“UPDATING THE PRECIPITATION MAP OF BANGLADESH AND SELECTING OPTIMUM INDICES FOR ANOMALY DETECTION.”

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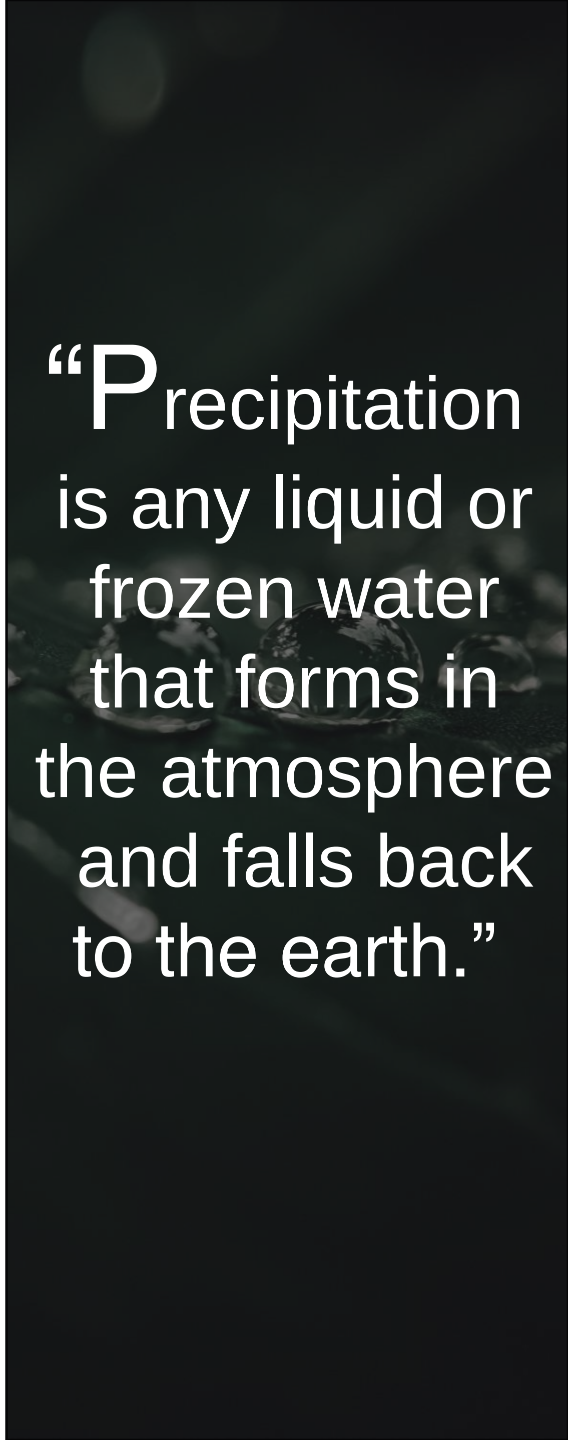
01

INTRODUCTION

Significance of Precipitation

Studying precipitation is of great significance for several reasons and it can have a substantial impact on the economy in various ways:

- As precipitation is the primary source of fresh water, understanding its patterns and amounts is crucial for managing water resources.
- Not only does an adequate and well-distributed precipitation is essential for crop growth, it also plays a vital role in the availability of water for hydropower generation.
- As the amount of precipitation widely controls Groundwater Recharge and Surface Water Run-off, it is also noteworthy that excessive or insufficient precipitation can lead to Floods or Droughts, both of which can have severe economic consequences.
- Recently, in the context of climate change, Precipitation and Temperature data are critical indicators for detecting anomalies which are the aftermaths of a changing climate.



02

BACKGROUND RESEARCH

LITERATURE REVIEW

Multiple analyses have been conducted in the last decade on both long-term and short-term trends of rainfall (Endo et al., 2015; Noorunnahar and Hossain, 2019). In addition, other studies have focused on Spatial and Temporal Variations (Gargol and Soja, 2016; Ahmed et al., 2019) as well as intraseasonal variation (Ohsawa et al., 2000).

LIMITATIONS

- These studies of trend analyses **are not up-to-date** and subject to further confirmation by a more detailed investigation.

- **No concise and thorough rainfall map** has yet been created upon analyzing the spatiotemporal distribution of rainfall.

LITERATURE REVIEW

- On the other hand, to detect anomalies in precipitation data which might indicate extreme rainfall or drought events, several Drought Indices have been used previously in the context of Bangladesh. Some of these drought indices are: the **Palmer Drought Severity Index (PDSI)**, the **Standardized Precipitation Evapotranspiration Index (SPEI)**, the **Effective Drought Index (EDI)**, the **Standardized Precipitation Index (SPI),** the **Rainfall Anomaly Index (RAI)** etc.

- As the SPI solely **focuses on precipitation data**, several studies have been carried out using this index.

- Some of these studies focused on comparing the SPI with other indices such as SPEI and EDI **to find the right statistical tools**.

LIMITATIONS

- Nevertheless, the comparison of drought indices in the context of Bangladesh is **inadequate.**

- **No comparison has yet been conducted** between the SPI and RAI, which have been used widely in other parts of the world.

03

OBJECTIVES

- To create an **updated precipitation map** of Bangladesh using GIS technique
- To analyze the spatial changes of rainfall
- To examine the temporal changes of rainfall
- To detect the **extreme precipitation events** using the SPI and RAI methods
- To compare the indices **to identify the most suitable one** for the context of Bangladesh

04

DATA AND METHODOLOGY

01

The required annual and monthly precipitation data have been collected from the **Bangladesh Water Development Board (BWDB).**

02

Six locations of rainfall anomaly have been **identified** upon analyzing the generated rainfall maps using BWDB data.

To further understand the behavior of such anomalies, **two drought indices** have been calculated using precipitation data.

The required data was collected from the Bangladesh Water Development Board for **22 years.**

03

Lastly, the **Standardized Precipitation Index (SPI)** developed by Mckee et al. (1993) and the **Rainfall Anomaly Index (RAI)** developed by Rooy (1965) have been calculated.

Even though, 22 years of data from **2000 to 2022** have been collected initially, due to absence and inconsistency of data between 2000 and 2008, these years were **omitted**.

In addition, the absence of data was much higher in Rajbari leaving with only 5 years of consistent data, which is far from less of the minimum threshold, this **location has been excluded** from the analysis.

05

SPATIAL ANALYSIS

Key Points

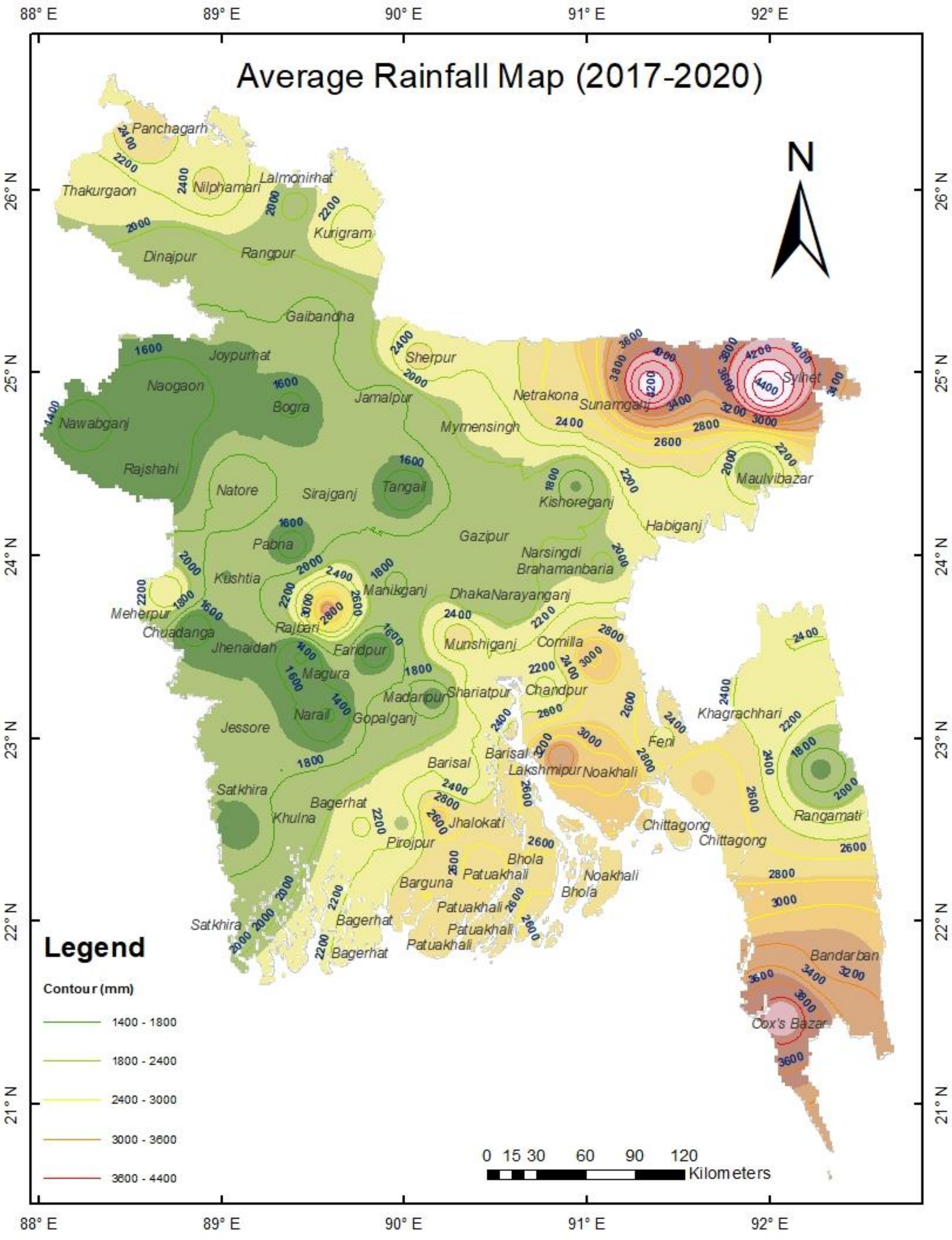
i. Precipitation **does not follow** the line of latitude.

