Trends and variability of rainfall in Mizoram

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Abstract

The cause of climate change detection is very tedious and complex phenomenon. The present study highlights the rainfall variability and has been identified using the nonparametric Mann-Kendall and Sen's slope estimators over for 20 years from 2001- 2020. The non-parametric tests have been tested at the 5% level of significance. The non-parametric tests were applied for 12 months and divided into four season as pre monsoon (March, April and May), monsoon period (June, July, August and September), post monsoon (October, November and December) and winter rainfall (January and February). Annual rainfall has also been evaluated to show the trends of rainfall in Mizoram.

Keywords: Mann-Kendall test, Sen's slope estimators, Mizoram.

Introduction

The uncertainty and uneven arrival of rainfall can be observed since from the last few years. The changing rainfall pattern and its impact on the water resources are an important climatic problems facing society today. Associated with global warming, there are strong indications that rainfall changes are already taking place on both the globe[2] and regional scale[7]. It has changed from increasing trend in the first half of the 20th century to a significant decreasing trend in rainfall during the south west monsoon observed in Chhattisgarh, Jharkhand, Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura[3].

There are few studies of rainfall trend in North East India and Mizoram. Kamal and Pachauri[5] found that overall, annual, monsoon and winter precipitation indicate declining trends whereas pre-monsoon rainfall shows most of the increasing trends at all stations during the whole Bora et al[1] in their study on North East India also observed that there is variability in annual and seasonal rainfall patterns in the seven States of NE India.

Jain et al[4] also reported in their study that annual rainfall also does not show much scatter but rainfall for winter and post-monsoon seasons has large variation from one year to the other.

In their study, there was large variability in magnitude and direction of trend of rainfall data from one meteorological subdivision to another. Overall, no clear pattern has emerged, either spatially or temporally. Decadal analysis of the data indicates that the inter-seasonal shifting of the rainfall during recent decades (1947-2006) increased where monsoon total is decreasing significantly and post monsoon is increasing. Strong positive correlation was observed between SOI and monsoon as well as post monsoon rainfall with decreasing trend during recent decades for monsoon rainfall[8].

Mizoram located in the extreme corner of North East India received more than 250 cm of rainfall in a year. A study conducted by Tiwari[9] reported that there has been erratic behavior of rainfall during the period of study. However, for certain years, a periodic decrease in rainfall is recorded but it does not continue for the whole period. There has been an increase in the mean maximum temperature by 1.8^0C just in 5 years which seems to be one of the reasons for erratic and non periodic nature of the rainfall. The study also concluded that irregular behaviour of rainfall and the rise in mean maximum and mean minimum temperatures may be due to a sharp decline in the forest cover due to various activities like road construction, lack of proper implementation of the forest acts and absence of the monitoring body.

The changes in the topographical landscape due to human interventions are likely to influence atmospheric circulation attitudinally to a large extent. Weaver et al[10] in their study also observed that human influences can significantly affect local weather and climate, at least in the short term. Since both natural and human-modified heterogeneous landscapes are ubiquitous around the globe (e.g. snow/ soil, land/water, pasture/forest, city/country), such atmospheric effects must influence global climate today.

The analysis of climate in Mizoram also shows a declining trend of precipitation since last decade while the analysis of temperature shows a positively high variation[3]. In view of the importance of variability in rainfall, as indicated above, it would be of interest to study the rainfall trend in Mizoram for 20 years as variation of pre-monsoon, monsoon, post-monsoon and winter rainfall over Mizoram.

Material and Methods

The source of rainfall is collected from Meteorological data of Mizoram published by Directorate of Economic and Statistic Government of Mizoram 2020. Annual rainfall, pre monsoon, monsoon, post monsoon and winter rainfall were constructed using monthly rainfall data. Monthly mean and standard deviation was computed season wise viz., Pre-monsoon (March- May), South West Monsoon (June-September), Post- monsoon (October- November) and Winter (December-February). The Mann Kendall test has been employed and Sens slope has also been calculated.

