Classification of karnataka into climatological Zones

Introduction: Karnataka, boasts a diverse landscape and climate, with significant variations in temperature, rainfall, and humidity across its vast territory. These fluctuations hold tremendous importance, influencing everything from agricultural patterns and water resources to human settlements and ecosystems. To better understand and manage these diverse regions, accurate classification based on their climatic characteristics is crucial. This research investigates the use of temperature, rainfall, and humidity data to delineate distinct climatic zones within Karnataka, providing valuable insights for sustainable development and regional planning.Utilizing comprehensive datasets for temperature, rainfall, and humidity, we propose a novel method for segmenting Karnataka into distinct climatic zones. This fine-grained classification promises deeper understanding of climatic patterns, more accurate weather prediction, and a stronger foundation for climate-sensitive decision-making in the region.

Dataset used: This study utilises high-resolution (0.5 degrees) daily data from the ERA5 reanalysis for the period 1980-2022, encompassing the Karnataka region. We focus on key climatic variables such as temperature, rainfall, and humidity, accessed through the NetCDF format.

Problem statement: Divide Karnataka into distinct climatic zones based on temperature, rainfall, and humidity.

Data pre-processing:

Missing values: Identified and handled missing values using imputation techniques.

Feature scaling: Standardized variables to similar scales using z-score to prevent variables with larger ranges from dominating the clustering process.

Clustering methodology:

1. **Data preprocessing:**
   1. As an initial step we have converted the variables from .nc file to **array** for easy data calculations and analysis.
   2. Then we have filled the **Nan values** with **imputing** technique with **mean**.
   3. Before using the clustering algorithms we have normalised the data using z-score normalisation.
2. **Clustering**: 1.The thought process of building clusters is that we want to check whether clustering can also cluster along time by giving seasons in a year along with space.

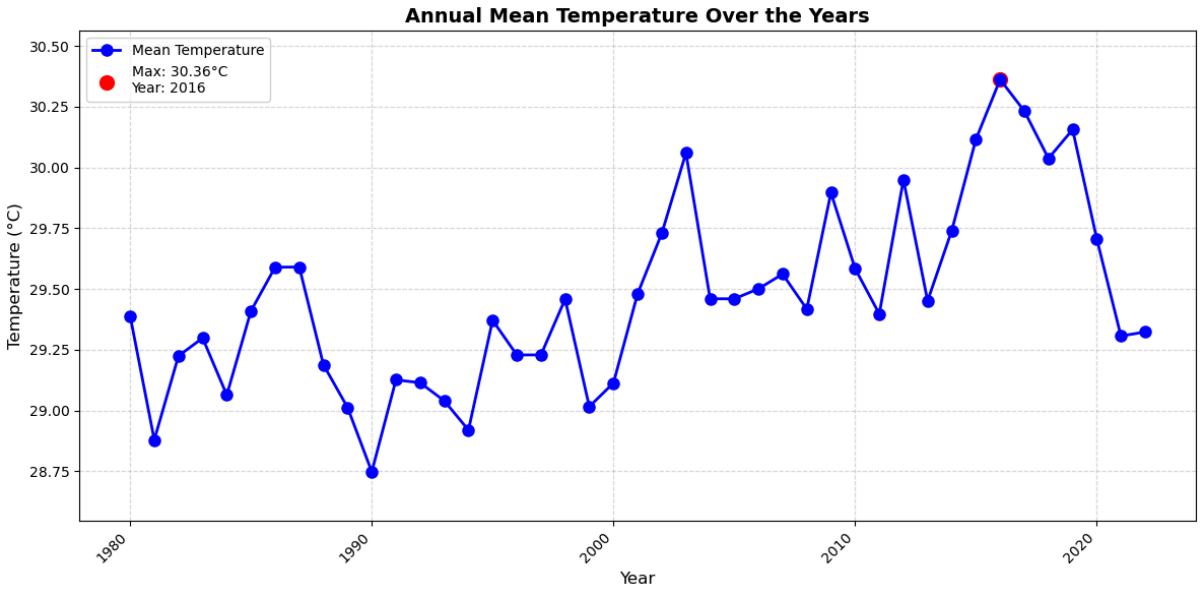
2. Initially we tried with temperature, rainfall, relative humidity individually and then their combinations of two and three variables.

For clustering we have tried 2 types of clustering algorithms

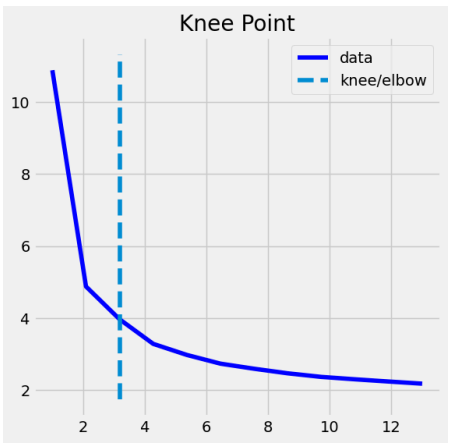
1. K-means clustering
2. Self organising maps.

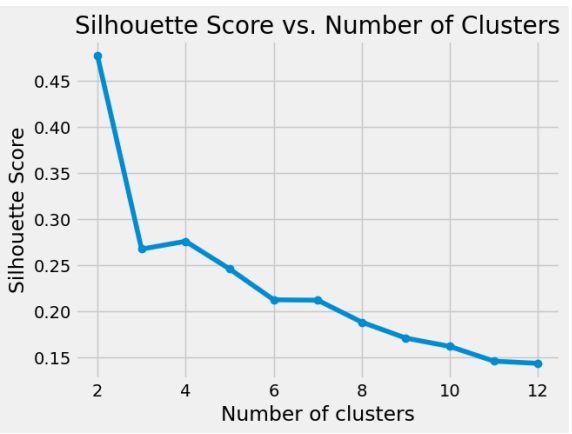
So below are the results of individual variables using k-means clustering.

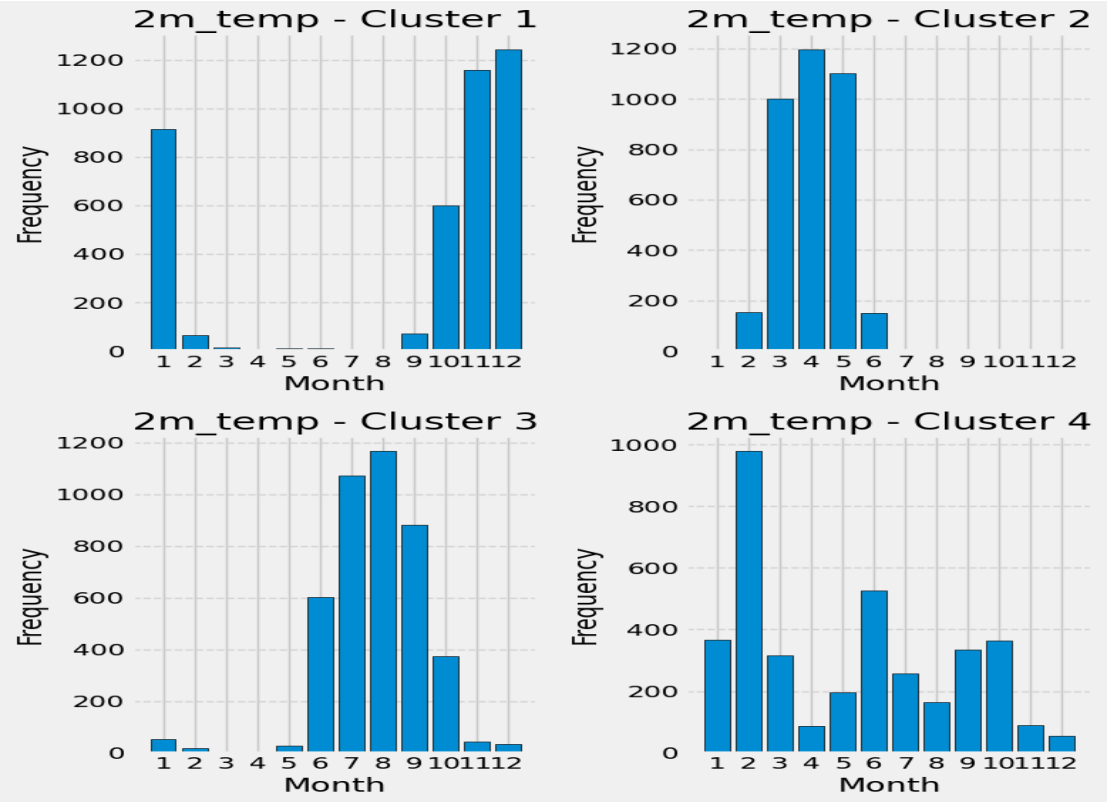
Temperature:

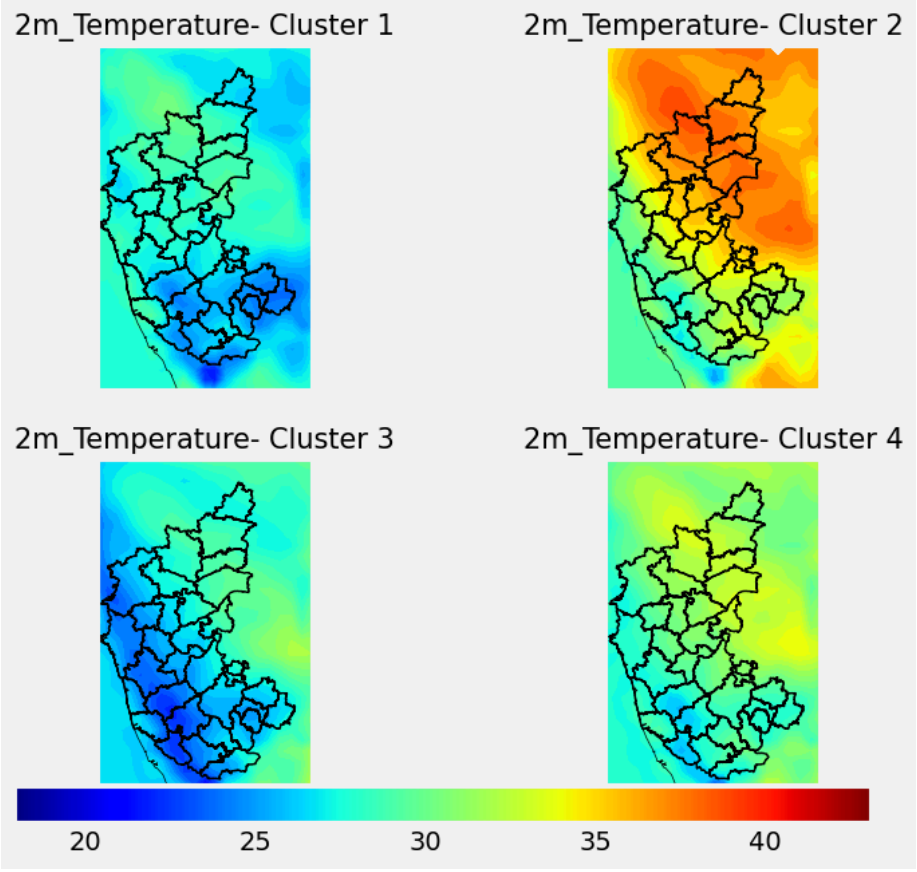


K-Means:






2m_temp - Cluster 1
2m_temp - Cluster 2
2m_temp - Cluster 3
2m_temp - Cluster 4
Frequency
Month
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12


2m_Temperature- Cluster 1
2m_Temperature- Cluster 2
2m_Temperature- Cluster 3
2m_Temperature- Cluster 4
20
25
30
35
40

Results:

From the last image we can see what are the seasons it clustered.

Cluster : Cold Winter (Late November to Early January)

- This cluster represents the peak winter season in southern Karnataka, characterised by significantly lower temperatures compared to western Karnataka. This temperature difference is most pronounced in December, with southern Karnataka averaging [4 degrees Celsius] less than western Karnataka.

Cluster 2: Hot Summer (March to May)

- This cluster marks the warmest period in northern Karnataka, where temperatures climb to their highest annual averages. Western Karnataka also experiences warm temperatures, but relatively cooler than the inland regions particularly in April and May.

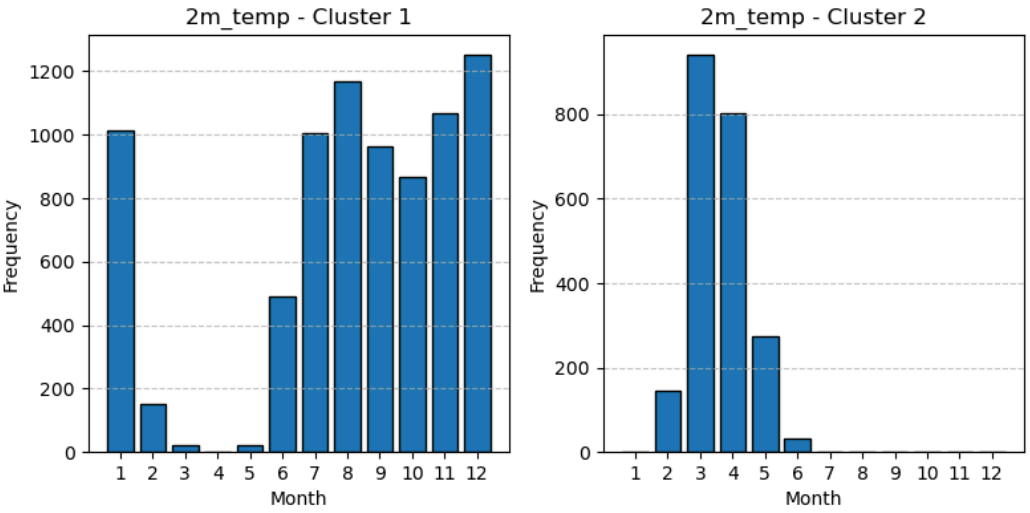
Cluster 3: Monsoon Season (July to September)

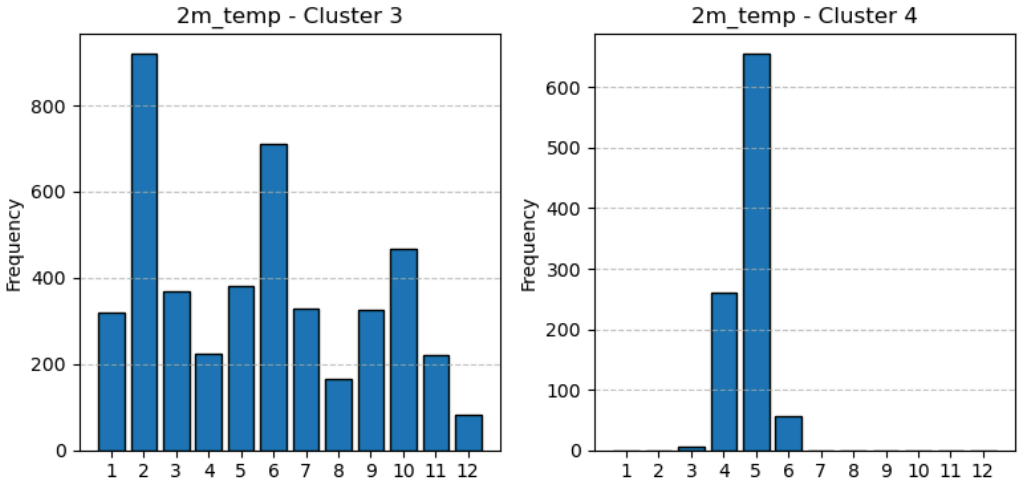
- This cluster encompasses the monsoon period, where western Karnataka enjoys significantly cooler temperatures compared to other parts of the state. This is due to the [e.g., proximity to the coast, prevailing winds]. The difference in temperature is most evident in July and August, with western Karnataka averaging [4 degrees Celsius] lower than inland regions.

