LECTURE-3

PROCESSING AND ANALYSIS OF PRECIPITATION DATA

OBJECTIVE

This lecture describes the processing of precipitation data and explains the use of some computer programmes for the purpose. Also, the distribution of daily precipitation data into shorter duration which is part of processing is explained. Methods of mean areal precipitation estimation in plain and mountainous areas are explained with illustrative example to enable participants to achieve the capability of carrying out the analysis themselves.

3.1 INTRODUCTION

It is common experience that the precipitation data in its raw form would contain many gaps and inconsistent values. As such preliminary processing of precipitation data is essential before it is put to further use in analysis. Processing of the data has two major objectives. One is to evaluate the data for its accuracy and the other is to prepare the data in a form appropriate for subsequent analysis.

Manual scrutiny for carrying out processing has obvious limitations. Computerised processing and analysis has several advantages over the manual scrutiny and analysis (Ramasastri et. al. 1985).

3.2 PROCESSING SYSTEM

The processing system consists of a series of steps and procedures. The efficiency, economy and speed of the system would depend upon the type of storage devices, the quality of machines and software (computer programmes). The methodology for executing the various steps involved in the processing system are briefly described.

3.9.1 Preliminary Scrutiny

Before the precipitation data is stored on computer compatible devices for computer processing, it becomes necessary to carry out preliminary checks, manual scrutiny etc. The reports received from manually observed stations by telephone or other communication channels are checked by a repeat back system.

Improper registering of data includes entering data against wrong time and date, alteration of figures etc. The official at receiving station could check the reasonableness of report by judging the report based on past experience and statistics of the station and region to which the station belongs.

Some of the climatological parameters used for checking the values of normal rainfall, highest observad rainfall or value of rainfall, corresponding to 25, 50 or 100 yr. return period.

3.2.2 Checking reasonableness of a daily reported precipitation

For example, daily precipitation reported from a station is 360.6 mm and the precipitation statistics of the reporting station are :

(i)	Normal monthly rainfall of the corresponding month	:	350.0 mm
(ii)	Mean ($\bar{x}$) maximum 1 day rainfall	:	210.6 mm
(iii)	Standard deviation (σ) of maximum 1 day rainfall	:	50.0 mm
(iv)	Highest observed 1 day rainfall	:	285.3 mm
(v)	100-year return period value of 1 day maximum rainfall	:	300.0 mm
(vi)	Probable maximum precipitation value of 1 day rainfall	;	370.8 mm

Tha reported daily rainfall value of 360.5 mm is more than the normal monthly rainfall of the corresponding month and is, therefore, doubtful but not unreasonable. The reasonableness is checked with other statistics. The value is compared with the mean 1 day maximum rainfall and the highest observed value. The reported value is more than the mean 1 day maximum and the highest ever observed value. It is also more than the 100 year return period value. The values corresponding to ($\bar{x}+\sigma$) and ($\bar{x}+2\sigma$) are computed. They are 261.1 mm and 311.5 mm respectively, The reported value is higher than both the values.

The reported daily value is compared with the 1 day PMP value which is 370.8mm. The value is less than the PMP and is, therefore, feasonable and is further checked by spatial consistency.

3.2.3 Storage of precipitation data

In India, precipitation data collected by state organisations is generally stored only in the form of printed record. The data are, however, transferred on to magnetic tapes by the office of Additional Director General of Meteorology (Research), India Meteorological Department, Poona.

3.2 3.1 Format of daily precipitation data

The daily rainfall data were punched in 31 card format as shown in Fig. 3.1 (a) Until 1970 and was switched over to 24 card format as shown in Fig. 3.1 (b) since 1971.

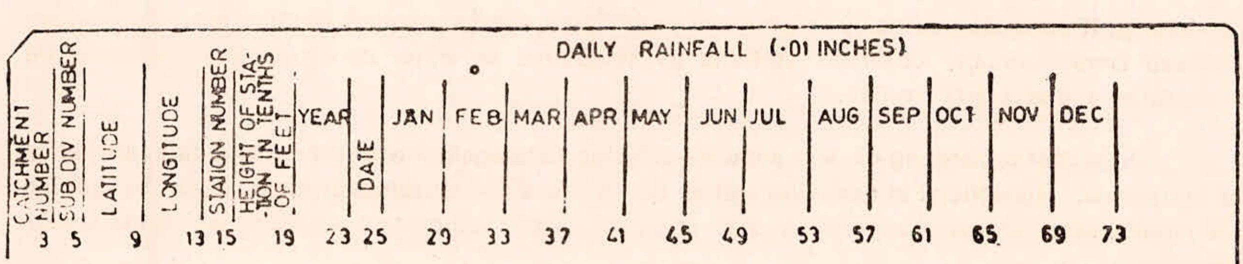


Fig. 3.1 (a) : 31 Card Daily Rainfall data Format

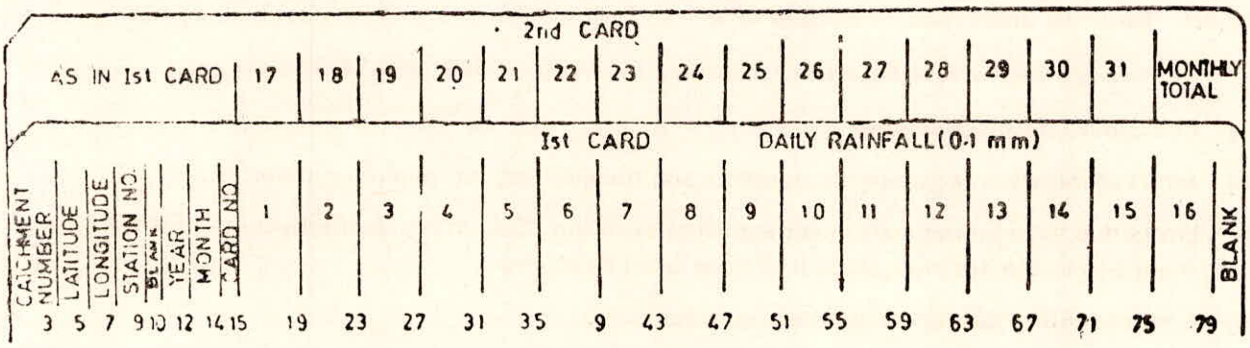


Fig. 3.1 (b) : 24 Card Daily Rainfall data Format

In the 31 card format, the data of 12 months for each day are punched on each card together with station related information, year and date. In the 24 card format, each month's rainfall data are punched on 2 cards, 16 days data on the first card, 15 days data and monthly total on the second card.

