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CLIMATIC GRADIENT AND HYDROMETEOROLOGICAL CHARACTERIZATION: STUDIES FROM THE CAUVERY RIVER BASIN SOUTH INDIA

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ABSTRACT

Humid, transition or sub-humid and Semi-arid lands are characterized by a combination of high temporal variability in rainfall and spatial heterogeneity of Hydro meteorological properties. As a consequence, presence of decadal variations in rainfall along with temporal variations will impact on groundwater extractions for irrigation requirements and their hydrological regime. In addition, during the past half century, changes have occurred in most semi-arid lands in the southern India agricultural abandonment and consequently a change in land use. In order to investigate the hydro meteorological consequences of such abandonment, three representative field sites on contrasting climate were instrumented additional field observations, experiments and secondary data simulations were performed to characterize the watersheds. A summary of the first long term results of analyses of rainfall, Temperature Evapotranspiration wind speed and other hydro meteorological variables are analyzed in climosequence zone at micro catchment scales is presented here.

KEYWORDS: Rainfall Variability, Climosequence, Hydrometeorology and Characterization of Watershed

INTRODUCTION

The climate of south India is strongly dependent on the south-west monsoon. During this rainy season the country receives 75% of the annual rainfall. The monsoon originates in the Indian Ocean and reaches the southern part of the Kerala State, in the south-west coast of India, by the end of May (Figure 1). The monsoon beginning is accompanied by south-westerly winds, which advance across the country in two branches, the Arabian Sea branch (west coast) and the Bay of Bengal branch (east coast).The monsoon is not a period of continuous rainfall. Indeed the weather is generally cloudy with frequent rains or storms at the end of the day.

Hydrometeorology is very important aspect to characterise the hydrological behaviours in the watershed studies. Temperature, precipitation, relative humidity and wind speed are the important climatic elements, among which precipitation is the major source of all groundwater. The study of the distribution of precipitation both in space and time is of great significance in climatological assessment of water resources of a region. According to the climatic classification of thronthwait the study areas belongs to different climatic conditions (semi-arid to sub-humid condition).

LOCATION AND COMMUNICATION

Upper Cauvery basin stretches from 11º 20’ to 12 º 40’ northward and from 75º 48’ to 77º 30’ eastward covering two major states – Karnataka and Kerala of South India. This upper Cauvery basin stretches along three main climatic zones demarked in terms of annual rainfall, starting from 2500 mm at the western end to 500 mm at the eastern end within a distance of 80 km. The three climatic zones are classified based on mean annual rainfall viz. ‘semi–arid’ (R = 500 - 800 mm/ yr), ‘humid’ (R = 1500-2500 mm/yr) and the intermediate ‘sub-humid’ (R = 800 - 1500 mm/yr) (Figure 2 & 4).

The studies as been carried out on three different watersheds at 11° 44' N and 76° 27'E to 12° 00' N and 76° 45' E. Mulehole watershed (4.5 km²) is located in Bandipur National Park, close to the Mulehole check post (Chamrajanagar district, Karnataka state). The second watershed, Maddur (6.3 km²) at 11° 46' N and 76° 34' E to 11° 47' N and 76° 32' E stretches at about 10 km East of Mulehole, at the edge of the forest. It includes a cultivated zone in its southern part, which represents approximately one third of its surface area. The other two third are covered with national forest. The third watershed, Terakanambi (92.5 km²) at 11° 53' N and 76° 42' E to 11° 49' N and 76° 48' E is located 30 km away from the Maddur watershed between Gundalpet and Chamarajanagar cities. These three watersheds (Figure 3) are located in the transition climatic zone. The area under investigation is approachable from different parts of the state by all well connected roads, southern railway line is connecting Mysore and Chamarajanagar passes close to study area.

Figure 1: India Monsoon Onset Map (Source: Wikipedia)