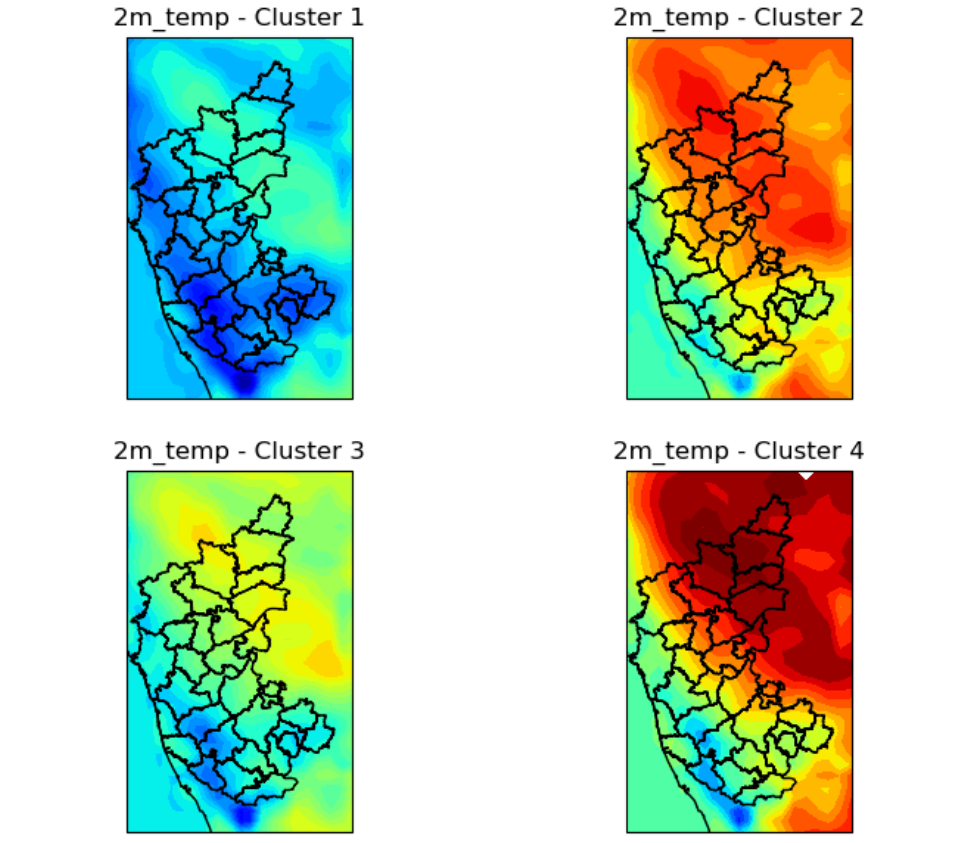
Cluster 4: Transitional Months (February and June)

- February and June exhibit temperature patterns that don't neatly fit into the other clusters. February often marks a gradual transition from winter to spring, with temperatures rising across most regions. June can be a mix of hot days and occasional monsoon showers, leading to more variable temperatures. Further analysis of these months might reveal interesting sub-clusters or unique regional trends.

Self organisng maps:

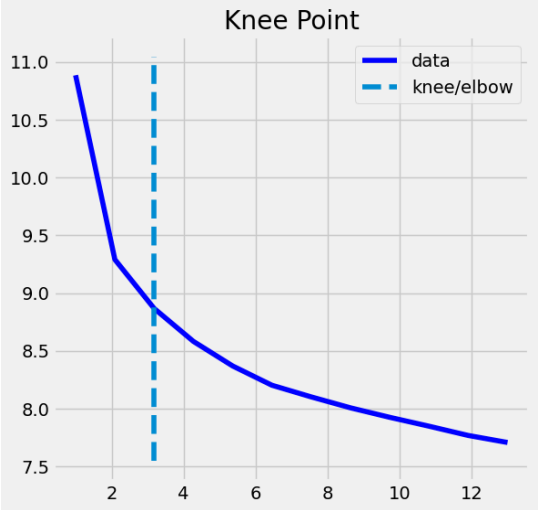


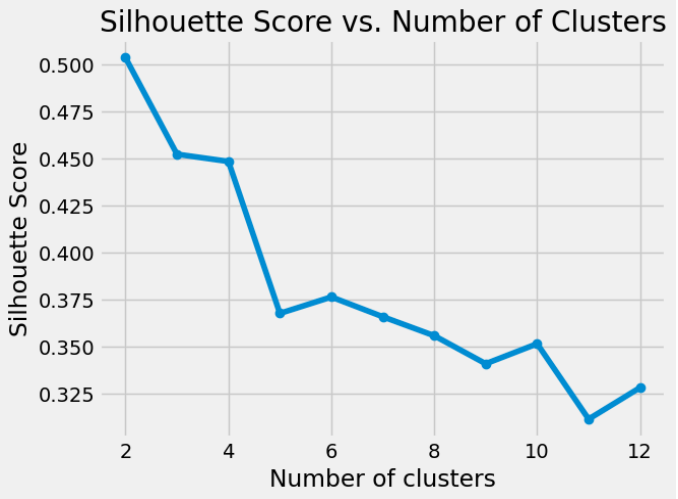


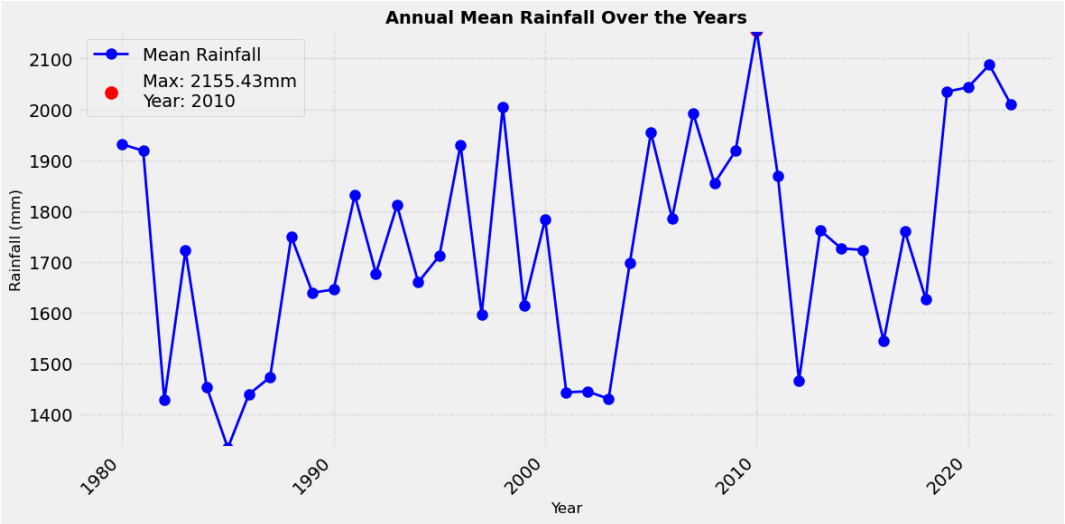


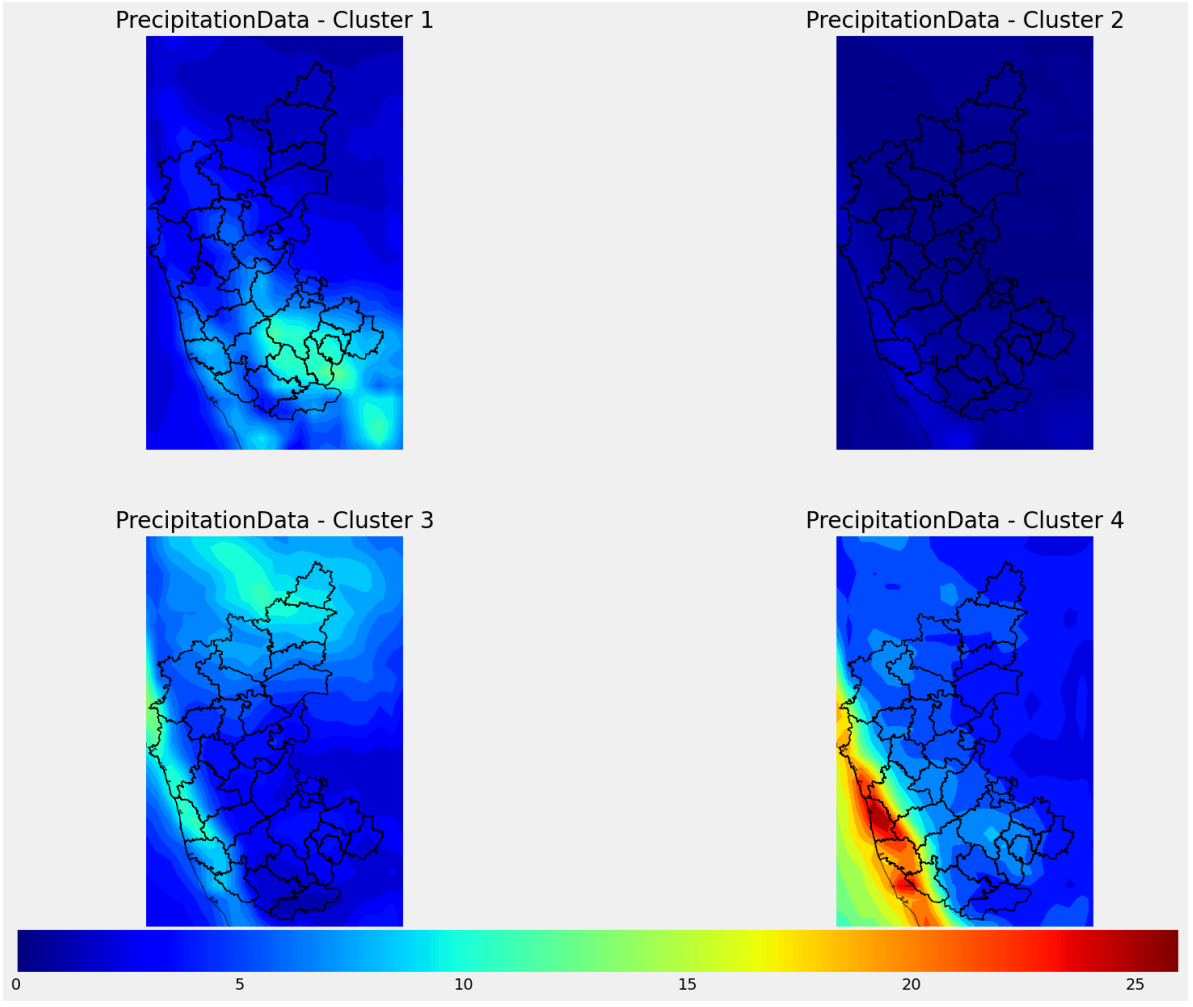
Rainfall:

K-Means Clustering:








PrecipitationData - Cluster 1
PrecipitationData - Cluster 2
PrecipitationData - Cluster 3
PrecipitationData - Cluster 4
0
5
10
15
20
25

Results:

Cluster 1: Monsoon Retreat (September, October,May)

- Southern Karnataka, particularly Bengaluru, enjoys its peak rainfall season in September,October. This period sees significantly higher precipitation compared to other parts of the state, making it ideal for agricultural activities and replenishing water resources.

Cluster 2: Dry Spell (November to April)

- From November to April, Karnataka experiences a dry spell with minimal rainfall across the state. This period provides respite from the monsoon and allows for agricultural harvest and land preparation for the next planting season.