3.2.3.2 Format of hourly rainfall data

Data of hourly rainfall recorded at the self recording raingauges maintained by either India Meteorological Department or other organisations were not published in printed form. India Meteorological Department, however, punches the data of self recording raingauge on punched cards and magnetic tapes. The data format is shown in Fig. 3.2.

The first card contains besides station code, year, month, date and card number, data of hourly rainfall corresponding to 1st to 16th hour. The second card contains besides station code and other details, data of hourly rainfall, time of maximum rainfall occurrence and total rainy duration in the day given in hours and minutes.

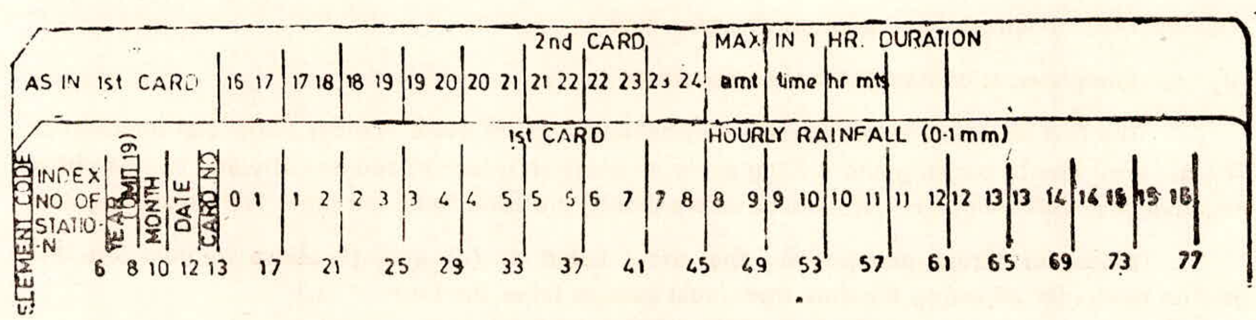


Fig. 3.2 : Hourly Rainfalf Data Format

3.2.4 Quality Control

Quality control is a pre requisite before the precipitation data are used either in an operational system for flood forecasting or archived for climatological purposes. The basic objective of the quaiity control procedure is to detect and if possible correct errors in observational data at the earliest stage possible in the flow of data from local data source to the centralised data base.

3.2,4.1 Sources and types of data errors

Measurement errors have been classified by WMO (1986) into various groups.

(a) Errors built into instruments

(b) Errors involved in regarding instruments and transmitting or recording data.

(c) Errors due to improper instrument exposure or to the lack of representativeness of the instrument site to the area for which it is to be used as an index,

(d) Errora occuring during the processing of the data.

Most of the errors described above could be further sub classified as

(i) Systematic errors and

(ii) Random errors.

(I) Systematic errors

Systematic errors are essentially due to malfunctioning of instrument, wrong exposure condi ions and/or lack of knowledge of observer. WMO (1983) listed the following errors for which adjustment needs to be made to get a near accurate estimate of precipitation from a measured precipitation report.

(a) error due to the systematic wind field deformation above the gauge orifice.

(b) error due to the wetting loss on the internal walls of the collector,

(c) error due to evaporation from the container (generally in hot climates),

(d) error due to the wetting loss in the container when it is emptied.

(e) error due to blowing and drifting snow,

(f) error due to splashing in and out of water, and

(g) random observational and instrumental errors.

The first six errors listed above are systematic and are listed in order of general importance The net error due to blowing and drilling snow and due to splash in and out of water can be either negative or positive while net systematic errors due to the wind field and other factors are negative

Since for liquid precipitation the errors listed at (e) and (f) above are near zero, the general model for adjusting the data from most gauges takes the form

$$P_K = XP_C = K\,(P_g + \triangle P_1 + \triangle P_2 + \triangle P_3)$$

where P_K = adjusted precipitation amount

K = adjustment factor for the effects of wind field deformation

P_C = the amount of precipitation caught by the gauge collector

P_g = the measured amount of precipitation in the gauge

$\triangle P_1$ = adjustment for the wetting loss in the internal wells of the collector

$\triangle P_2$ = adjustment for wetting loss in the container after emptying

$\triangle P_3$ = adjustment for evaporation from the container

For further details of adjustment WMO (1982) may be referred to

The data needed to make the adjustments include wind speed, drop size, precipitation intensity, air temperature, humidity and other characteristic of the gauge site.

(II) Random errors

Some of the random errors could arise due to spilling of the water when transferring it to the measuring jar, leakage into or out of the receiver, observational error etc. The others which could be due to observer are

(i) misreading and transposing digits,

(ii) misrecording because of faulty memory,

(iii) recording the data at a wrong place on the recording sheet,

(iv) misplacing the decimal point,

(v) making readings at improper interval,

(vi) incorrect dating of the report,

(vii) making an estimate of the precipitation in some case because of non-availability or other problems with the gauge,

(viii) incorrectly reading or communicating the data to a reporting centre etc.

It may, therefore, appear that automation may be solution to reduce the error, However even without human intervention chances of erroneous reading may be possible because of

(a) evaporation from gauge

(b) overflowing gauge

(c) mechanical or electrical mal-functions.

3.2.5 Estimation of missing data

While retrieving data for climatological purpose or inputing data in real time, one often comes across missing data situations. Since blank in a data set is read as zero by computer, necessary software for identifying the blanks and marking them appropriately need to be developed.

Data for the period of missing rainfall data could be filled using estimation technique. The length of period upto which the data could be filled is independent on individual judgement. Rainfall for the missing period is estimated either by using the normal ratio method or the distance power method.

