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Rainfall Analysis of Vrishabhavathi Valley in Bengaluru Region

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Abstract: ***Vrishabhavathi valley is a part of river Arkavathi. It covers parts of Bengaluru Urban and Ramanagara districts with an area of 381.46 sq. kms. Due to rapid urbanization in Bengaluru lot of pervious strata is converted into non-pervious concrete or asphalt surfaces. Rainfall is a major event, which is resulting flood in Bengaluru city. Recently observed heavy rainfall, rapid urbanization, encroachment of streams and water bodies are the major causes of flooding in Bengaluru. Disturbance to human activities and damages to properties has been observed in Vrishabhavathi valley region due to heavy rainfall especially in heavy rain events. Rainfall data analysis has been carried out statistically and graphically on Vrishabhavathi valley from 1970 to 2018. Rainfall analysis was made on converting daily rainfall data to monthly average data and seasonal analysis of rainfall has made for three different monsoon seasons Pre- monsoon, South- West and North- East monsoon, distribution and frequency of rainfall has been analyzed and results are represented graphically. From the annual rainfall study it is observed that less rainfall variations till 1990 and rainfall pattern seem to be increasing constantly from 1990's onwards till 2018, particularly in the months of August, September and October. The rainfall contribution during south-west monsoon is almost equal to 50% of total annual rainfall. Rainfall analysis is essential to develop appropriate flood prediction models utilizing latest rainfall data collected (KSNDMC Telemetric station data) and available geospatial data to address the issues of urban flood observed in many locations in Vrishabhavathi valley region and in Bengaluru.***

Keywords: Flood, Rainfall, Urbanization, Vrishabhavathi.

I. INTRODUCTION

Bangalore is one of the rapidly developing urban areas in India and is awarded as 'Silicon Valley of India' for its continuous improvement of Information Technology (IT) based companies in India. Bengaluru is located at 12.971 North latitude and 77.594 East longitudes and is situated at 920 meters above mean sea level.

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Recent floods observed in many areas of Bangalore are a consequence of heavy rainfall, urbanization and encroachment of streams/ water bodies. Poor urban planning may be one of the reasons behind flooding happening in recent years. Study area (BBMP) consists of four watersheds viz. Hebbal valley, Vrishabhavathi valley, Koramangala valley and Challagatta valley watershed. Proper analysis of rainfall and adoption of better flood prediction models will help in arriving at measures (structural & non-structural) to minimize the damages to life and properties and also to address other issues like traffic jams, waterlogging etc. Rainfall analysis is carried out under the ISRO sponsored RESPOND Project titled "Urban Flood Monitoring and Management in Bangalore City Using Remote Sensing and GIS", covering Vrishabhavathi valley for past 49 years from 1970 to 2018. The results of rainfall analysis are presented both statistically and graphically in this paper [1] [9].

II. STUDY AREA

Vrishabhavathi valley is a part of river Arkavathi. It covers parts of Bengaluru Urban and Ramanagara district with an area of 381.46 sq. kms lying between latitudes 120 4413711 to 13231 N and longitude 772314 to 773459 E. Vrishabhavathi river is originated from Peenya located at Bengaluru at a MSL of 930m above mean sea level. Fig 2.1 shows the location of the study area [1].

