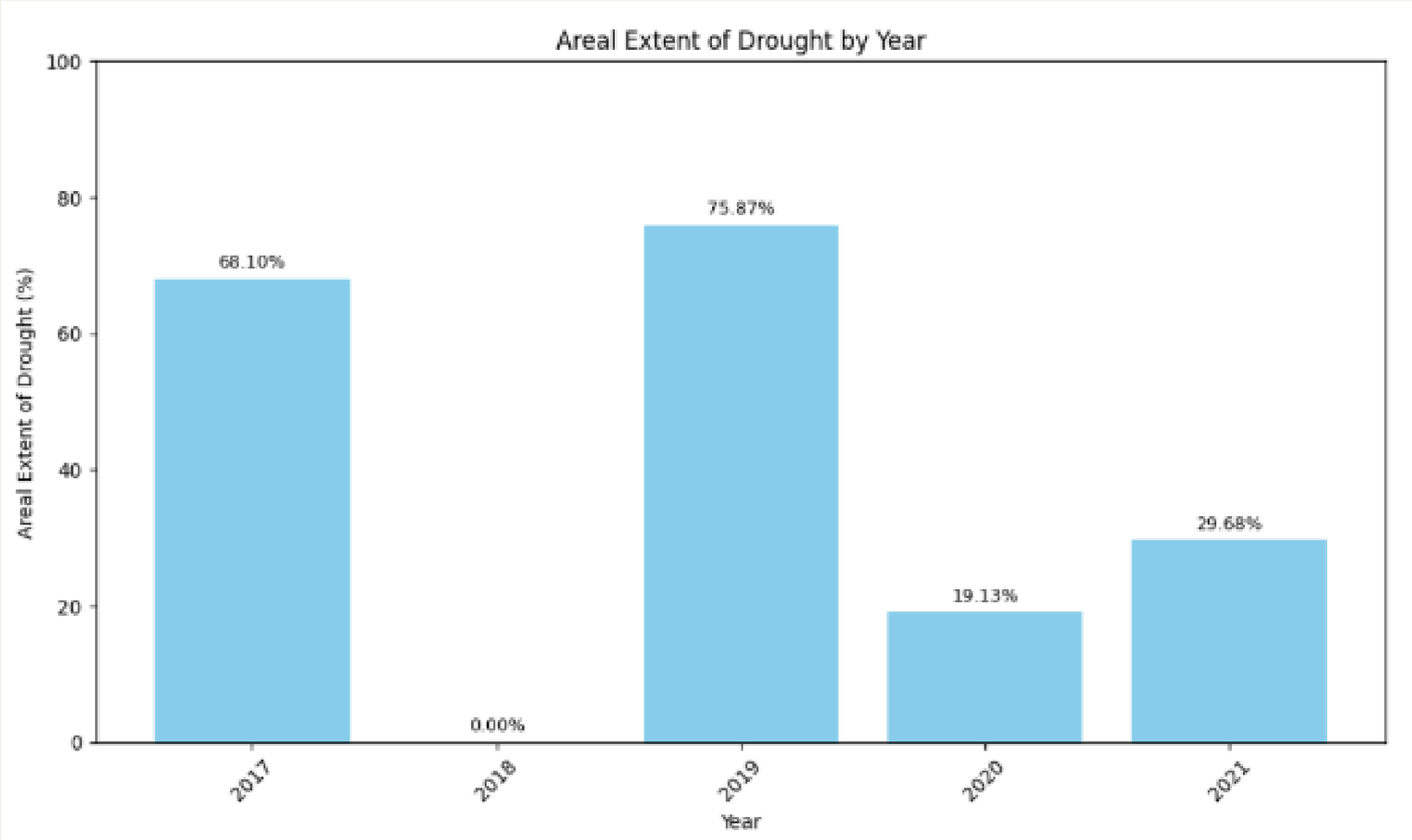
Spatial interpolation of SPI

- The griddata function from scipy.interpolate is being applied to interpolate the SPI values over a grid defined by longitude (X) and latitude (Y).
- Cubic interpolation (triangulated cubic interpolation) is done throughout the basin.