3.2.5.1 Normal ratio Method

In the normal ratio method, the rainfail R_A at station A is estimated as a function of the normal monthly or annual rainfall of the station under question and those of the neighbouring stations for the period of missing data at the station under question.

$$R_A = \frac{\sum_{i=1}^{n} \frac{NR_A}{NR_i} \times R_i}{n} \qquad (3.2)$$

where R_A is the estimated rainfall at station A

R_i is the rainfall at surrounding stations

NR_A is the normal monthly or seasonal rainfall at station A

NR_i is the normal monthly or seasonal rainfall at station i

n is the number of surrounding stations whose data are used for estimation

The observed rainfall at the estimator stations B, C and D are :

Station	B	C	D
Rainfall (mm)	98 9	120.5	110.0

The normal monthly, seasonal or annual rainfall at the estimated stations :

Station	A	B	C	D
Monthly rainfall (mm)	331.3	290.8	325.9	360.5

The rainfall at station A is :

$$P_A = \frac{\frac{331.3 \times 98.9}{290.8} + \frac{331.3 + 120.5}{325.9} + \frac{331.3 \times 110.0}{360.5}}{3}$$

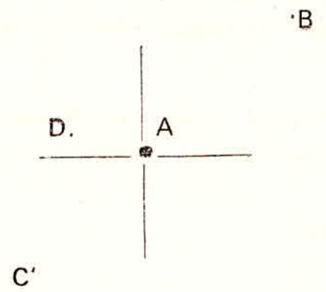
$$= \frac{1.14 \times 98.0 + 1.02 \times 120.5 + 0.92 \times 110\,0}{3} = 112.3 \text{ mm}$$

3,2.5.2 Distance Power method

In this method, the rainfall at a station is estimated as a weighted average of observed rainfall at the neighbouring stations. The weights are taken as equal to the reciprocal of the distance or some power of distance of the estimator sta tions.

$$R_A = \frac{\sum_{i=1}^{n} \frac{R_i}{D_i^2}}{\sum_{i=1}^{n} \frac{1}{D_i^3}} \qquad (3.3)$$

Where R_A and R_i has the same notation as in Eq. 3.2. and D_i is the distance of estimator station from the estimated station. The precedure for estimating rainfall data by this technique is indicated through an example.



If A, B, C, D are the location of stations discussed in the example of normal ratio method, the distance of each eatimator station (B, C and D) from the station (A) whose data is to be estimated is computed with the help of the coordinates using the formula

$$D_i = [\ (x-x_i)^2 + (y-y_i)^2] \qquad (3.4)$$

Where x and y are the coordinates of the station whose data is estimated and x_i and y_i are the coordinates of stations whose data are used in estimation.

The weights $\frac{1}{D_i^2}$ are computed for each station and the rainfall at the station A is estimated as follows.

Station	Distance from Station A	$\frac{1}{D_i^2}$	Rainfall mm	Weighted Rainfall mm
B	28	1.27×10^{-3}	98.9	125.6×10^{-3}
C	17.7	3.19×10^{-3}	120.5	384.6×10^{-3}
D	42 5	0.65×10^{-3}	110.6	60.5×10^{-3}
	Total	5.01×10^{-3}		570.7×10^{-3}

$$\text{Rainfall at station A} = \frac{570.7 \times 10^{-3}}{5.01 \times 10^{-3}} = 113\,9 \text{ mm}$$

3.2.6 Internal Consistency Check

The internal consistency or self consistency checks are applied by using statistical information based on historical data of the station and current data in case of short duration rainfall. Example of checking the data by the internal consistency is given below :

Example : Hourly rainfall data reported at a station are as follows :

Hour	1	2	3	4	5	6
Rainfall	8.0	10.8	85.8	28.5	19.8	15.0

The hourly rainfall reported during 3rd hour is suspected though it could not be ruled out. When the 3 hourly total 1-3 hours is reported, the value in 3rd hour could be checked. If the 3 hourly total reported is 54.1 mm it could be seen that the value is 50.5 mm less than the three hourly total computed from the reported hourly data which is 104.6. Thus the value in the 3rd hour is 35.3 mm and not 85.8 mm as reported in the first place.

When the 6 hour total 117.4 mm is reported, the value of 55 3 mm is confirmed for the 3rd hour. Further checking for erroneous value is carried out similarly.

3.2,7 Spatial consistency checks

Spatial consistency checks for precipitation data are carried out by relating the observations from surrounding stations for the same duration with the rainfall observed at the station. This is achieved by interpolating the rainfall at the station under question with rainfall data of neighbouring stations. An example of spatical consistency check is given below.

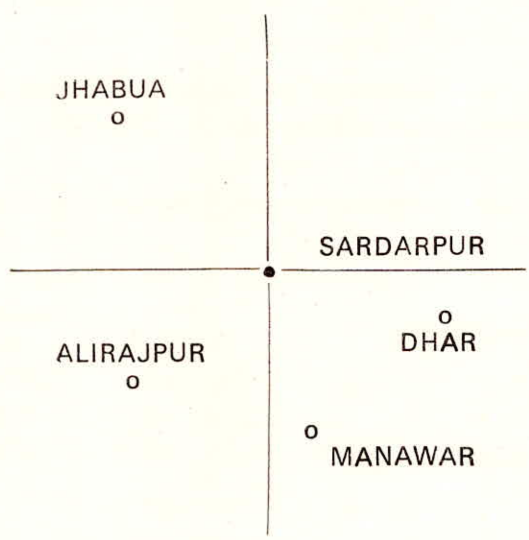


Fig. 3.3

Data reported at a group of five stations is as follows

Station	Jhabua	Sardarpur	Dhar	Manawar	Alirajpur
Rainfall [mm)	132.1	10.3	103 3	125.7	149.8

During the quality control process, the data at Sardarpur is identified as doubtful. The data at Sardarpur is checked by spatial consistency check. The rainfall data at Sardarpur is estimated using the distance power method and compared with the observed value. From the four quadrants around Sardarpur (Fig. 3.3) on nearest from each quadrant is selected for the estimation of rainfall at Sardarpur.

Using the reference coordinate system, the distance of each of the estimator stations from Sardarpur is determined and the rainfall at Sardarpur is estimated using the Eq. (3.3).

