Chapter 15: Rainfall Data in India

Introduction

Rainfall is the primary source of water for most hydrological systems, particularly in a country like India where agriculture, drinking water supply, and hydroelectric power generation largely depend on the monsoonal rainfall. Understanding rainfall data is essential for planning, designing, and managing water resource projects. This chapter provides an in-depth discussion on the collection, processing, classification, and analysis of rainfall data in India.

15.1 Rainfall and Its Importance in India

India receives the bulk of its annual precipitation during the southwest monsoon (June to September), contributing nearly 75%–80% of the annual rainfall. This spatially and temporally uneven distribution creates challenges for water resource engineers.

- **Monsoon Systems:**
  - Southwest Monsoon (June–September)
  - Northeast Monsoon (October–December)
- **Climatic Zones and Rainfall:**
  - Heavy rainfall in the Western Ghats and Northeast India
  - Low rainfall in Rajasthan and the rain-shadow regions

15.2 Types of Rainfall in India

- **Convectional Rainfall:** Localized rain due to heating, mostly during summer.
- **Orographic Rainfall:** Caused by the lifting of air over the Western Ghats and Himalayan slopes.
- **Cyclonic Rainfall:** Associated with depressions and cyclonic storms, especially in coastal regions.

15.3 Rainfall Data Collection Agencies

Rainfall data in India is collected and maintained by several agencies:

- **India Meteorological Department (IMD)** – primary agency.

- **Central Water Commission (CWC)**
- **State Meteorological and Irrigation Departments**
- **Central Ground Water Board (CGWB)**
- **Agricultural Universities and Research Institutes**

Instruments Used:

- **Non-recording Rain Gauges**
  - Symons Rain Gauge (widely used by IMD)
- **Recording Rain Gauges**
  - Tipping bucket gauge
  - Weighing bucket gauge
  - Float-type gauge

15.4 Rain Gauge Network in India

The density of rain gauge stations depends on terrain and importance:

- **IMD Norms:**
  - **Plain areas:** 1 station per 520 km^2
  - **Hilly areas:** 1 station per 190 km^2
  - **Heavy rainfall areas:** Higher density required

Network Planning:

- Based on hydrological homogeneity
- Need for balanced spatial distribution
- Coverage across river basins and catchments

15.5 Classification of Rainfall Data

Rainfall data can be classified based on:

- **Time Scale:**
  - Hourly, daily, monthly, annual
- **Spatial Scale:**
  - Point rainfall vs areal rainfall
- **Format:**
  - Raw data (from rain gauges)
  - Processed data (statistical summaries, trends)

15.6 Data Quality, Checking and Corrections

Rainfall data must be carefully checked for errors:

- **Common Errors:**
  - Instrumental (leakage, blockage, overflow)
  - Observer mistakes
  - Missing or doubtful entries
- **Corrections:**
  - **Double Mass Curve Analysis**
  - **Interpolation methods** for missing data
  - **Consistency checks** using neighboring stations

15.7 Rainfall Data Processing and Analysis

Data Processing:

- Compilation of daily/monthly/annual series
- Conversion of point rainfall to areal rainfall using:
  - **Arithmetic Mean Method**
  - **Thiessen Polygon Method**
  - **Isohyetal Method**

Statistical Analysis:

- Computation of Mean, Median, Mode
- Standard Deviation and Coefficient of Variation
- Skewness and Kurtosis

15.8 Rainfall Frequency Analysis

Used for hydrologic design like flood estimation and dam spillways.

- **Return Period (T):** $T = \frac{n+1}{m}$, where n is the number of years, m is the rank
- **Probability Distributions Used:**
  - Gumbel Distribution
  - Log Pearson Type III
  - Normal and Log-Normal Distributions

15.9 Annual and Seasonal Rainfall Patterns in India

- **Annual Patterns:**
  - Varies from <100 mm (Rajasthan) to >11,000 mm (Mawsynram, Meghalaya)
- **Seasonal Variations:**
  - Summer pre-monsoon rains (March–May)
  - Southwest monsoon (major contributor)
  - Post-monsoon and winter rains (minor but crucial in South and North India)

15.10 Long-Term Rainfall Trends and Climate Variability

- **Trend Analysis:**
  - IMD and other agencies monitor decadal trends
  - Evidence of erratic rainfall and climate shifts
- **Climate Change Effects:**
  - Increased frequency of extreme rainfall events
  - Changing monsoon onset and withdrawal
  - Regional disparities in rainfall trends

15.11 Use of Remote Sensing and GIS in Rainfall Analysis

- Satellite rainfall estimates from:
  - INSAT, METEOSAT, TRMM, GPM
- Integration with GIS tools for:
  - Spatial mapping of rainfall
  - Catchment-wide planning
  - Flood and drought risk assessment

15.12 Applications of Rainfall Data in Civil Engineering

- Design of:
  - Storm water drains
  - Reservoirs and dams

  - Flood control systems
  - Irrigation planning
- Drought and flood forecasting
- Urban water supply schemes

15.13 Limitations and Challenges

- Sparse data in remote/hilly regions
- Inconsistent historical records
- Instrumental limitations and maintenance issues
- Lack of real-time data integration in many regions