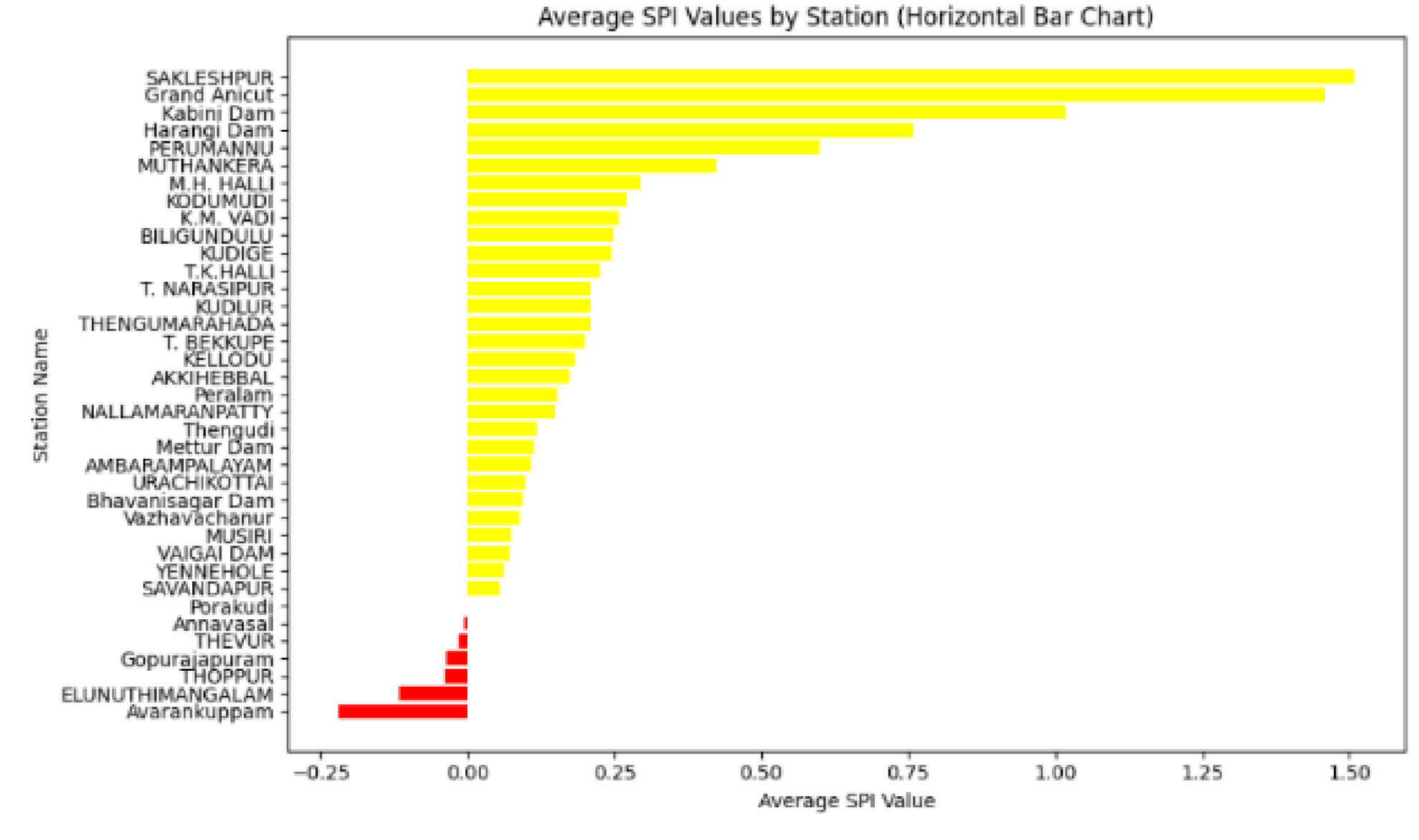


Areal Extent

- The geographical scope or spatial coverage of the drought, often expressed as the total area affected by drought conditions.
- The output indicates that approximately **18.35%** of the area experiences drought conditions.



SPI values vs Stations



Remote Sensing analysis using NDVI

Introduction to NDVI

- Values range from -1 to 1
- Low NDVI: Below 0.3 (represents barren areas or unhealthy vegetation).
- Medium NDVI: Between 0.3 and 0.5 (representing stressed vegetation).
- High NDVI: Above 0.5 (healthy and dense vegetation).

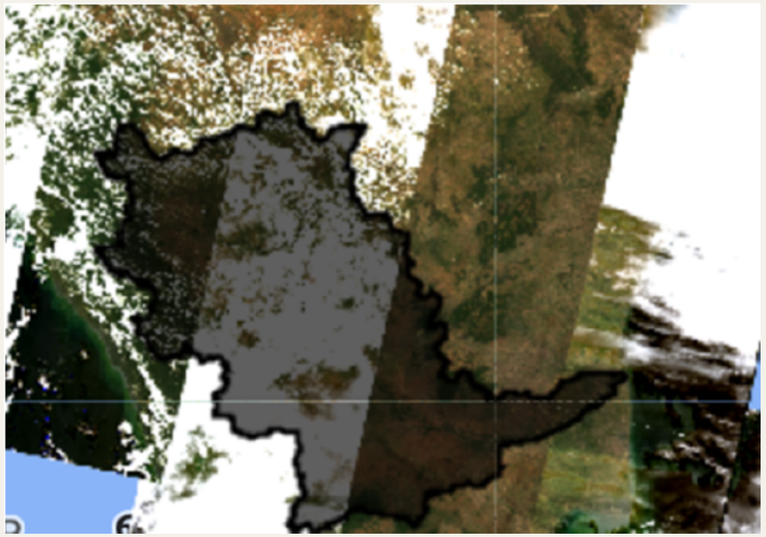
$$\text{NDVI} = \frac{(NIR - Red)}{(NIR + Red)}$$

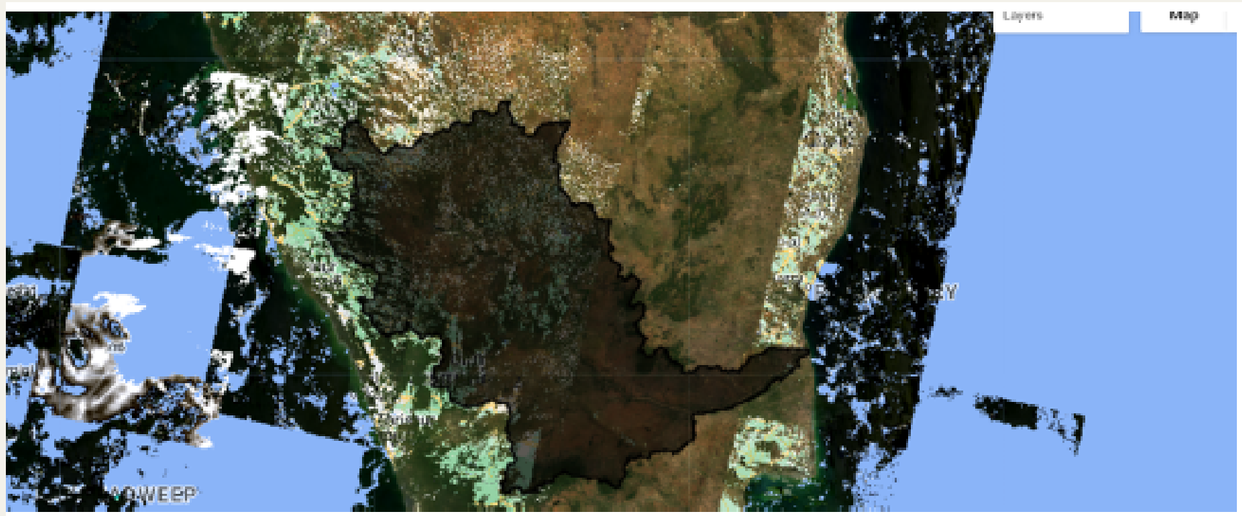
Data Collection & Processing

- Landsat 8 -> T1, L2
- Time -> 2021 due to computational complexity (Have taken small AOI of Kaveri Basin to show the analysis - from 2019 to 2021)

Steps Taken

1) Cloud Masking - To ensure accuracy, we applied a cloud mask to filter out pixels obscured by clouds.