ii. Precipitation decreases from **east to the westward** direction.

iii. From the coast the precipitation decreases towards the interior of the country.

iv. The greater the altitude, the greater the amount of precipitation, specifically valid for the **eastern coastal area**.

v. Area adjacent to contrasted elevation **receive high precipitation.**



22.28%

Summer

66.24%

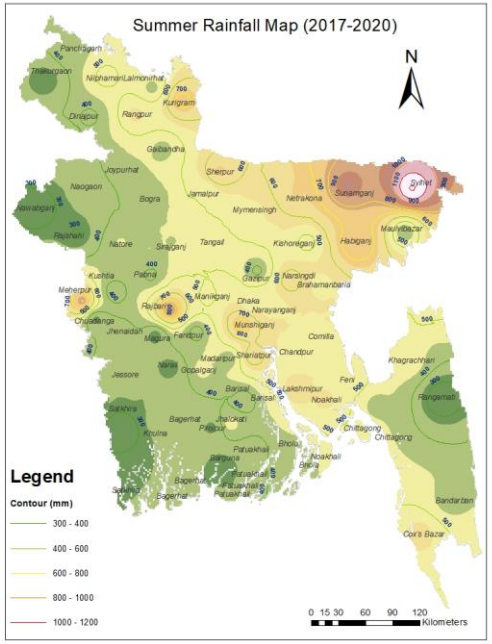
Monsoon

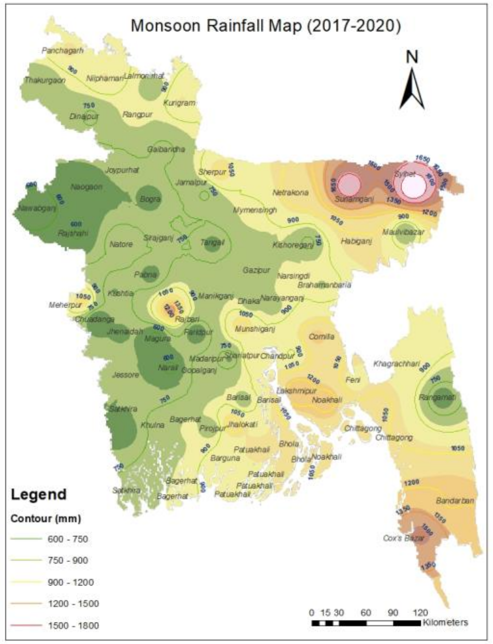
9.61%