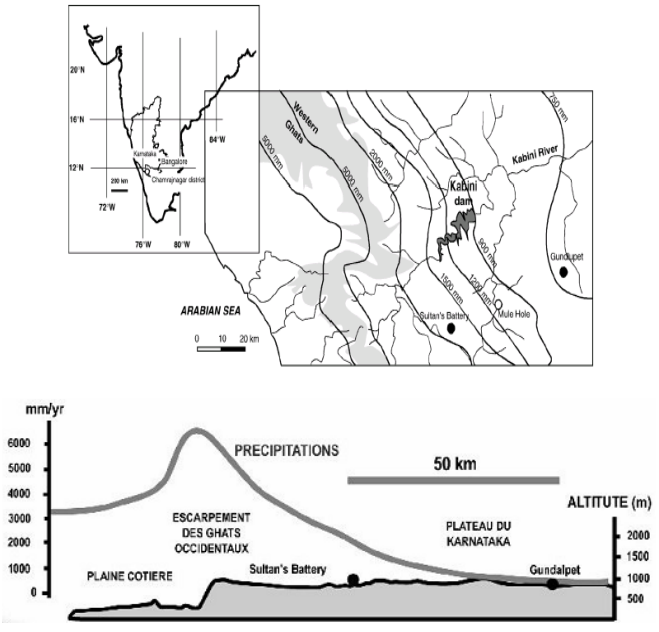

Figure 2: Climatic Gradient on the Backslope of the Western Ghats (Black Lines are Isohyets), Main River Course and Location of the Mulehole Studied Site in Southern India (Modified from Gunnell and Bourgeon, 1997)

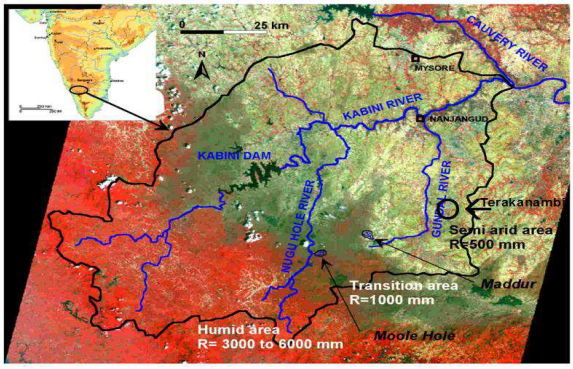

Figure 3: Location of the Study Area

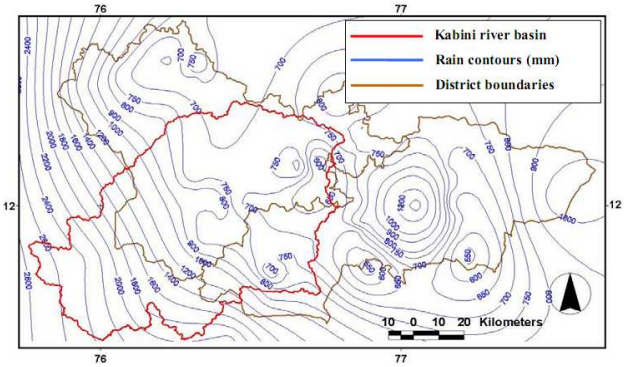

Figure 4: Isohytal Map of South Cauvery

CLIMATIC SETUP OF THE STUDY AREA

The Mulehole watershed is located in the climatic sub-humid transition area, the elevation varies from 820 - 910 m above MSL and the mean annual rainfall (n=20 years) is 1125 mm. The climate is characterized by recurrent but non-periodic droughts, depending on monsoon flows. The mean yearly temperature is around 27°C. Streams are temporary flowing for a few hours to a few days after the stormy events of the rainy season. Maddur watershed is located in transition area from sub humid to semi-arid zone and the mean annual rainfall is 900mm. The area presents two distinct parts viz. a forested part in the North and an inhabited and cultivated part in the South representing respectively two thirds and one third of the watershed. The elevation varies from 872 to 1116 m above MSL, with an average elevation of 923 m. The relief is more marked in the North of the watershed. Terakanambi watershed located in Semi- arid zone nested in the Gundal sub-basin and the mean annual rainfall is 700 mm.

The climate of Terakanambi watershed is quite moderate throughout the year with fairly hot summer and cold winter. March to May is summer months, June to September is the southwest monsoon period, October (106 mm) and November is the post monsoon. The ground level at the lowest point at the outlet of watershed is 760 m above MSL with about 860 m above MSL in the upland regions. This provides gentle topographical slopes in the watershed influencing the groundwater movement. This watershed is characterized by higher level of pumping, which is used for growing crops both in the monsoon and non-monsoon seasons.

Another feature characterizing the precipitation in the study areas are irregular annual distribution. Different sub-basins lying along this climatic gradient of Upper Cauvery basin (Figure 2) among that pristine watershed Mulehole (Sub-humid) and Maddur (transistion between Sub-humid to semi-arid) cultivated and Terakanmbi watershed (Semi-arid)

MATERIALS AND METHODS

Data Collection

The climatic data of the study area has been collected from automatic weather station (CIMEL, type ENERCO 407 AVKP) from 2003. It records hourly and daily Rainfall, Temperature, Relative Humidity, Global radiation, Wind speed and Wind direction. These parameters allow the calculation of Penman.s PET. Data are also collected from Indian Meteorological Department for 1976 to 2010.

