Occurrence of Droughts in Hoskote Town, Bangalore Rural District, Karnataka, India

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Abstract— *Hoskote Taluk is one of the eight Taluks of Bangalore Rural District in Karnataka with a current approximate population of 3, 03, 428; the total water demand comes out at around 49.5 MLD @ 135 LPCD, (WHO Standard). However with increasing population and depleting water resources, the people there do not get water even @ of 80 MLD (GOI standard for urban areas). With no surface water and declining water table below the ground, the greatest challenge the Taluk is currently facing and will face in the future is to meet the water demand of the population.*

There are five rain gauge stations in the area and are located in Hoskote, Hindiganala, Sulibele, Jadigenahally and Anugdanahally. In view of the scantiness and the variability in duration of these rainfall data, only data of Hoskote station, which is incidentally the taluk head quarter station, has been considered for the present study. For suggesting any remedies to solve water shortage and to help improve the current water resources, rainfall data from different sources for past 43 years is collected and analysed. And as such this report presents the rainfall data collected from Hoskote rain gauge station.

Long term mean annual rainfall and its seasonal variability, trends of rainfall and probability studies with respect to drought, etc. Graphs are then prepared from these collected data and used for analyzing the data and to project the assumed future data. Statistical analysis of data yields rainfall pattern of the study area, rainfall pattern can be used to predict future rainfall quantity in Hoskote Town.

Keywords— hoskote Town, rainfall,moonsoon

I. INTRODUCTION

Water is the most essential and widely distributed renewable resource. Man depends on water for his basic needs of domestic, agricultural and industrial uses. This is evident from the history of humanity as the dispersal of human race in all continents and development of human civilization. Primarily along river valleys and fresh water lakes.

Ground water plays the crucial role in maintaining productions during droughts. In Karnataka State, most of the area is occupied by hard rocks and the state experiences erratic rainfall which cause frequent droughts.

Hoskote town is facing drought due to drying up of tanks and rapid depletion of ground water source resulting from extensive exploitation. Failure and delay in occurrence of monsoons is common with the Town being situated in almost a rain shadow region. The cultivation of wet crops and cash crops has resulted in overexploitation of available surface and ground water sources. It is observed that no definite crop pattern is practiced in the Town. The ground water replenishment is very poor because the usage of water is much more than the recharge. The systematic study of ground water potential of the Town is necessary to provide water supply for drinking and agriculture throughout the year. The available water should be judiciously utilized though proper development and management techniques. These operations require knowledge of several related disciplines such as geomorphology, geology, meteorology, geophysics, geochemistry and pedology. Therefore a study of hydrogeological characteristic of the Town is felt to be essential. With this in view, a detailed quantitative and qualitative study of the hydrogeological aspects of the Town has been undertaken in the present work.

Location : Hoskote is a taluk in Bangalore Rural District and forms the northern part of the district. It features in the survey of India Top sheet Nos. 57 G/12, 57 G/16, 57 H/9 and 57 H/I 3 and lies between 12°51' to 13°15' N.Latitude and 77° 41' to 77° 58' E Longitude, covering an area of 582 sq.km (Fig 1.1). Physiographically, the area is characterized by undulating topography. The highest elevation is seen near Nandagudi, which rises above 940 in above MSL. The low lying valleys and depressions are intensely cultivated.

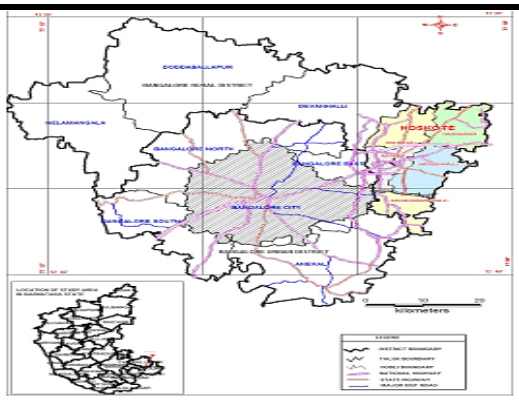


Fig.1.1 depicts the location of Hoskote Taluk in Karnataka State.