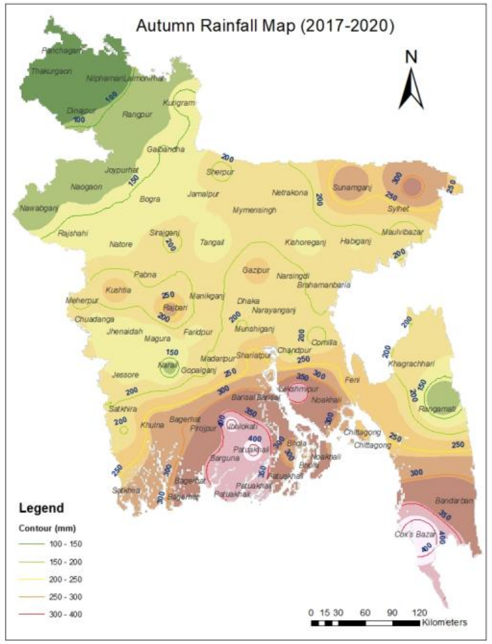
Autumn

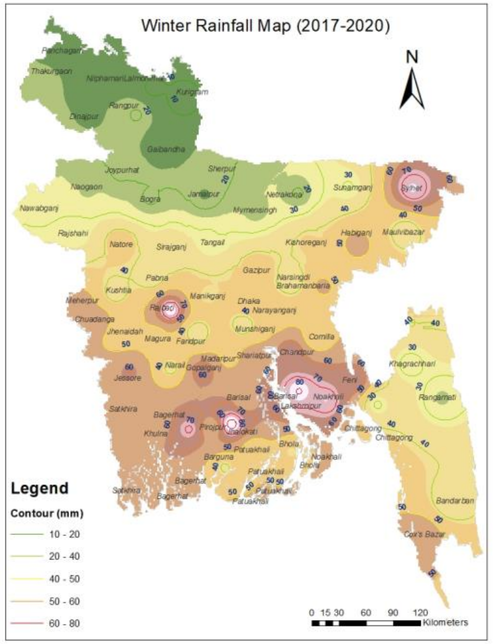
1.86 %

Winter



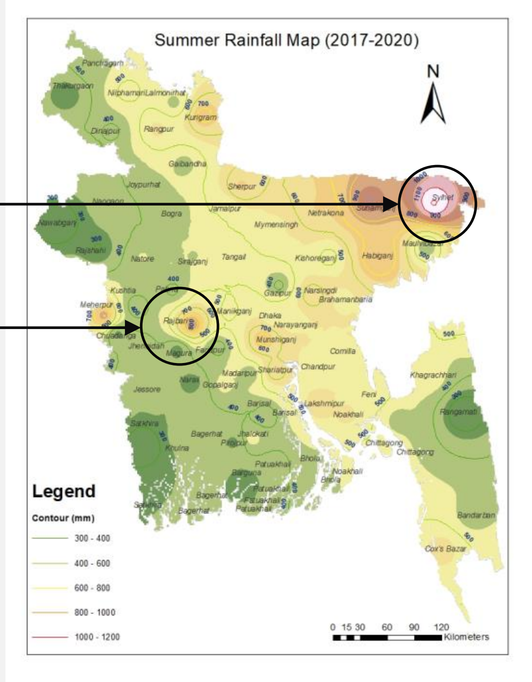


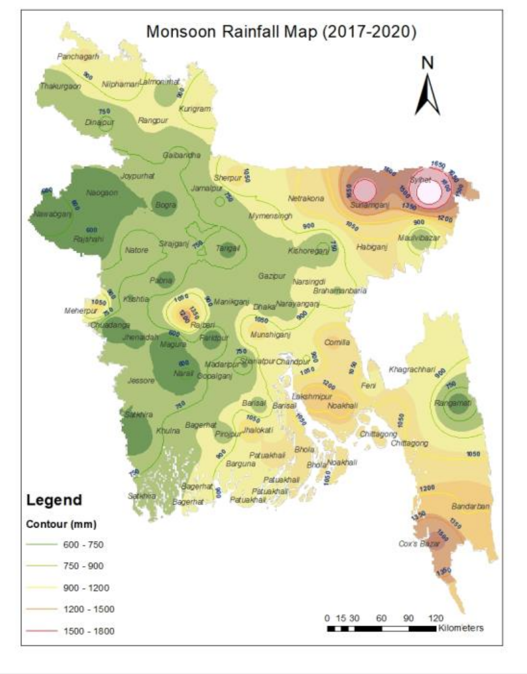




Sylhet

Rajbari



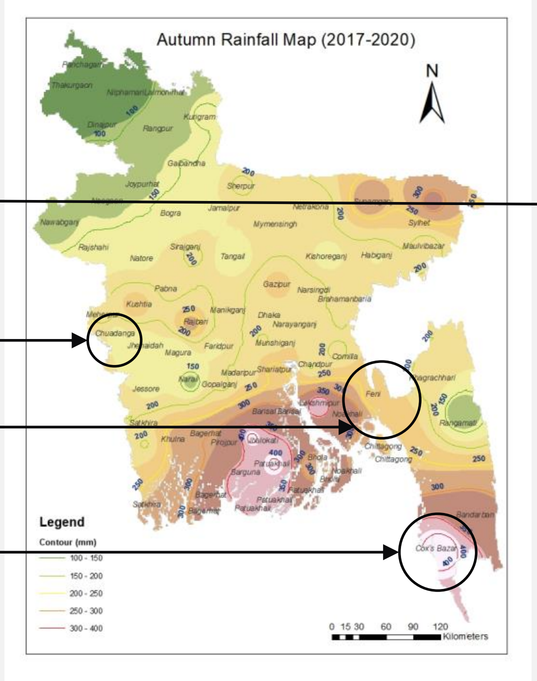


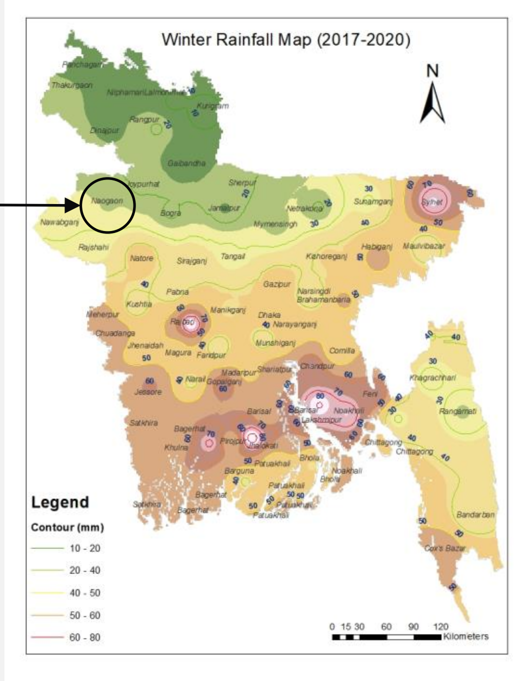
Naogaon

Chuadanga

Feni

Cox’s Bazar





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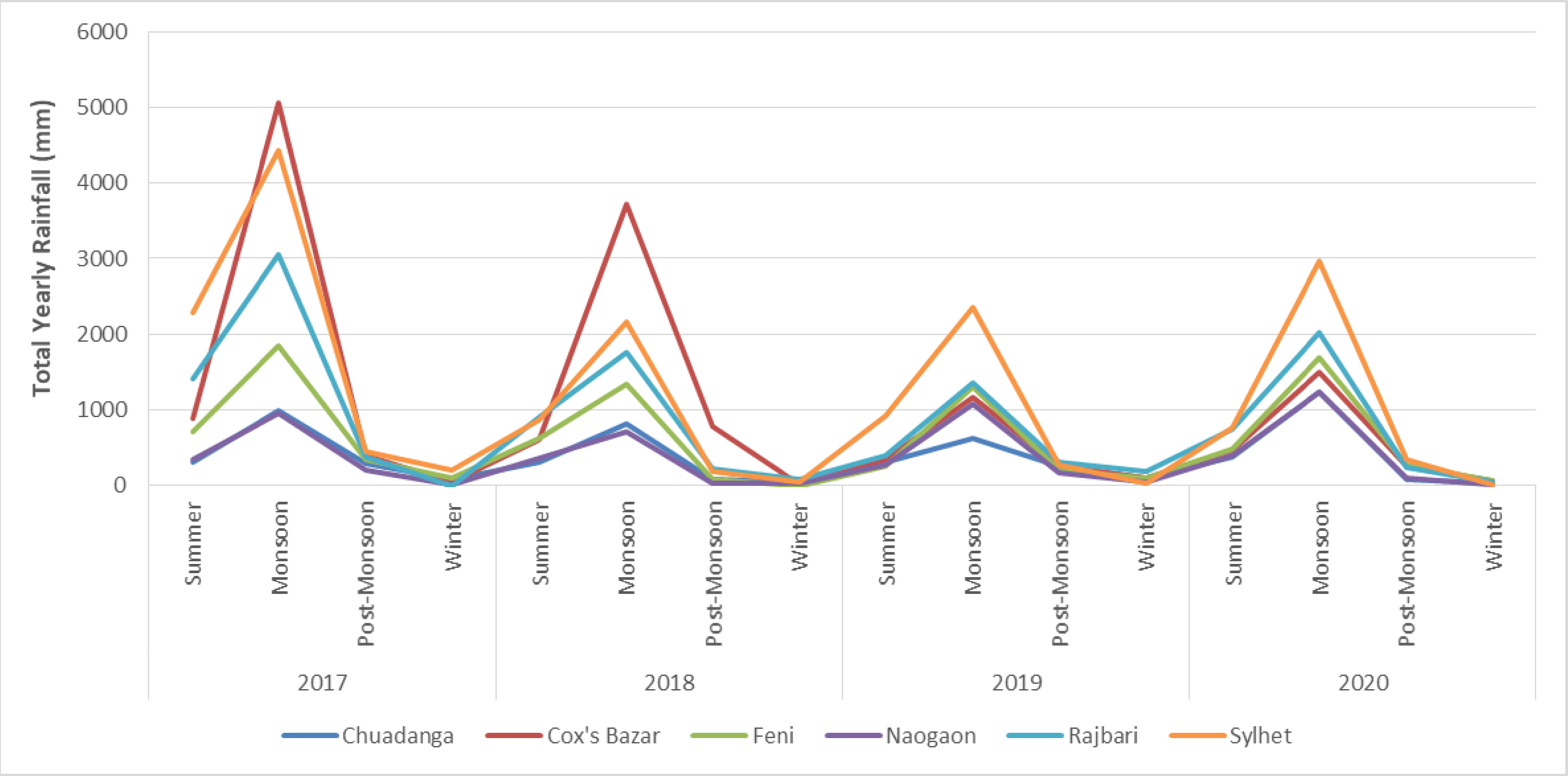
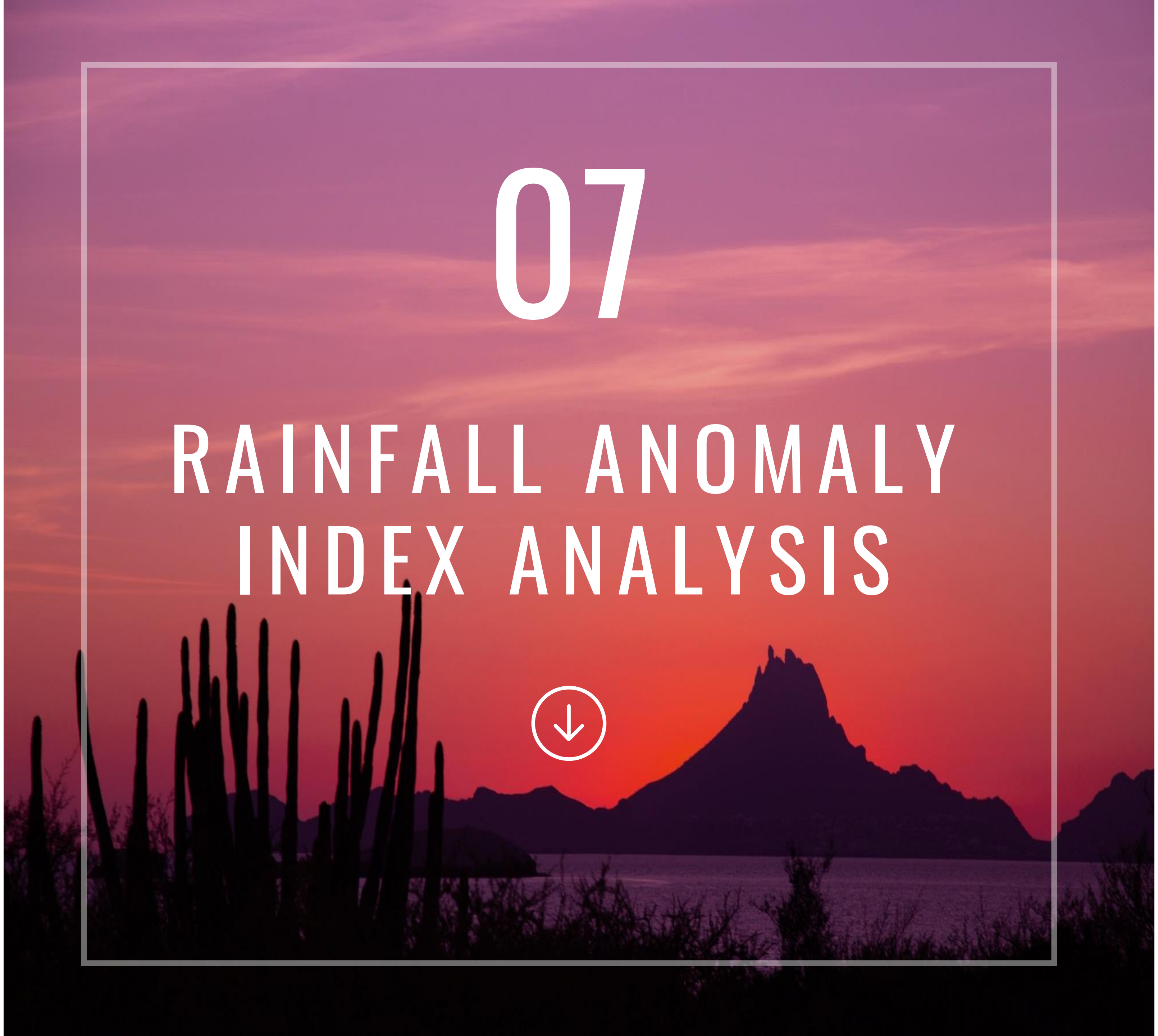
TEMPORAL ANALYSIS