The non- parametric MK test is the most widely applied statistics for the detection of trends in a time series. If the

total number of data in the time series is indicated by N, then statistics S can be computed as:

$S = \sum_{I=1}^{N-1} \sum_{J=I+1}^{N} sgn\,(Y_{j-}Y_{j}\ )$

where Y_j indicates the value of the jth data, n indicates the number of the data and sgn (θ) is the sign function.

$$\text{sgn}(\theta) = \begin{cases} +1\ if\ \theta = \text{Yj} - \text{Yi} > 0 \\ 0\ if\ \theta = \text{Yj} - \text{Yi} = 0 \\ -1\ if\ \theta = \text{Yj} - \text{Yi} < 0 \end{cases}$$

The positive or negative values show upward trend and downward trend.The variance for the S statistic is defined by: E[S] =0

$$\text{var(S)} = \frac{(N(N-1)(2N+5) - \sum_{i=1}^{n} tii(i-1)(2i+5)}{19}$$

where t_i indicates the number of the data in the ith tied group. Finally, the standardized test statistics Z can be computed as:

$$\text{Z} = \begin{cases} S - 1/\sqrt{Var(s)}\ S > 0 \\ 0 \qquad\qquad S = 0 \\ S + 1/\sqrt{\text{Var(s)}}\text{S} < 0 \end{cases}$$

A positive value of Z shows an increasing trend, while the negative value shows a decreasing trend.

b_{sen} = Median (Y1-Yj /i-j)

where Yi and Yj are data at the time i and j respectively. If the total number of data points in the series is n, then there will be n(1)/2 – slope estimates and the test statistic bSen is the median of all the slope estimates. The positive and negative sign of the test statistic indicates increasing and decreasing trends respectively.