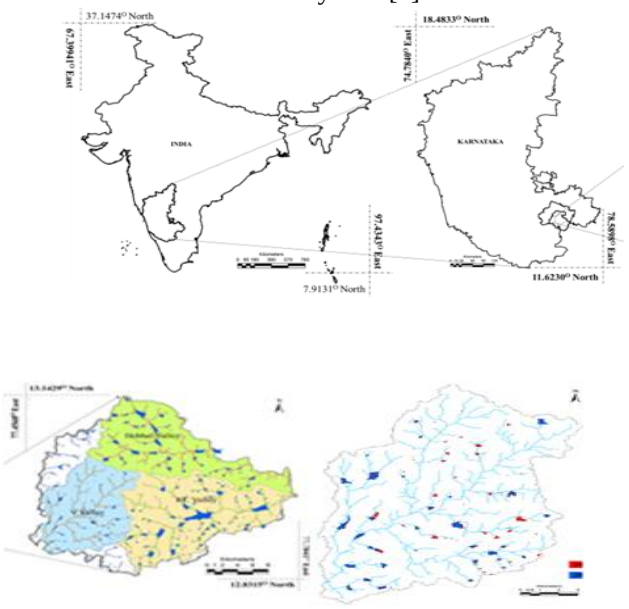

Fig 2.1 Map showing Vrishabhavathi Valley

III. RAINFALL ANALYSIS

The daily rainfall data collected for the period of 1970 to 2018 from KSNDMC is analyzed here. Which is completed in two different parts; firstly by Graphical and Tabular Analysis where the rainfall data inserted in tabular format. The comprehensive analysis will be made after plotting the rainfall data in graphs. Day wise rainfall data collected from single rain gauge station for Vrishabhavathi valley till 2015 and after 2015 KSNDMC has installed 43 rainguage stations till 2018 under Vrishabhavathi valley among that Kengeri station has been considered for further analysis of rainfall. This rainfall details are converted into average monthly and seasonal rainfall and total annual rainfall is calculated and shown in Table 3.1.

