AN ESTIMATION OF ANNUAL AND SEASONAL RAINFALL ANOMALY INDEX FOR AIZAWL DISTRICT, MIZORAM

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Abstract : *The occurrence of anomalies in rainfall over an extensive period of time is a major hydro-meteorological event which may result into climate change and further may affect the hydrological imbalance and production of agricultural which are mainly dependent on rainfall. The study explores the annual and seasonal changing behavior of rainfall in Aizawl district of Mizoram for the period of 35 years from 1986-2020. Rainfall Anomaly Index (RAI) was employed to assess the dry and wet years in the rainfall pattern in the study area. The RAI shows an increasing number of dry and extremely dry years. Our findings also suggested that majority of the dry years in the study area were observed in recent decades.*

Keywords : *Climate Change, Rainfall Anomaly Index, Aizawl, Mizoram.*

1. Introduction

Recently, significant change in weather conditions has gained notable interest among researchers (Livada and Asimakopoulos, 2005). By examining the long-term series of precipitation variability, the study of climatic changes in a geographical area may be assessed (Sadiq et al., 2020). Rainfall characteristics and patterns directly influence water demand and availability of water resources for human use. The annual and seasonal pattern of rainfall, such as arrival of the wet season directly affected the extremely sensitive tropical ecosystem including the life stages of crop plant (leaf flushing and flowering), the timing of leaf fall and the total transpiration period are also heavily controlled by the duration of the wet season (Schwartz, 2003; Borchert, 1994). The extreme annual and seasonal rainfall patterns also have potential adverse effects to local population, posing challenges to the agricultural practices and sustainable management of soil and water resources (Rockstorm et al., 2003; Wani et al., 2009).

India being an agrarian country, the agriculture and water resources in the country are vulnerable to the effects of climate change and variability (Sinha et al., 1998; Kumar et al., 2004). Rainfall and climate highly determine agricultural and related sectors including food security and energy security. Moreover, the

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demand of water in various sectors like agriculture, domestic, industrial and hydro-power generation are highly determined by the amount of rainfall received in an area (Jain et al., 2012). Due to the adverse effect of climate change, the intensity and amount of precipitation and temperature in monsoon season have changed drastically largely because of increased evaporation (Khavse et al., 2015).

There is a very limited study on variability of rainfall and temperature in Mizoram particularly at district level. A few studies have claimed that there is a decreasing trend in the rainfall pattern and increasing temperature in the past few years (see GoM, 2012; Sahoo et al. 2018; Singh et al., 2016). Majority of the rural population in the state solely depends upon agriculture and any minor changes in the climate system may disrupt their livelihood. Considering the vitality of agriculture for Mizoram's economy and the livelihood of its people, investigating the changing pattern of temperature and rainfall in the region is crucial for understanding the process of development in the state. It is also expected that the present study will be beneficial for future research studies in the field of hydrology, climatology, agriculture and disaster risk management.

2. Methodology

2.1 Study Area

Geographically, Aizawl district lies between 92°39'54"E to 92°46'57"E longitude and 23°39'54"N to 23°50'35"N latitude which is also the capital of the state. The elevation of Aizawl districts varies from 800-1200 meters. The climate is generally monsoonal in characteristics. The area receives annual average rainfall of 2350 mm and temperature in Aizawl is characterized with warm and humid during summer season where the maximum temperature usually peak 30° C and 10° C during winter.

According to the 2011 census, the district of Aizawl consisted of 26.89 per cent of the total population of Mizoram. Agriculture holds a dominant place in the economy of the state as well as the district of Aizawl. As per the 2011 census Mizoram account about 60 per cent of total workers as engaged in agriculture and allied sector. Rural areas of Aizawl districts practices subsistence agriculture, however the dominant farming system in the region falls under shifting cultivation.

2.2 Data and Methods

2.2.1 The rainfall data for the period of 34 years (1986-2020) were obtained from Indian Meteorological Department (IMD) and Directorate of Economic and Statistics, Government of Mizoram.

