551.578.13 (540.65)

RAINFALL TREND ANALYSIS OF KOLLI HILL, TAMIL NADU, INDIA

1. Rainfall uncertainty is one among the slices of climate variation which has a vital role in many aspects like, ecological, economical and aesthetical diversity of the country. In India many studies have been done to investigate the significance of rainfall events with a special concern of monsoonal changes and global warming (Balachandran *et al*., 2006). Though there are a number of rainfall trend analysis studies for different parts of India. The rainfall trend analysis of Kolli hill further stretches significance due to the fact of study area's complex topography and floristic composition. The purpose of this study is to reveal the temporal rainfall trends and the seasonal changes in Kolli hill, Tamil Nadu.

The study area Kolli hill falls under the Eastern Ghats of India which lies between longitudes of 78° 15′ to 78° 30′ E and latitudes of 11° 10′ to 11° 30′ N, covering about 503 km^2 with an altitude ranging from 200 m at the foot hills to 1415 m at the plateau (Fig. 1).The area mainly experiences rainfall during four seasons winter (January-February), summer (March-May), southwest monsoon (June-September) and northeast monsoon (October-December) respectively. Among the inhabitants, 97% are scheduled tribes who primarily are dependent up on agriculture for their economy. Of the total area 44% of the hill comes under forest domain and 51.6% has been used for agriculture and less than 5% for other activities. The entire forest area (27156.61 ha) circumscribes 14 reserve forests (Jayakumar *et al*., 2009).

2. The required source for Kolli hill rainfall data (41 years 1970-2011) were obtained from the Horticulture Department at Padacholai in Kolli Hill (Long. 78° 22' 9.76" E and Lat. 11° 20' 50.02" N) The data were subjected for rigorous statistical analysis to identify the rainfall trends in the area. The data was also subjected for Mann-Kendall test. Since this test has been recognized as the robust statistical tool and is suggested to be the most appropriate statistical method for analyzing long term data set. Hence, this has been applied in analyzing the significance of annual, seasonal and monthly rainfall trends. However five years running mean anomaly of annual and seasonal rainfall were also carried out and subjected for the Mann Kendall test. The equation used is,

$$Tt = 0 \pm tg\sqrt{\left[4N + 10/9N\left(N-1\right)\right]}$$

where *tg* is the desired probability point of Gaussian normal distribution. This study considered *tg* at 0.05 as the points of significant. Seasonal classification of the data

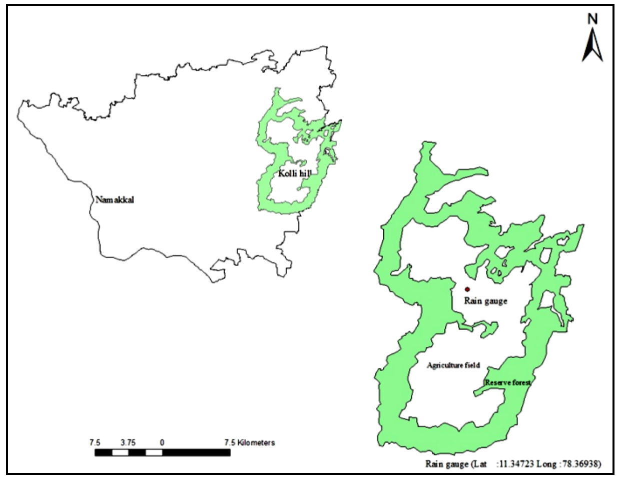

Fig. 1. Study area (Kolli Hill)

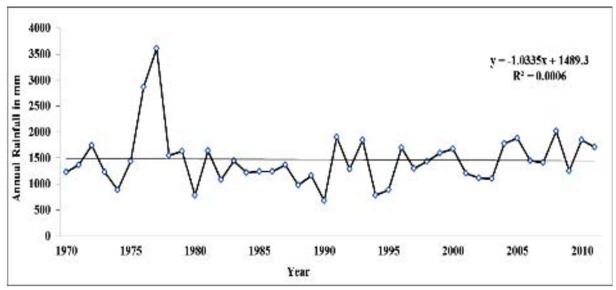

Fig. 2. Annual rainfall trend of Kolli hill

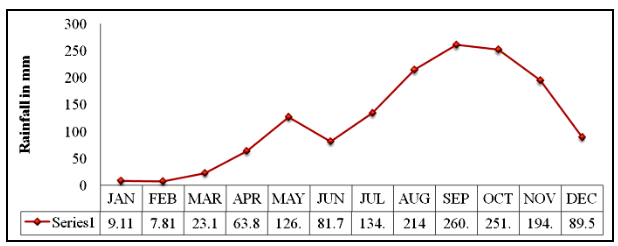

Fig. 3. Forty one (41) years monthly average rainfall

as well as the excess and deficit rainfall years within the study period were defined based on the India Meteorological Department (IMD) norms followed by Tiwari *et al*. (2007).