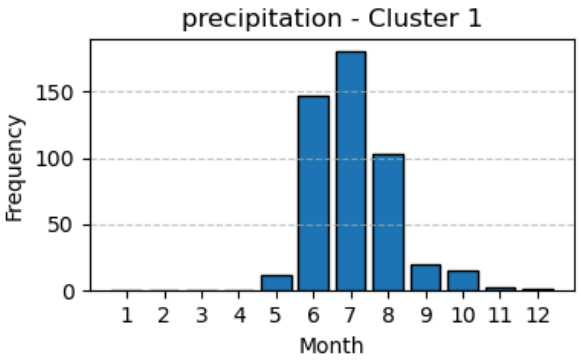
Cluster 3: Western Monsoon Burst (June to September)

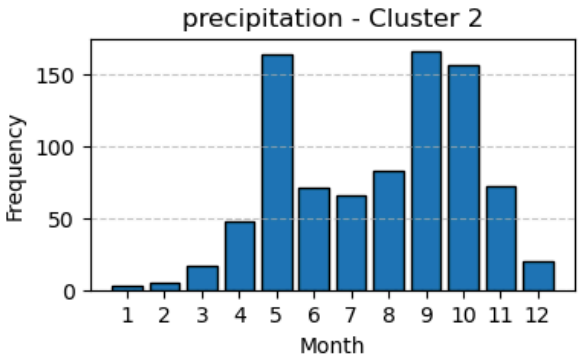
- The core monsoon months of June to September bring the highest rainfall to western Karnataka, with an average maximum of 1.5mm. This abundant precipitation nourishes the coastal ecosystem and supports a lush green landscape.

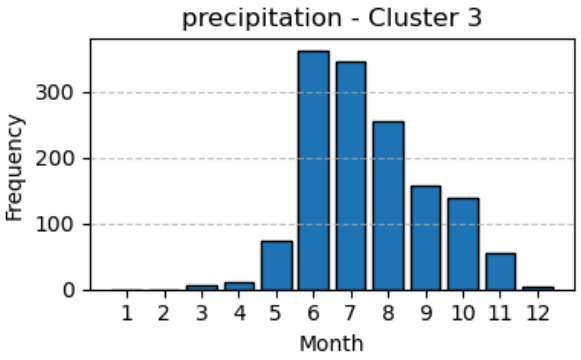
Cluster 4: Coastal Downpour (June to August)

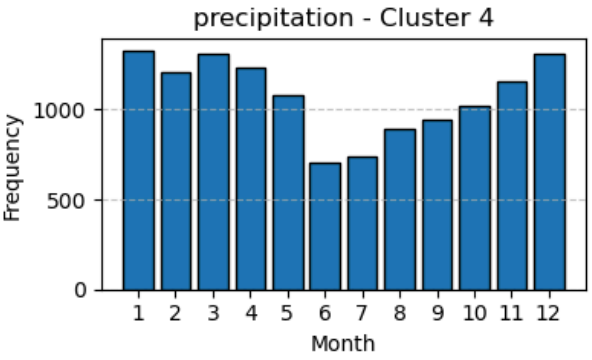
- The central monsoon months of June to August witness the most intense rainfall along the coastal areas of Karnataka, averaging a maximum of 2.85mm. This concentrated downpour replenishes coastal water bodies and fuels the growth of tropical vegetation.

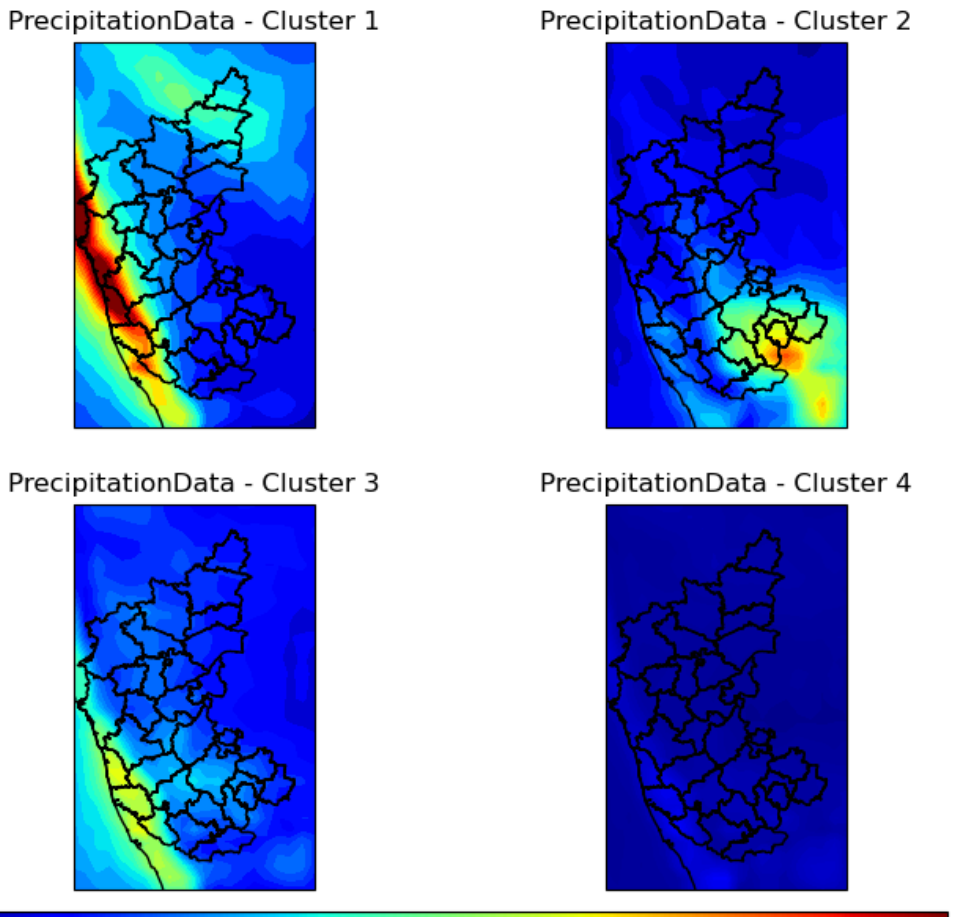
Self organisng maps:



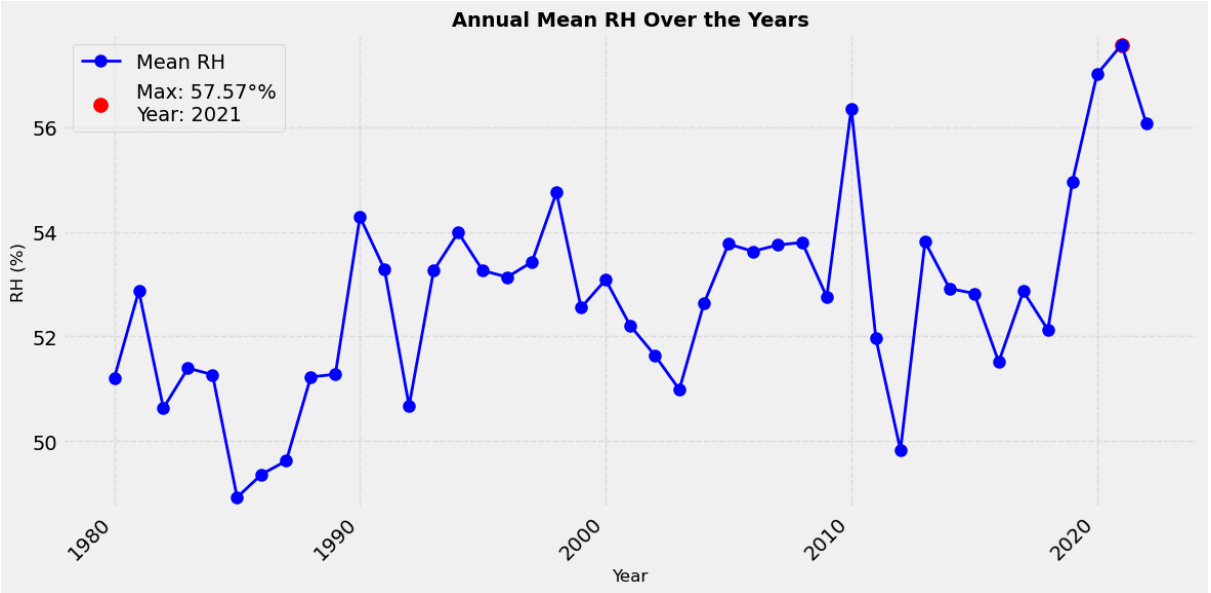


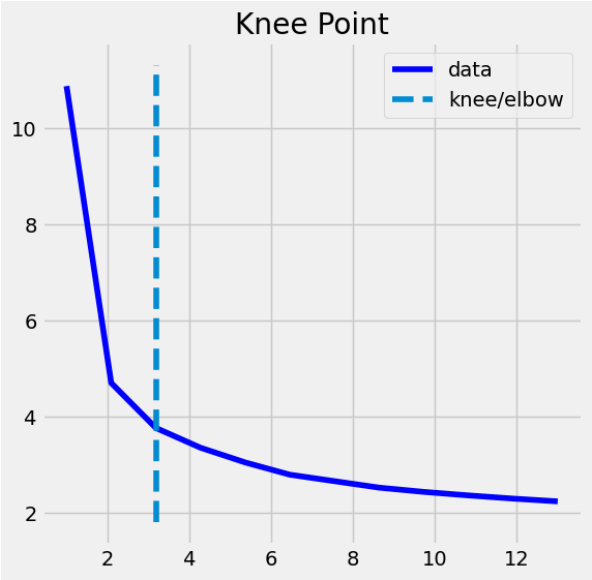


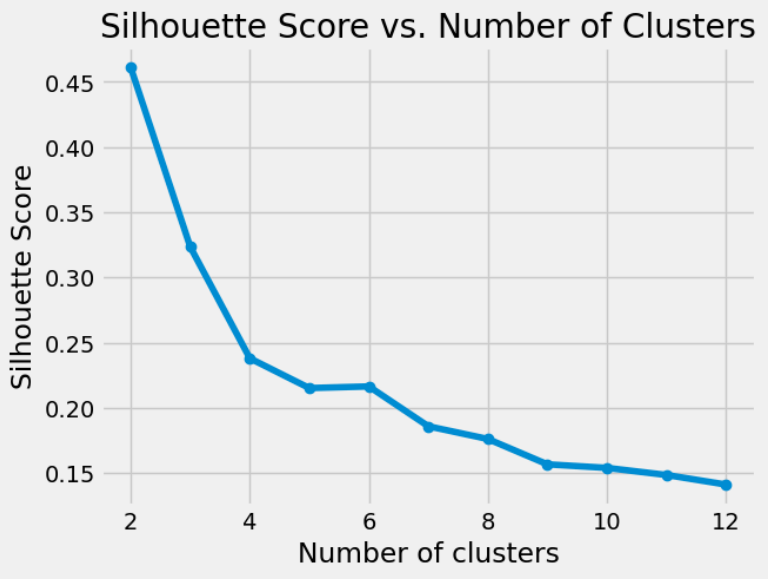


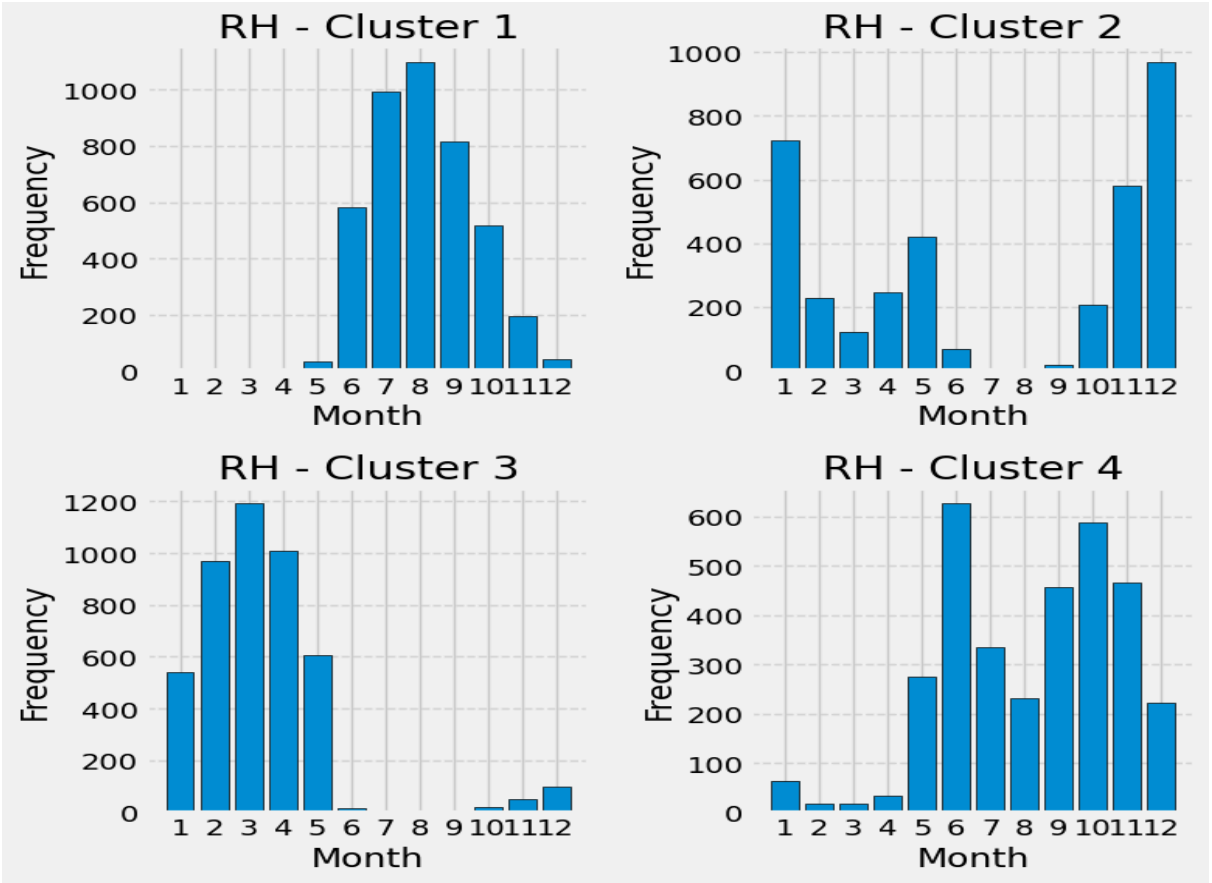


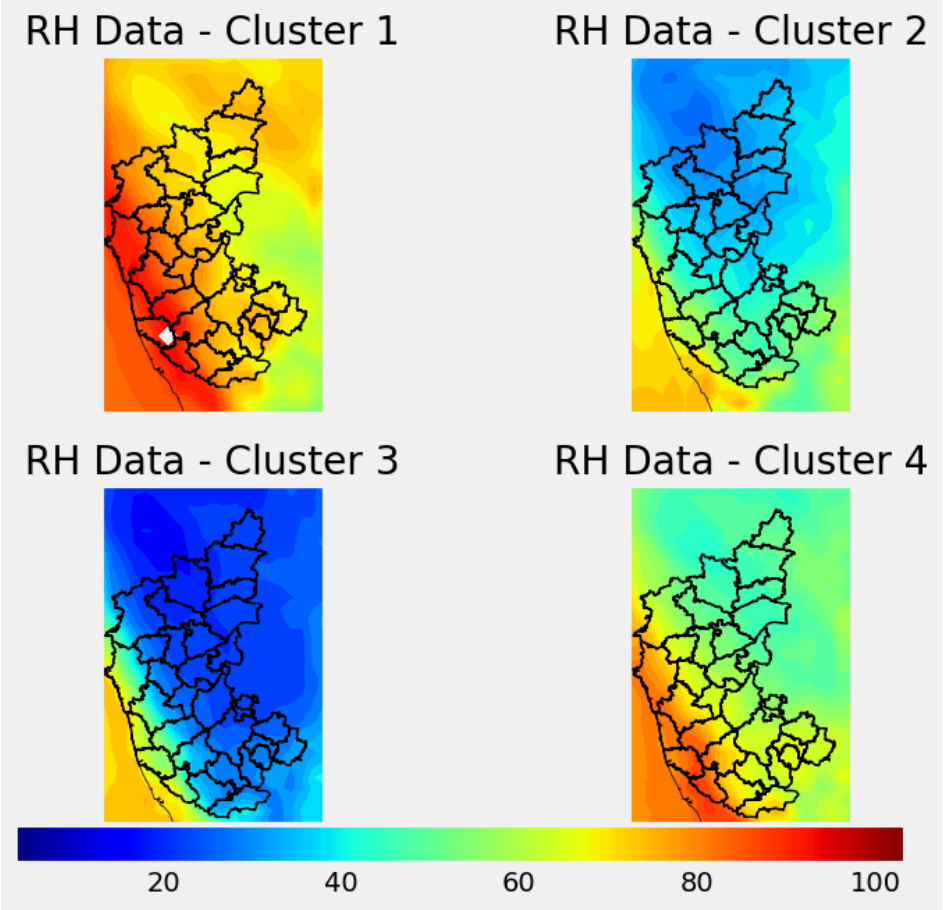
Relative humidity:








RH - Cluster 1
Frequency
Month
RH - Cluster 2
Frequency
Month
RH - Cluster 3
Frequency
Month
RH - Cluster 4
Frequency
Month


RH Data - Cluster 1
RH Data - Cluster 2
RH Data - Cluster 3
RH Data - Cluster 4
20
40
60
80
100

Results:

Cluster 1: Coastal Oasis (June to September)

- Coastal Karnataka basks in the highest relative humidity during this cluster, averaging a comfortable 90%. This moisture-rich environment contrasts with inland Karnataka, which maintains a more moderate 75% average.

Cluster 2: Dry Winter (November to January)

- Northern Karnataka experiences its driest phase in terms of relative humidity during these months, dipping below 35%. The rest of the state, including coastal and southern regions, enjoys a more comfortable average of 60%.

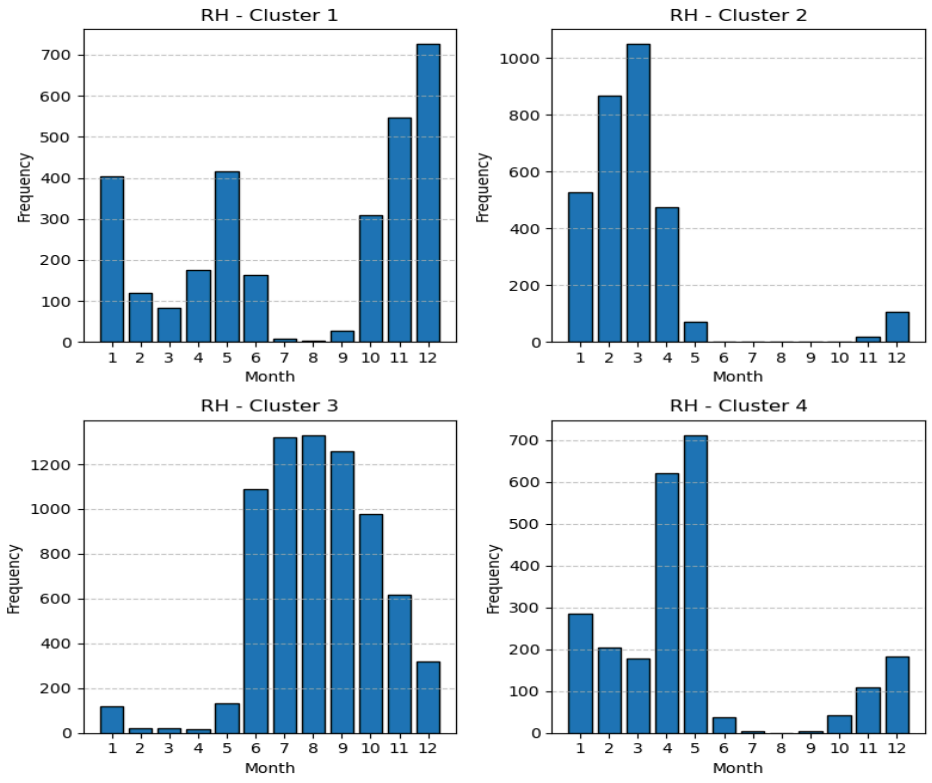
Cluster 3: Transitional Tussle (February to May)