2.2.2 Rainfall Anomaly Index (RAI)

The RAI (Rainfall Anomaly Index) is an incorporation of ranking procedure to assign magnitudes to positive and negative precipitation anomalies. It is calculated to assess the intensity and frequency of dry and rainy years (Costa and Rodrigues 2017). The equation for calculating positive RAI, first used by

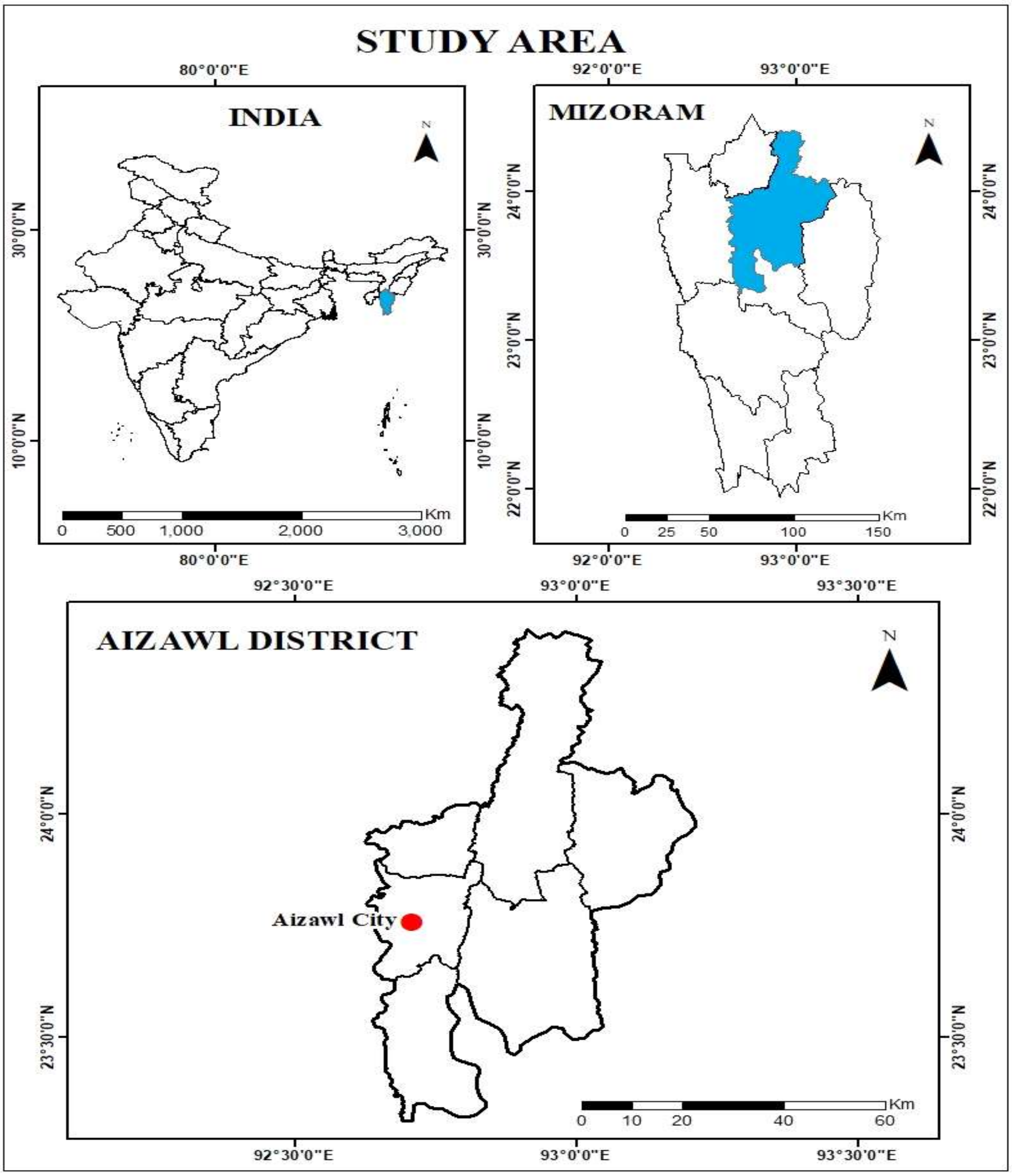


Fig. 1. Location of the Study Area, Aizawl District.

Rooy (1965) and adapted by Freitas (2005) is given by:

$$RAI = +3\frac{N - \bar{N}}{\bar{M} - \bar{N}}, \text{ for positive anomalies}$$

$$RAI = -3\frac{N - \bar{N}}{\bar{X} - \bar{N}}, \text{ for negative anomalies}$$

Where, N = current monthly/yearly rainfall (mm)
$\bar{N}$ = monthly/yearly average rainfall of the historical series (mm)
$\bar{M}$ = average of the ten highest monthly/yearly precipitation of the historical series (mm)
$\bar{X}$ = average of the ten lowest monthly/yearly precipitation of the historical series (mm)

Positive anomalies have their values above average and negative anomalies have their values below average.