S. No.	Station	Distance from Sardarpur (Km)	$\frac{4}{D^2_i}$	$\frac{R}{D^2_i}$
1	Jhabua	42	5.67×10^{-4}	.075
2	Dhar	39	6.57×10^{-4}	.068
3	Alirajpur	75	1.78×10^{-4}	.027
			14.02×10^{-4}	.170

The estimated rainfall in Sardarpur in 121.3 mm and is very much different from the observed value and is rejected and replaced by estimated value.

3.2.8 Adjustment of data

To obtain homogenity among and within measurements of precipitation, adjustment of data becomes necessary. Adjustment on data has two principal objectives. First is to make the record homogeneous with a given environment and the second is to eliminate or reduce extraneous influences by correcting for change in gauge location or exposure. Adjustments for these errors is made by 'Double Mass Analysis'.

Double mass analysis is a graphical method for identifying and adjusting inconsistencies in a station's data by comparing with the trend of reference stations' data. As the name itself implies, a double mass curves both axis are accumulated precipitation values. Usually, the accumulated seasonal or annual precipitation values of reference station or stations is taken as abscissa and those of the station under test as ordinate (Fig. 3.4).

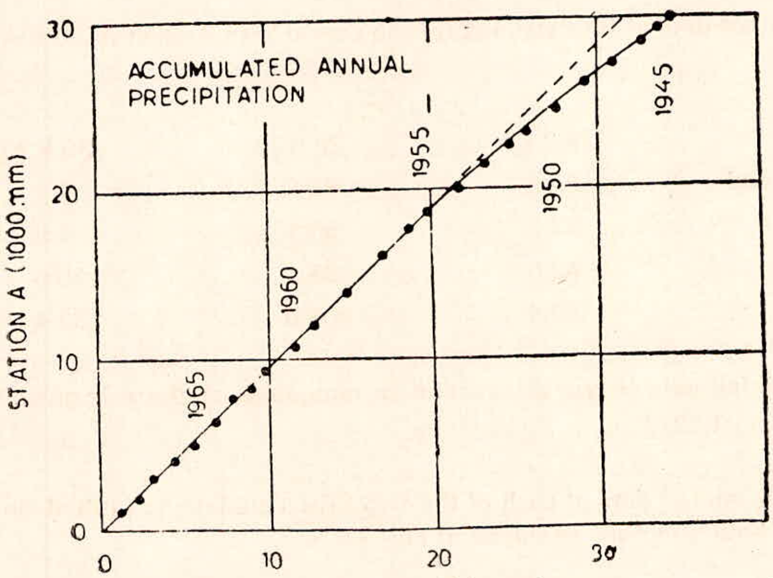


Fig 3.4 : Double Mass Analysis

A change in the regime of the raingauge such as change in exposure, change in location is revealed by a change in the slope of the straight line fit as shown in Fig. 3.4. The other records are adjusted by multiplying the precipitation values by the ratio of the slope of the later period to the slope of the earlier period.

3.2.9 Data Conversion

For hydrological analysis, rainfall data of shorter duration is required. The net work of recording raingauges in India being small in comparison to that of daily (non-recording) raingauge, it becomes necessary to convert the daily rainfall into shorter period intervals either manually or by using appropriate computer routines. The information of short interval rainfall is used together with information of daily rainfall from nearby non-recording (daily) gauges.

3.2.9.1 Mass curve

Mass curve is a graphical display of accumulated rainfall Vs time. Mass curve of accumulated rainfall at (non-recording) daily stations and recording station are prepared by plotting the accumulated rainfall values against time for the storm duration under analysis.

A comparison of the mass curves of the recording raingauge stations with those of the non-recording stations would help in deciding which recording raingauges or group of gauges could be considered as representative of which of the non-recording raingauge for the purpose of distributing daily rainfall into hourly rainfall.

The procedure for distribution of daily rainfall at non-recording raingauge stations into hourly rainfall is explained with the help of an example.

Daily rainfall data of four stations for the period 28th August to 30th August 1973 is given below :

	28 8 73	29 8 73	30.8 73
Pendra Road	65.3	80 8	1.1
Dindori	23.2	58 4	1.0
Ghansore	42.0	98.0	20.6
Niwas	30 4	203 0	33.4

Hourly rainfall data of two self-recording raingauge stations is given in Table 3 1 for the period 27-29th August 1973.

The hourly rainfall data at each of the two SRRG stations is plotted on a graph to prepare the mass curve of hourly rainfall as shown in Fig. 3.5.

The daily rainfall data at each of the four stations is cumulated and plotted on a graph as shown in Fig. 3.6. The points are joined to form the mass curve of daily rainfall.

