Module 2: Precipitation

1. Forms of Precipitation

Precipitation is water released from clouds in the form of rain, snow, sleet, hail, or drizzle. The main forms include:

- **Rainfall:** Drops larger than 0.5mm in diameter; principal form in India.
- **Drizzle:** Fine droplets <0.5mm; intensity usually <1mm/hour.
- **Snow:** Ice crystal aggregates forming flakes.
- **Sleet:** Frozen raindrops or ice pellets formed as rain falls through a freezing layer.
- **Hail:** Irregular balls or lumps of ice >5mm, formed in intense convective storms.
- **Glaze/Freezing Rain:** Rain freezes upon contact with a cold surface, forming a coating of ice[1] [2] [3].

2. Characteristics of Precipitation in India

- **Annual Average:** India receives an average annual rainfall of about 1,170mm, with large regional variations.
- **Seasonal Pattern:** Nearly 70% of annual rainfall occurs during the Southwest Monsoon (June–September). The remaining occurs during the post-monsoon, winter (western disturbances), and pre-monsoon (convective thunderstorms) seasons.
- **Monsoon Dynamics:** The southwest monsoon enters Kerala in early June and sweeps across India by July. Withdrawal starts in September.
- **Spatial Variation:** The west coast (Western Ghats), northeast (Assam, Meghalaya), and Himalayan foothills receive the highest rainfall, sometimes exceeding 10,000mm in spots like Cherrapunji. Northwestern and interior peninsular regions receive much less, sometimes <500mm annually[4].

3. Measurement of Precipitation

- **Rain Gauge:** The standard instrument for measuring rainfall. Types include:
  - *Non-recording (Symons, standard gauges)*—collects total amount over a period.
  - *Recording (tipping bucket, weighing, float)*—provides a continuous record, helps study intensity and duration.
- **Placement:** Gauges are ideally placed in open areas, above ground, away from obstructions.
- **Manual and Automatic Networks:** The India Meteorological Department (IMD) operates both manual and automatic rain gauge networks for national coverage[5] [6] [7].

4. Rain Gauge Network in India

- **Density Recommendations:**
  - 1 rain gauge/500km² in non-orographic regions.
  - 1/260–390km² in moderately elevated regions.
  - 1/130km² in hilly/heavy rainfall areas[8].
- **Coverage:** India has thousands of rain gauges managed primarily by IMD, with a well-developed real-time and historical rainfall data infrastructure[7] [9] [10].

5. Mean Precipitation Over an Area

Mean rainfall is determined by integrating gauge measurements across a basin:

- **Arithmetic Mean:** Simple average for evenly spread gauges and uniform rainfall[11] [12].
- **Thiessen Polygon Method:** Assigns weights based on areal influence of each gauge for non-uniform networks[13] [12].
- **Isohyetal Method:** Involves drawing contours of equal rainfall on a map, calculating area between them, and weighting accordingly[14] [12].

Method	Suitability
Arithmetic Mean	Uniform gauge density and rainfall
Thiessen Polygon	Irregular distribution, moderate accuracy
Isohyetal	Most accurate, for variable rain regions

6. Depth-Area-Duration (DAD) Relationships

- DAD curves describe how the average precipitation depth decreases as the area considered increases for a given storm duration.
- Used for catchment and basin design; larger areas rarely experience the highest local rainfall everywhere at once.
- Relationships are typically determined using envelope curves from data of past extreme storms[15] [16].

7. Maximum Intensity/Depth-Duration-Frequency (IDF/DDF) Relationship

- **IDF Curves:** Show the relationship between rainfall intensity, duration, and frequency (return period). Critical for hydraulic structure and urban drainage design.
- Procedure: Analyze historical rainfall at various durations, apply statistical distributions (e.g., Gumbel), plot intensity vs. duration for different return periods (e.g., 2, 5, 10, 50, 100 years) [17] [18] [19] [20] [21].
- **Use:** Determine design storms (e.g., 10-year, 1-hour rainfall) for engineering applications.