Table 3.1: Rainfall analysis of Vrishabhavathi Valley in mm.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	IUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1970	0	12.2	0.4	22.4	167.7	64.3	113.8	128.5	98.4	153.8	101.6	0.8	863.9
1971	0	0	0	95.8	115.9	5.2	45.3	225.9	164	115.7	12	22.5	802.3
1972	0	0	0	1.6	174.7	103.7	42.8	74.5	132.7	174.5	14.8	74.1	793.4
1973	0	0	0	15.4	26.5	141.5	73.3	97.2	287.6	171.7	42.1	26.2	881.5
1974	0	0	0	24.9	179.9	31.4	65.9	95.2	260.9	161	52	0	871.2
1975	0	5.5	0.3	6.2	50.1	70.6	237.1	104.2	161.6	147.5	169.6	10.3	963
1976	0.9	0	0	123.6	100.8	5.9	73.9	182.7	57.4	47	122.3	5.3	720
1977	0	0	29.9	51.5	102	90	86.6	100	109.6	252.6	134.5	0	956.7
1978	0	10.1	0	17.7	129.4	36.4	104.1	87.2	189.6	77.2	52.7	18.4	722.8
1979	0	41.6	0	20.4	28.6	130.7	117.4	35	245.1	154.1	110.8	0	883.7
1980	0	0	7.9	3.5	94.3	21.2	139.7	74.3	129.3	80.3	55.5	0.4	606.4
1981	0.4	0	75.5	53	84	5.7	74.3	123.9	170	98.7	80.2	29	794.7
1982	0	0	0	8.9	102.4	134.5	60	58.3	252.2	78.9	58	0	753.2
1983	0	0	0	0	93.8	177.9	52.2	151.5	146.2	41.7	0.3	42.4	706
1984	0.3	34.5	71.5	22.7	58.4	37.5	148.8	35.8	153.4	114	11.1	14.1	702.1
1985	7.2	0	34	10.6	55.4	74.6	90.5	57.3	99.3	119.2	44.4	3.4	595.9
1986	3.9	42.5	0	4.9	56.4	123.3	25.4	120.6	226.7	36	0	0	639.7
1987	0	0	54.7	47	37.5	69.8	23.9	117.4	156.6	181.4	43.6	39	770.9
1988	3.9	42.5	23.4	67.7	93.9	2.7	203.8	180.6	215.6	20.6	7.6	13.3	875.6
1989	0	0	8.4	1.9	90.9	46.6	175.1	68	191.1	186.2	5.5	0.3	774
1990	0	0	20.2	12.1	122.2	47.4	28.7	108.7	142.2	38.1	49.1	9.9	578.6
1991	0	0	0	73.4	165.3	149.4	75.8	104.6	264.9	247.7	184.7	0	1265.8
1992	0	0	0	3.5	95.6	172.7	65.8	82.8	85	161.1	66.1	0.6	733.2
1993	0	0	20.9	0.1	85.4	146.6	96	135.9	220.1	212.1	29.9	84.8	1031.8
1994	0	1.6	0	26.6	92.4	24	81.1	61.7	63.2	219.6	21.3	7.6	599.1
1995	3.4	0	4.4	21.7	131.4	107	135.8	163.2	67.7	181.5	1.7	0	817.8
1996	0	0	0	65.3	101.2	229.7	13.5	277.9	199.3	91.8	2	21	1001.7
1997	5.4	0	26.7	64.4	95.1	79.4	25.6	162.3	277	324.5	164.4	14.7	1239.5
1998	0	0	0.8	76.2	23.2	74.8	128.4	292.4	295.6	185	69.4	22.8	1168.6
1999	0	9.8	0	78.2	163.7	39	74.6	21.1	175.7	264.4	56.9	21.2	904.6
2000	0	58.4	0	53.1	45.3	119	84.2	214.9	199.4	242.8	8.9	13.5	1039.5
2001	4.2	0	3.4	230.2	9.3	13.1	80.6	74.4	380.4	146.4	34.8	3.2	980
2002	0	0	1.6	3	262.2	82.6	28.8	24.5	93.3	122.6	38.6	4.6	661.8
2003	0	1.6	4.7	20.2	1.9	62.1	80.3	123.5	100.5	183.2	31.7	1	610.7
2004	0.1	0.7	19	19.6	184.1	113.5	241.2	81.7	156.6	247.7	27.1	0	1091.3
2005	2.4	3.2	0	45.3	129.8	142.2	179.5	98.1	279.4	443.5	81.6	6.6	1411.6
2006	0	0	36.9	6.5	124.6	175.1	42.4	78.3	33.2	28	64.1	0	589.1
2007	0	0	0	120.5	90.1	87.9	139.5	140.4	205.9	182.2	9.2	42.5	1018.2
2008	0	17.7	219.9	78.2	77.2	54.4	140.2	263	77.3	195.8	47.5	0	1171.2
2009	0.0	0.0	24.8	83.6	159.8	175.4	18.3	166.5	372.0	39.5	70.2	61.7	1171.80
2010	4.3	0.0	0.0	76.5	121.6	42.5	110.5	120.0	131.0	124.6	170.5	1.5	903.11
2011	0.0	23.0	0.0	96.0	217.3	58.6	85.6	184.9	108.0	178.6	16.5	1.2	969.9
2012	0.4	0.0	0.1	2.0	44.1	6.5	63.2	67.0	37.4	60.4	95.9	19.5	396.51
2013	0.0	1.8	2.1	39.9	138.1	157.2	101.9	104.4	259.2	170.8	45.2	2.2	1022.65
2014	0.0	0.0	8.0	1.0	24.5	84.5	94.5	80.0	100.0	167.0	21.8	3.0	584.31
2015	3.0	0.0	42.0	114.0	131.0	154.5	44.0	226.0	228.0	94.0	196.0	6.0	1238.5
2016	18.5	0.0	4.0	11.0	185.0	311.0	192.0	74.0	24.5	41.0	24.5	75.0	960.5
2017	2.5	0.0	35.5	79.5	358.5	44.5	71.0	297.0	676.5	228.5	17.0	17.5	1828
2018	1.0	3.0	100.5	44.0	318.0	79.0	51.5	144.0	294.0	159.0	42.5	1.5	1238

IV. YEAR/SEASON WISE ANALYSIS OF RAINFALL

Vrishabhavathi valley receives on an average of 896mm of rainfall annually. Bengaluru usually receives rainfall from south-west as well as North- East monsoon. Bengaluru receives majority of rainfall from June to September and November to December. An amount 896mm of annual rainfall is not a heavy rainfall while comparing rainfall amounts in other parts of state and do not seem to be causing havoc situations. However, due to urbanization happening from past two decades in Bengaluru and encroachments of natural drains resulting in causing floods in Bengaluru (mainly due to conversion of pervious surfaces to impervious strata) . Following graphs shows variations in annual rainfall, Pre- Monsoon, South- West Monsoon and North- East Monsoon for past 49 years.