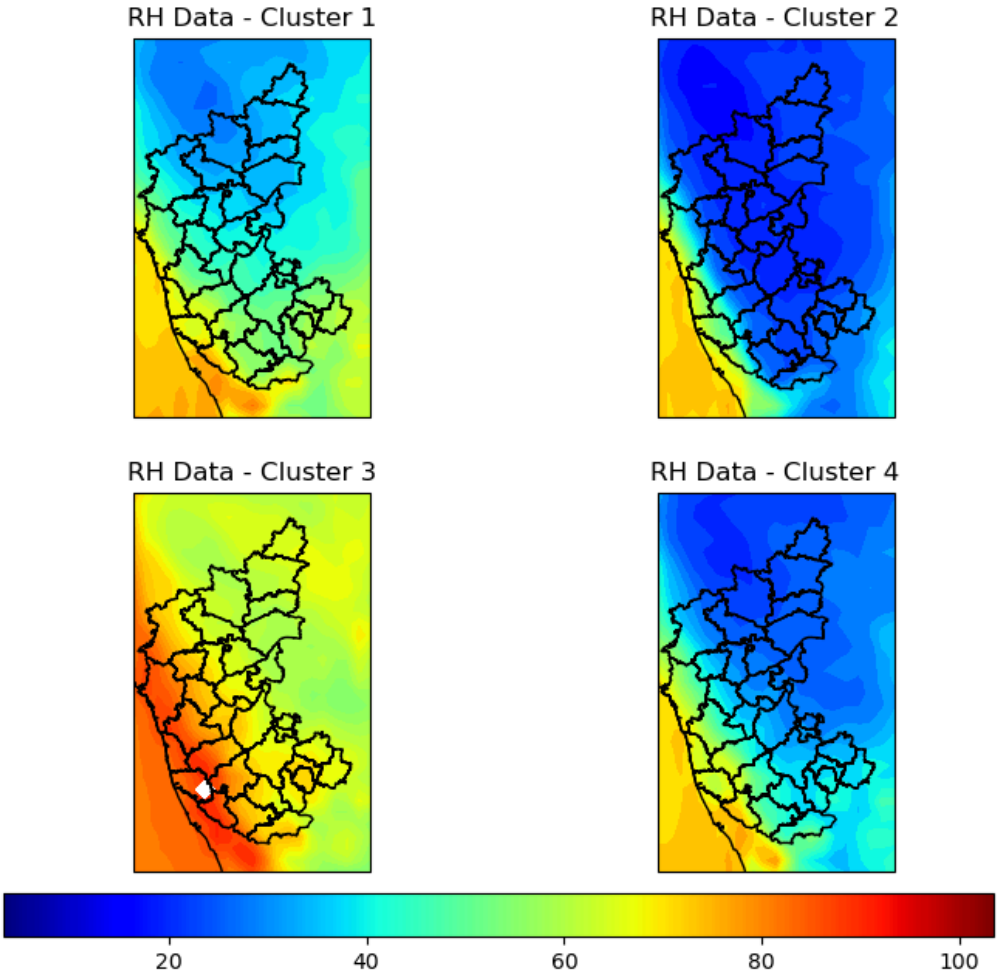
- This cluster marks a shift in humidity patterns. Except for the coastal belt with its consistent 50-60% average, inland Karnataka faces significant dryness, falling below 30%.

Cluster 4: Monsoon Mosaic (Peak June,peak October & September, November)

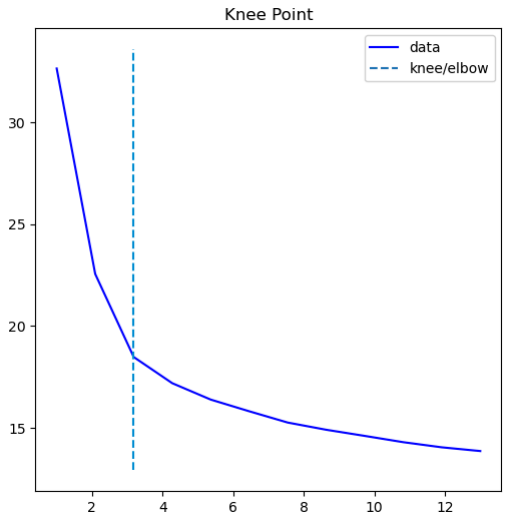
- The monsoon brings a complex humidity tapestry across Karnataka. Coastal areas luxuriate in the highest average of 80%, while central and southern regions experience moderate 60-65%. Northern Karnataka finds itself in the middle, with humidity ranging from 40 to 50%.

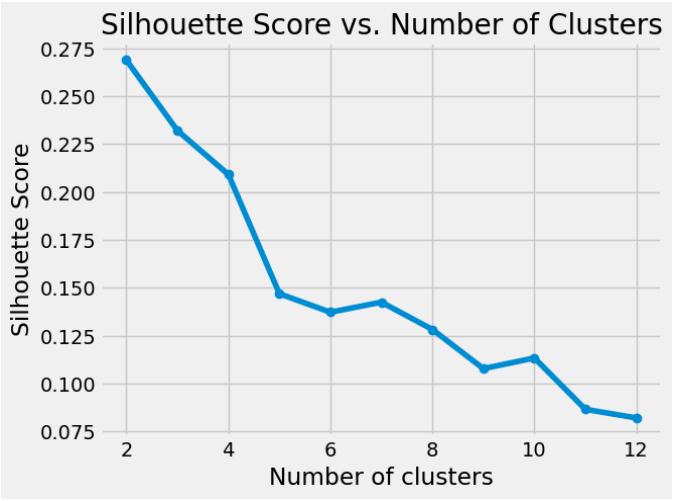
Self Organising Maps:

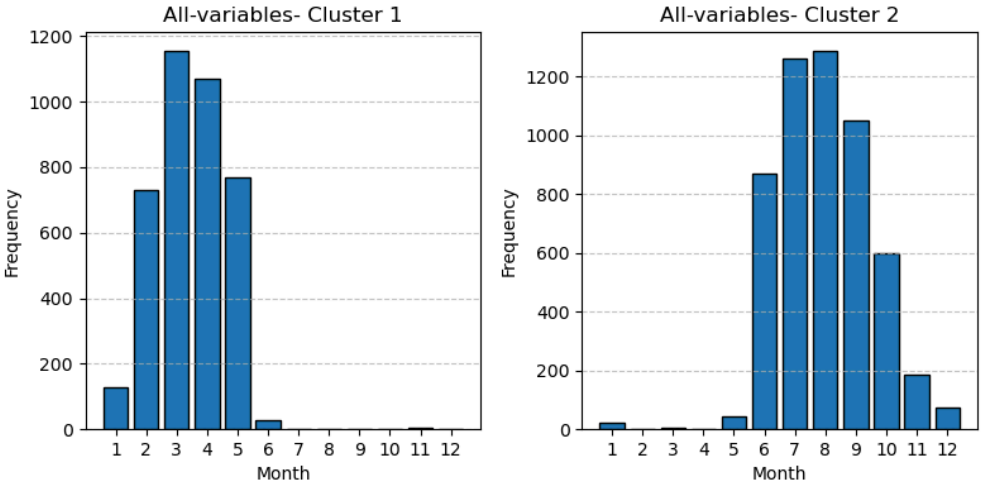




All Variables:






All-variables- Cluster 1
Frequency
Month
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12

All-variables- Cluster 2
Frequency
Month
0
200
400
600
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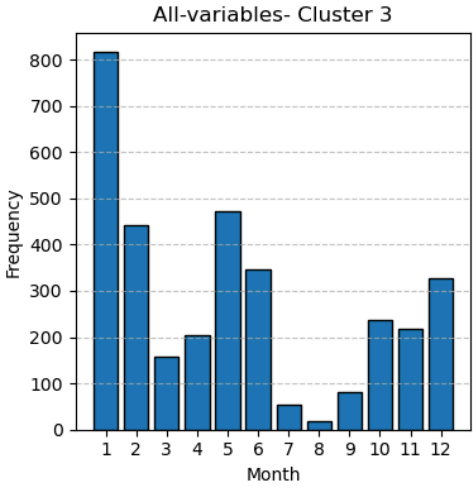
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12