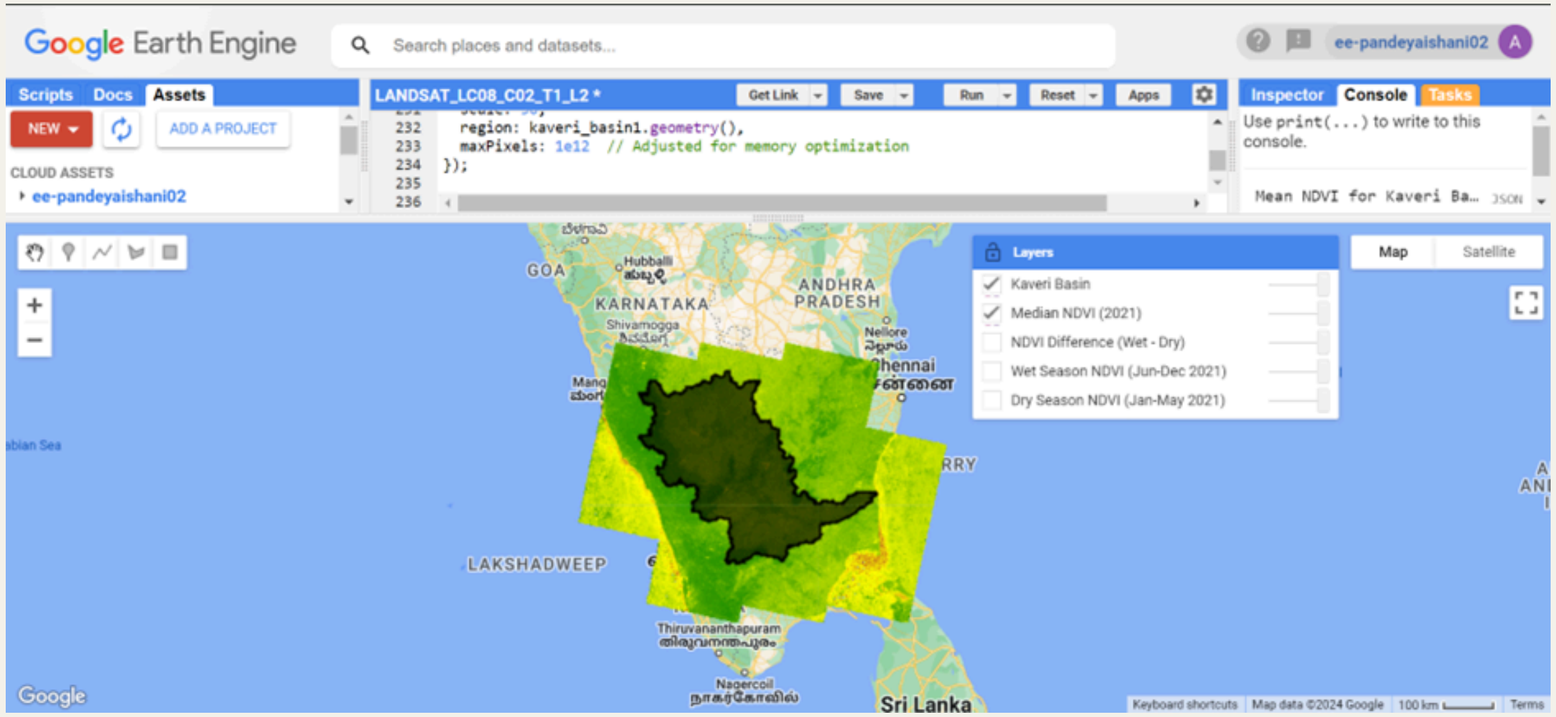




2) Scaling Factors - To convert raw pixel values to reflectance.

Steps Taken

3) NDVI Calculation for whole basin (2021) - We compute both mean and median NDVI.



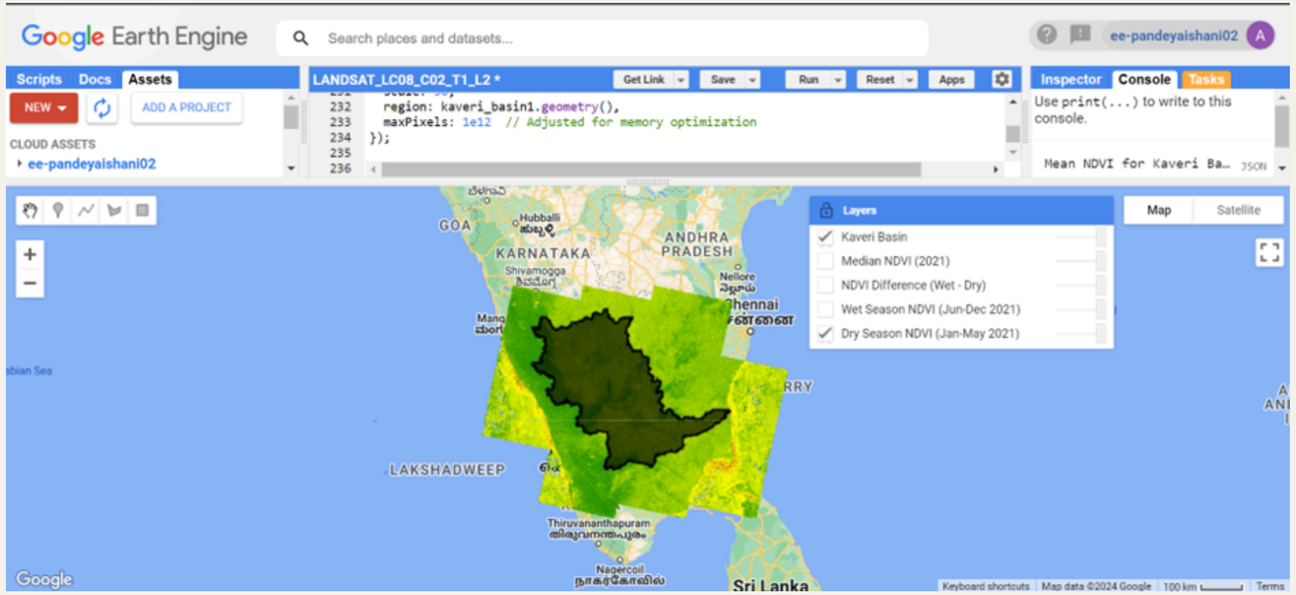
Mean NDVI for 2021 = 0.5170405744673834. This indicates ”Healthy” vegetation in Kaveri basin

Steps Taken

4) Seasonal Analysis (2021) :

- We also calculated the NDVI separately for the dry (Jan-May) and wet (Jun- Dec) seasons in 2021.
- Dry Season (Jan-May): The dry season typically experiences lower NDVI values due to reduced rainfall.
- Wet Season (Jun-Dec): The wet season sees higher NDVI values due to increased water availability for vegetation.