- Rainfall was **highest** in all these locations in **2017**.
- Total Yearly Rainfall (TYR) continued to **drop gradually** till 2019.
- There was a **slight increase** in the TYR in 2020.


07
RAINFALL ANOMALY
INDEX ANALYSIS

For calculating the positive RAI of any year,

$$\boldsymbol{RAI = 3\left\{\frac{N - \overline{N}}{\overline{\overline{M}} - \overline{\overline{N}}}\right\}}$$

Where, $\overline{M}$ is the mean of the ten highest precipitation records for the period (mm), $\overline{N}$ is the mean of all records for the period (mm), and **N** is the current monthly/yearly rainfall (mm).

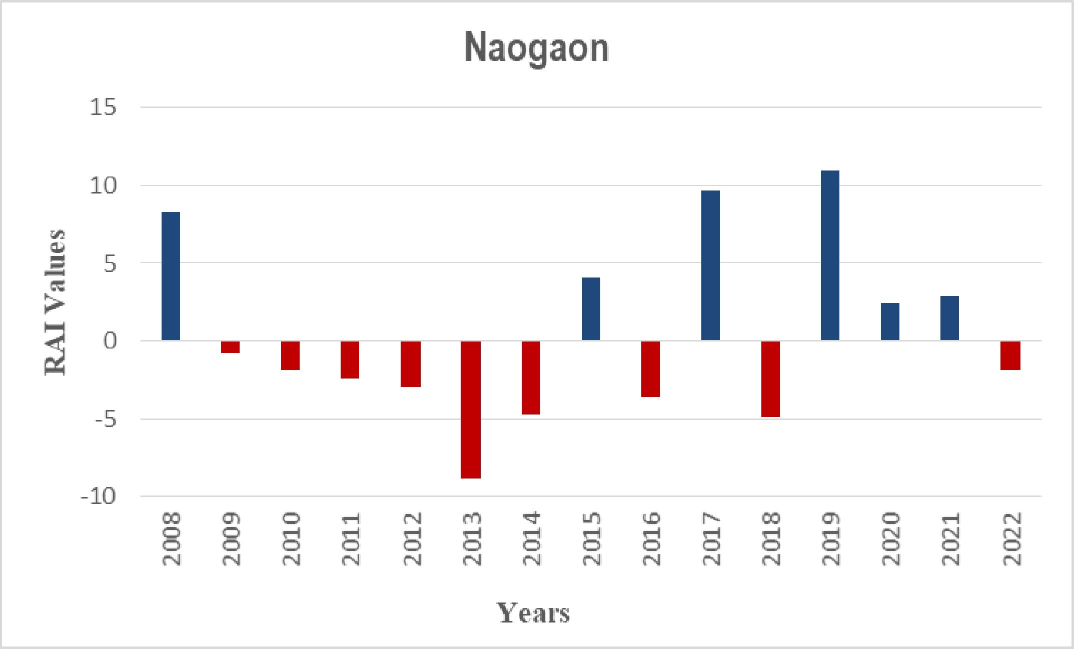
On the other hand, for calculating negative RAI of any year,

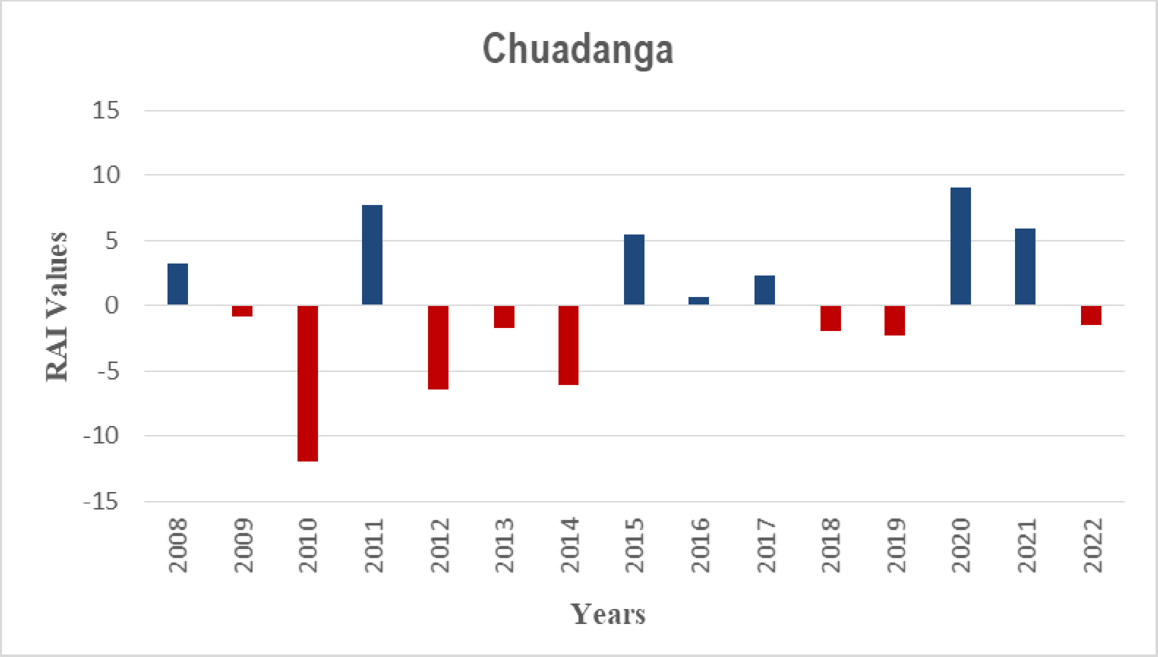
$$\boldsymbol{RAI = -3\left\{\frac{N - \overline{N}}{\overline{\overline{X}} - \overline{\overline{P}}}\right\}}$$

Where, $\overline{X}$ is the mean of the ten lowest precipitation records for the period (mm).