3. Results and Discussion

3.1 Annual Rainfall Anomaly Index (RAI) Analysis

During the study period of 35 years, the average rainfall recorded 171.1mm. The year 2017 recorded the highest annual average rainfall with 223.9mm and the lowest annual average rainfall was recorded in 2019 with 126.5 mm of rainfall. As shown in Figure 5, the temporal distribution of rainfall in Aizawl district indicates that the rainy monsoon season starts from the month of May and last until the September. The highest precipitation was observed in August with a monthly average rainfall of 341.41mm during 1986-2020.

The annual RAI of Aizawl districts during the study period indicates a higher number of dry years as compared to wet years. It also shows an increase in continuous prolonged dry year cases from the year 2004 (Figure 3). The results shows that an extremely low rainfall was observed in 2019 with an index of -4.29 recording the driest year in the last 34 years (1986-2020), whereas the year of the greatest positive value was in 2017 with RAI of 4.25 therefore being classified as extremely humid (Appendix I).

3.2 Seasonal Rainfall Anomaly Index (RAI) Analysis

The seasonal rainfall data shows that spring and winter seasons with maximum years of low rainfall anomaly values as compared to summer and autumn season. In the spring season the rainfall anomaly with the lowest RAI value was observed in 2006 with -4.21 showing extremely dry year with the following years recording continuous dry years. The highest RAI value was

Table 1. Classification of Rainfall Anomaly Index (RAI) Intensity

	RAI Range	Classification
Rainfall Anomaly Index (RAI)	Above 4	Extremely humid
	2 to 4	Very humid
	0 to 2	Humid
	-2 to 0	Dry
	-4 to -2	Very dry
	Below -4	Extremely dry

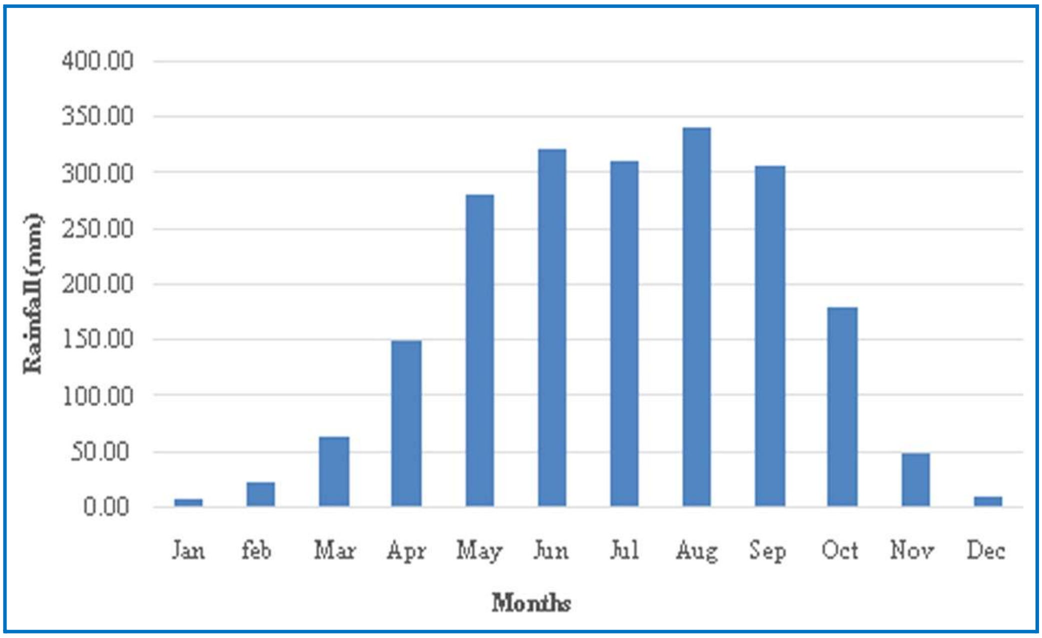


Fig. 2 Climatological monthly rainfall average from 1986-2020 for Aizawl district