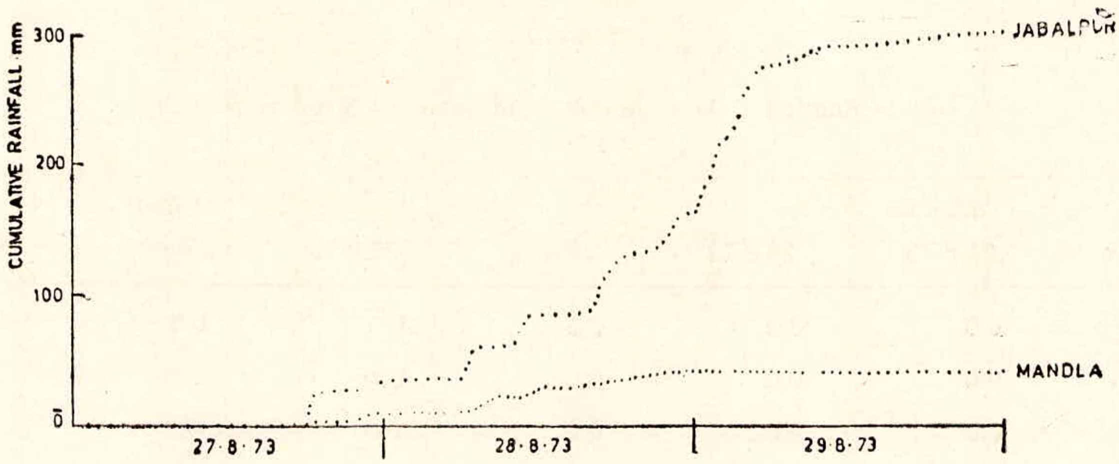


Fig. 3.5 : Hourly Rainfall Mass Curve

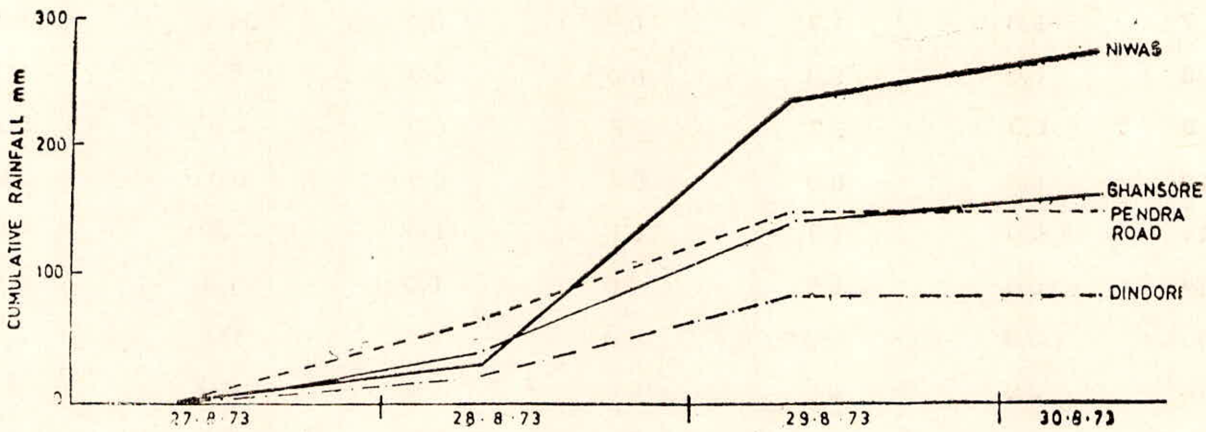


Fig. 3.6 : Daily Rainfall Mass Curve

The mass curves of daily rainfall are compared with those of hourly rainfall to determine which of the daily rain-gauge stations are represented by which of the SRRG stations. It may be seen that the daily rainfall stations at Pendra Road and Dindori are represented by Mandla while Jabalpur represents Niwas and Ghansore stations.

For converting the daily rainfall into hourly rainfall, the hourly rainfall from 0800 hr to 0800 hr for consecutive days is cumulated and the rainfall during hour is expressed as a ratio of the total rainfall during 24 hours (0800 to 0800). These ratios are used to distribute the daily rainfall for the corresponding duration at those raingauge stations which are represented by the SRRG. The daily rainfall distributed for 1 day, i.e. corresponding to 28-29 August 1973 is given in Table 3.2.

Table 3.1

Hourly Rainfall Data of Mandla and Jabalpur S R R G Stations

	Mandla			Jabalpur		
Hour	27.8.73	28.8.73	29.8.73	27.8.73	28.8.73	29.8.73
1	0.0	0.0	0.0	0.0	0.0	23.5
2	0.0	0.0	0.0	0.0	0.0	30.5
3	0.0	0.0	0.0	0.0	0 3	10.2
4	0.0	0.0	0.0	0.0	0.5	30.8
5	0.0	0.0	0.0	0.0	0.1	16.9
6	0.0	0.0	0.0	0.0	1.0	1.9
7	3.0	1.7	0.0	0.0	24.4	0.6
8	0.0	9.0	0.0	0.0	0.2	3.1
9	0.0	2.3	0.5	0.0	0.0	5.3
10	0.9	0.0	0.4	0.0	0.0	3.8
11	0.0	1.5	0.1	0.0	23.8	0.8
12	0.0	5.5	0.0	0.0	1.3	1.5
13	0.0	0.0	0 0	0.0	0.2	0.0
14	0.0	0.0	0.0	0.0	0.0	0.3
15	0.0	0.0	0.0	0.0	0.1	0 9
16	0.0	2.5	0.3	0.0	0.6	1.5
17	0.2	1.5	0.4	0.0	29.0	0.4
18	2.1	0.8	0.3	0.0	11.0	0.5
19	0.7	3.4	0.0	25.7	7.1	0.1
20	0.3	0.6	0.0	0.0	0.4	0.5
21	0.1	2.5	0.0	0.1	2.7	0.7
22	0.1	0 0	0.0	1.0	6.8	0.0
23	4.7	0.0	0.0	6.0	20.6	0.0
24	0.0	0.0	0.0	1.3	0.0	0.0

Table 3.2

Daily Rainfall Distributed into Hourly Rainfall (28-29 August 1982)

Hour	Distributed on the basis of Mandia				Distributed on the basis of Jabalpur			
	Pendra Road		Dindori		Niwas		Ghansore	
	28	29	28	29	28	29	28	29
1		0.0		0.0		21.5		10.5
2		0.0		0.0		28.0		13.7
3		0.0		0.0		9.3		4.5
4		0.0		0.0		28.2		13.7
5		0.0		0.0		13.4		7.5
6		0.0		0.0		1.7		0.8
7		0.0		0.0		0.5		0.2
8		0.0		0.0		2.8		1.3
9	8.9		6.4		0.0		0.0	
10	0.0		0.0		0.0		0.0	
11	5.6		4.1		21.9		10.7	
12	21.8		13 8		1.0		0.5	
13	0.0		0.0		0.2		0,1	
14	0.0		0.0		0.0		0.0	
15	0.0		0.0		0.1		0.0	
16	9.7		7 0		0.5		0.2	
17	6.5		4.7		26.6		13.3	
18	2.5		1.8		10.1		4.9	
19	13.7		9.9		6.5		3.1	
20	2.4		1 7		0.4		0.2	
21	9.7		7 0		2.4		1.1	
22	0.0		0.0		6.1		2.9	
23	0.0		0.0		18.9		9.1	
24	0.0		0.0		0.0		0.0	

9.3 ESTIMATION OF MEAN AREAL PRECIPITATION

Precipitation observations from gauges are point measurements and is characteristic of the precipitation process, exhibits appreciable spatial variation over relatively short distance. An accurate assessment of mean areal precipitation is a pre-requisite and basic input in the hydrological analysis.