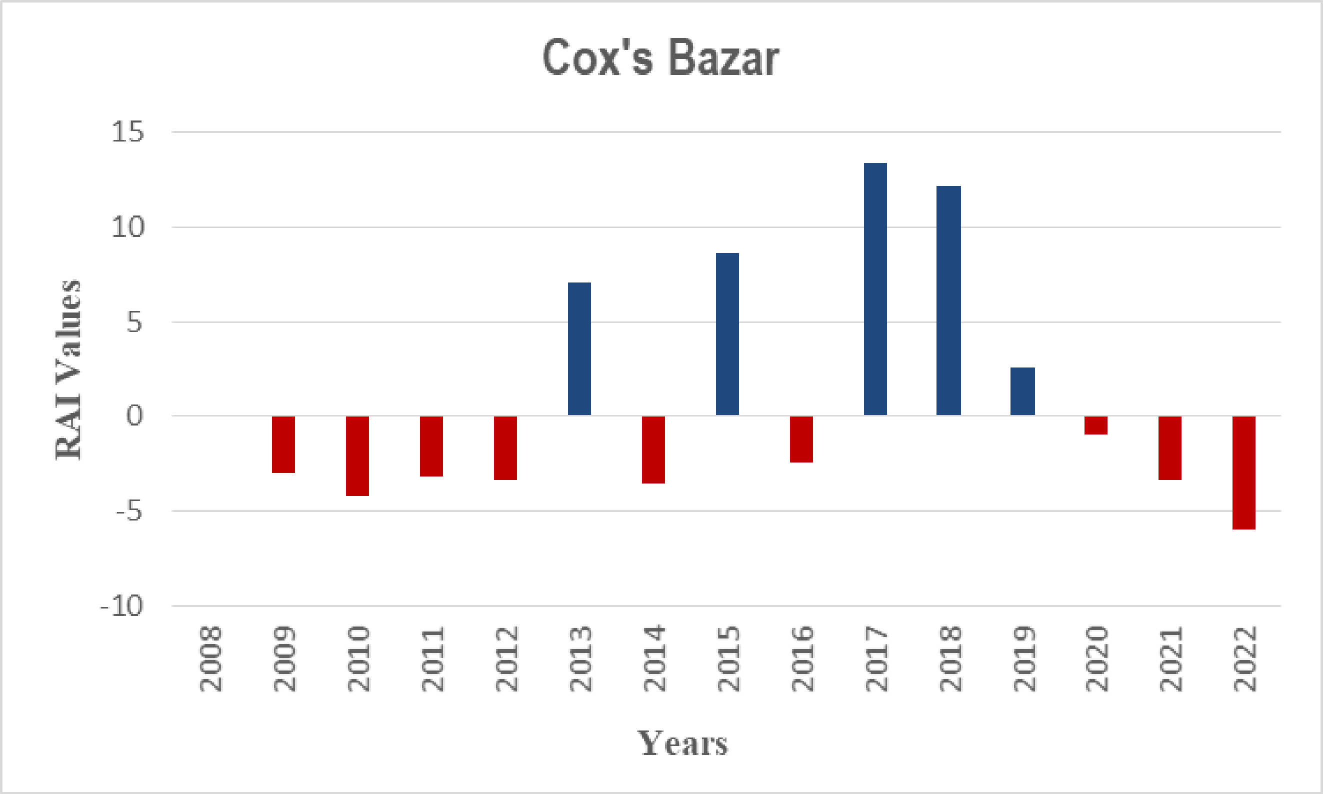
RAI Values	Classification
Above 4	Extremely Humid
2 to 4	Very Humid
0 to 2	Humid
-2 to 0	Dry
-4 to -2	Very Dry
Below -4	Extremely Dry

Analysis of the Rainfall Anomaly Index was conducted based on the classification of Freitas (2005) adopted by Araújo (2009).

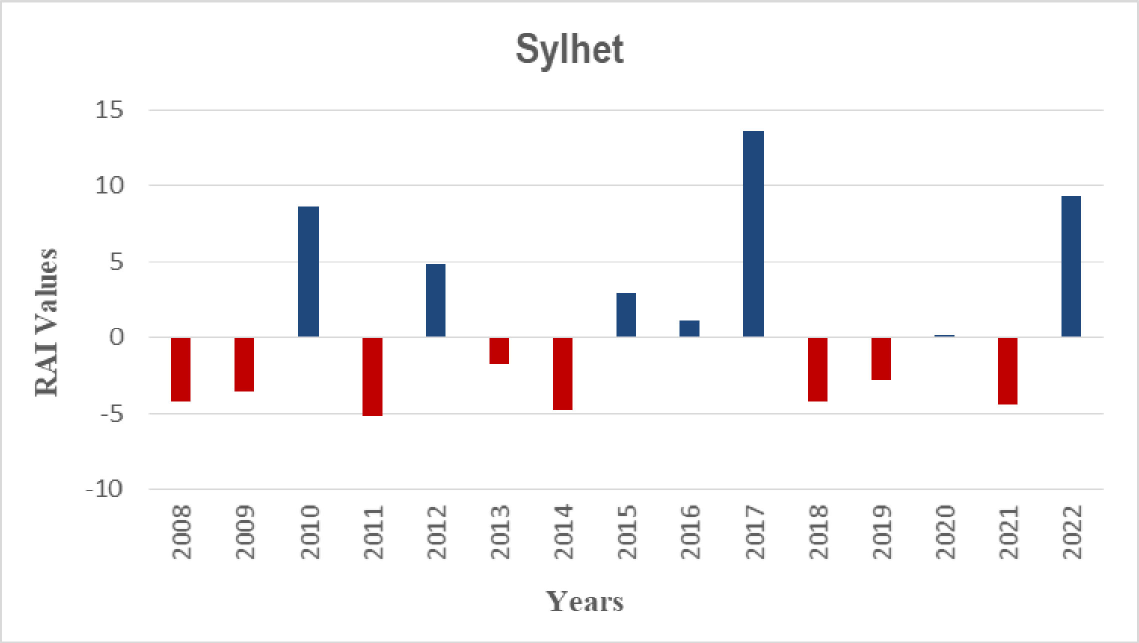


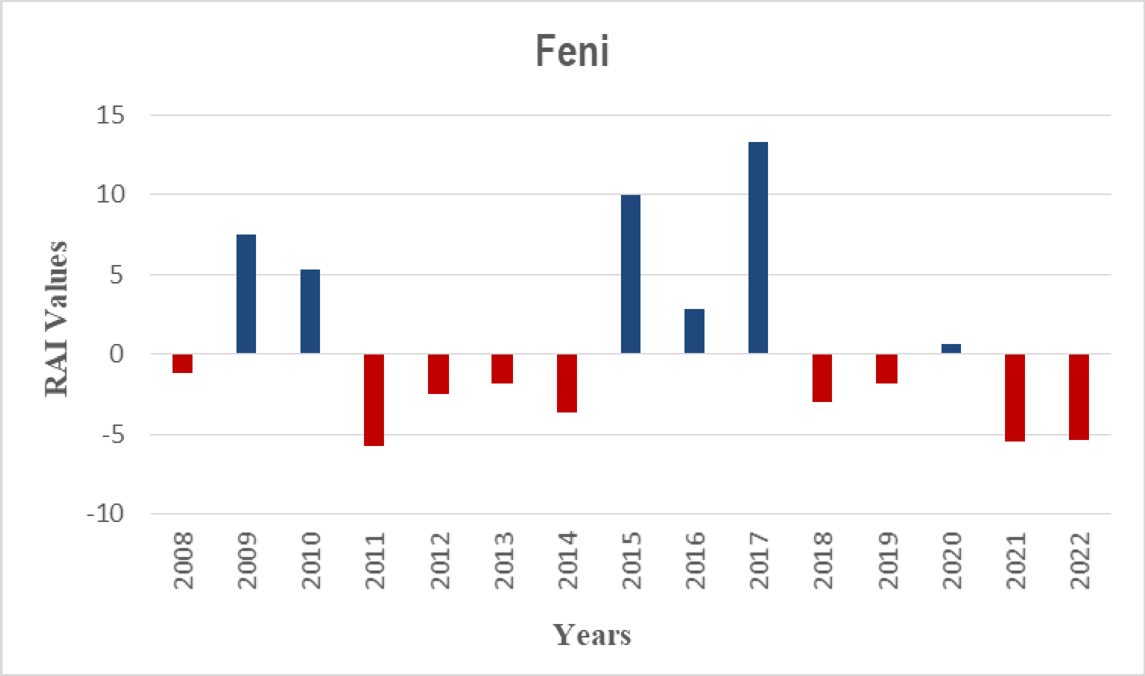


The RAI values recognized 2010, 2012, 2014 and 2013, 2014, 2018 as **extreme drought** events in Chuadanga and Naogaon, respectively.