Climate: Physiographically Hoskote Taluk presents an undulating topography with gentle slope towards Southwest. The general elevation of the ground is around 870 in above MSL. The highest elevation is seen near Nandagudi which rises above 940 m N1SL. Hoskote Taluk enjoys a salubrious climate with mild summers and pleasant winters. The summer temperature touches 37°C during May and the winter temperature around 19°C during December/January. The relative humidity is around 77% during monsoon and 50% during dry month.The study area receives an average rainfall of 838mm.

II. GENERAL PHYSIOGRAPHY OF HOSKOTE TOWN

Table 2.1 General Information about the Taluk

Sl. no	Particulars	Details
01	No. of Hobli's	5
02	No. of farmer communication centers	5
03	No. of Grampanchayats	26
04	No. of villages with public communications.	254
05	No. of villages without public communications.	45
06	Total No. of villages in the taluk and Hobli's Hobli	
	i. Hoskote	41
	ii. Sulibele	69
	iii. Nandagudi	72
	iv. Jadigenahalli	75
	v. Anugondanahalli	42
07	Total No. of villages	299

Table 2.2 Land Use Details of Hoskote Taluk

Sl.No.	Particulars	Area In Ha
1.	Total geographical area	54,587
2.	Land not available for cultivation	13,631
3.	Forests	3,444
4.	Not cultivated	9,492
5.	Barren Land	1,049
6.	Reserved Pastures	456
7.	Trees and Groves	4,041
8.	Dry Land	4,004
9.	Net sown area	35,348
10.	Area sown more than once	2,081
11.	Net irrigated area	7,385
	a) From Tanks	2,702
	b) From Wells	731
	c) From Bore wells, others	3750, 203
	d) No. of tanks	198

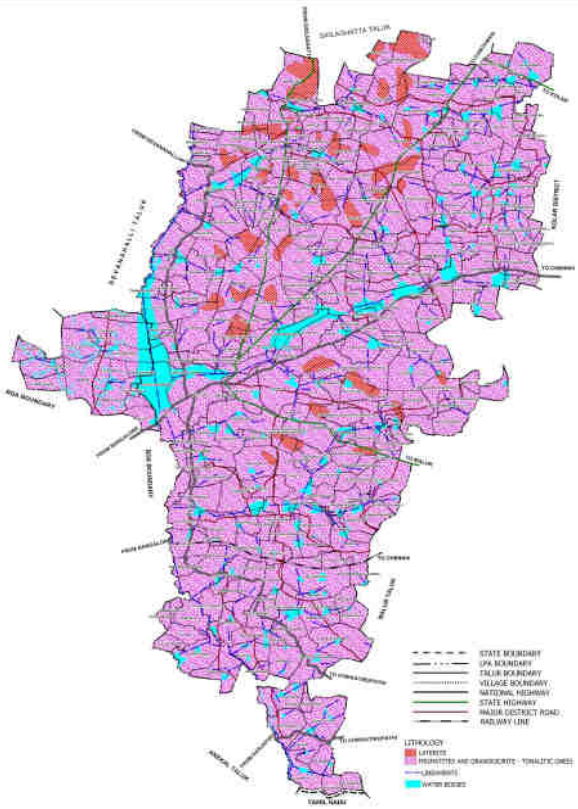


Fig 1.2 Geology of Study area

Table 2.3 Population Projection

Sl. No	Year of Census	Population	Increase or Decrease in Population	Percentage Increase or Decrease
1.	1971	12163		
2.	1981	17538	5375	44
3.	1991	25516	7978	45
4.	2001	36333	10817	42
5.	2011	56613	20280	56
	Total		44450	

	Average	11113	47
	Method	**Present Year(2015)**	**Ultimate Year(2027)**
1.	Arithmetic Projection method	58453	74393
2.	Geometric Projection method	59426	104863
3	IncrementalProjectio nmethod	58667	84727
	Average	59186	87995