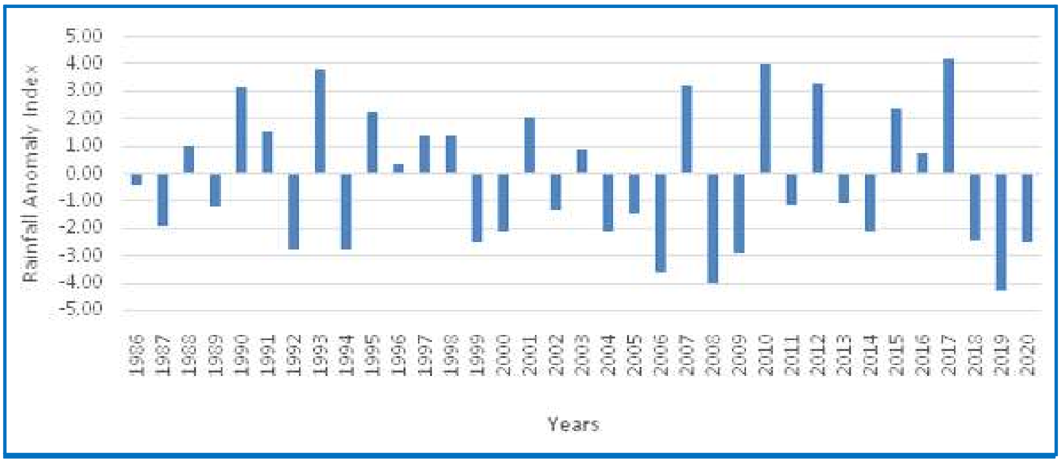
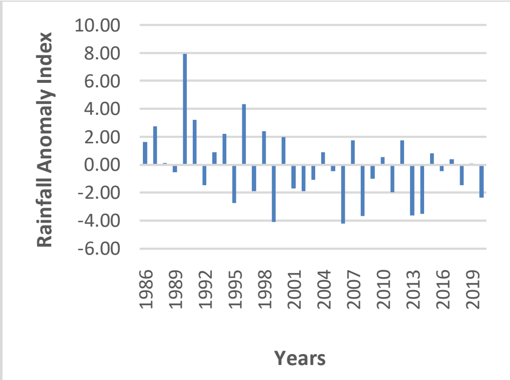


Fig. 3 Annual rainfall anomaly of Aizawl District, 1986-2020

Table 2. Rainfall Anomaly Index of Aizawl District, 1986-2020

Index Classification	Annual	Spring Season	Summer Season	Autumn Season	Winter Season
Extremely humid	2010, 2017.	1990, 1996	1993, 2017.	2007, 2010	1986, 1990, 1995, 1997.
Very humid	1990, 1993, 1995, 2007, 2012, 2015.	1987, 1991, 1994, 1998.	1988, 1995, 2001, 2003, 2010, 2015.	1990, 2001, 2012, 2015, 2020.	2007
Humid	1988, 1991, 1996, 1997, 1998, 2016.	1986, 2010, 2015, 2017, 2019.	1991, 1997, 2002, 2007, 2011, 2012, 2013, 2016, 2018.	1992, 1995, 1996, 1997, 1999, 2000, 2004, 2005, 2009, 2017.	1987, 1991, 2010, 2012, 2016, 2019.
Dry	1986, 1987, 1989, 2002, 2005, 2011, 2013.	1989, 1992, 1997, 2001, 2002, 2003, 2005, 2009, 2001, 2016, 2018.	1986, 1989, 1996, 1999, 2002, 2005, 2006, 2014.	1988, 1993, 1994, 2003, 2008, 2013, 2016.	1988, 1989, 1992, 1994, 1996, 1998, 1999, 2002, 2003, 2005, 2017, 2020.
Very dry	1992, 1994, 1999, 2000, 2001, 2004, 2006, 2009, 2014, 2018, 2020.	1995, 2008, 2013, 2014, 2020.	1987, 1990, 1992, 1994, 2000, 2008, 2009, 2019, 2020.	1986, 1987, 1989, 1991, 1998, 2002, 2006, 2011, 2019.	1993, 2000, 2004, 2006, 2008, 2009, 2011, 2013, 2014, 2018.
Extremely dry	2008, 2019.	1999, 2006.	-	-	-



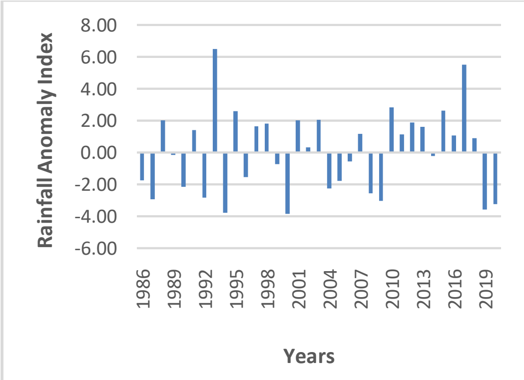
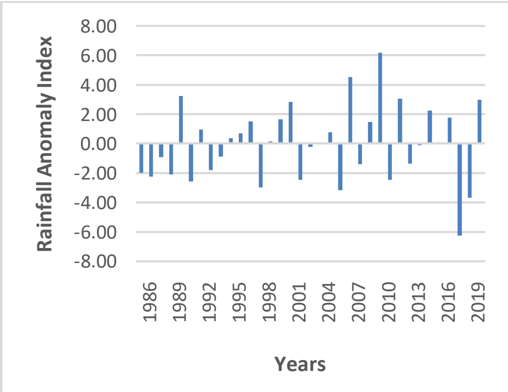


