# Analysis of Optimum Number of Rain Gauge in Shetrunji River Basin, Gujarat - India

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## Abstract

For any type of Hydrological and meteorological study it is important that an optimum number of rain gauge are available in particular catchment area. Rainfall records constitute the most important and fundamental data required for hydrological investigations. To obtain reliable results, the various raingauges should be evenly and uniformly distributed within a given catchment. Moreover, the total number of raingauges installed within a given catchment area should neither too many as to be costly nor should be too less as to give unreliable results.

**Keywords: Raingauge, Shetrunji basin, Rainauge network, Average annual rainfall, Optimum raingauge network**

## I. INTRODUCTION

Rainfall is one of the most important and at the same time one of the most complex meteorological and hydrological parameters on which the economy of India depends. India is one of the worst flood affected country in the world, as it is surrounded by ocean. As per the geographical survey of India, the major flood prone areas of India which cover almost 12.5 % area of the country. About 40 million hectare of land in India is prone to be flooded as per National Flood Commission. Gujarat has seen various damaging floods. Almost all major river in Gujarat pass through a wide stretch of very flat terrain before meeting to the ocean. These flat lands of lower river basins are prone to be flooded every year. To analysis of flood by any hydrological method or mathematical model main important input parameter is rainfall data. So collection of rainfall data in particular basin or catchment area is the main important for any hydrological any meteorological analysis.

## II. STUDY AREA

The Shetrunji is a major river basin among 71 river basins of Saurashtra region of Gujarat state, India. Which encompassing district of Junagadh, Amreli and Bhavnagar. The shetrunji river basin is the Eastern most basin of Saurashtra region and it is located approximately between 21°00' N to 21°47' N Latitude and 70°50' E to 72°10' E Longitude. The Shetrunji river originates at Chchai hills in Gir forest of Junagadh district and flows towards East direction, where it passes north of Palitana's hills called Shetrunjaya, then flow towards south easterly direction past Talaja hill and then it confluence with the Gulf of Cambay near Sartanpar. The shtrunji river has a maximum length of 227 km and the total catchment area of the basin is 5636 sq.km.

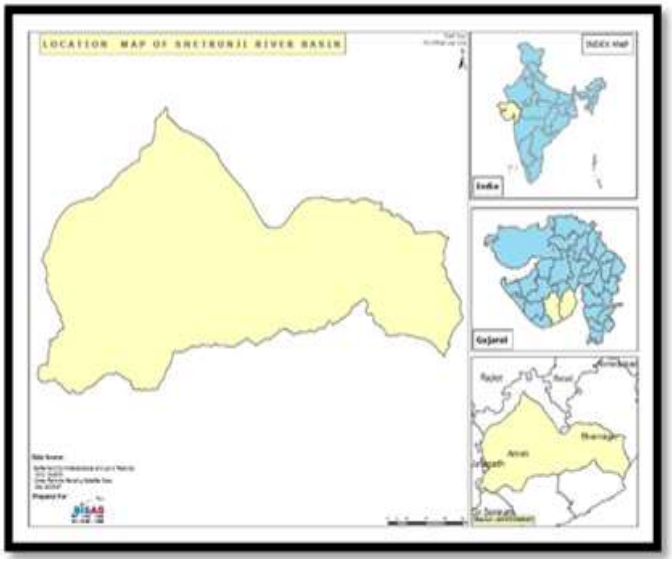


Fig. 1: Location map of Shetrunji river basin

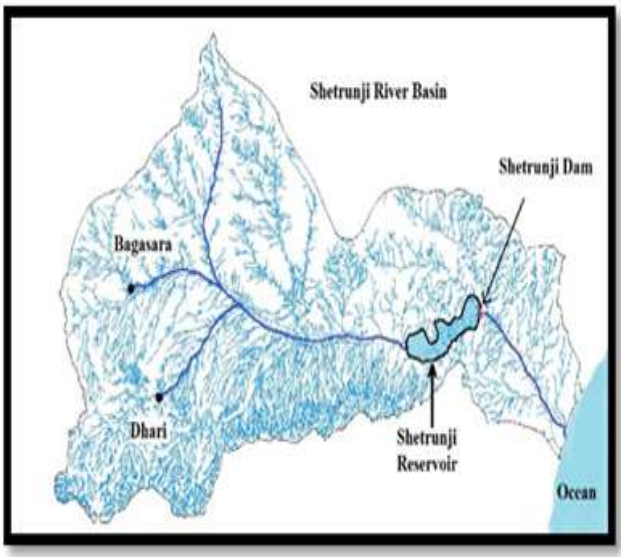


Fig. 2: Drainage map of Shetrunji River

## III. DATA COLLECTION

The Shetrunji Basin map is collected from BISAG, Gandhinagar. Which shows the various drainage of river and its tributaries? The daily rainfall and monthly rainfall data for total 19 raingauge station are collected from State Water Data Centre, Gandhinagar for a period of 54 years from 1961 to 2014. Shel, Khari, Talaji are right bank tributary and Satali, Gagriyo, Rajawal and Kharo are left bank tributary of the shetrunji river. The Khodiyar dam and the Shetrunji dam are located on the Shetrunji River at 55km and 160km from the origin of the river.