Table 2.4 Projected water Demand

Year	Projected Population	Water demand(MLD)@ 135LPCD	Total Water Demand(MLD) including 15% losses
2012	58837	7.9	9.34
2013	61148	8.3	9.71
2014	63549	8.6	10.09
2015	66045	8.9	10.49
2016	68640	9.3	10.9
2017	71336	9.6	11.33
2018	74138	10.0	11.77
2019	77050	10.4	12.24
2020	80076	10.8	12.72
2021	83221	11.2	13.22
2022	86490	11.7	13.74
2023	89887	12.1	14.28
2024	93418	12.6	14.84
2025	97087	13.1	15.42
2026	100900	13.6	16.03
2027	104863	14.2	16.65

III. RAINFALL PATTERN OF HOSKOTE TOWN

3.1 Annual rainfall in Hoskote Taluk

Table 4.1 presents the normal rainfall, actual rainfall and percentage departure from the normal for the period from 1971 to 2013. The mean rainfall is 955.10 mm. The highest rainfall recorded for the period from 1971 to 2013 is 1745.80 mm in the year 1988 and lowest annual rainfall is 315 mm during 1994.The extraordinary rainfall exceeding 1000 mm has occurred in 1972, 73, 74, 75, 78, 79, 83, 86, 87, 88, 91, 93, 95, 96, 98, 2001, 2004, 2005 and 2008. The coefficient of variation of annual rainfall (CV) is 85%, which is very high and not dependable.

3.2 Seasonal Rainfall

In Hoskote the percentage contribution of rainfall in different season to annual rainfall indicates that major rainfall season in the town is southwest monsoon, which accounts for 54% and northeast monsoon 34%. The pre-monsoon rains contribute 15% to total annual rainfall.

3.2.1 Southwest Monsoon

The mean normal southwest monsoon recorded 452 mm of rainfall with 52% coefficient of variation (cv). The highest rainfall in southwest monsoon recorded is 772 mm. The minimum for the season recorded during 2002 is only 134 mm.

3.2.2 Northeast Monsoon

The mean northeast monsoon is 262 mm. The maximum amount of 842 mm of rainfall occurred during 1988 and least amount of 50.20 mm rainfall occurred in 1971.

3.2.3 Pre-Monsoon

The mean Pre-monsoon is 124 mm. The highest amount of 386 mm of rainfall occurred in 2004 and least amount of 0 mm rainfall occurred in 1994 and 1999. The cv value of 146% was observed during Pre-monsoon season.

3.3 Monthly Rainfall Pattern

Table 3.2 presents the mean monthly rainfall. Monthly mean rainfall exceeds 10 mm from March to December. The same gradually increases and reaches the peak during July and another peak in October. The period between December and February receives very little rainfall. The mean rainfall exceeding 100mm is noticed between July and October. The coefficient of variation is comparatively low in these months and hence probability of getting good rains is very high.

3.4 Frequency of Rainfall Deficiency

3.4.1 Annual rainfall

Water deficiency would have been experienced in 9 years where the rainfall deficiency exceeds >- 20%

3.4.2 Rainfall during Southwest monsoon

There are 11 years with Southwest monsoon rainfall deficiency causing water deficiency during those years.

3.5 Moving Average Curve

Table 3.3 shows the annual rainfall records from 1971 to 2013. Moving average curve of 3 and 5year duration curves have been drawn. The 3 years moving curve shows a slight improvement in rainfall towards the year 1971 to 1974, 1980 to 1986, 1992 to 1995 and shows a decline towards 1975 to 1981, 1987 to 1991 and 1996 to 1998. Then it remains almost constant from 1998 till date.

The 5 year moving average curve shows slight improvement in rainfall towards the year 1982 to 1986 and shows a decline towards 1971 to 1981, 1987 to 1991 and 2001 to 2006. It remains almost constant from 1991 to 1996 and from 2006 till date.

The moving average curve can thus show the general trend and pattern of the rainfall recorded over a large number of years.

3.6 Occurrence of Drought in Hoskote Taluk

Drought is a normal recurrent feature of climate. It occurs virtually in all climatic zones. Drought originates from a deficiency of precipitation over an extended period of time resulting in extensive damage to crops and deficiency in yields. The rainfall data for the period of 1971 to 20013 of Hoskote Taluk has been analyzed and drought years determined. Actual drought years have so been depicted pictorially in Table1 3.6 along with the annual rainfall departures the individual years. Thus the percentage of drought years in Hoskote Taluk is 21 %. The highest number of 3 years of drought occurred during 1971 to1980 followed by 2 years during 1981 to 1990 and1991 to 2000 and one year of drought during 2000 to 2007.