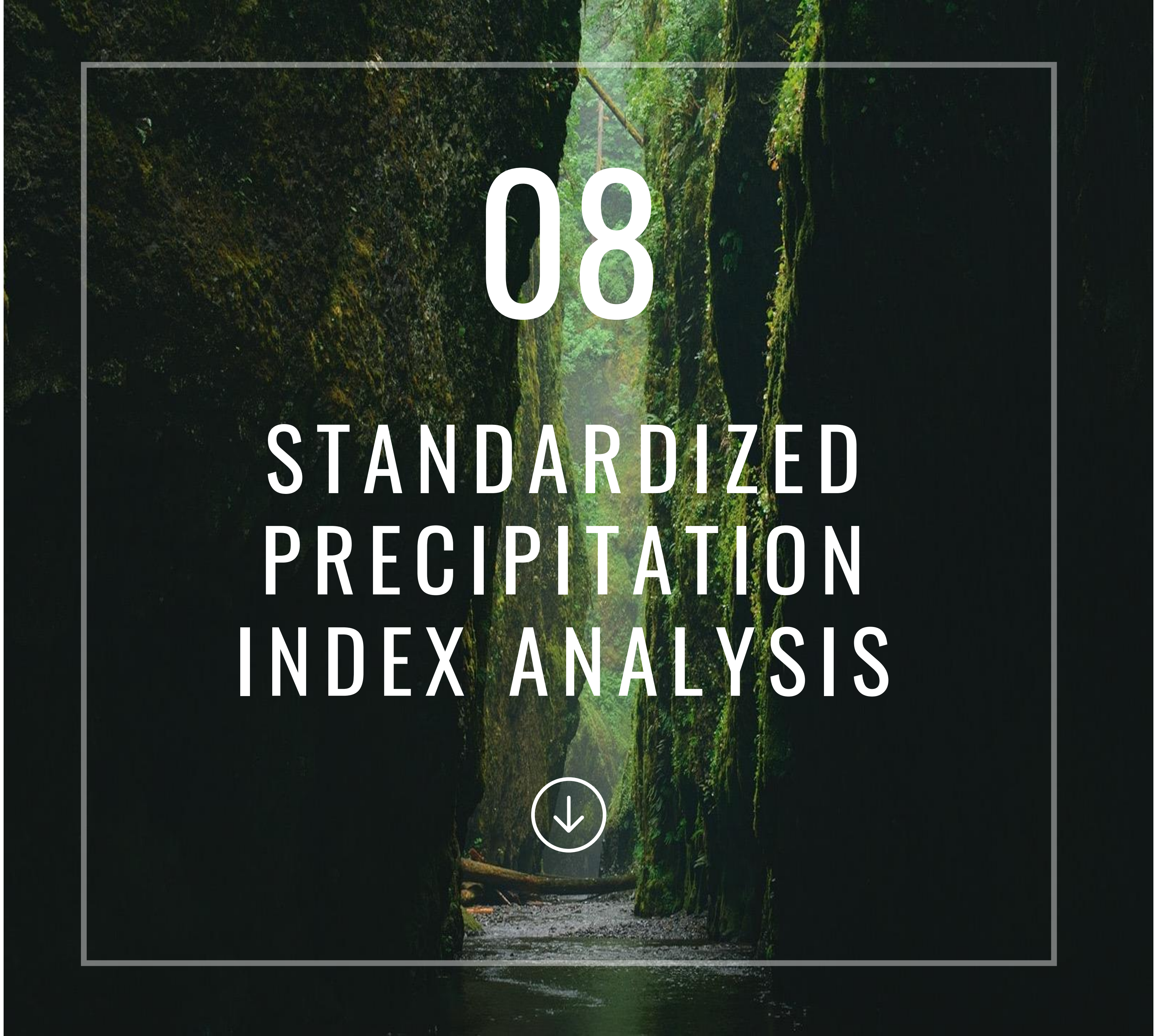
According to RAI values, 2009 through 2012, 2014, and 2021 in Cox's Bazar were characterised as **very dry**, while 2022 was **extremely dry**.





In Sylhet, the RAI values suggest that 2011 was **extremely dry**, while 2014 and 2018 were characterised as **very dry** years.

In Feni, the RAI values suggest that 2011, 2021, and 2022 were **extremely dry**.



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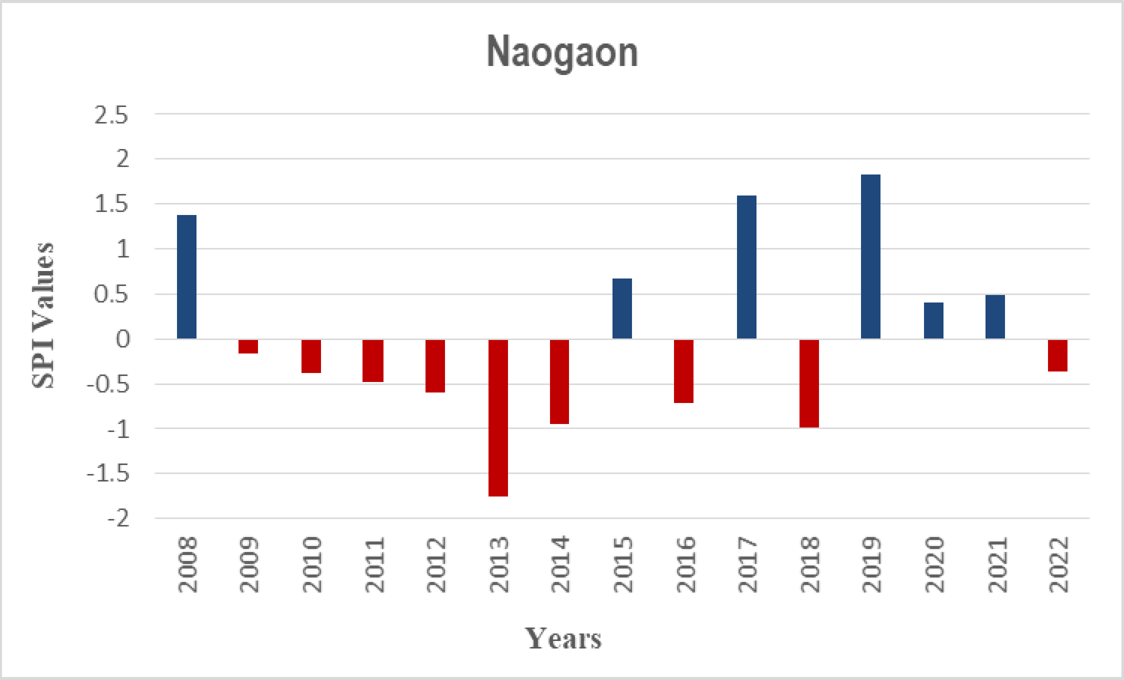
STANDARDIZED PRECIPITATION INDEX ANALYSIS

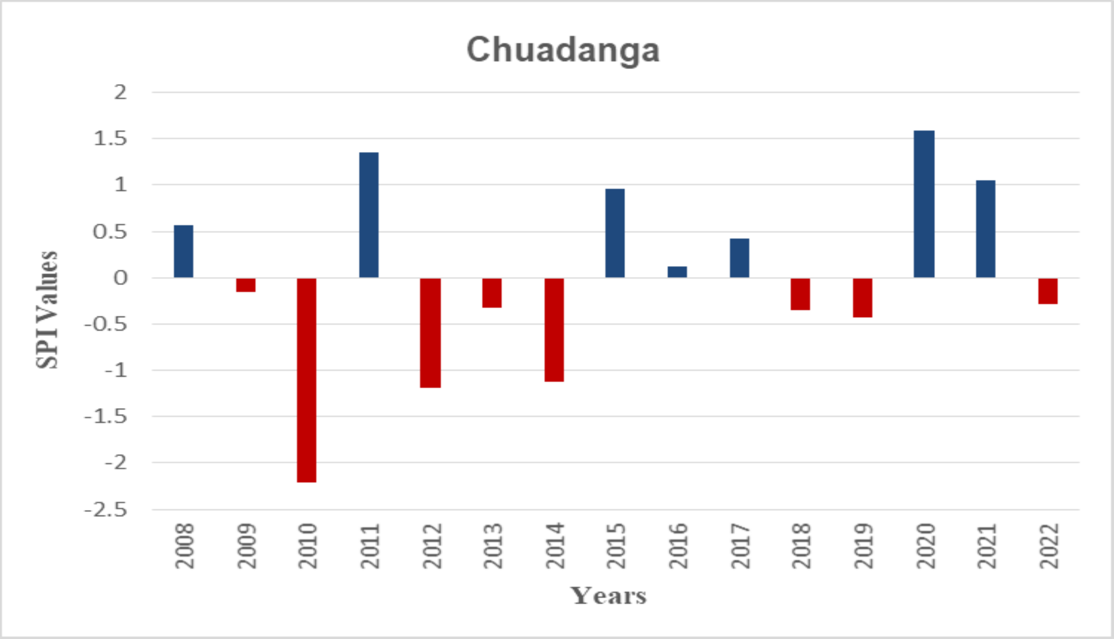
$$\boldsymbol{SPI = \frac{(P_{ij} - \bar{P})}{\sigma}}$$

Where P is the seasonal precipitation at the ith gauge site and jth observation, $\bar{P}$ is the long-term seasonal mean, and σ is its standard deviation.