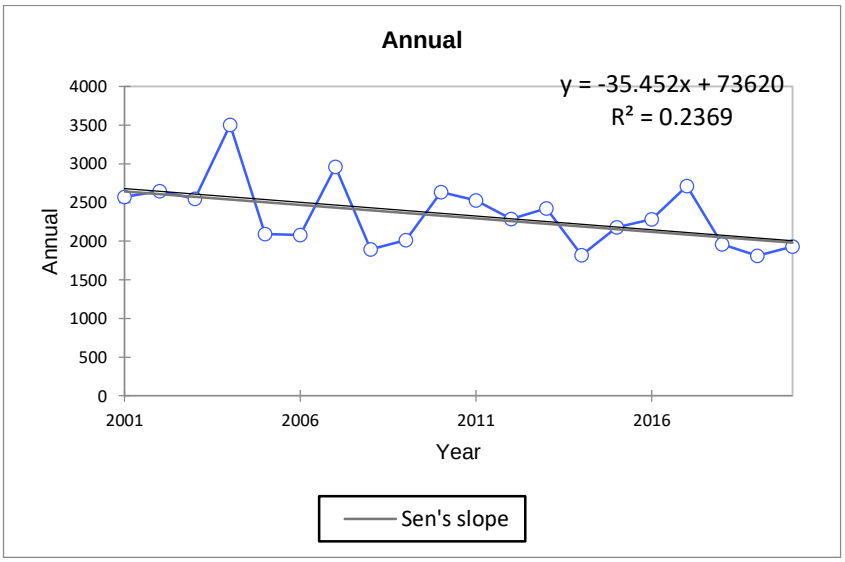

Figure I: Annual

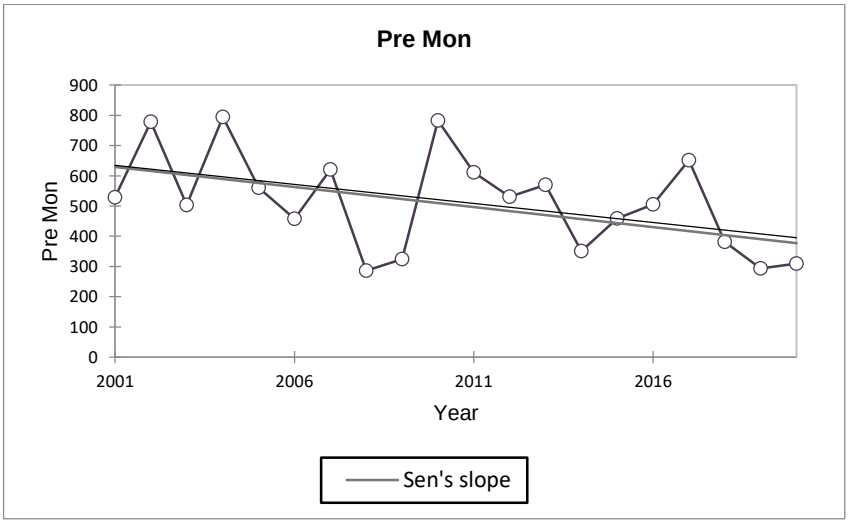

Figure II: Pre-Monsoon

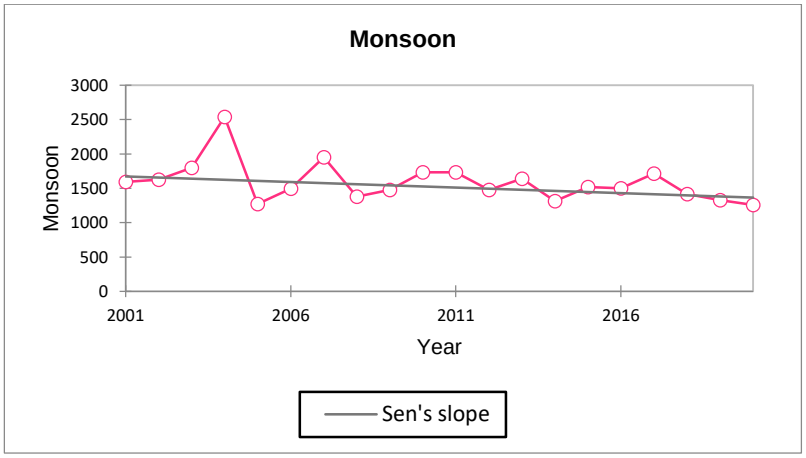

Figure III: Monsoon

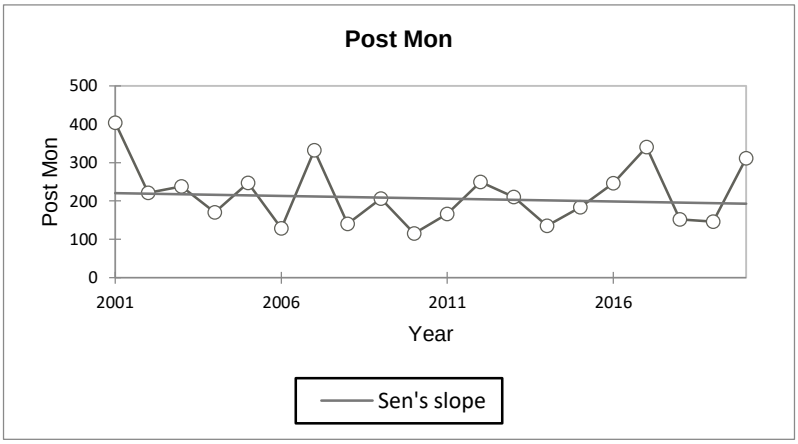

Figure IV: Post-Monsoon

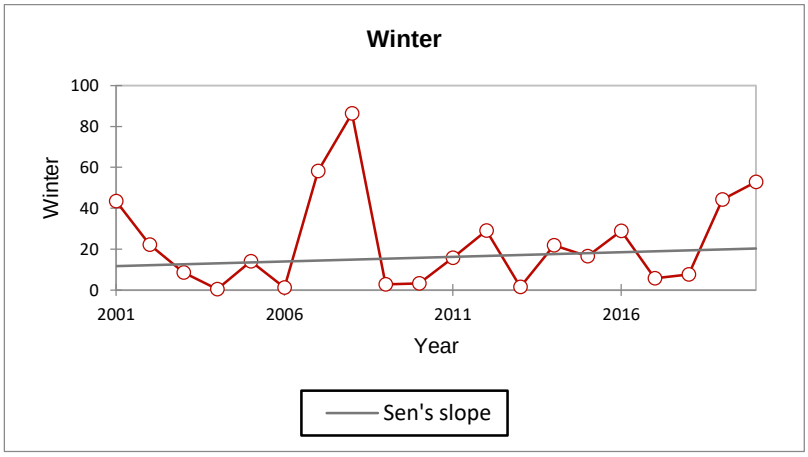

Figure V: Winter

Results and Discussion

Mizoram comes under the direct influence of south west monsoon. The State received adequate amount of rainfall (south west monsoon) and is more or less evenly spread throughout the State. The rainy seasons generally starts from late April and lasts till October. May, June, July and August received the highest amount of rainfall. The winter season from November to February is generally dry except a small amount of rainfall. On an average, the State received more than 250cm of rainfall in a year. The statistical data of Mizoram for 20 years at district level shows that the southern part of Mizoram received the highest amount of average rainfall (Lunglei, Siaha and Lawngtlai) while the north western part received the lowest amount of rainfall.