The number of drought years is 9 for the period from 1971 to 2004. Seasonal distribution of rainfall indicates more number of deficits: drought years where the rainfall deficiency exceeds 20% of its normal during southwest monsoon season. The Northeast monsoon rainfall shows more than 20% deficiency in these years .Study of distribution of monthly rainfall indicates that in all the months number of deficit rainfall events are more than normal or abnormal.

Table 3.1 Season wise Rainfall (mm) Analysis

Year	Pre-Monsoon			South West Monsoon		
	Normal Rain		124	Normal Rain		452
	Actual Rain	Departure	Class	Actual Rain	Departure	Class
1971	196.00	-58.06	**BN**	614.30	-35.91	**BN**
1972	144.90	-16.85	**N**	439.00	2.88	**N**
1973	21.60	82.58	**AN**	635.60	-40.62	**BN**
1974	160.00	-29.03	**BN**	429.20	5.04	**N**
1975	97.10	21.69	**AN**	750.40	-66.02	**BN**
1976	138.40	-11.61	**N**	378.30	16.31	**N**
1977	87.30	29.60	**AN**	360.00	20.35	**AN**
1978	79.00	36.29	**AN**	533.10	-17.94	**N**
1979	150.40	-21.29	**BN**	572.80	-26.73	**BN**
1980	76.40	38.39	**AN**	211.90	53.12	**AN**
1981	127.10	-2.50	**N**	349.20	22.74	**AN**
1982	107.00	13.71	**N**	315.20	30.27	**AN**
1983	102.80	17.10	**N**	495.40	-9.60	**N**
1984	229.00	-84.68	**BN**	295.90	34.54	**AN**
1985	87.70	29.27	**AN**	193.50	57.19	**AN**
1986	165.40	-33.39	**BN**	739.70	-63.65	**BN**
1987	91.60	26.13	**AN**	462.40	-2.30	**N**
1988	131.00	-5.65	**N**	772.00	-70.80	**BN**
1989	58.00	53.23	**AN**	457.00	-1.11	**N**
1990	104.00	16.13	**N**	325.00	28.10	**AN**
1991	174.00	-40.32	**BN**	522.00	-15.49	**N**
1992	102.00	17.74	**N**	448.00	0.88	**N**
1993	108.70	12.34	**N**	553.40	-22.43	**BN**
1994	0.00	100.0	**AN**	187.20	58.58	**AN**
1995	191.00	-54.03	**BN**	448.00	0.88	**N**
1996	136.00	-9.68	**N**	603.00	-33.41	**BN**
1997	59.00	52.42	**AN**	450.00	0.44	**N**
1998	141.40	-14.03	**N**	449.80	0.49	**N**
1999	0.00	100.0	**AN**	305.60	32.39	**AN**
2000	130.60	-5.32	**N**	407.00	9.96	**N**
2001	251.60	-102.9	**BN**	605.40	-33.94	**BN**
2002	141.80	-14.35	**N**	133.80	70.40	**AN**
2003	31.40	74.68	**AN**	392.00	13.27	**N**
2004	386.00	-211.3	**BN**	548.30	-21.31	**BN**
2005	138.60	-11.77	**N**	548.80	-21.42	**BN**
2006	0.00	100.0	**AN**	0.00	100.00	**AN**
2007	114.00	8.06	**N**	456.40	-0.97	**N**
2008	200.00	-61.29	**BN**	723.40	-60.04	**BN**
2009	52.00	58.06	**AN**	476.60	-5.44	**N**
2010	64.00	48.39	**AN**	585.80	-29.60	**BN**
2011	91.80	25.97	**AN**	569.72	-26.04	**BN**
2012	37.20	70.00	**AN**	427.10	5.51	**N**
2013	31.40	74.68	**AN**	478.80	-5.93	**N**

