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A Study of Severe and Extreme Drought in Central Dry Zone of Myanmar

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Conflicts of Interest
There are no conflicts to declare.

ABSTRACT

The objective of this study is to examine the severe and extreme drought conditions in the Central part of Myanmar. The study covers (15) Stations in Lower Sagaing Region, Magway Region, Mandalay Region and Nay Pyi Taw Union Territory. (30) Years Monthly rainfall data from 1990-2019 were used with spi_sl_6 Package to compute the (3) Month Standardized Precipitation Index (SPI-3). Study found that severe and extreme drought years or driest years in Central Myanmar dry zone stations are associated with moderate and strong El Nino years. The results of the present study are very likely to be support for developing climate risk management, local climate change adaptation activities, drought hazard mapping, and formulating local drought policy.

Keywords: STANDARDIZED PRECIPITATION INDEX (SPI), CENTRAL DRY ZONE OF MYANMAR

Introduction

Myanmar is located between 93º2´ to 28º31´ and 92º10´ to 101º11´with total area of 261228 square miles. It enjoys the Southwest Monsoon with (3) different seasons. Most of the areas receive 90% of annual rainfall by Monsoon season. Prominent mountains and highlands, (1385) miles coastal length with Bay of Bengal and Andaman Sea, Plateau, Deltaic areas and Gulf, Major rivers and tributaries are significant. As Myanmar also a country of Agricultural based developing Country, application of weather and Climate factors play an important role for the Rice and other food production, Energy, Irrigation and Water Resource, Transportation and other weather and climate sensitive sectors. Weather and Climate of Myanmar is influenced by Mountains, Plateau, topography and distance from Sea. Intensity and timing of seasonal summer and winter monsoon wind, Frequency and movement of cyclones, depressions and other synoptic scale, regional and global scale climate systems trigger the weather and climate of Myanmar. Monsoon rain is essential water resources for agriculture production, water resource utilization, energy, transportation.

Myanmar is one of the world's most disaster-prone countries exposed to multiple hazards, including floods,

cyclones, earthquakes, landslides, and droughts, ranking 2nd out of 187 countries in the 2016 Global Climate Risk Index and 9th out of 191 countries in the INFORM Index for Risk Management. Myanmar is at risk to several natural hazards, including extreme temperatures, drought, cyclones, flooding and storm surge, and heavy rainfall events. Drought is considered the most severe natural hazard in the country based on the impacts that it has on health, property, assets, and livelihoods. There has been an increase in the prevalence of drought events in Myanmar. Drought years with moderate intensity were frequent in the 1980's and the 1990's. Extended dry seasons and increased temperatures have caused an increase in the prevalence of drought. Severe droughts have increased in frequency from 1990 to 2002. In 2010, severe drought diminished village water sources across the country and destroyed agricultural yields of peas, sugar cane, tomato, and rice. Rainfall patterns in Myanmar have become unpredictable with regular reports of record-breaking rainfall. Over the period 1960-2009, shorter rainfall seasons in combination with erratic and intense rainfall resulted in numerous flooding events. (World Bank, 2021).

The Dry Zone is a part of the Central Inner Burma (Myanmar) Basin located between 19° to 23° N and between 94°to 96°E. It covers an area of 67,700 sq km, 10 percent of country, partially over Sagaing, Magway and Mandalay Divisions. It is 403 km. north-south while 120 km. East-West. The dry zone is surrounded on three sides by mountain ranges and opens towards South. It consists of undulating plateau with elevation of 150-200 m and a number of steep hilly chains rise above the plateau with peaks of hill reaching altitude of 300-400m. The precipitation in dry zone is controlled by the monsoon circulation system. The mountain ranges running north-south present effective barriers to the Southwest monsoon in summer and North-East monsoon in winter, thus the central region falls under rain shadow zone. The annual precipitation in dry zone is less than 750 mm, while the national average precipitation is 2353.06 mm. The dry zone receives 3.2% of the country's total rainfall, while geographically it comprises 10% of the total area of the country. (Hazard Profile of Myanmar, 2009). Drought years or driest years in Central Myanmar dry zone Stations were occurred during, moderate and strong El Nino years. (Soe.A.A, 2019).