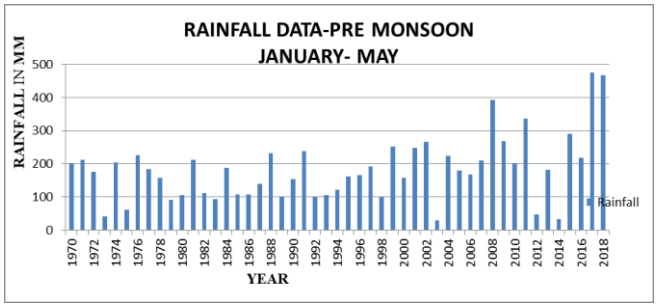

Figure 4.1: Rainfall distribution for Pre-Monsoon period.

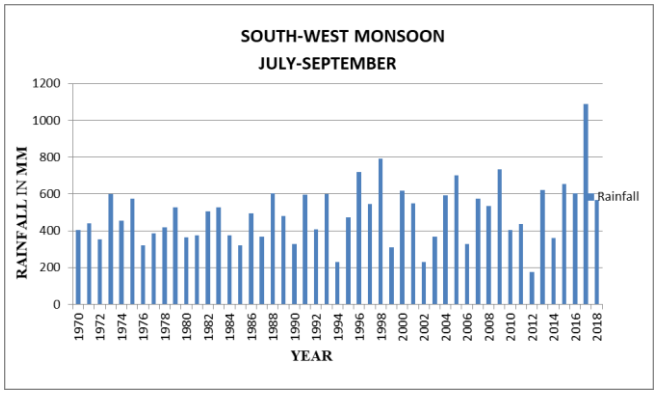

Figure 4.2: Rainfall distribution for South- West Monsoon

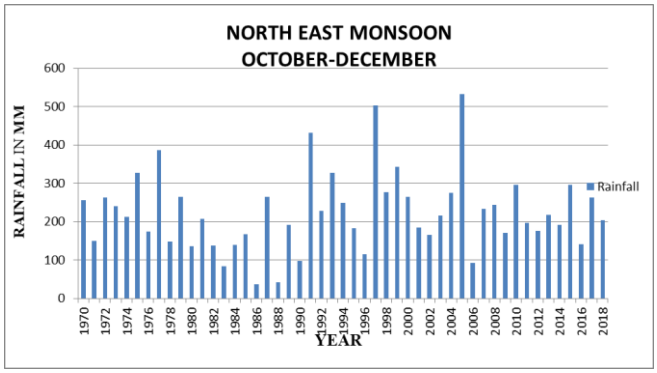

Figure 4.3: Rainfall distribution for North East Monsoon

V. STATISTICAL ANALYSIS OF RAINFALL DATA

A huge number of data, when it is analyzed statistically it gives lot of information, which can be utilized for many useful interpretations, here statistical analysis for Vrishabhavathi valley has been conducted considering rainfall parameter.

A. Statistical Facts

- The highest rainfall recorded in Vrishabhavathi valley is 676.5mm in the month of September 2017.
- The highest rainfall in Vrishabhavathi valley occurs in the month of September, which is on an average of 184mm.
- The least rainfall in Vrishabhavathi valley occurs in the month of January with an average of less than 1mm rainfall.
- South-West monsoon contributes 54% of total annual rainfall for the period i.e. from June to September.

Fig 5.1: News and newspaper clippings of rainfall at Bengaluru VV region[11]

B. Rainfall Distribution

For the study period after analyzing rainfall for Vrishabhavathi Valley, rainfall distribution pattern was studied through graphical representation in Fig 5.2. It can be seen that for the month from December to March total annual rainfall distribution for particular month is less than 2% of the total annual rainfall. June, July, August, September and October contributes more than 70% of the total annual rainfall.

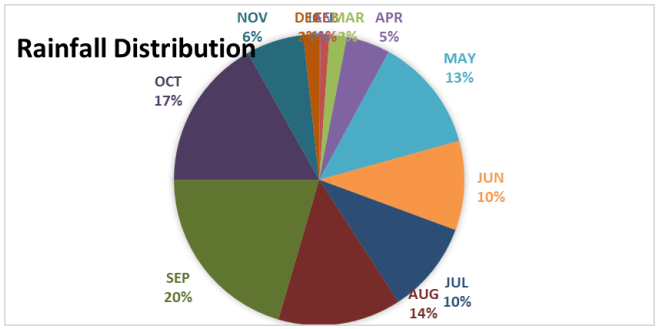

Fig 5.2: Distribution of Rainfall

Annual rainfall pattern studied for Vrishabhavathi Valley for the period of 1970-2018. It is seen that average annual rainfall pattern was lesser than 800mm till the year 1990. It is observed that rainfall pattern was altered drastically in the area after the year 1990 resulting in more than 800mm of rainfall in particular year. The maximum annual rainfall of 1828mm occurred in the year 2017 resulting in heavy flood events. Annual rainfall pattern for the study period is given graphically in fig 5.3.