3. Annual rainfall - From the data analyzed, the average annual rainfall of Kolli hill in the period of 41 years is found to be 1467.05 mm with a standard deviation of 527.06 mm. It is observed that the annual average rainfall exhibited from the hill is much higher when compared to the Namakkal district annual average rainfall (840 mm) as per North Western Zone - Status Report (http://www.tnau.ac.in/), which may be because of the orographic pattern of the hills. Though the data shows a decreasing trend in the mean annual rainfall the *tg* value

TABLE 1

Rainfall and Mann-Kendall tau coefficient

Month	Rainfall (RF)		Kendall's tau	Linear trend equation	R^2	p
	S.D.	% of annual RF				
January	22.04	0.62	0.106	$y = -0.0905\,x + 11.065$	0.0025	0.381
February	15.13	0.53	-0.085	$y = -0.1167\,x + 240.07$	0.009	0.489
March	45.86	1.58	-0.180	$y = -0.4578\,x + 934.49$	0.015	0.112
April	63.18	4.35	0.095	$y = 1.0581\,x - 2042.3$	0.0422	0.385
May	76.40	8.64	0.097	$y = 1.2183\,x - 2298.3$	0.0383	0.374
June	64.22	5.57	-0.163	$y = -0.6223\,x + 1320.5$	0.014	0.494
July	93.06	9.15	**-0.211**	$y = -2.553\,x + 5216$	**0.1133**	0.051
August	133.48	14.59	0.103	$y = 0.7495\,x - 1277.8$	0.0047	0.34
September	140.95	17.74	**-0.238**	$y = -4.5916\,x + 9399.9$	**0.1597**	**0.027**
October	168.66	17.47	0.186	$y = 2.6375\,x + 199.6$	0.0368	0.085
November	166.83	13.53	**0.186**	$y = 2.906\,x + 136.02$	0.0457	0.085
December	108.69	6.23	-0.045	$y = -1.1708\,x + 116.58$	0.0175	0.688
Annual	527.06	100	0.103	$y = -1.0335\,x + 1489.3$	0.0006	0.343
Winter	29.16	1.41	0.005	$y = -0.0173\,x + 1.7841$	0.0043	0.973
Summer	110.65	14.98	0.148	$y = 0.0942\,x + 13.045$	0.0334	0.1733
Southwest	298.31	47.27	**-0.247**	$y = -0.4175\,x + 56.532$	**0.1499**	**0.020**
Northeast	305.23	36.34	**0.323**	$y = 24.327\,x - 462.21$	**0.1426**	**0.005**

*Bold values are significant at 5%
S.D. - Standard Deviation

TABLE 2

Excess and deficit rainfall years of Kolli hill during 1970-2011

Rainfall excess years	1976	1977	1991	1993	2004	2005	2010			
Rainfall deficit years	1974	1980	1982	1988	1989	1990	1994	1995	2002	2003

from the Mann-Kendall test indicate its insignificants at 0.05 level (Table 1). The decreasing mean annual rainfall trend in the study area resembles the previous rainfall trend studies carried out in the country (Kumar *et al.*, 2013). Excess and deficit rainfall years over Kolli hill have been analyzed and tabulated (Table 2).

Monthly and seasonal rainfall - The highest rainfall recorded during the period of study in the hills was in 1977 while the lowest was in 1990. The contribution of the north east monsoon is conspicuously less in all the deficit rainfall years. Of all the deficit years, 1982, 1994 and 2002 were El Nino years. The highest rainfall in the Kolli hill is recorded in the month of September which accounts for 17% of the total annual rainfall while the lowest (0.53%) in the month of February (Table 1). Four decades of monthly rainfall normal show a decreasing trend in September ($R^2 = 0.1597$), June ($R^2 = 0.014$) and July ($R^2 = 0.1133$) months (Table 1).

The significant decreasing trend of rainfall in the month of September is confirmed by Mann-Kendall tau coefficient. The major contribution of seasonal rainfall in the study area is by the southwest monsoon (47.27%) followed by northeast monsoon (36.34%). Winter and summer monsoon contribute 1.41% and 14.98% as well (Table 1). Normally Tamil Nadu receives its major part of rainfall from the northeast monsoon, followed by the southwest (Kumar *et al.*, 2004) but in contrast Kolli hill receives its predominant contribution from southwest monsoon which may be because of its strategic location near the Palghat Gap of Western Ghats facilitating the