Dry Season: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maxPixels: 1e12 // Adjusted for memory optimization
});
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Kaveri Basin
Median NDVI (2021)
NDVI Difference (Wet - Dry)
Wet Season NDVI (Jun-Dec 2021)
Dry Season NDVI (Jan-May 2021)
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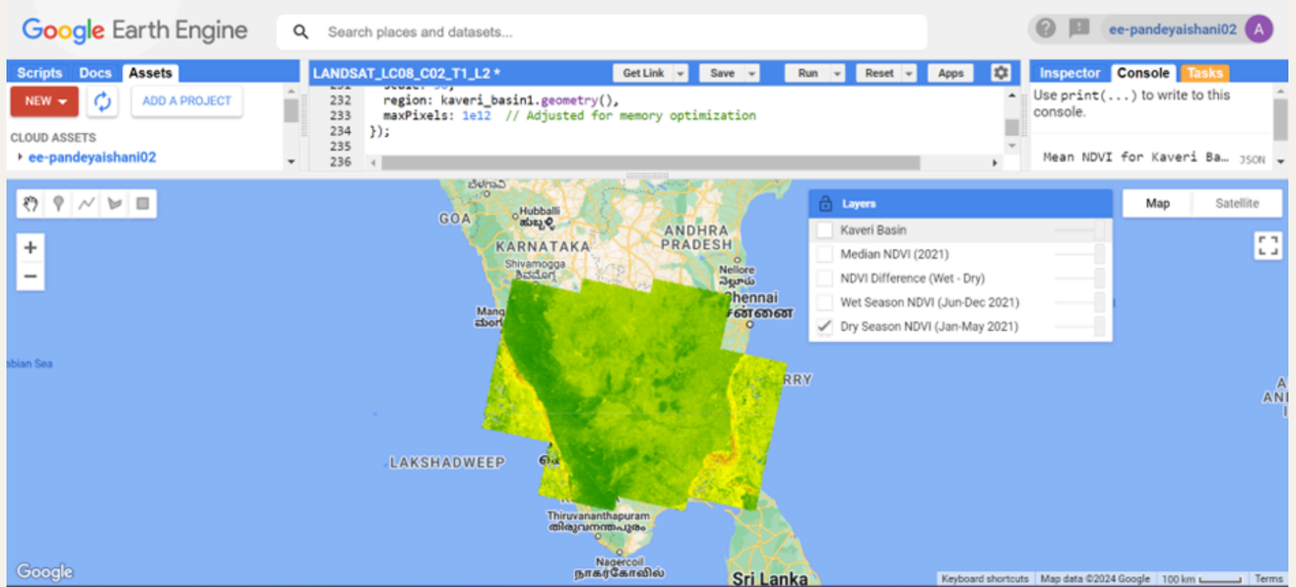