Myanmar is extremely vulnerable to the impacts of climate change and highly exposed to severe weather events such as heavy rains, storm surges, severe droughts, floods, cyclones and landslides which have increased in intensity and frequency over the last 60 years. The increasing severity of weather events and changing weather patterns can be attributed to climate change. Myanmar has also observed the effects of changing climatic patterns on productive systems, in particular in the agriculture sector. In Myanmar, the most recent climate change projections confirm these increasing and changing temperature and precipitation trends; and related events such as heat waves, droughts and floods; the likelihood of intense tropical cyclones; sea level rise; salinity intrusion; a further shrinking monsoon season among other effects. These effects will likely continue to impact all vital sectors of Myanmar's society and economy and threaten the social and economic development of the country, as it remains vulnerable due to the heavy dependency on climate-sensitive sectors for livelihoods. Also, millions of Myanmar's people are concentrated in regions naturally exposed to severe climatic events, in particular the Central Dry Zone Area, the Delta Region and the Coastal Areas. People living

in Hilly regions and Plain lands will also be diversely affected by several effects of climate change. (Myanmar Climate Change Policy, 2019).

Myanmar has also clear evident of the Abnormal Climatic conditions, such as abnormal cyclone landfall, Late Monsoon Onset, early Monsoon withdrawal, Monsoon strength, Monsoon Rainfall, summer Temperature, winter Temperature. Likewise, Myanmar also links with the Regional Climatic teleconnection with some atmospheric oscillation like El Nino and other and linkage and time lag, modulation of warm and cool sea surface temperature abnormalities. Severity and duration of this abnormal regional climatic pattern strongly influenced the Climate of Myanmar. Agriculture is main business in the Dry Zone Area but the less rainfall and extreme temperature affect the Agricultural production, livestock, water resource and environment. Drought information are important and need to provide climate risk information including drought to the users from climate sensitive sectors. This study is aim to know the severe and extreme meteorological drought conditions in the Central part of Myanmar.

Materials and methods

This study covers (15) Stations from Lower Sagaing Region, Magway Region, Mandalay Region and Nay Pyi Taw Union Territory. It is 403 km. north-south while 120 km. East-west (Figure 1). Stations are situated in Central Myanmar Dry Zone area except Pyinmana Station. Monthly rainfall data used in this study were obtained from Climate Record Section, Myanmar Department of Meteorology and Hydrology. The monthly data cover the period of (30) years from 1990-2019 for (15) meteorological observation stations in the study area. The distribution of (15) meteorological observation stations Central Myanmar is shown in Table (1). Spi_sl_6.exe Package was utilized to compute the 3-month Standardized Precipitation Index (SPI3). This study examines SPI3 to determine the temporal patterns for severe and extreme droughts in the Central Myanmar. SPI is designed to quantify precipitation deficit for multiple timescales and can be calculated from 1 month up to 72 months. In this study, SPI 3 month is calculated and used the SPI category as by WMO-1090, 2012.

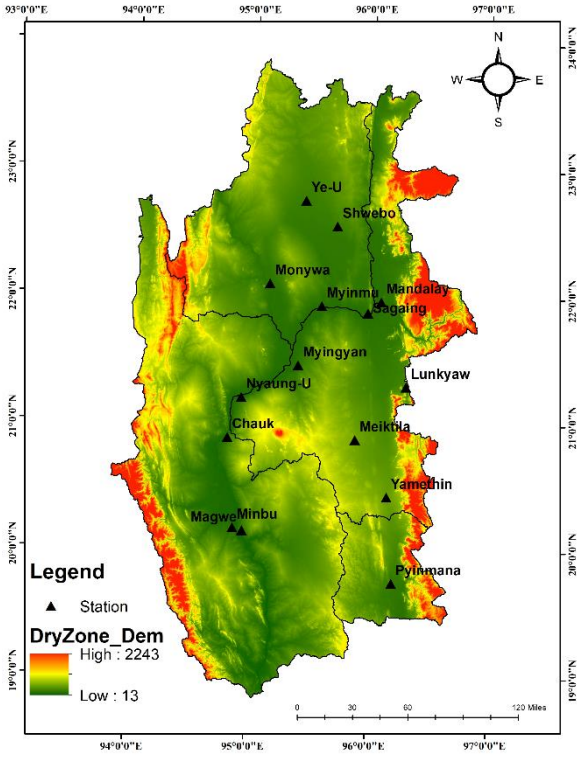

Figure 1. Map of stations in study area

Table (1) Detail information of selected Meteorological Stations

No	Station Name	WMO Code	Latitude	Longitude	Elevation(m)
1.	Mandalay	48042	21.97	96.08	74
2.	Myingyan	48047	21.46	95.39	60
3.	Nyaung-U	48048	21.20	94.92	61
4.	Meiktila	48053	20.88	95.88	214
5.	Yamethin	48067	20.43	96.15	199
6.	Pyinmana	48074	19.75	96.20	101
7.	Lunkyaw	-	21.30	96.30	112
8.	Sagaing	48039	21.88	95.97	64
9.	Monywa	48037	22.10	95.14	81
10.	Shwebo	48033	22.56	95.70	106
11.	Ye-U	48032	22.76	95.43	103
12	Myinmu	-	21.93	95.58	69
13.	Magwe	48065	20.15	94.95	52
14.	Minbu	48064	20.17	94.87	51
15.	Chauk	48052	20.88	94.81	82