Numerous methods of computing areal rainfall from point raingauge measurements have been proposed. Some of the well known methods are described in text books of Hydrology (Chow, 1964; Linsley et al. 1958). Manual of hydrometeorology (IMD, 1972) etc.

The most commonty used methods are

(a) arithmetic average,

(b) thiessen polygon method and

(c) isohyetal method

The choice of the method is dependent on

(i) quality and nature of data

(ii) importance of use and required precision

(iii) availability of time and

(iv) availability of computer,

Computerised procedures for estimation of mean areal precipitation have been described by US National Weather Service, Ramasastri et. al. (1985) etc. Some of the commonly used methods and other computerised methods are described below :

3 3.1 Arithmetic average

The simplest technique for computing the average precipitation depth over a catchment area is arithmetic average of the values at gauges within the area for the time period of concern. If the gauges are relatively uniformly distributed over the catchment and the values are not greatly different from the average value, this technique will yield reliable results.

3.3.2 Thiessen Polygon

The Thiessen Polygon method is used with non-uniform stations spacing and gives weights to stations precipitation data according to the area which is closer to that station than to any other station. This area is found by drawing the perpendicular bisector of the linee joining the nearby station so that the polygons are formed around stations. The polygons thus formed around each station are the boundaries of the effective area assumed to be controlled by station. The area governed by each station is planimetered and expressed as a percentage of total area. Weighted average precipitation for the basin is computed by multiplying each station precipitation amount by its assigned percentage of area and totaling.

The weighted average precipitation is given by

$$\overline{P} = \frac{\sum_{i=1}^{n} P_i W_i}{\sum_{i=1}^{n} W_i} \tag{3.5}$$

Where $\overline{P}$ is the average catchment precipitation, P_i is the precipitation at stations 1 to n, w_i the weights of respective station. An examples of Thiessen network and computation of mean areal precipitation estimating using Thiessen weights is given below :

30 Aug., 1982

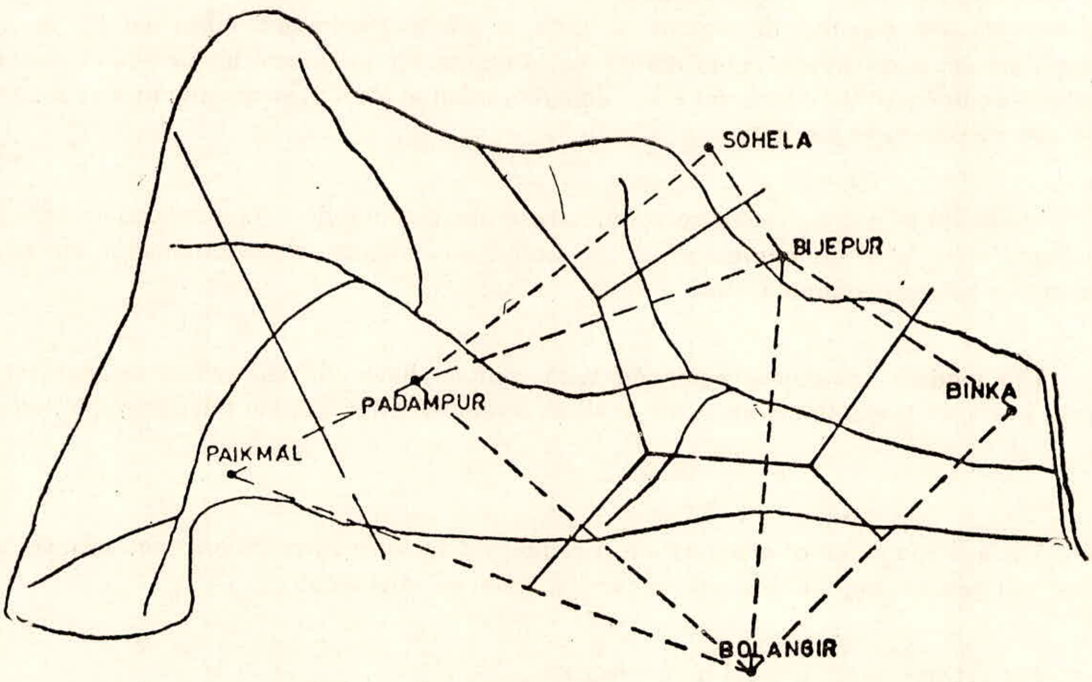


Fig. 3.7 Thiessen Polygon Method

Estimation of mean areal catchment rainfall by Thiessen Polygon Method

Sl. No.	Station	Station weight	Rainfall Value (mm)	Weighted rainfall (mm)
1.	Sohela	06	262.0	15.7
2.	Bijepur	.12	521.0	62.5
3.	Padampur	.42	177 0	74.3
4.	Paikmal	.28	338.0	94.6
5.	Binka	.04	158 0	16.1
6.	Bolangir	.08	401.6	12 6

Weighted catchment rainfall = 275.8

The advantage of this method is stations outside the catchment may also be used for assigning weights of marginal stations within the catchment. The disadvantage, however, is it assumes that precipitation between two stations varies linearly and does not make allowance for variation due to orography. Also, when ever a set of stations are added to or removed from the network, new set of polygons have to be drawn. If a few observations are missing it would be convenient to estimate the missing data than to construct new set of polygons.

3.3.3 Isohyetal Methed

The isohyetal method employs the area encompassed between isohyetal lines. Rainfall values are plotted at their respective stations on a suitable base map and lines of equal rainfall, called isohyets are drawn. In regions of little or no physiographic influence, the drawing of isohyetal contours is relatively simple matter of interpolation in which the degree of smoothness of contours and of profiles which may be drawn or inferred from their spacing of stations and the quality and variability of the data.

In regions of pronounced orography, where the precipitation in influenced by topography, the analyst should take into confideration the orographic effects, storm orientation etc. to adjust or interpolate between station values.