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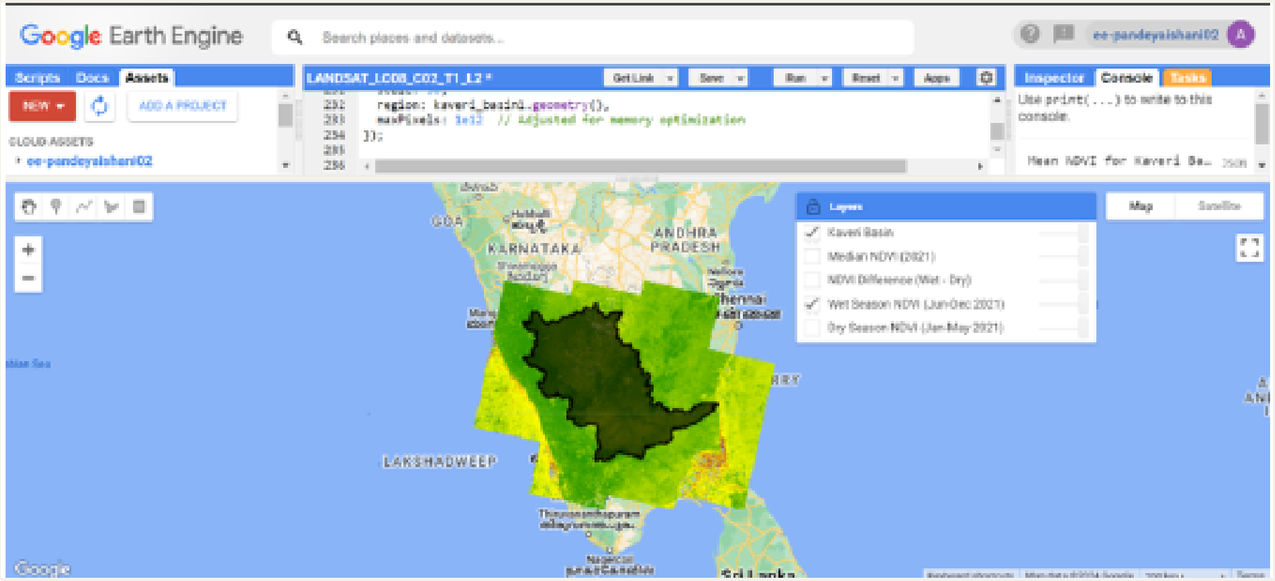
Wet Season: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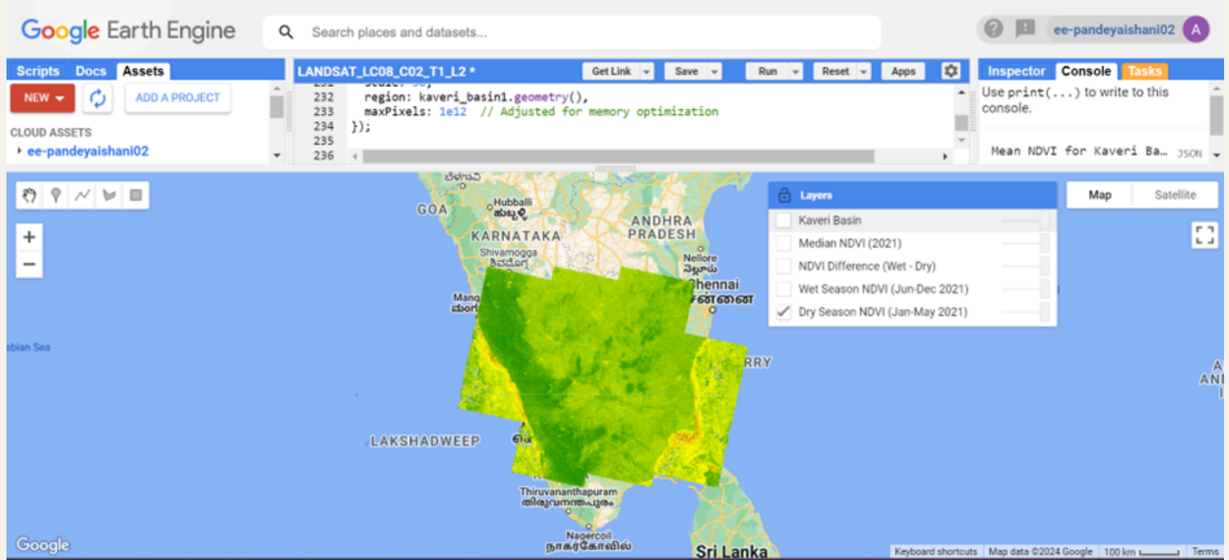
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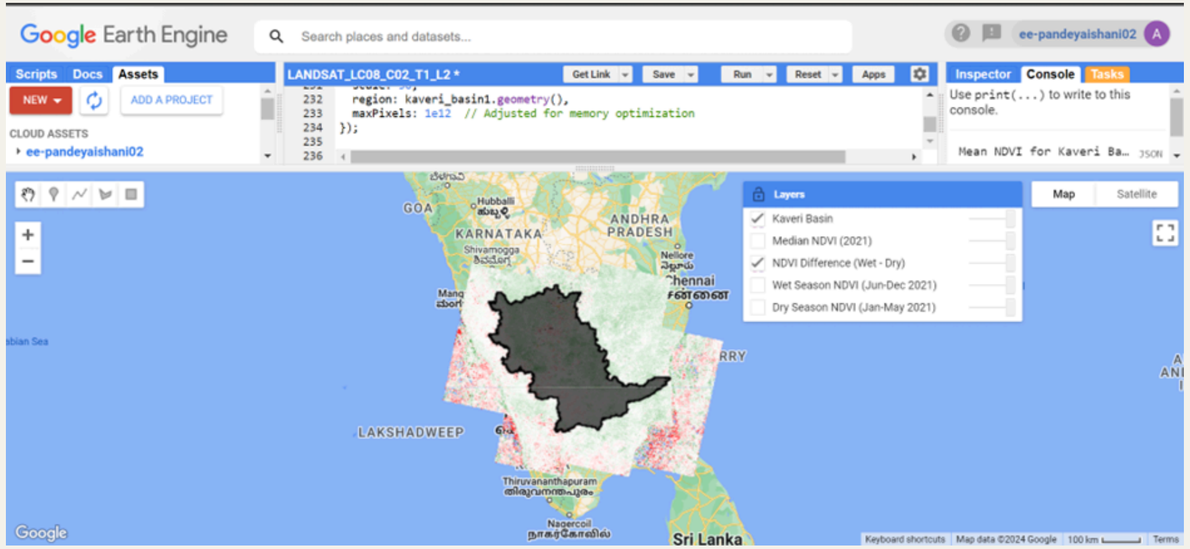
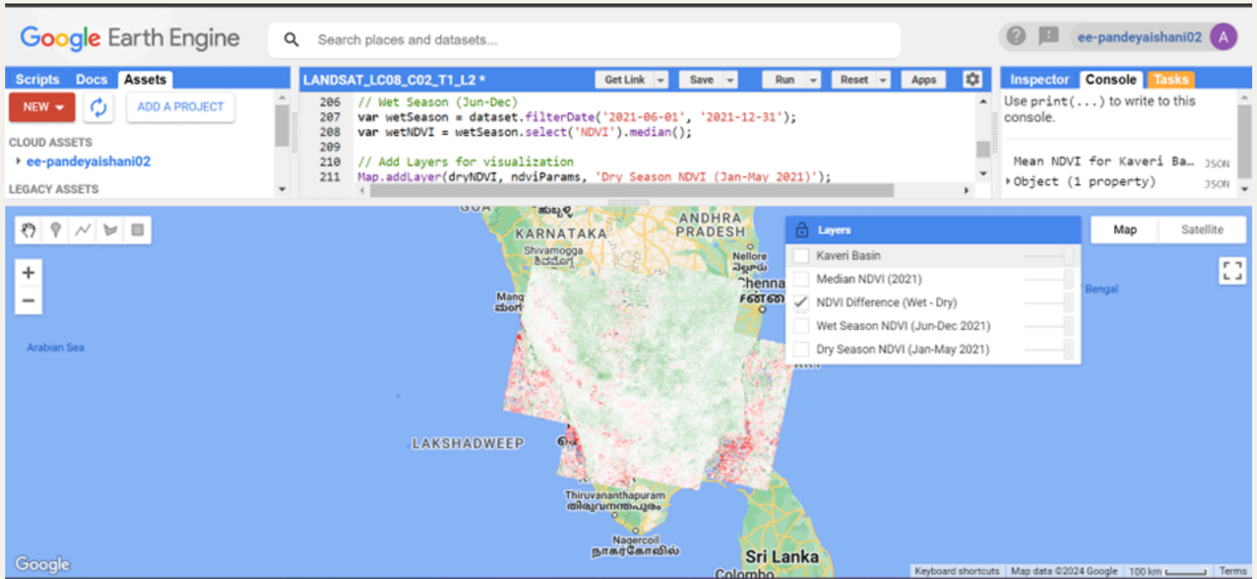
Steps Taken