Year	North-East Monsoon			Total
	Normal Rain		262	
	Actual	Departure	Class	955.09581
1971	50.20	80.84	**AN**	860.5
1972	436.10	-66.45	**BN**	1020
1973	676.20	-158.09	**BN**	1333.4
1974	424.20	-61.91	**BN**	1013.4
1975	816.40	-211.60	**BN**	1663.9
1976	362.30	-38.28	**BN**	879
1977	339.60	-29.62	**BN**	786.9
1978	551.10	-110.34	**BN**	1163.2
1979	599.50	-128.82	**BN**	1322.7
1980	158.90	39.35	**AN**	447.2
1981	326.50	-24.62	**BN**	802.8
1982	284.90	-8.74	**N**	707.1
1983	505.00	-92.75	**BN**	1103.2
1984	261.40	0.23	**N**	786.3
1985	136.30	47.98	**AN**	417.5
1986	803.30	-206.60	**BN**	1708.4
1987	464.70	-77.37	**BN**	1018.7
1988	842.80	-221.68	**BN**	1745.8
1989	458.10	-74.85	**BN**	973.1
1990	296.90	-13.32	**N**	725.9
1991	537.50	-105.15	**BN**	1233.5
1992	447.10	-70.65	**BN**	997.1
1993	575.80	-119.77	**BN**	1237.9

1994	128.30	51.03	**AN**	315.5
1995	447.10	-70.65	**BN**	1086.1
1996	636.40	-142.90	**BN**	1375.4
1997	450.40	-71.91	**BN**	959.4
1998	449.20	-71.45	**BN**	1040.4
1999	273.20	-4.27	**N**	578.8
2000	397.00	-51.53	**BN**	934.6
2001	639.20	-143.97	**BN**	1496.2
2002	63.40	75.80	**AN**	339
2003	405.30	-54.69	**BN**	828.7
2004	569.60	-117.40	**BN**	1503.9
2005	351.70	-34.24	**BN**	1039.1
2006	0.00	100.00	**AN**	0
2007	299.80	-14.43	**N**	870.2
2008	177.60	32.21	**AN**	1101
2009	27.20	89.62	**AN**	555.8
2010	254.60	2.82	**N**	904.4
2011	114.50	56.30	**AN**	776.02
2012	237.20	9.47	**N**	701.5
2013	205.40	21.60	**AN**	715.6

Note	BN=Below Normal(<20%)	N=Normal (-20%to +20%)	AN=Above Normal(>+20%)

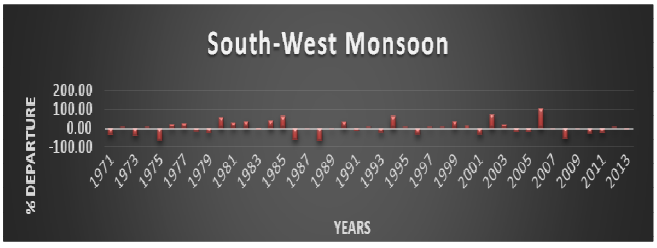
	Pre-monsoon	**South-West monsoon**	**North-East monsoon**	**Annual**
Mean	124mm	452.2mm	262.2mm	955.10 mm
Std.Dev.	74	159	194	558.04
CV %	146	52	25	58
Max R.F.	386mm-2004	772mm-1988	842mm-1988	1745mm-1988
Min. R.F.	0mm-1994,99	134mm-2002	50mm-1971	315mm-1994
Below Normal	10	11	29	10
Normal	15	17	7	21
Above Normal	18	15	7	12