The modern computers equipped with plotters have the ability to draw isohytel maps. Analysts, however, prefer to carry out the analysis manually after getting the values plotted on the maps.

The average depth of precipitation is computed by measuring the area between successive isohyets and determining the total volume and dividing by total area.

The average depth is givel by the relation

$$\overline{P} = \frac{\sum_{i=1}^{n} P_i A_i}{\sum_{i=1}^{n}} \qquad (3.6)$$

Where A_i is the area between successive isohyets; $\overline{P}$ and P_i have the same notation as in Section 3.3.2.

A typical isohyetal map and example of the mean areal precipitation computation is given below :

30, Aug. 1982

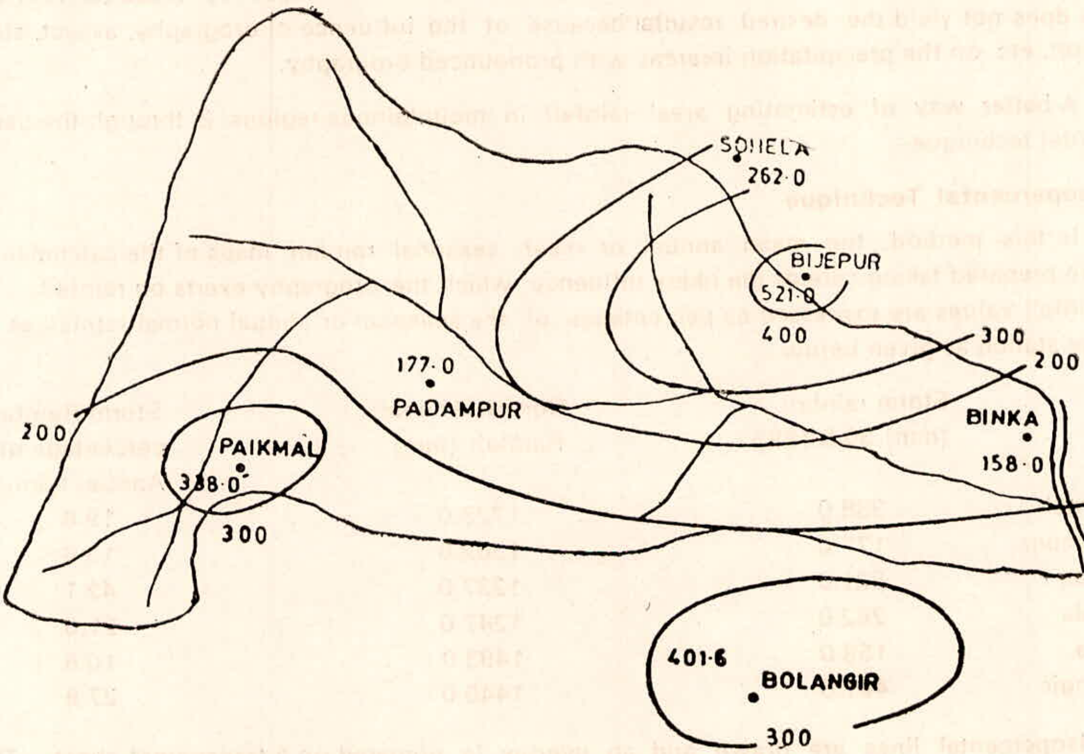


Fig. 3.8 : Isohyetal Analysis

Estimation of Mean Areal Catchment Rainfall by Isohyetal Method

Isohyetal range (mm)	Average value (mm)	Area (km²)	Volume (10^3 m^3)
521.0-500 0	510.5	70	357.4
500.0-300.0	400.0	500	2120.0
338.0-300.0	319,0	100	319.0
200.0 300.0	250.0	2080	5200.0
158.0-200.0	179.0	2820	5047.8
		5600	13044.2

$$\text{Average catchment rainfall} = \frac{13044.2}{5600} = 232.9 \text{ mm}$$

3.4 ESTIMATION OF MEAN AREAL PRECIPITATION IN MOUNTAINOUS AREAS

Precipitation data which exhibits appreciable spatial variation over relatively short distance is often used as areal estimate for use as input in hydrological models. Several methods are commonly used for estimating average precipitation over a specific area, such as a drainage basin. The choice of the method is, generally, dependent on the quality and nature of data, the importance of its use and required precision of the result.

Any method of areal estimation such as isohyetal, Thiessen weights etc. involves implicitly or explicitly, inferences concerning the depth of precipitation at all points in the area of interest. Estimation of mean areal precipitation in mountainous areas by these conventional methods does not yield the desired results because of the influence of orography, aspect. storm orientation, etc. on the precipitation in areas with pronounced orography.

A better way of estimating areal rainfall in mountainous regions is through the use of isopercental technique.

3.4.1 Isopercental Technique

In this method, the mean annual or mean seasonal rainfall maps of the catchment or region are prepared taking care of the likely influence which the orography exerts on rainfall. The storm rainfall values are expressed as percentages of the seasonal or annual normal rainfall at the raingauge station as given below.

	Storm rainfall (mm) 30 8.1982	Normal Annual Rainfall (mm)	Storm Rainfall percentage of Annual normal
1. Paikmal	338.0	1728.0	19.6
2. Padampur	177.0	1302.0	13.6
3. Bijepur	521.0	1237.0	42.1
4. Sohela	262.0	1247.0	21.0
5. Binka	158.0	1493.0	10.6
6. Bolangir	401.6	1440.0	27.9

Isopercental lines are drawn and an overlay is prepared on a transparent sheet. This overlay is superimposed on seasonal isohyetal map (Fig. 3 9). The various points at which the isopercentals cross the seasonal isohyetal pattern are marked and isohyetal values are multiplied by the percentage value to obtain a new set of points and the corresponding values. An isohyetal map is now prepared (Fig. 3.10) using these values which incorporate the characteristics of storm isohyetal pattern and seasonal isohyetal pattern which is supposed to be governed by the orography of the region. To illustrate the method an example is given below :

Estimation of Mean Areal Precipitation by Isopercental Technique

Isohyetal Range	Mean Value	Area Km²	Volume Km² × mm
110-150	130	80	10400
150-200	175	600	105000
177-200	188 5	600	113100
200-250	225	3370	758250
250-300	275	620	170500
300-400	350	230	80500
400-500	450	90	40500
500-521	510 5	10	5105
		5600	1283355