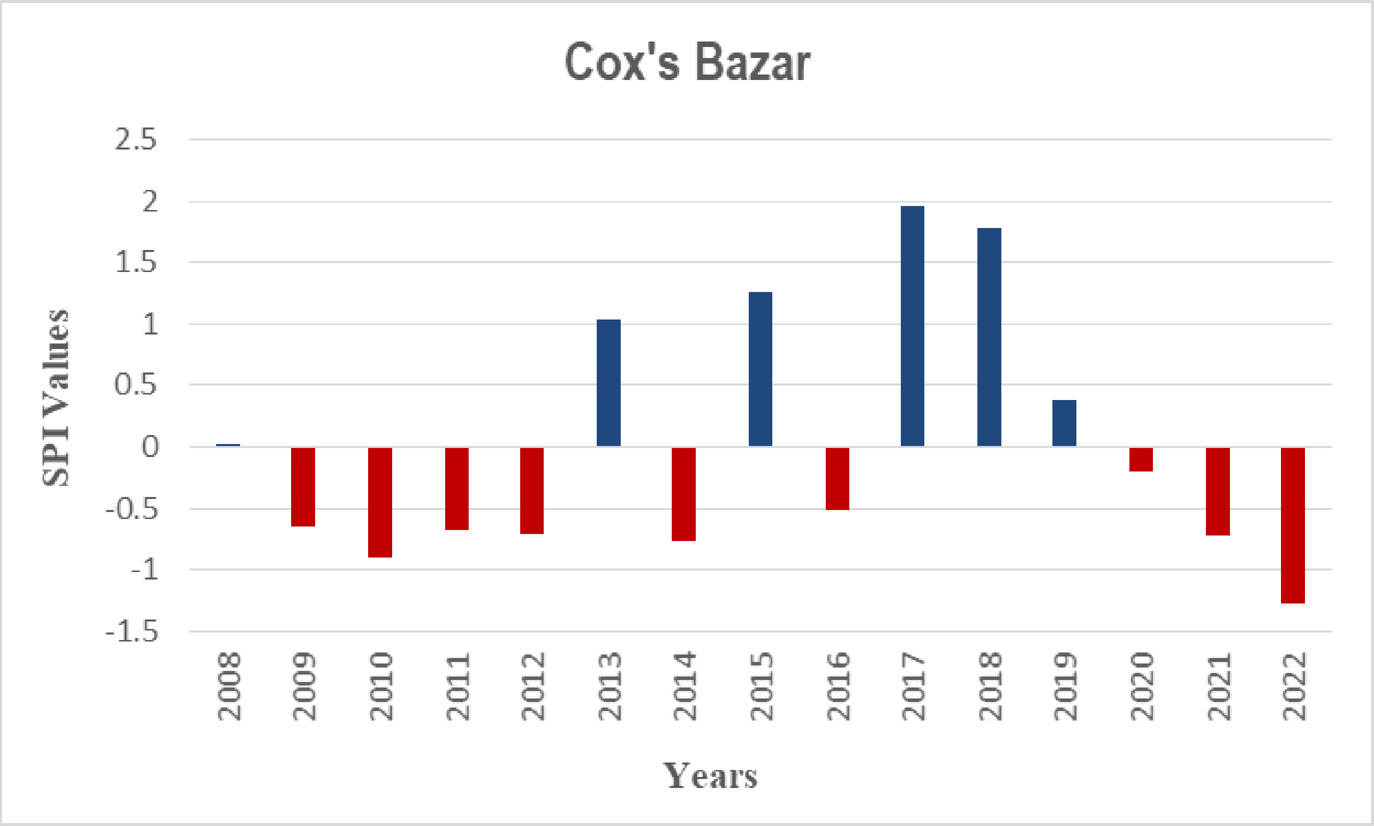
SPI Values	Category of Drought
>2.0	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to – 1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
<-2	Extremely Dry

The classification developed by Mckee et al. (1993) was used to assess the drought conditions.

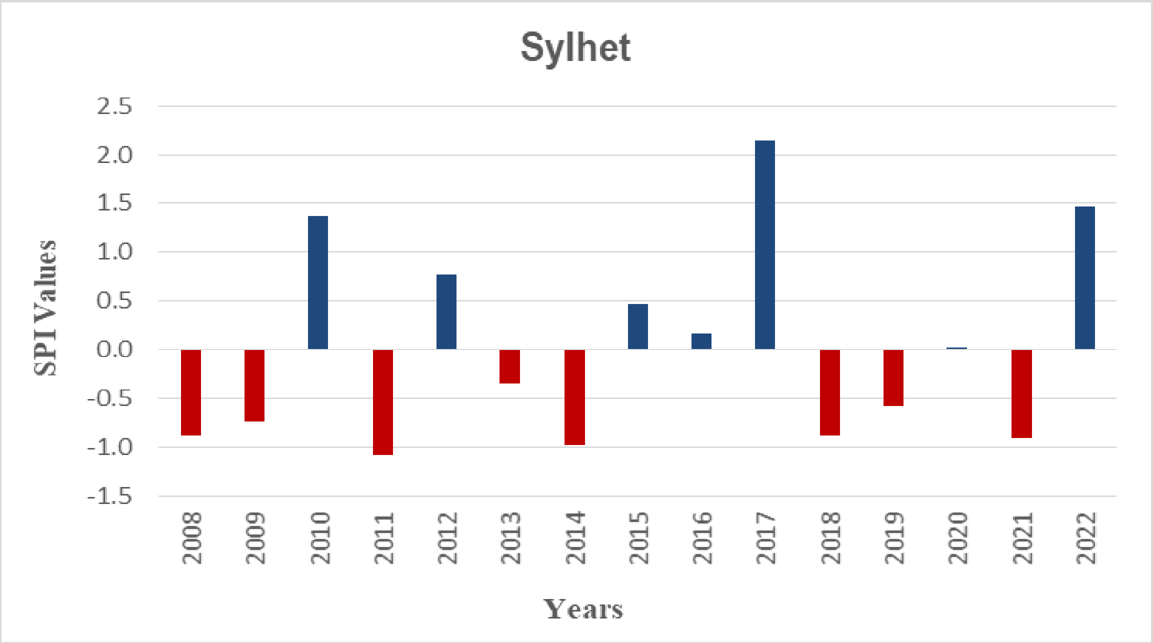


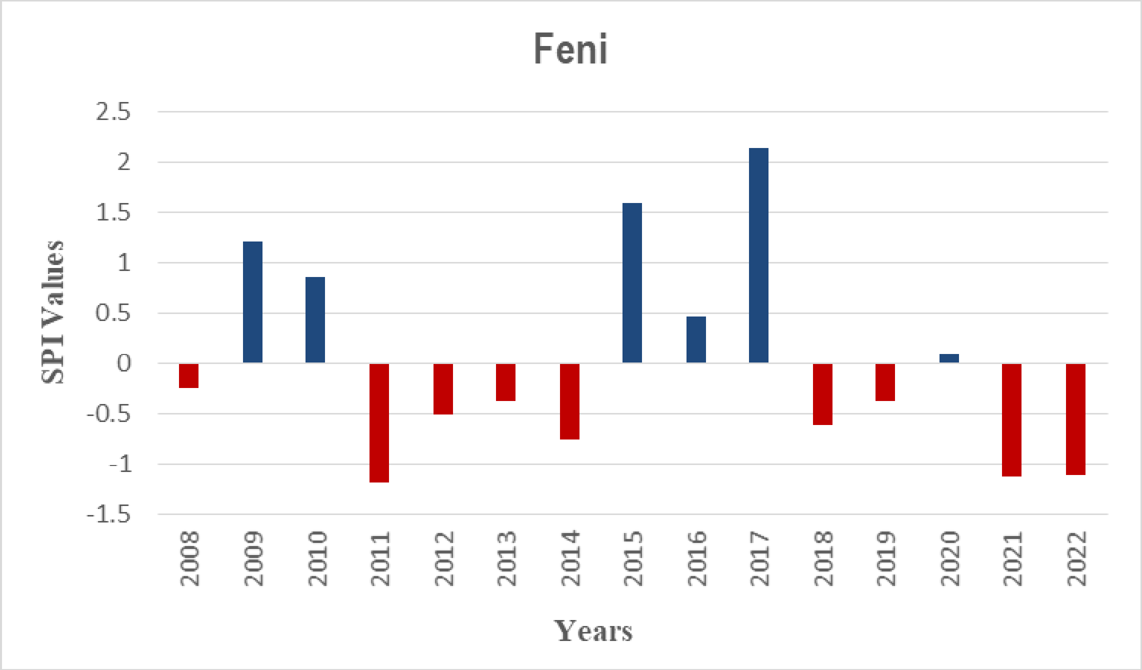


The SPI values identified 2010 and 2013 as **extreme** and **severe drought** periods in Chuadanga and Naogaon, respectively. Besieds that, 2012 and 2014 in Chuadanga was recognized as **moderate drought** periods.