Table – 1
Avg. Annual Rainfall Data for 52 Years

| *Rain Gauge Station Data* | | | | |
|---|---|---|---|---|
| *Sr. No.* | *Raingauge Station* | | *District* | *Avg. Annual Rainfall* |
| *1* | *P1* | *Amreli* | *Amreli* | *625* |
| *2* | *P2* | *Damnagar* | *Amreli* | *724* |
| *3* | *P3* | *Dhari* | *Amreli* | *657* |
| *4* | *P4* | *Gariyadhar* | *Bhavnagar* | *665* |
| *5* | *P5* | *Gopnath* | *Bhavnagar* | *649* |
| *6* | *P6* | *Jesar* | *Bhavnagar* | *543* |
| *7* | *P7* | *Kharo* | *Bhavnagar* | *602* |
| *8* | *P8* | *Khodiyar* | *Amreli* | *593* |
| *9* | *P9* | *Lathi* | *Amreli* | *603* |
| *10* | *P10* | *Liliya* | *Amreli* | *640* |
| *11* | *P11* | *Palitana* | *Bhavnagar* | *653* |
| *12* | *P12* | *Rajawal* | *Bhavnagar* | *668* |
| *13* | *P13* | *Sartanpar* | *Bhavnagar* | *674* |
| *14* | *P14* | *Savarkundla* | *Amreli* | *661* |
| *15* | *P15* | *Shetrunji dam* | *Bhavnagar* | *641* |
| *16* | *P16* | *Talaja* | *Bhavnagar* | *657* |
| *17* | *P17* | *Talaji* | *Bhavnagar* | *624* |
| *18* | *P18* | *Tarasra* | *Bhavnagar* | *683* |
| *19* | *P19* | *Thebi* | *Amreli* | *686* |

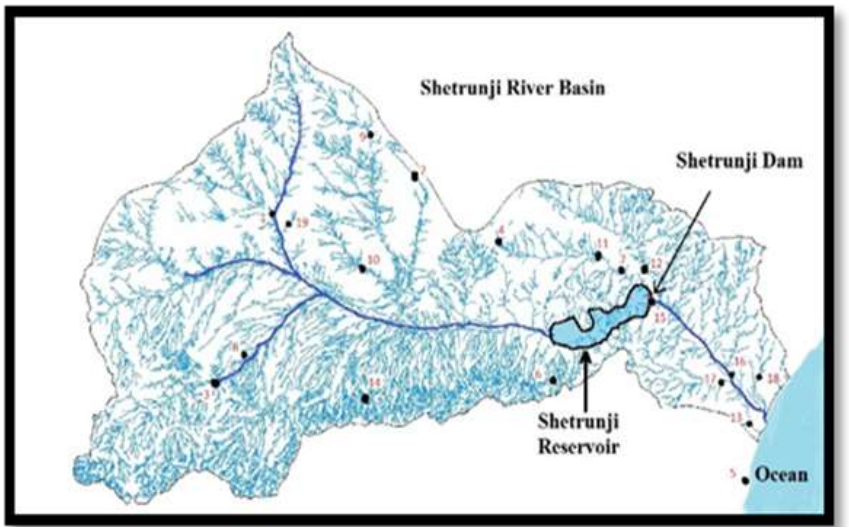


Fig. 3: Location of Raingauge Station in Shetrunji basin

As from the collected rainfall data Average annual rainfall data are calculated and presented in above table. The time period is 54 year (From 1961 to 2014). The maximum rainfall occurs in 1983, 2006 & 2007. Total catchment area of Shetrunji basin is 5636 sq. km.

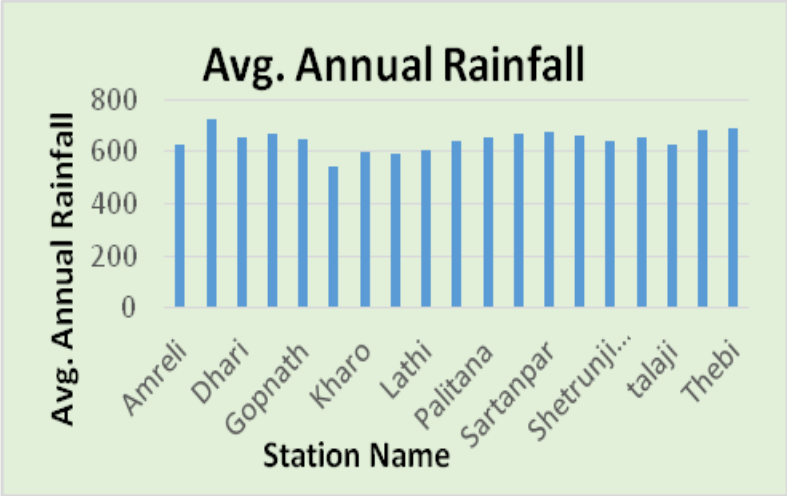


Fig. 4: Graphical Analysis of Avg. Annual Rainfall

## IV. METHODOLOGY

There are two types of network i) Primary network and ii) Secondary network. A Primary network aims at establishing a permanent network of raingauges for climatological purposes. A secondary network is purely of a temporary nature for meeting specific requirements of certain major projects. In plains, one raingauge up to 500 sq.km shall be sufficient. However, if the catchment lies in the path of low pressure systems which cause precipitation in the area during their movement, the network should be denser, particularly in the upstream.