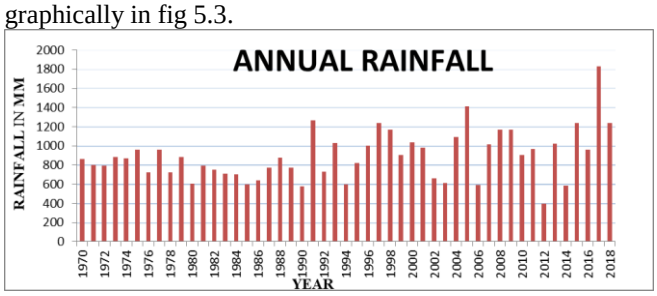

Fig 5.3: Annual rainfall

C. Frequency distribution of rainfall

The rainfall frequency is divided into range of 50mm, 50-100mm, 100-200mm and greater than 200mm. Frequency of rainfall is calculated for different months of the year from 1970-2018. For the months of January to April and December the rainfall never crossed 100mm for more than five years, these months considered completely free from floods. From the month May to October region has crossed 100mm of rainfall more than half of study period. Highest rainfall was observed in the month of September 2017 & least rainfall is observed in the month of January most of the years. The frequency distribution table is shown in Table 5.1.

Table 5.1: Frequency distribution table

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<50mm	49	48	44	30	8	16	11	5	3	8	27	45
50-100mm	0	1	3	15	15	15	21	16	9	6	12	4
100-200mm	0	0	1	3	22	16	15	22	20	25	10	0
>200mm	0	0	1	1	4	2	2	6	17	10	0	0

From the above study we assessed that January, February, March, April, November and December are least flood vulnerable months. If a month receives, more than 200mm then those months are considered as vulnerable to flood. A graph is drawn for average monthly rainfall of more than 200mm for accessing flood vulnerability. From the graph, we can conclude that heavy rain majorly occurred in the months of August, September and October. Number of heavy rainfall occurrences has represented graphically in Fig 5.4.

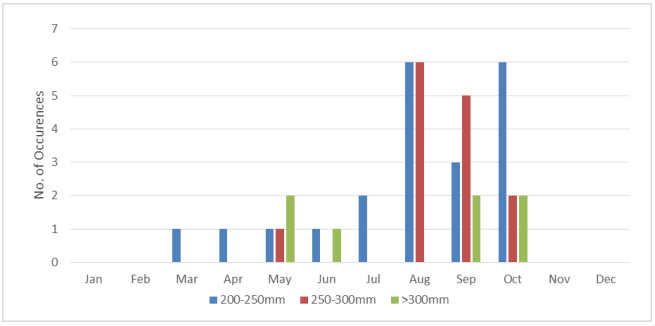

Fig 5.4: No. of heavy rainfall occurrences

VI. CONCLUSION

Rapid urbanization in Bengaluru city is the major reason behind flooding. August, September and October are the three months, which are highly vulnerable for flooding. Increase in concreting surfaces, asphalting pervious spaces and encroachment of water bodies, natural drainages resulting surface runoff. Lakes and Rajakaaluve existing in Bengaluru were encroached for different purposes, which gives rise to overflow of storm water. From statistical analysis, it is concluded that more than 50% of rainfall for that year occurs in the months of August, September and October. From the annual rainfall graph, it is clearly seen that rainfall events are increasing drastically from 900mm till 1990's, and an average rainfall of 1800mm can be seen in the year 2017. As increase in urbanization and increasing trend of rainfall requires better assessment of runoff in flooding locations to minimize damages to human activities and properties. Proper maintenance of drainages, latest technologies to overcome the heavy rainfall events structural and non-structural measures has to be taken care considering flooding situations.

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