According to SPI values, 2022 was period of **moderate dryness**, whereas the other negative values indicated **near-normal conditions**.



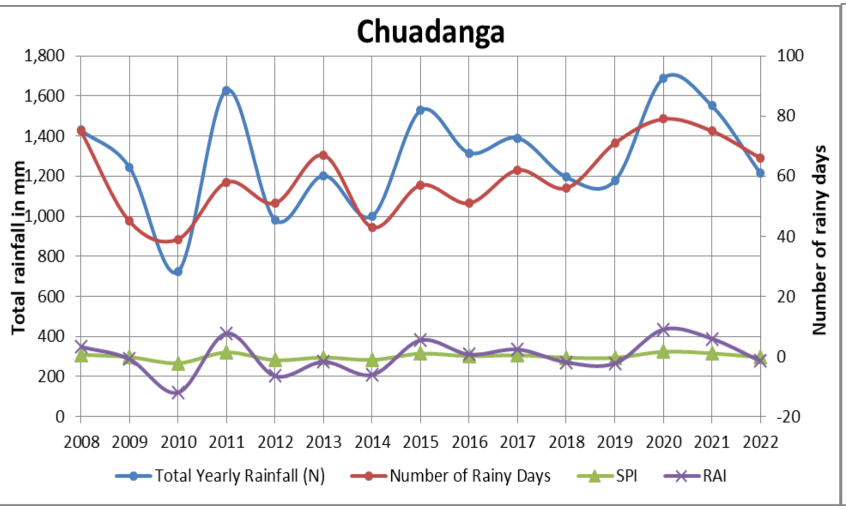


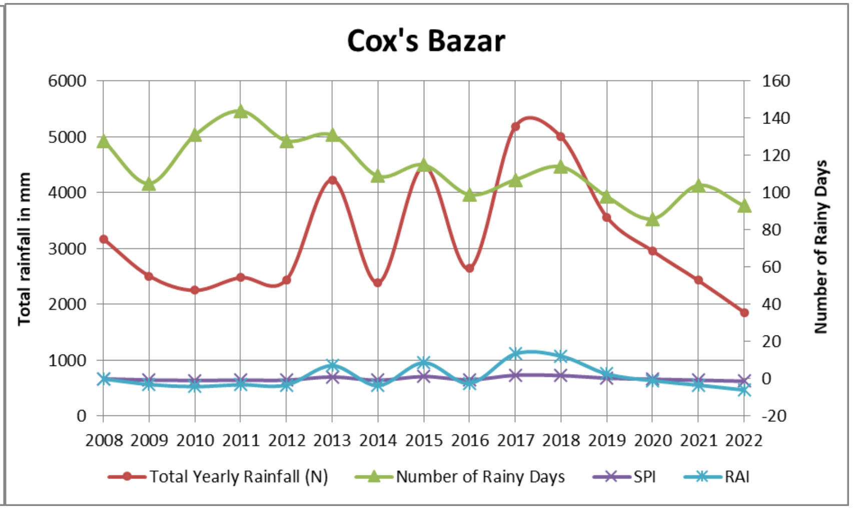
In Sylhet, the SPI values suggest that only 2011 was a period of **moderate dryness**.

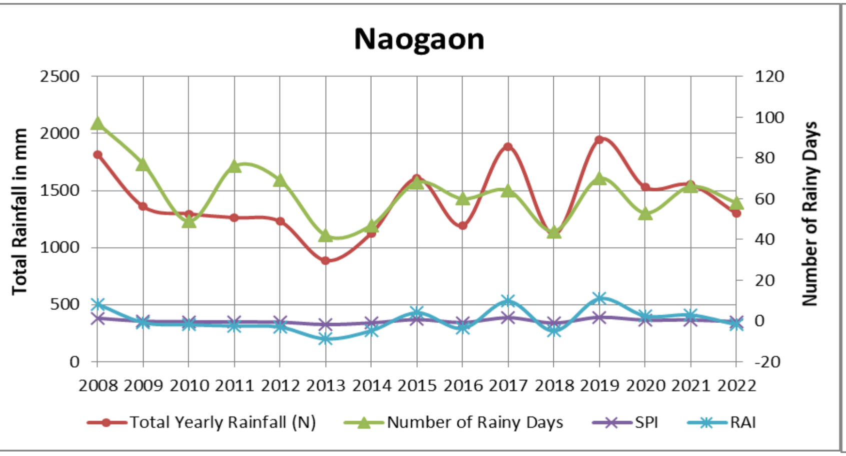
In Feni, the SPI values suggest that 2011, 2021, and 2022 were **moderately dry**.

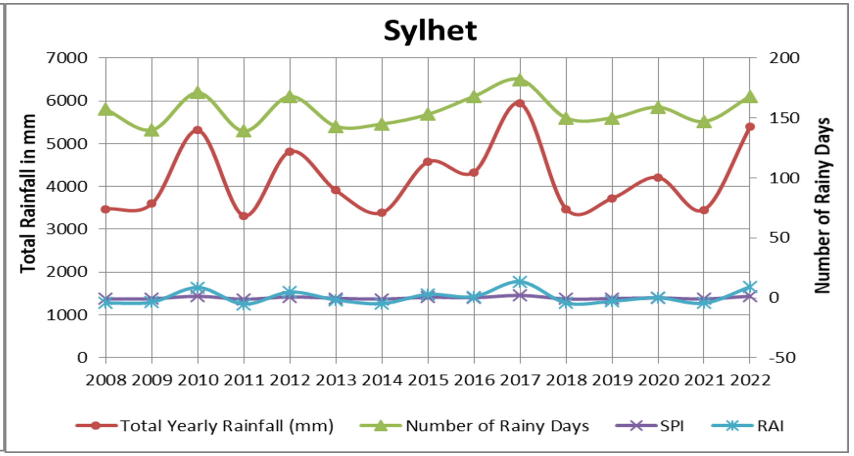
09

CORRELATION OF NRD AND TYR WITH SPI AND RAI









The relationship between NRD and total yearly rainfall (TYR) is **mixed**, with variations observed in different years and locations.

There is a **clear correlation** between NRD and both the Standardized Precipitation Index (SPI) and Rainfall Anomaly Index (RAI)

Higher NRD corresponds to **wetter conditions** (positive SPI and RAI), and **vice versa**, with this pattern consistent across various locations.

However, the intensity of events as indicated by the TYR, **is exaggerated in case of RAI values.**

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DISCUSSIONS

01

Spatial heterogeneity in Bangladesh is **very large** with amount of rainfall ranging between **700-3000 mm** throughout the country.

02

Wide temporal variations are observed.

03

Sylhet, Sunamganj, Cox’s Bazar, Lakshmipur, and Rajbari are regions with **highest average rainfall**.

04

Nawabganj, Narail, Magura, Rajshahi, and Faridpur are regions with **lowest average rainfall**.

05

Five anomalous zones, namely Chuadanga, Cox’s Bazar, Feni, Naogaon, and Sylhet have been considered for drought assessment.

06

SPI performs better than RAI in case of **short-term data**.

07

The findings are aligned with historical drought events where previous investigations found the Bangladesh experienced drought events in **2004, 2006, 2010** (Rahman and Lateh, 2016) and also in **2009 and 2011** (Mondol et al., 2009).

RECOMMENDATION

To evaluate the whether RAI is effective in case of Bangladesh, **longer-term data is required**.

Both the Standardized Precipitation Index (SPI) and Rainfall Anomaly Index should be analyzed using longer periods of data to select the **optimum method for drought detection** in Bangladesh.

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ANY

QUESTION?