5) NDVI Difference Calculation (Wet - Dry) :

- This highlighted areas where vegetation either improved or worsened.
- The difference between the wet and dry season NDVI was calculated to highlight areas that saw
- **I**mprovement in vegetation (positive NDVI difference) or degradation (negative NDVI difference).
- Red indicates loss of vegetation, green indicates improvement

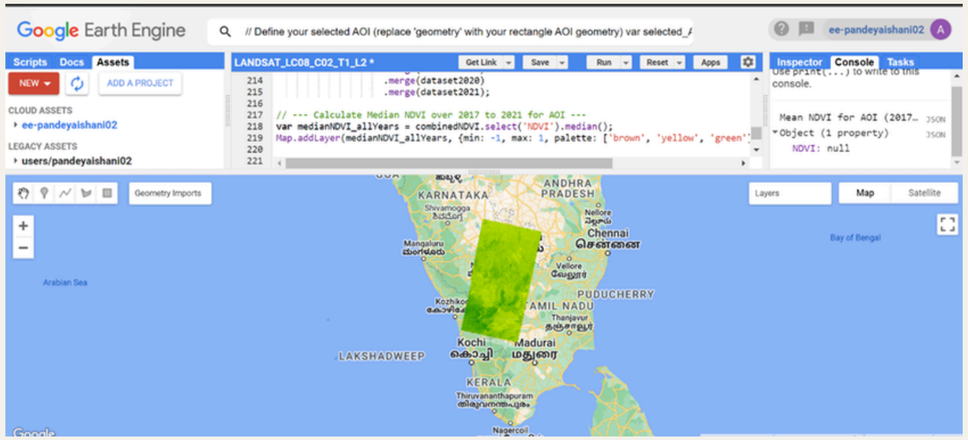
NDVI Difference:





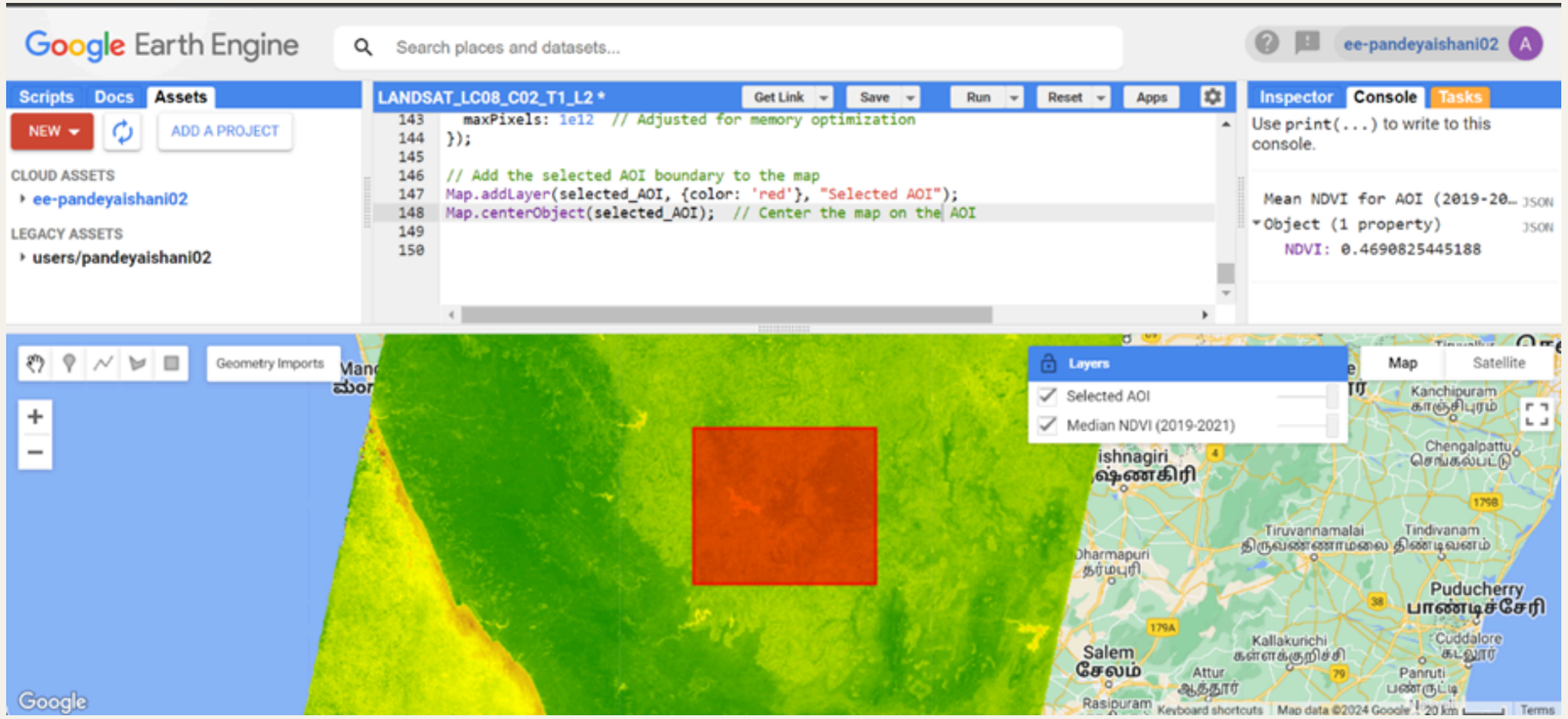
NDVI Calculation for AOI (2019-2021)

- Initially, we tried calculating the NDVI from 2017-2021 and 2018-2021, but got NULL values and incomplete result.



- So, we calculated for 2019-2021. Mean NDVI Output: In the console, the mean NDVI for the selected AOI (from 2019-2021) is printed, with a value of 0.4690825445188. This value reflects the average vegetation health in that region over the three years.