The highest rainfall is found during south west monsoon period. The State from 2001 to 2020 (20 years) on an average received annual rainfall of 2344.131 mm of rainfall. The coefficient of variation during the 20 years is 18.38 percent (Table I) indicating a highly stable rainfall. Rainfall during June is highest and contributes to 18.19 percent (Table I) of annual rainfall, followed by July and August with 17.91

percent and 17.20 percent of annual rainfall. The lowest rainfall is observed in January (0.39%) and December (0.43%). The coefficient of variation is also the highest (Table I) in the months of January (191.61 %) followed by December (191.23%) and February (115.61%) and the least during the south west monsoon period from May to October (Table I).

The study period also reveals that the pre-monsoon period, monsoon and post-monsoon rainfall show a declining trend. Result show that the rainfall which is supposed to show maximum variation during pre-monsoon, south west monsoon and post monsoon, had not recorded a significant variation, while the maximum variation of rainfall was observed in winter season indicating the unstable incidence of rainfall in these season. The study on rainfall over Mizoram for four seasons also shows that 67.77 percent of rainfall during 20 years was concentrated during monsoon period from June- September followed by pre-monsoon (table II).

Table I

Variable	Mean	Std. deviation	CV(%)	Rainfall in %
Jan	8.762	16.789	191.6172	0.39
Feb	14.468	16.726	115.6136	0.61
March	50.443	43.514	86.26415	2.15
April	153.627	106.984	69.63912	6.5
May	311.009	121.266	38.99104	13.27
June	426.441	152.152	35.67957	18.19
July	420.000	129.273	30.77933	17.91
Aug	403.163	80.138	19.87729	17.2
Sept	338.942	99.943	29.4869	14.46
Oct	174.268	64.766	37.16476	7.43
Nov	32.898	35.120	106.7569	1.4
Dec	10.113	19.340	191.2345	0.43
Annual	2344.131	430.922	18.38302	
Pre Mon	515.079	161.404	31.33576	21.97
Monsoon	1588.546	291.455	18.34731	67.77
Post Mon	217.278	80.099	36.86469	9.27
Winter	23.229	23.228	99.99364	0.99

Table II

Year	Pre Mon	Monsoon	Post Mon	Winter
2001	528.8	1594.4	404.3	43.5
2002	778.5	1625.7	221.4	22.23
2003	503.6	1797	238	8.63
2004	794.1	2541.3	170.2	0.5
2005	560.8	1272	247.06	14
2006	458	1494.35	128.4	1.17
2007	620.72	1950.31	332.42	58.17
2008	286.41	1379.7	140.33	86.36
2009	324.5	1478.65	206.45	2.75
2010	783.1	1731.9	115.1	3.2
2011	611	1733.1	166.3	15.8
2012	531.2	1477.5	249.8	29.1
2013	569.6	1640.9	210.5	1.46
2014	350.9	1313	135.5	21.8
2015	458.8	1520.5	183.9	16.5
2016	505.6	1500.9	246	28.9
2017	651.6	1714.1	340.9	5.7
2018	380.9	1417.8	152.1	7.7
2019	293.84	1328.7	145.9	44.3
2020	309.6	1259.1	311	52.81
	21.97%	67.77%	9.27%	0.99%

The highest annual rainfall was observed in 2004 which accounts for 7.48 percent during 20 years while the lowest annual rainfall is found in 2019 with only 3.87 percent (Table II). The yearly variation (Table II) of rainfall shows that the highest rainfall occurred in 2004. It declined sharply in 2005 (with yearly percentage variation of -40.28 percent) and still with negative value in 2006. In 2007, rainfall percentage yearly variation is the highest in 20 years to + 42.54 percent.