Table 3.2 3-Year and 5-year Moving Average Curve

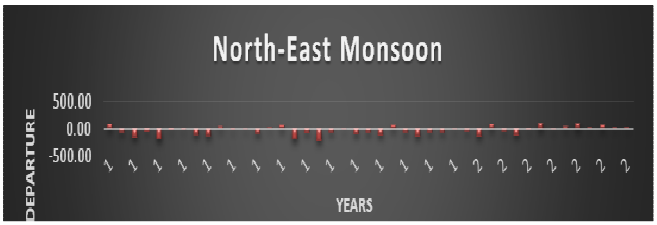
Year	**Actual Rain**	**3 year**	**5 year**
1971	860.5	1071.30	1178.24
1972	1020		
1973	1333.4		
1974	1013.4	1185.43	
1975	1663.9		
1976	879		919.80
1977	786.9	1090.93	
1978	1163.2		
1979	1322.7		
1980	447.2	652.37	
1981	802.8		763.38
1982	707.1		
1983	1103.2	769.00	
1984	786.3		
1985	417.5		
1986	1708.4	1490.97	1234.38
1987	1018.7		
1988	1745.8		
1989	973.1	977.50	
1990	725.9		
1991	1233.5		974.02
1992	997.1	850.17	
1993	1237.9		
1994	315.5		
1995	1086.1	1140.30	
1996	1375.4		977.72
1997	959.4		
1998	1040.4	851.27	
1999	578.8		
2000	934.6		
2001	1496.2	887.97	1041.38
2002	339		
2003	828.7		
2004	1503.9	847.67	
2005	1039.1		
2006	0		686.28
2007	870.2	842.33	
2008	1101		
2009	555.8		
2010	904.4	793.97	
2011	776.02		731.04
2012	701.5		
2013	715.6		

Graph 3.1 %Departure during Pre-Monsoon Period

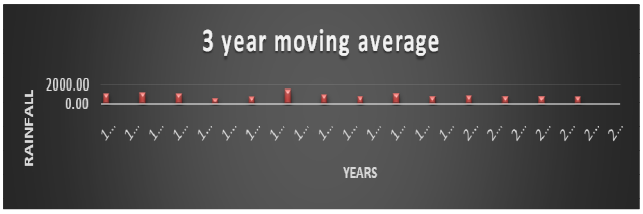
Graph 3.2 %Departure during South-West Monsoon Period



Graph 3.3 %Departure during North-East Monsoon Period



Graph 3.4 3-Year Moving Average Curve



Graph3.5 5-Year Average Moving Curve

Table 3.6 Drought Chart of Hoskote Town

Year	DECADES			
	1971-80	1981-90	1991-2000	2001-2010
1	25		55	
2				
3	20.4		38	
4				36
5	57.5			
6		40.3		
7		20.4		
8		26		
9				
10				
Total	3	3	2	1

IV. REMEDIAL MEASURES

The ground water of the taluk is over exploited (225%), and designated a dark area by DMG of Govt. of Karnataka. Water supply is 20 % of demand (even @ of 100 lpcd) Hence there is an urgent need to revive the water resources of the Taluk, to:

i. Conserve the ground water
ii. Meet the demand
iii. To prevent future water shortage problems.

And as such the following are the remedies suggested to improve the water resources of the Taluk:

Rain Water Harvesting, Construction of Nalabunds, Check Dams and Weirs, De-silting of Tanks, Construction of Farm Pond, Agro Forestry, Recharging of Ground Water, Conservation of Water, Waste Water Treatment and Recycling, Regulation of Ground Water Development.

V. CONCLUSION

With a current approximate population of 3, 03,428, Hoskote Taluk is facing severe water problems and it is seen that with the current availability of water resources in the Taluk, it is impossible to meet the demand for water. Hoskote Taluk can no longer depend on its main sources of water, rainfall and ground water as it has been exhausted to its core and is now in its critical stages. The next main source of water for both drinking and irrigation are Tanks, which too are now running on their 50 % capacity owing to unpredictable rainfall and deposition of silts.

Hoskote TMC supplies water for 1-2 hours @ of 50 LPCD on an average, which falls short of Demand @ of 80 LPCD.The people there meet the rest of their water demand through private tankers. Rainfall though very variable, both seasonally and yearly, it still has provided an average minimum of 450 mm of water yearly. But however rainfall harvesting is still in its initial stages in the Taluk. The best and most economical methods of improving the water scenario would be not to concentrate on a single source of water but to give equal importance to every source. Rain water harvesting on large scale would be economical and will be able to meet the demand set by the population. Small projects like construction of Nalabunds, Check Dams, etc., must be taken up at all the places possible, for they will check the surface flow of rain water, form percolation ponds. Later on, all the waste water from the Taluk can be treated on a large scale and reused. And for that the required data, such as water

demand of population, quality of sewage, etc., must be collected and examined.

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