NDVI for AOI (2019-2021):



- We were also able to calculate NDVI for the whole basin for 2019-2021

NDVI Time Series

- Exported to a CSV file for each month - date-wise.
- Enabled temporal analysis of NDVI values over the study period
- Helped us track the progression of drought conditions and their effects on vegetation health.

A	B	C	D	E	F	G	H	I	J	K	L
system:inc	date	mean_NDV	.geo								
LC08_142(	31-01-2021	0.551579	{"type":"MultiPoint","coordinates":[]}								
LC08_142(	16-02-2021		{"type":"MultiPoint","coordinates":[]}								
LC08_142(	04-03-2021	0.510406	{"type":"MultiPoint","coordinates":[]}								
LC08_142(	20-03-2021	0.473032	{"type":"MultiPoint","coordinates":[]}								
LC08_142(	05-04-2021	0.427537	{"type":"MultiPoint","coordinates":[]}								
LC08_142(	21-04-2021	0.430638	{"type":"MultiPoint","coordinates":[]}								
LC08_142(	07-05-2021	0.456852	{"type":"MultiPoint","coordinates":[]}								
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LC08_142(	08-06-2021	0.47828	{"type":"MultiPoint","coordinates":[]}								
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Drought Mapping and Comparison

- Visual Comparison between spatial distribution of SPI values across the Kaveri Basin for the period 2017–2021 and NDVI values in raster format, representing vegetation health, for the year 2021.

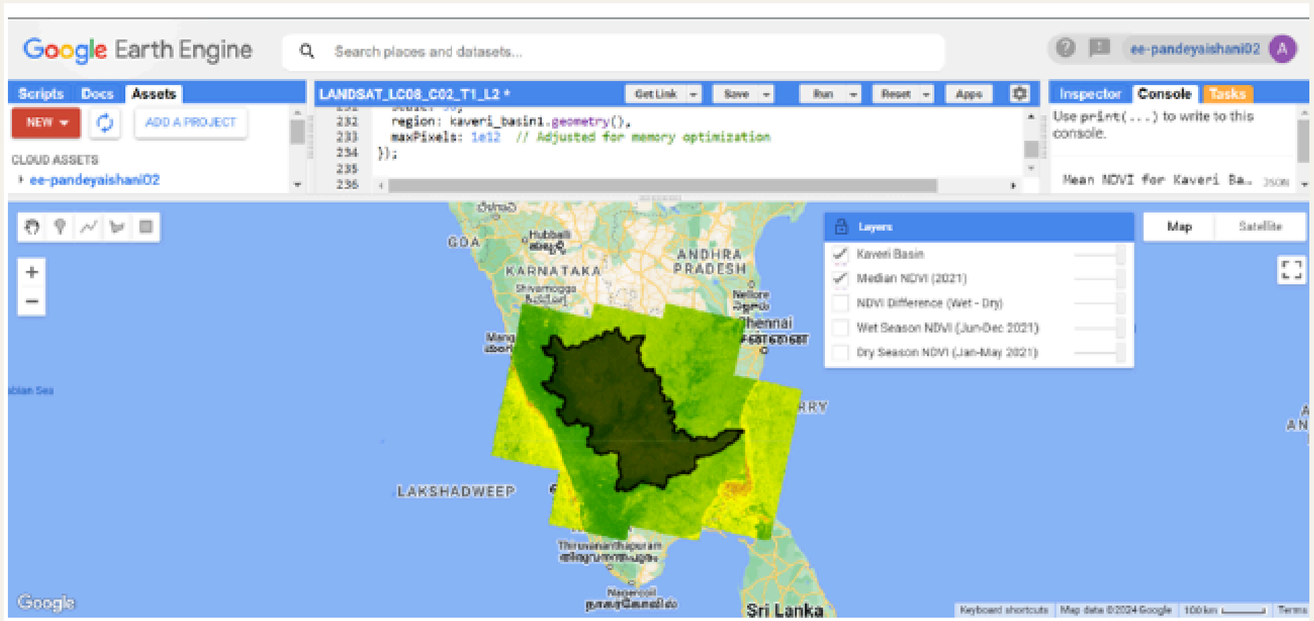


Figure 15: NDVI for the Kaveri Basin (2021)