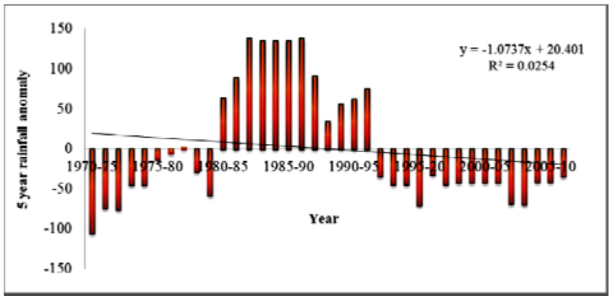

Fig. 4. Running mean anomaly of winter rainfall

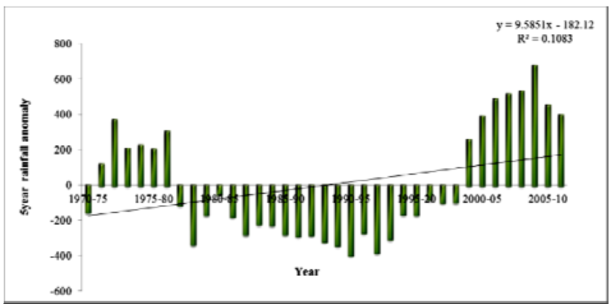

Fig. 5. Running mean anomaly of summer rainfall

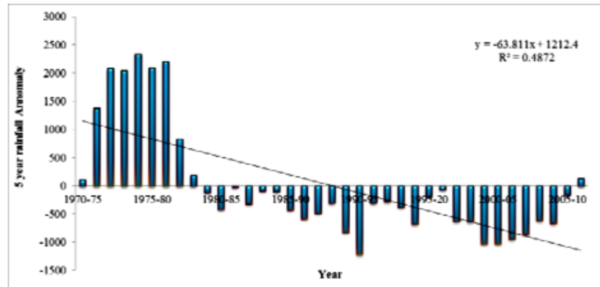

Fig. 6. Running mean anomaly of southwest monsoon rainfall

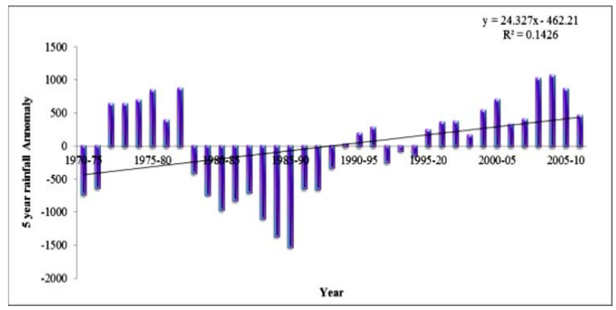

Fig. 7. Running mean anomaly of northeast monsoon rainfall

flow of southwest monsoon currents in the gap (Jegankumar *et al*., 2012). The seasonal running mean anomaly exhibits 1.07 mm decrease in the winter rainfall and 9.58 mm increase in the summer rainfall (Figs. 4 & 5). Though there is a decreasing and increasing trend in the winter (1.073 mm) and summer (9.585 mm) rainfall respectively, Mann-Kendall test revealed that both the trend is insignificant (Table 1). But at the same time the running mean anomaly of the southwest monsoon and northeast monsoon rainfall indicated 63.81 mm of decrease and of 24.32 mm increase respectively in the study area (Figs. 6 & 7). Both the trends are statistically significant at 0.05 levels when confirmed with the Mann Kendall test (Table 1).

Many researchers have identified the impacts of rainfall uncertainty on forests as well as agricultural ecosystems throughout the world including India (Kumar *et al*. 2004). Even though Kolli hill comes under dry deciduous forest type the hills holds evergreen forest in its high altitudes. The present study suggests that the evergreen forest in the uphill may become more vulnerable to the seasonal changes and hence requires further detailed analysis. In addition to the forest sector, the agriculture sector also plays a major role in the economy of the hills as most of the tribes are agriculture dependent for their livelihood. The progressive change from the traditional agricultural pattern (paddy, millets etc.) of Kolli hill to cash crop like tapioca, pineapple etc. is clearly visible. Unavailability of the adequate rainfall is one of the reasons for this shifted pattern of cultivation. It is crucial to study the change in climate variables and its impact on the hills under these circumstances.

4. The study concludes that there is no significant trend in the annual rainfall of the study area but at the same time significant decreasing trend in the southwest monsoon is seen which is the principal rainfall season of this area and people are dependent on it. However an increasing trend in northeast monsoon seasonal rainfall is seen. Though the decreasing southwest monsoon can be compensated with the contribution of northeast monsoon trend, the agriculture as well as forest seasonal pattern could be altered which in turn will affect the whole bio-diversity of this area. Rainfall being a key determinant resource for both agricultural and natural vegetation of Kolli hill, this study may be relevant to build sustainable forest management plans, taking into considerations of the climate change. Also declining monsoon rainfall in the study area might be a sign of climate change. Detailed analysis of climate variables and its impact on the bio-diversity as well as livelihood are required in the Kolli hill in order to conserve its rich diversity.

5. The authors would like to thank University Grant Commission (UGC), Government of India for the financial support, the Centre for Climate Change and Adaptation Research group for the moral support, both Forest & Horticulture department at Kolli hill and Anna University for providing all the facilities. We would also

extent our gratitude to Dr. Jayanti Narendran and Dr. Brinda Sivakumar for their valuable advices during the paper discussion.

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