Climate Change Impact on Food Security

Using NASA POWER Climate Data

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Abstract

Climate change poses a significant threat to food security through altered rainfall patterns and increasing temperature stress. This project uses NASA POWER climate data to quantify climate risk and construct a Food Security Risk Score for selected Indian cities using rainfall variability and temperature normalization techniques.

1 Introduction

Food security is highly sensitive to climatic factors such as rainfall variability and rising temperatures. Changes in precipitation patterns and heat stress directly affect crop productivity, water availability, and agricultural stability. This study aims to analyze climate data and assess food security risk using a composite index.

2 Data Source

The data used in this study is obtained from the **NASA POWER (Prediction Of Worldwide Energy Resources)** database.

- Format: CSV
- Temporal Resolution: Yearly
- Parameters: Rainfall and Temperature
- Units:
  - Rainfall: millimeters (mm)
  - Temperature: degree Celsius (°C)

3 Study Area and Metadata

Each dataset contains the following geographical identifiers:

- City
- State
- Climate Type (e.g., Indo-Gangetic Plain, Coastal, Arid)

These parameters were assigned based on geographic and climatic classification.

4 Parameters Used and Derivation

4.1 Annual Rainfall (Rainfall_mm)

Annual rainfall was directly obtained from the `ANN` column of the dataset.

$$\text{Rainfall\_mm} = \sum_{i=1}^{12} P_i$$

4.2 Rainfall Normalization (Rainfall_Norm)

Rainfall values were normalized using Min-Max scaling:

$$\text{Rainfall\_Norm} = \frac{X - X_{\text{min}}}{X_{\text{max}} - X_{\text{min}}}$$

4.3 Climate Risk Score

Climate risk was calculated as the deviation of normalized rainfall from its long-term mean:

$$\text{Climate Risk Score} = \left|\text{Rainfall\_Norm} - \overline{\text{Rainfall\_Norm}}\right|$$

4.4 Average Temperature (Avg_Temperature_C)

Average annual temperature was derived from NASA POWER temperature parameters.

4.5 Temperature Normalization (Temp_Norm)

Temperature normalization was performed using Min-Max scaling:

$$\text{Temp\_Norm} = \frac{T - T_{\text{min}}}{T_{\text{max}} - T_{\text{min}}}$$

4.6 Low Rainfall Penalty

$$\text{Low Rainfall Penalty} = 1 - \text{Rainfall\_Norm}$$

5 Food Security Risk Score

A composite Food Security Risk Score was computed using weighted parameters:

$$\text{Food Security Risk Score} = 0.5 \times \text{Climate Risk Score} + 0.3 \times \text{Temp\_Norm} + 0.2 \times (1 - \text{Rainfall\_Norm})$$

5.1 Weight Justification

- Rainfall variability (0.5): Primary driver of agricultural risk
- Temperature stress (0.3): Affects crop yield
- Low rainfall penalty (0.2): Represents drought impact

6 Food Security Classification

$$\text{Food Security Status} = \begin{cases} \text{Severe Insecurity} & \text{if Score} \geq 0.66 \\ \text{Moderate Insecurity} & \text{if } 0.33 \leq \text{Score} < 0.66 \\ \text{Relatively Secure} & \text{if Score} < 0.33 \end{cases}$$

7 Visualization Techniques

The following visualizations were used:

- Heatmaps for parameter correlation
- Line graphs for rainfall and temperature trends
- Bar charts for city-wise comparison

8 Conclusion

This study provides a data-driven approach to assess food security risk under changing climatic conditions. The Food Security Risk Score effectively highlights climate-vulnerable regions and can support policy planning and adaptation strategies.

9 References

- NASA POWER Data Portal
- Pandas Documentation
- Scikit-learn MinMaxScaler