RESULTS AND DISCUSSIONS

Mulehole Watershed

The average monthly rainfall data of Mulehole watershed are computed in Chart 1. The result follows a bimodal statistic with the larger mode usually during the month of July and second peak during the month of October. However, number of rainfall days is maximum during the month of July. The watershed receives larger storm events during the months of April - May and September - October as compared to the month of June - August where the rainfall is characterized more number of shorter duration rainfall.

The month of April and May is usually associated with the starting of the Southwest monsoon season and September and October with the Northeast monsoon. The rainfall is highly erratic in nature during the month of March during which the region receives pre-monsoon showers.

Maddur Watershed

The rainfall data at Maddur station has been analysed (Chart 2), the trend of the precipitation looks similar to Mulehole but the precipitation is comparatively low, however the rainfall is higher at July and October due to the southwest and northeast monsoon set. Rains of October could be important for aquifer recharge because they arrive at the end of the monsoon, when the soil is probably saturated with water. These precipitations could represent a good contribution to the aquifer.

Terakanambi Watershed

Terakanambi watershed receives rainfall from southwest monsoon from June to September and northeast monsoon from October to December (Chart 3). Overall on an average, there are 50 normal rainy days. Retreating monsoon season with clear bright weather and during December to February weather remains dry. During October and November some of the depressions and cyclonic storms originates in Bay of Bengal, which passes through the district, causing wide spread heavy rains and high winds.

There is a good coherence between Mulehole, Maddur and Terakanambi data. The precipitation presents the same dynamic, but different amplitudes (Chart 5), it could be fulfilled that, theoretically the pressure on water is higher in Maddur and Terakanambi than in Mulehole. But we observe that the south-west monsoon permit a good recharge of the aquifer from July to September (Chart 4). Uniqueness of sub-humid and semi-arid zone is the bi-modal rainfall pattern with rainfall occurring once in April to June period and again during September to November period of the same year.

The comparative results of the watersheds shows a unique climosequence in a short distance from West to East and the long term rainfall observations shows increasing droughts are higher and moderate to low from East to West.

Relative Humidity

The relative humidity is the degree of water vapour present in the air and expressed in terms of weight percent by volume. The relative humidity is the percent ratio of the absolute humidity to the saturation humidity for the temperature of the air mass (saturated air as100% and the dry air as 0% relative humidity). The mean monthly relative humidity at Mulehole watershed varies from (minimum and maximum) 10 to 115 %, Maddur is 18 to 105 % and Terakanambi is 24 to 84%.

Wind Velocity

The mean wind velocity for the whole year is about 8.3, 9.1 and 10.6 km per hour in Mulehole, Maddur and Terakanambi watersheds respectively. The mean wind velocity is highest during the months of May to September, ranging from 6.1 to 11.5, 7.3 to 13.7 and 10.2 to 14.1 km per hour respectively. The low velocity winds occur during the months of October to November ranging from 3.1 to 7.3, 4.5 to 8.5, and 7.9 to 9.3 km per hour, respectively.

Temperatures

The evaporation from the surface water and soil are directly related to the temperature. It also affects the process of transpiration. Temperature is essential for the calculation of evapotranspiration. In the study area summer is the hottest season with an average maximum temperature of 27.3, 29.8 and 33.6º C in Mulehole, Maddur and Terakanambi watersheds respectively and sometimes rise up to 39º C at Terakanmbi watershed. The lowest mean temperature in this season is 17.6, 18.5 and 20.9º C respectively. November and December are the coldest months with an average maximum temperature of 25.4 to 27.8º C and mean minimum temperature of 15.1 to16.4º C and sometimes drop to as low as 12.6º C.

Potential Evapotranspiration

The Potential evapotranspiration (PE) is the evapotranspiration that would occur when there is an adequate soil moisture supply to meet the demand. This is an important factor in water balance studies. There are number of methods of estimation of PE. The methods suggested by Penman (1948), are widely used. Based on Thornthwaite equation, the PE and AE for different stations in Karnataka State were worked out by Subrahmanyam (1964).The PET as been calculated using Penman method with SWAP software, the Average annual ETP for Mulehole is 1067 mm, Maddur is 1132 mm and Terakanambi is 1183 mm.