All-variables- Cluster 3
Frequency
Month
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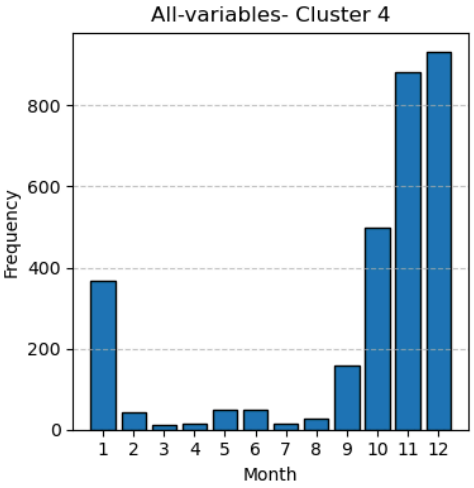
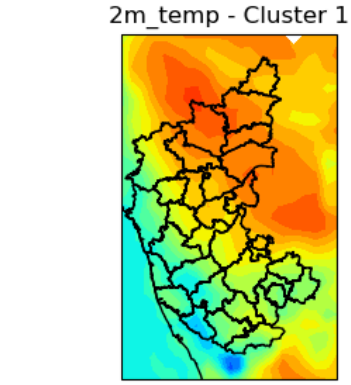
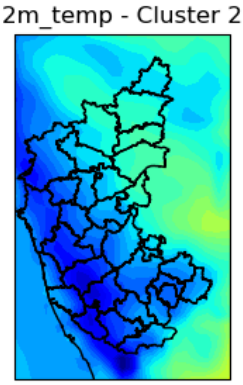
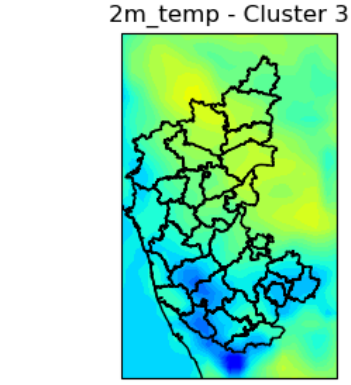
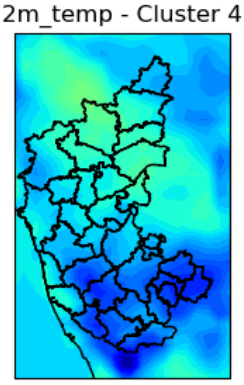
100
200
300
400
500
600
700
800
1 2 3 4 5 6 7 8 9 10 11 12

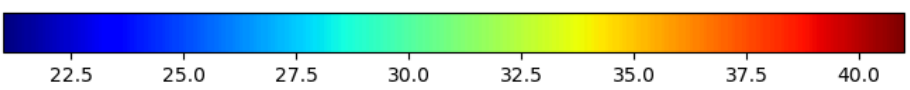

All-variables- Cluster 4
Frequency
Month
0
200
400
600
800
1 2 3 4 5 6 7 8 9 10 11 12

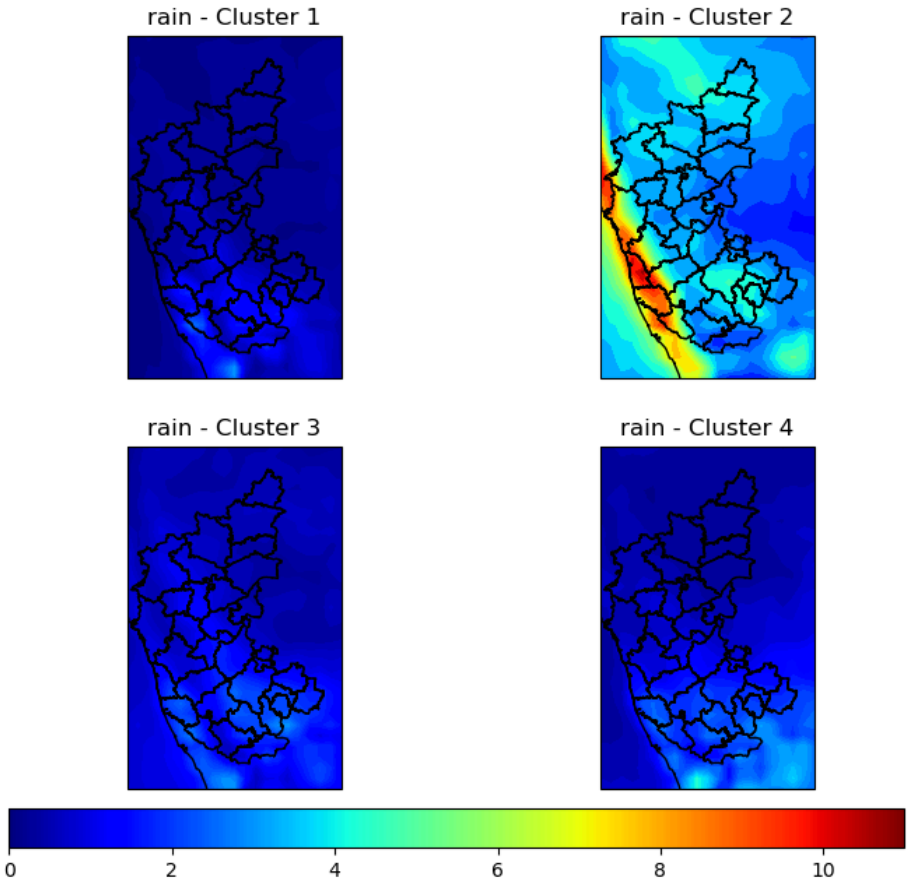

2m_temp - Cluster 1

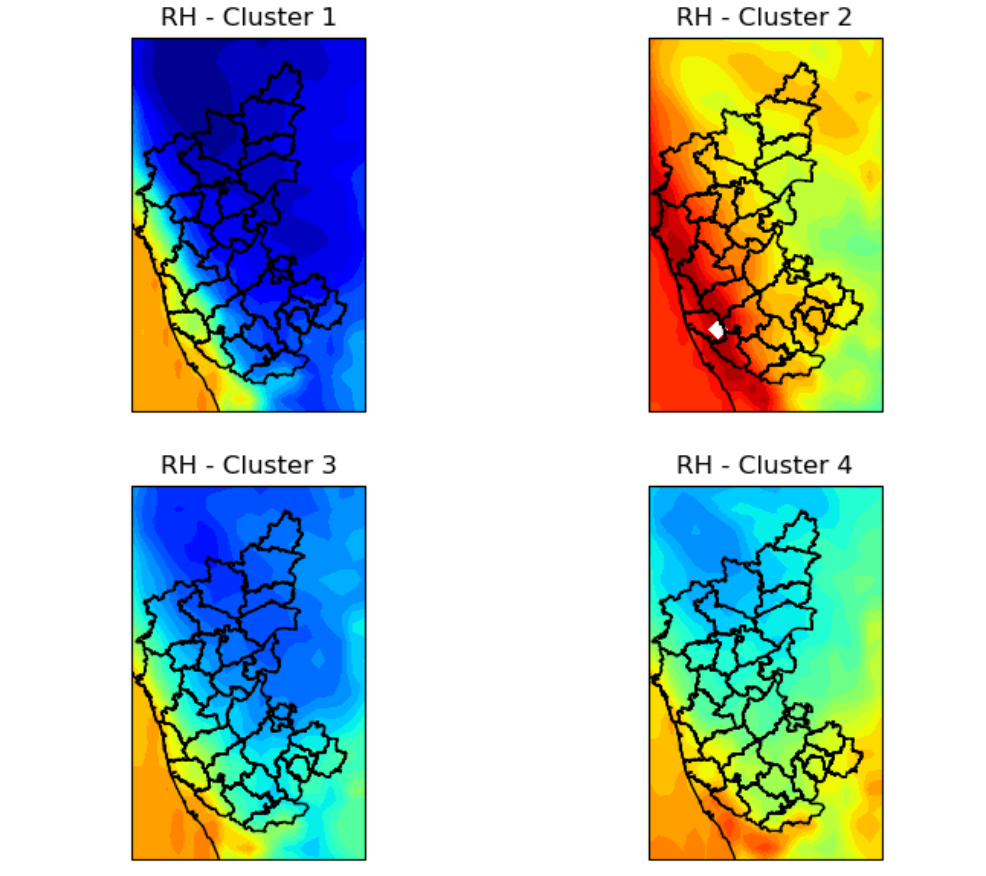

2m_temp - Cluster 2


2m_temp - Cluster 3


2m_temp - Cluster 4


22.5
25.0
27.5
30.0
32.5
35.0
37.5
40.0


rain - Cluster 1
rain - Cluster 2
rain - Cluster 3
rain - Cluster 4
0
2
4
6
8
10


RH - Cluster 1
RH - Cluster 2
RH - Cluster 3
RH - Cluster 4
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