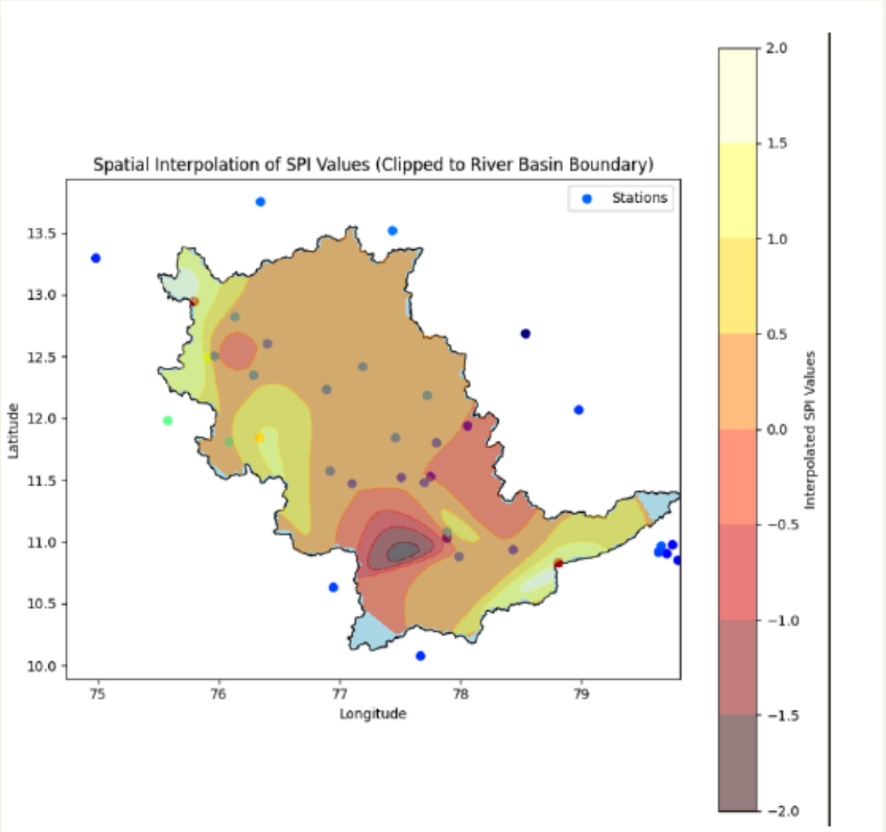
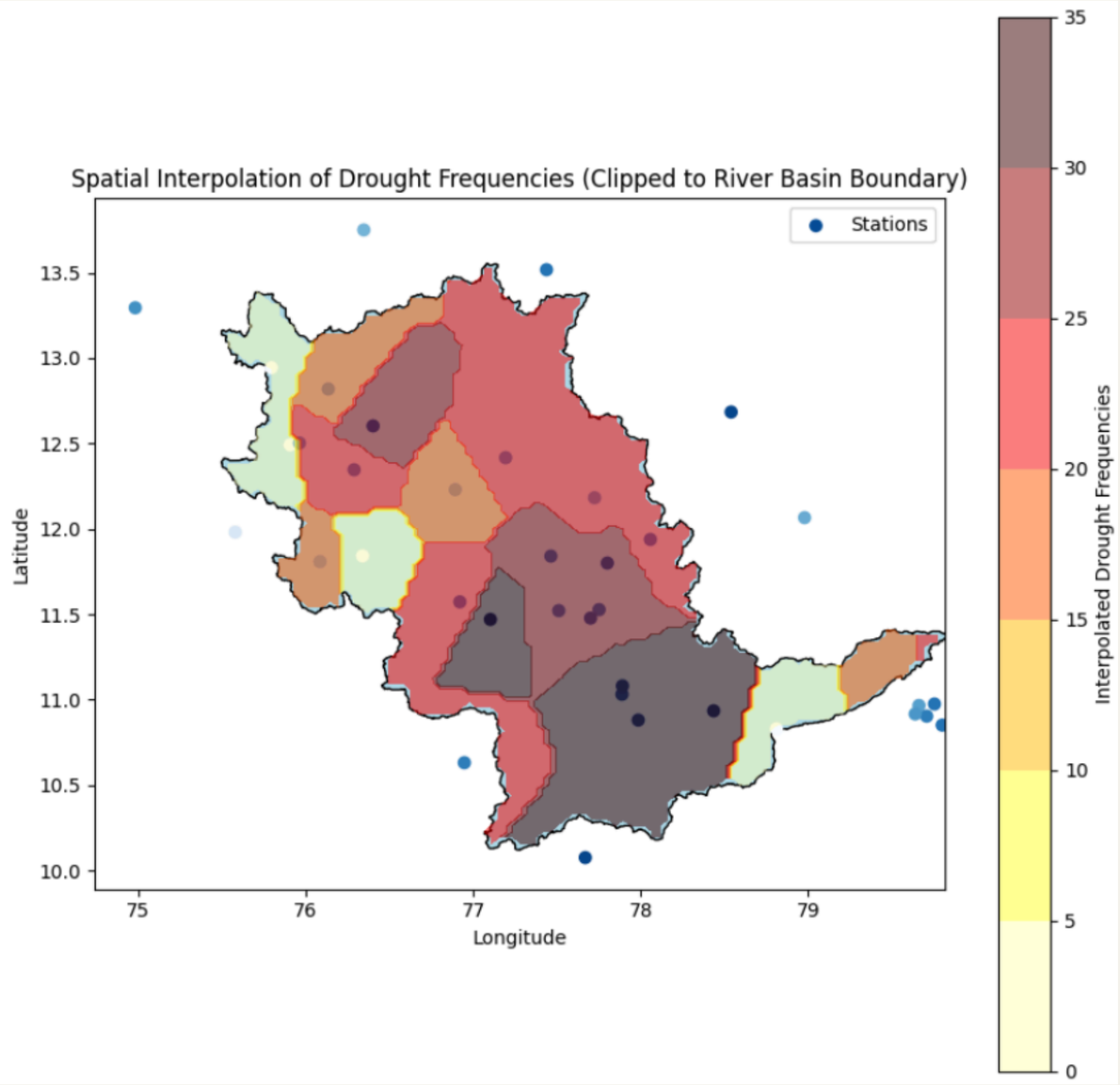


Figure 16: Spatial interpolation of SPI values

- By comparing these plots, we can clearly observe how areas with low SPI values, indicative of drought, align with regions of low NDVI, signifying stressed vegetation.

- Close relationship between precipitation deficits and the health of ecosystems in the basin.

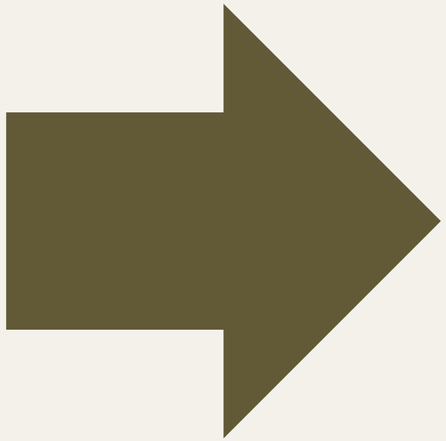
- Below is the plot for Drought frequencies:



- While the SPI contour plot highlights drought intensity and distribution (2017-2021) and the NDVI plot shows vegetation response in 2021, the drought frequency plot reveals how often areas experienced drought.

- This reinforces the link between SPI (precipitation deficits) and NDVI (vegetation health), showing that regions with frequent droughts tend to have lower SPI and NDVI values, emphasizing persistent drought impacts.

Conclusion



- Analyzed SPI values, NDVI data, and spatial interpolation to characterize drought in the Kaveri Basin (2017-2021).
- SPI values quantified drought intensity and duration; contour maps showed spatial variation.
- 2021 NDVI data revealed a correlation between low SPI and reduced vegetation health.
- Despite computational constraints, the single-year NDVI data provided meaningful insights.
- Drought frequency plot added a temporal dimension, linking precipitation deficits to vegetation stress.
- These insights aid in water resource management, resilience planning, and sustainable strategies for the Kaveri Basin.