Actual Evapotranspiration (AET)

The actual evapotranspiration (AET) is less than the PET when there is no adequate water supply for evaporation and transpiration. Evapotranspiration (ET) may be measured (directly or indirectly) or estimated. Estimation of actual evapotranspiration (AET) is objective of most of the budgeting water balance in the watersheds. The AET in Mulehole was found to 83%, 76% in Maddur and 70% is at Terakanambi of the average annual rainfall, the average annual evapotranspiration is 929, 747 and 581 mm respectively

CONCLUSIONS

Hydrometeorological parameters has been monitored and studied in Mulehole, Maddur and Terakanambi watersheds. These watersheds are falling under Climo-sequence and also the representative watersheds of upper Kabhini basin a tributary of main river of Cauvery in Chamarajanagar district of Karnataka in southern India. The upper Cauvery

basin stretches along three main climatic zones based on the rainfall. Western Ghats at the western end is the humid zone receives a rainfall about 1500 mm to 3000 mm and at the sub-humid zone is forested area receives about 900 to 1500 mm (Mulehole watershed) and at the eastern end is semi-arid zone receives about 500 to 900 mm (Maddur and Terakanambi watersheds) within a distance of 80 km. In humid zone shows uni-model type of rainfall showering in one stretch from April to November and the uniqueness of the sub-humid and semi-arid zones has bimodal type of rainfall due to the South west monsoon from April to June and North East monsoon is from September to November, there are eastern cyclones and also local rain exist during December.

The climate is charecterised by recurrent but non periodic droughts depending on monsoon flows. In a humid region the runoff flows all the year as a flood and as a base-flow but in sub-humid and semi-arid streams are temporary flowing for few hours to few days after the storm events. The analysis of the rain data indicates that there is a very wide variation in the rainfall pattern compared to the long term average. This stresses the importance of long term studies.

The actual evapotranspiration was found about 95% at western end and 70% at the eastern end. Average maximum temperature shows increased trend from sub-humid to semi-arid region. The mean monthly relative humidity decreases from sub-humid to semi-arid and the mean wind velocity is highest during the months of May to September, shows increased trend.

ACKNOWLEDGEMENTS

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APPENDICES

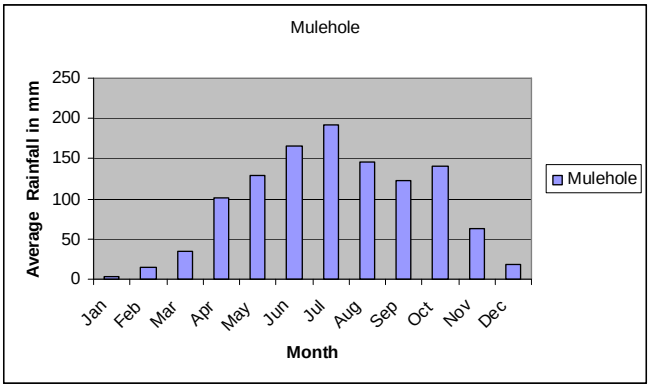

Chart 1: Showing Monthly Average Rainfall at Mulehole (1976-2010)

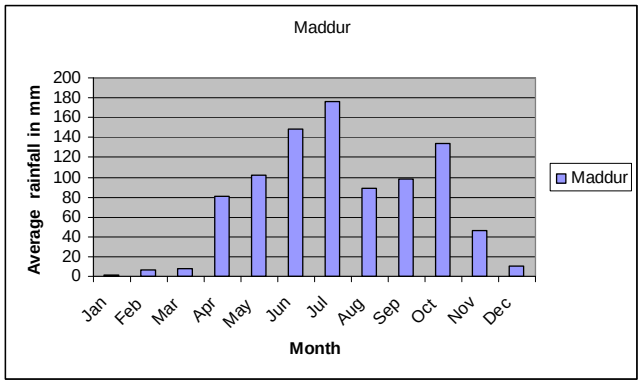

Chart 2: Showing Monthly Average Rainfall at Maddur (1976-2010)

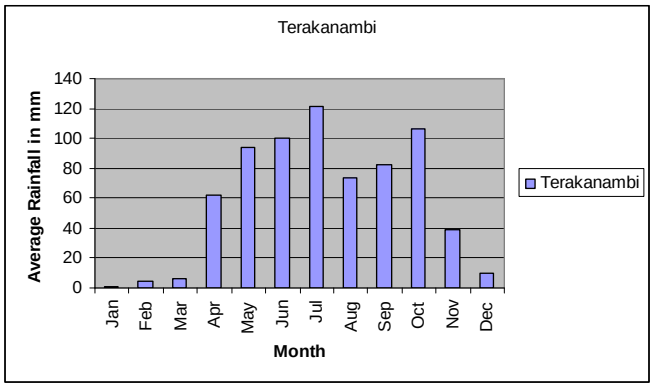

Chart 3: Showing Monthly Average Rainfall at Terakanambi (1976-2010)