8. Probable Maximum Precipitation (PMP)

- Theoretical upper limit for precipitation in a given place and period, based on meteorological analysis.
- Used for designing critical infrastructure such as dams and nuclear plants where extreme safety is a priority.
- Estimated using statistical analysis and comparison with the highest recorded events in similar climates[22] [23].

9. Rainfall Data in India

- **IMD Rainfall Records:** IMD provides real-time and historical rainfall data, maps, and time series for all 36 meteorological subdivisions, states, river basins, and stations[24] [25] [26] [10].
- **Recent Trends:** May 2025 was the wettest since records began in 1901, with pan-India rainfall 106% above its long period average[27] [28].
- **Districtwise, statewise, and sub-divisional summaries** are provided for operational and research purposes via IMD's official platforms.

Region/Month	May 2025 Rainfall (mm)	Record Status
All-India	126.7	Highest since 1901
Central India	100.9	Highest since 1901
South Peninsular	199.7	2nd highest since 1901[27] [28]

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1. https://byjus.com/chemistry/precipitation/
2. https://www.slideshare.net/slideshow/froms-types-of-precipitation/249822900
3. https://davuniversity.org/images/files/study-material/Precipitation.pdf
4. http://elearn.psgcas.ac.in/nptel/courses/video/105105214/lec6.pdf
5. https://en.wikipedia.org/wiki/Rain_gauge
6. http://www.bom.gov.au/climate/cdo/about/rain-measure.shtml
7. https://mausam.imd.gov.in/imd_latest/contents/hydrological-services.php
8. https://nhp.mowr.gov.in/HIS/IS_guidelines.aspx
9. https://www.tropmet.res.in/awnew/aw-45.pdf
10. https://mospi.gov.in/sites/default/files/Statistical_year_book_india_chapters/Ch_34_SYB2017.pdf
11. https://www.yourarticlelibrary.com/water/precipitation/calculating-average-depth-of-precipitation-3-methods/60452
12. https://seismicconsolidation.com/wp-content/uploads/2020/03/Computation-of-Average-Rainfall-over-a-Basin.pdf
13. https://www.caee.utexas.edu/prof/maidment/ce394k/rainfall/rainfall.htm
14. https://www.scribd.com/presentation/521273058/Mean-Precipitation
15. https://testbook.com/question-answer/depth-area-duration-curves-of-prec--585cd4920328212b78003696

16. https://zonetech.in/question-answer/the-dad-depth-area-duration-analysis-for-a-catchement-would-indicate-t-94095e3de9bd
17. http://elearn.psgcas.ac.in/nptel/courses/video/105105214/lec10.pdf
18. https://en.wikipedia.org/wiki/Intensity-duration-frequency_curve
19. https://metnet.imd.gov.in/docs/mausamdocs/173412_F.pdf
20. https://www.mhwm.pl/pdf-79175-15962?filename=15962.pdf
21. https://mausamjournal.imd.gov.in/index.php/MAUSAM/article/view/3530
22. https://study.madeeasy.in/ce/engineering-hydrology/what-is-probable-maximum-precipitation-pmp/
23. https://mde.maryland.gov/programs/water/DamSafety/Pages/Probable_Maximum_Precipitation_Study.aspx
24. https://mausam.imd.gov.in/responsive/rainfall_page_station_rainfall.php
25. https://mausam.imd.gov.in/responsive/rainfallinformation_swd.php
26. https://www.data.gov.in/catalog/rainfall-india
27. https://www.hindustantimes.com/india-news/imd-says-may-2025-breaks-124-year-record-as-wettest-month-in-india-since-1901-101749382580452.html
28. https://economictimes.com/news/new-updates/india-sees-heaviest-may-rainfall-since-1901-imd-details-how-much-every-state-received/articleshow/121705857.cms