The normal network, if economically feasible, should be one raingauge in not more than 150 sq.km, the denser network being preferable. In some cases it may not be necessary to design dense network because information from meteorologically and geologically homogeneous catchments around the project catchment, with better network may already be available. It should, therefore be examined whether information about such catchments already exists and from the rainfall analysis already carried out for the catchment whether it could be possible to obtain the design storm, fulfilling those requirements.

The aim of Optimum network design is that, by interpolation between values of different stations, it should be possible to determine with sufficient accuracy, for practical purpose, the characteristics of the basic hydro meteorological elements at any point of interest.

When the means rainfall is calculated by simple arithmetical average method, the optimum number of raingauge is obtained by the following equation:-

$$N = (Cv/E)^2$$

Where

N= Optimum number of raingauge stations
Cv= Coefficient of variation of the rainfall values of the existing raingauge stations
E= Allowable degree of percentage error in the estimate of basin mean rainfall

*1) Procedure:*

1) Step-1 Calculate total rainfall

$\sum P$= P1 +P2+P3+……. + P19
$\sum P$=12248 mm

2) Step-2 Calculate means rainfall

$$\bar{P} = \frac{\sum P}{n}$$

$\bar{P}$=12248 / 19
$\bar{P}$= 644.63 mm

3) Step-3 Calculate the sum of the square of all the rainfall of the gauges

$$\sum P^2 = P1^2 + P2^2 + P3^2 + \ldots + P19^2$$
$$\sum P^2 = 7924808$$

4) Step-4 Calculate the mean of square

$$\overline{P^2} = \sum P^2 / n$$
$$= 417095.15$$

5) Step-5 Calculate the standard deviation

$$\sigma = \{\frac{n}{n-1}(\overline{P^2} - \bar{P}^2)\}^{0.5}$$
$$\sigma = 40.41$$

6) Step-6 Calculate the coefficient of variation

$$Cv = (\frac{100\sigma}{n})$$
$$Cv = 6.26\ \%$$

Step-7 Optimum number of raingauge

$$N = (Cv/E)^2$$

If assume that consisting raingauge stations are optimum
Then *N*=19
So, now we can find the value of E
E= 1.43 %
So Allowable percentage of error in the estimate of basic mean rainfall is 1.43 %.

## V. RESULTS AND DISCUSSION

The total catchment area of Shetrunji river basin is 5636 sq.km. Total consisting raingauges are 19.

Avg. area covered by each raingauge = 5636 / 19
= 296.63 sq.km

This study area is fall in the flat and hilly region. Where average elevation is around 600 m above mean sea level.

### *A. WMO Recommendations on Raingauge Density*

- Flat regions of temperate, Mediterranean and tropical zones
- Ideal – 1 station for 600-900 sq.km.
- Acceptable – 1 station for 900-3000 sq.km.
- Mountainous regions of temperate, Mediterranean and tropical zones
- Ideal – 1 station for 100-250 sq.km.
- Acceptable – 1 station for 250-1000 sq.km.
- Arid and polar zones
- Ideal – 1 station for 1500-10000 sq.km. Depending on the feasibility.

### *B. Bureau of Indian Standards (BIS) Recommendations on Raingauge Density*

- In plains – 1 station for every 520sq.km.
- In regions with average elevation 1000m – 1 station per 260-390 sq.km.
- In hilly areas with heavy rainfall – 1 station for every 130 sq.km.

Based on the above recommendations as per Indian Standards this area required 1 station for 300-400 sq.km. Because this area is mix of flat and hilly terrain. The consisting raingauge station is 19 for Shetrunji basin. So every raingauge station cover average of 297 sq.km area as per above calculation. So this calculation fulfils the requirements of minimum number of raingauge required for Optimum Raingauge Network. But from the practical point of view it is not feasible as there are many raingauge stations which

are located very close to each other. And some area in Shetrunji river basin is not covered accurately by raingauge network especially west and central part of the Shetrunji basin.


Fig. 5: Consisting Raingauge Network for Shetrunji basin

As we can see from the above Fig-5 which shows that Raingauge station No 1 to 19 for Shetrunji river basin, in which raingauge station No. 8,7,17,18 & 19 are placed very close to nearby rain gauge station while some area of basin are not covered accurately by consisting raingauge network. So efforts are made such that whole catchment area is covered by raingauge station network with the use of optimum number of raingauge.

## VI. CONCLUSION

From the above results it has been concluded that optimum number of raingauges for Shetrunji river basin is 19 and one raingauge covers an average area of 297 sq.km but the current location of Five raingauge station are not accurate as we can see in the above Fig-5. These five raingauge stations can be well allocated in the area which is not properly covered by current raingauge network. Specifically these five raingauge stations can be relocated in the western and the central part of the Shetrunji basin.

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