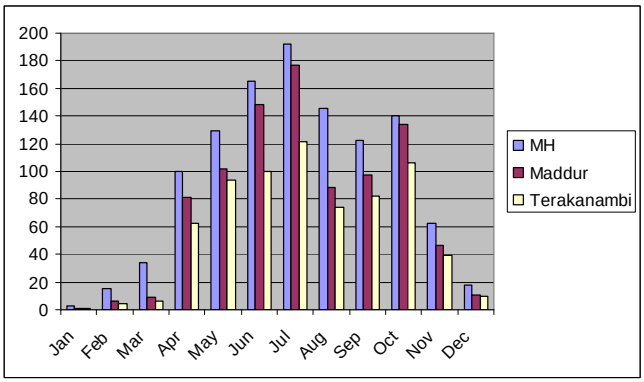

Chart 4: Average Monthly Rainfall of Mulehole, Maddur and Terakanambi Areas

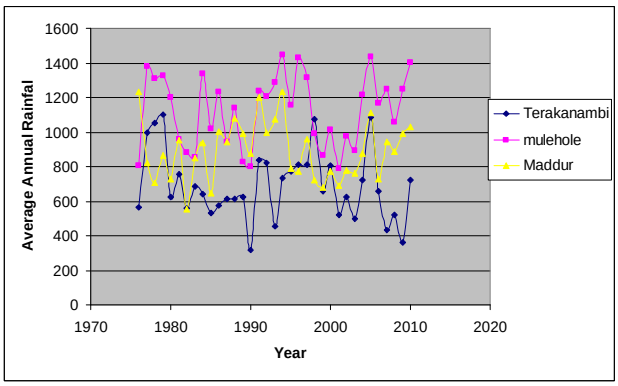

Chart 5: Average Annual Rainfall of Mulehole, Maddur and Terakanambi

Table 1: Comparison of Monthly Rainfall in Mulehole, Maddur and Terakanambi

Month	Mulehole	Maddur	Terakanambi
Jan	2.5	1.2	1
Feb	15.35	6.1	4.4
Mar	34.1	8.6	6.1
Apr	100.4	81.1	62.4
May	129.2	101.76	94
Jun	164.8	147.8	100.3
Jul	191.6	176.7	121
Aug	145.2	88.4	73.8
Sep	122	97.43	82
Oct	140	134	106.4
Nov	62.7	46.65	39.3
Dec	18	10.6	10
Total	**1125.85**	**900.34**	**700.7**

Table 2: Average Annual Rainfall of the Study Areas

Years	Terakanambi	Maddur	Mulehole
1976	564.6	1234.2	807.6
1977	996.2	822	1380
1978	1051.4	705.6	1311.4
1979	1101.8	967.8	1327.2
1980	623.7	727.1	1202.3
1981	782.8	912.2	958.9
1982	682.3	552	882.2
1983	682.3	848	987.8
1984	639.1	937.4	1245.4
1985	533.9	787.3	1018.1
1986	574.4	1005.2	1235
1987	613.7	943.3	1118.9
1988	616.3	1080.8	1142.2
1989	626.8	993.4	854.4
1990	432.4	886	948.76
1991	839.3	1200.6	1237.2
1992	819.6	996	1119.4
1993	456.8	1075.1	1268.5
1994	735.1	1231.5	1444.8
1995	755.8	789.4	1153.6
1996	809	770.6	1430.1
1997	811	958.7	1314.4
1998	1073.4	722.4	989.8
1999	756.3	698.4	868.4
2000	808.2	785.5	1012
2001	518.8	688.1	789.8
2002	609.4	876.43	678.79
2003	501	761.3	894.4
2004	724	879.3	1215.8
2005	1085	1110	1434
2006	655.4	727	1169.5
2007	435.1	941	1252
2008	521.8	887.9	1059.5
2009	362.4	992	1250.5
2010	721	1028	1400.5

Table 3: Average Relative Humidity, Wind Velocity, Temperature, PET and AET

Details	Mulehole	Maddur	Terakanambi
Avr. Relative Humidity (%)	10-115	18-105	24-84
Avr. Wind Velocity kph	3.1-11.5	4.5-13.7	7.9-14.1
Avr.Temperature. ºC	17.6-27.3	18.5-29.8	20.9-33.6
Avr.PET (mm)	1067	1132	1183
Avr.AET (%)	83	76	70