Fig. 4(a) Spring rainfall anomaly, **Fig. 4(b) Summer rainfall anomaly**



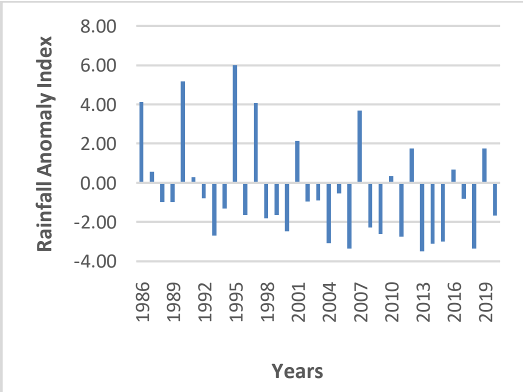


Fig. 4(c) Autumn rainfall anomaly **Fig. 4(d) Winter rainfall anomaly.**

observed in 1990 with 7.49 resulting to extremely humid years, with the consecutive years records with descending values of RAI. Along the spring season, winter shows a maximum number of years observed under low values of RAI, the lowest RAI value was observed in 2013 with RAI value of -3.52 of very dry year. On the other hand, the highest RAI value was observed in 1995 with RAI 5.19 showing extremely humid year.

4. Conclusion

The study reveals significant changes in the annual and seasonal patterns of rainfall in the study area during the study period. The Rainfall Anomaly Index reveals the declining state of annual and seasonal rainfalls. The analysis also shows relatively more number of dry years in comparison to wet years. The year 2019 was significant as the lowest RAI was experienced in this year. In addition, with comparison to the season of summer and autumn the seasons of spring and winter have been observed with the highest increase of dry years, from the present study, it is suggested that the change in the climate variables is significant enough that can pose a potential threat to the different socio-economic activities in the region.

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Appendix

Table 4. Rainfall Anomaly of annual and seasonal period, 1986-2020.

Years	Total Annual	Spring	Summer	Autumn	Winter
1986	-0.45	1.63	-1.73	-2.00	4.12
1987	-1.96	2.75	-2.90	-2.24	0.57
1988	1.01	0.12	2.03	-0.94	-0.99
1989	-1.20	-0.55	-0.13	-2.11	-0.99
1990	3.15	7.94	-2.13	3.23	5.19
1991	1.55	3.23	1.41	-2.59	0.27
1992	-2.80	-1.45	-2.81	0.95	-0.80
1993	3.83	0.88	6.52	-1.80	-2.71
1994	-2.79	2.22	-3.76	-0.89	-1.32
1995	2.22	-2.74	2.61	0.36	6.02
1996	0.36	4.33	-1.53	0.69	-1.66
1997	1.39	-1.89	1.65	1.52	4.07
1998	1.43	2.40	1.81	-2.98	-1.82
1999	-2.48	-4.09	-0.71	0.15	-1.64
2000	-2.15	1.98	-3.83	1.67	-2.49
2001	2.06	-1.71	2.04	2.82	2.15
2002	-1.34	-1.88	0.34	-2.48	-0.96
2003	0.88	-1.09	2.08	-0.21	-0.91
2004	-2.10	0.91	-2.24	0.08	-3.09
2005	-1.45	-0.47	-1.76	0.77	-0.53
2006	-3.64	-4.21	-0.53	-3.16	-3.36
2007	3.23	1.77	1.18	4.52	3.69
2008	-4.05	-3.67	-2.53	-1.41	-2.27
2009	-2.88	-0.98	-3.02	1.47	-2.62
2010	4.01	0.55	2.85	6.18	0.35
2011	-1.15	-1.98	1.14	-2.46	-2.74
2012	3.28	1.76	1.90	3.05	1.74
2013	-1.06	-3.64	1.64	-1.37	-3.52
2014	-2.10	-3.54	-0.21	-0.13	-3.11
2015	2.41	0.83	2.64	2.25	-3.01
2016	0.72	-0.48	1.09	-0.02	0.68
2017	4.25	0.39	5.52	1.78	-0.81
2018	-2.44	-1.48	0.90	-6.27	-3.36
2019	-4.29	0.07	-3.55	-3.68	1.74
2020	-2.50	-2.37	-3.21	2.99	-1.67