Average Depth 229 2 mm

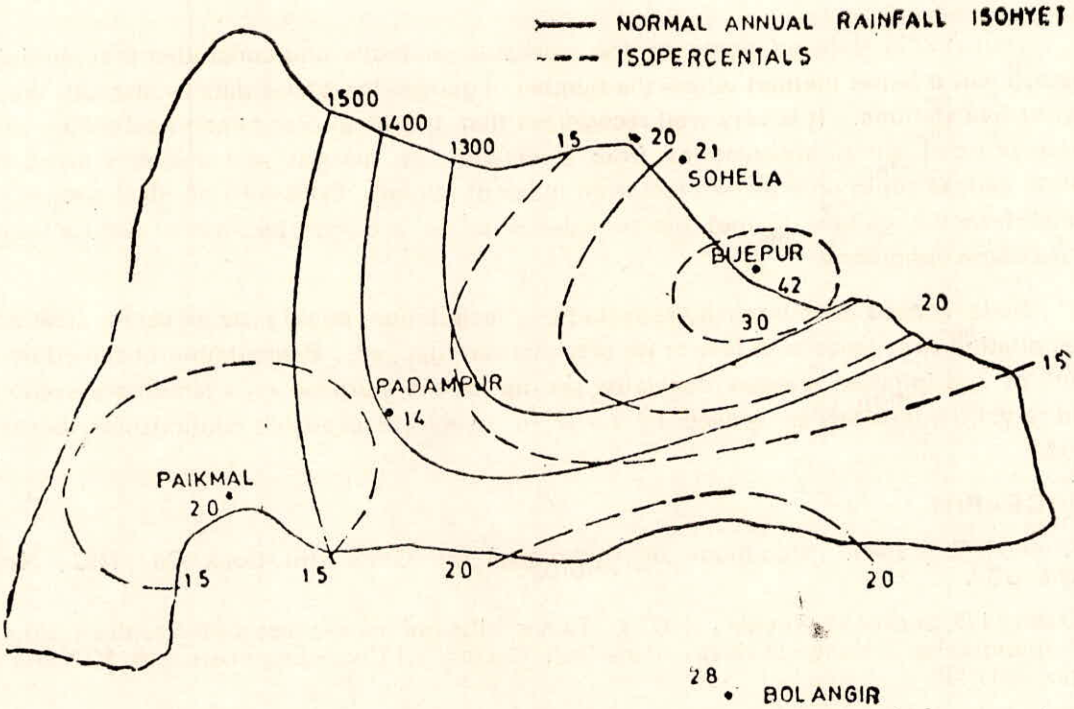


Fig. 3.9 : Isopercental map

30 Aug. 1982

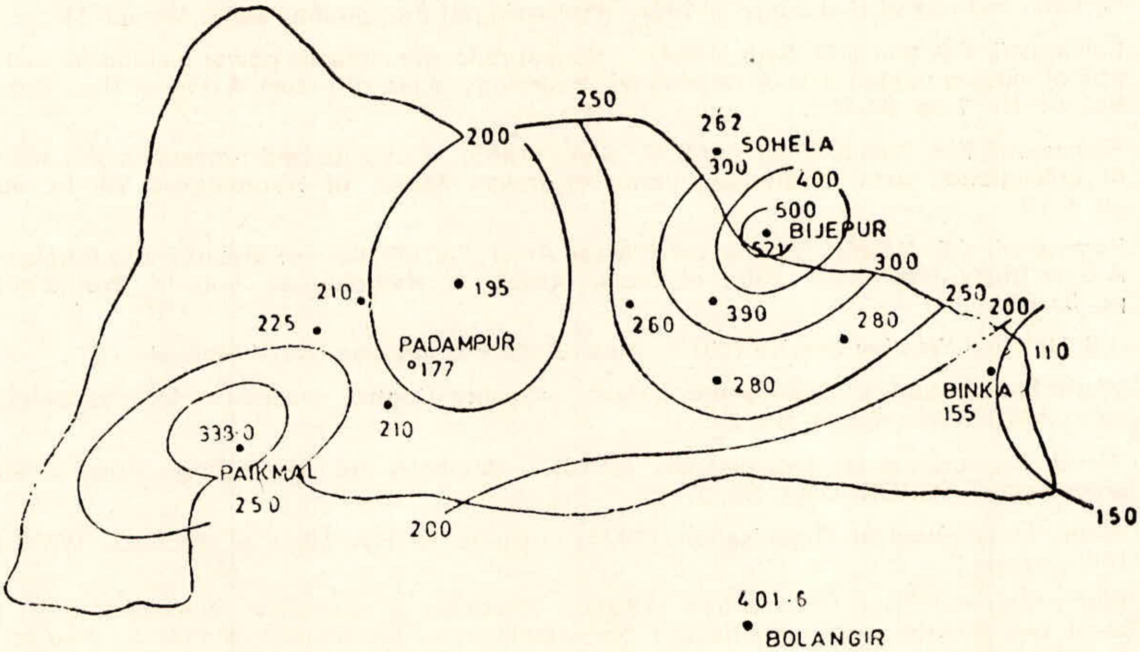


Fig. 3.10 : Isohyetal map drawn by isopercental method

3.5 REMARKS

Hall (1972) reviewed some of the available methods and concluded that multiple linear regression was a better method where the number of gauges for whose data availability was limited to four or five stations. It is very well recognized that the areal precipitation estimates derived on the basis of point rainfall observations from a network of sparsely and unevenly distributed precipitation gauges could only be regared as an index of rainfall. Even with an ideal gauge coverage, the catch from the gauges cannot be considered to be accurate because of wind influence and other exposure conditions.

Radar sensed echo intensity reflected by precipitation could provide useful areal estimates of precipitation over areas with few or no precipitation gauges. Precipitation observed by a dense network of precipitation gauges specially set up for the purpose on a temporary basis could be related to echo intensities as sensed by radar to develop reasonable relationships for the area of interest.

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