Table III

Year	Percentage of Rainfall (annual)	Yearly variation	Percentage yearly variation
2001	5.48		
2002	5.65	76.83	2.96
2003	5.43	-100.6	-3.8
2004	7.48	958.87	37.64
2005	4.47	-1412.24	-40.28
2006	4.44	-11.94	-0.57
2007	6.32	879.7	42.54
2008	4.04	-1068.82	-36.09
2009	4.29	119.55	6.31
2010	5.62	620.95	30.86
2011	5.39	-107.1	-4.06
2012	4.88	-238.6	-9.44
2013	5.17	134.86	5.89
2014	3.88	-601.26	-24.82
2015	4.65	358.5	19.68
2016	4.87	101.7	4.66
2017	5.79	430.9	18.89
2018	4.18	-753.8	-27.79
2019	3.87	-145.76	-7.44
2020	4.12	119.77	6.61

Table IV

Year	Mean	Std. deviation	CV
2001	214.25	184.4082	86.07149
2002	220.6525	212.2906	96.21039
2003	212.2692	219.0175	103.1791
2004	292.175	305.4269	104.5356
2005	174.4883	146.841	84.15521
2006	173.4933	206.0009	118.7371
2007	246.8017	212.1567	85.96244
2008	157.7333	150.5907	95.4717
2009	167.6958	164.6381	98.17664
2010	219.4417	209.9412	95.67063
2011	210.5167	205.2893	97.51689
2012	190.6333	167.0178	87.61206
2013	201.8717	216.3712	107.1826
2014	151.7667	156.7025	103.2523
2015	181.6417	176.4786	97.15756
2016	190.1167	156.952	82.5556
2017	226.025	184.1238	81.46168
2018	163.2083	181.9262	111.4687
2019	151.0617	158.296	104.789
2020	161.0425	148.179	92.01237

Table V

Series\Test	Kendall's tau	p-value	Sen's slope
Jan	0.049	0.792	0.000
Feb	0.147	0.381	0.286
March	-0.042	0.820	-0.698
April	-0.011	0.974	-0.454
May	-0.347	0.035	-11.280
June	-0.221	0.183	-8.770
July	-0.095	0.581	-2.627
Aug	-0.116	0.496	-2.931
Sept	-0.189	0.256	-3.782
Oct	0.000	1.000	-0.036
Nov	-0.021	0.922	-0.215
Dec	-0.023	0.918	0.000
Annual	-0.379	0.021	-34.786
Pre Mon	-0.284	0.086	-13.249
Monsoon	-0.305	0.064	-16.207
Post Mon	-0.063	0.721	-1.456
Winter	0.137	0.417	0.450

The descriptive statistic of the annual rainfall shows that the standard deviation for 20 years of rainfall in the State varies from 305.43 to 146.84 (Table IV). The highest variation (standard deviation) in rainfall was observed in 2004 (305.43) followed by 2003 (219.02) and 2013 (216.3712) while the minimum variation was recorded 2005 (146.841), 2020 (148.179) and 2016 (156.952). The co efficient of variation also shows that the minimum fluctuation was registered in the year 2017(81.46), 2016(82.56), 2005(84.16), 2007(85.96) and 2001(86.07). This result indicates that there was very less inconsistent rainfall trend for 20 years while the highest co efficient of variation was found in the year 2006(118.74) followed by the year 2018(111.47), 2013(107.18), 2019 (104.79), 2004(104.54), 2014(103.25) and 2003(103.18) indicating the irregular occurrences of rainfall throughout the year.

The highest rainfall occurred in monsoon period between June to September followed by pre monsoon period from March to May. Winter period is considered as dry period. In the Sens slope estimation, majority of the months have negative values except for the December, January and February where there are positive values. The table also shows the smallest value of Sen slope on the monsoon period. When it comes to analytical test on the rainfall trend using Mann Kendall, it is statistical significant with the value of the Sen's slope. Further both Mann Kendall and Sens' slope show that during monsoon, the value is very small which concludes that there is no trend during this season. The rainfall trend is neither increasing nor decreasing in this season.

Conclusion

Trends and variability of monthly, annual, pre monsoon, monsoon, post monsoon and winter rainfall were analyzed for 20 years. From the results of the study, it can be concluded that there is a slight decreases of annual rainfall from 2001 to 2020. Overall, pre monsoon, monsoon and post monsoon indicate declining trends whereas winter rainfall shows an increasing trend. In monthly time steps, the lowest value for the slope of rainfall -11.280 trend line was found in May during 2001-2020 and the highest value for the slope of rainfall 0.286 trend line was found in February.

Thus decreasing rainfall in annual, pre monsoon and post monsoon indicates the possibility of water scarcity in the future. This is going to be an impact on rain fed agriculture system like shifting cultivation. The result obtained might help the decision makers when designing water resource planning of agriculture sectors.

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