Table 2. Classification of SPI values (SPI User Guide by WMO-No. 1090, 2012**)**

SPI **Values**	**Drought classification**
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near Normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

Conclusion

Severe and Extreme Drought in Mandalay Region

Mandalay Region include Mandalay, Lunkyaw, NyaungU, Meiktila, Myingyan and Yamethin Stations. Severe drought had occurred in **Mandalay** during 1993 Sep-Oct, 1995 May, 2000 Nov, 2001 April, 2004 Oct, 2005 June, 2010 April-May, 2012 May, June and Aug, 2014 May-July and 2019 Nov. And extreme drought was observed during 1995 April, 2004 Dec, 2005 July and 2012 July. Figure (2). For the **Lunkyaw** Station, severe drought occurred during 1991 Oct, 1995 April, 1997 July, 1998 Nov-Dec, 2001 April, 2002 April, 2005 May-June, 2011 July, 2013 Aug, 2014 Oct, 2018 Sep and 2019 April. Extreme drought years are recorded during 1997 May-June, 2004 Dec, 2008 Sep and 2019 May. Figure (3)

NyaungU station shows severe drought in 1991 May, 1994 Nov-Dec, 1995 May and July, 1997 Nov, 1998 July, 2000 Sep, 2004 Dec, 2007 Sep, 2009 Aug and Oct-Nov, 2010 June and 2015 May. Extreme drought had occurred during the year of 1995 June, 1998 Aug, 2009 Sep and 2010 July. Figure (4). Similarly, **Meiktila** station, severe drought had occurred in 1992 July, 1993 May and July, 1994 Dec, 1995 June, 1997 Oct, 2003 Aug-Sep, 2004 Dec, 2009 Dec, 2010 April and 2012 August. The extreme drought was more significant during the year of 1992 May-June, 1994 Sep-Nov, 2008 Aug, 2009 Nov and 2014 July. Figure (5).

For **Myingyan** station, severe drought had occurred in 1990 Aug-Oct, 1994 Nov, 1998 Aug, 2008 Sep, 2009 Nov, 2012 May and 2018 Nov. The extreme drought also observed 1997 May-July , 1998 Aug, 1999 Sep , 2004 Dec and 2012 June. Figure (6). The severe drought in **Yamethin** Station showed 1997 Oct and Dec, 1998 July, 2000 Aug, 2003 Sep, 2004 April, 2009 Sep, 2010 May-June, 2012 June, 2013 April and 2016 April. And extreme drought occurred 1994 Nov, 1997 Nov, 1998 June and Dec, 2012 May and July. Figure (7). **Pyinmana** Station, near the Capital City of Nay Pyi Taw, experienced severe drought on 1990 Dec, 1992 June, 1998 Sep, 2000 May, 2003 July and Sep, 2004 May and July, 2009 Aug-Dec, 2012 Dec and 2014 Nov. Extreme drought had occurred in 1998 August, 2003 August, 2004 June and 2012 Oct-Nov. Figure (8).

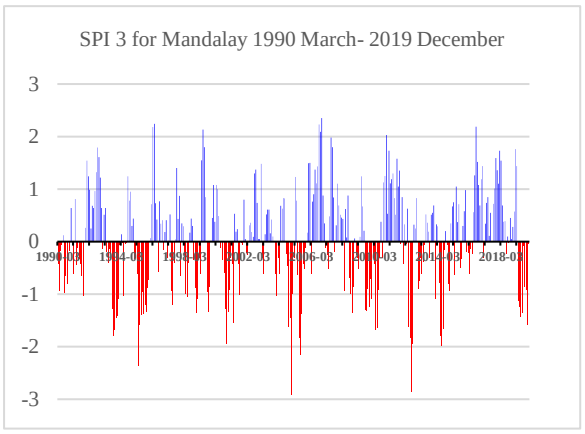

Figure (2) SPI-3 for Mandalay

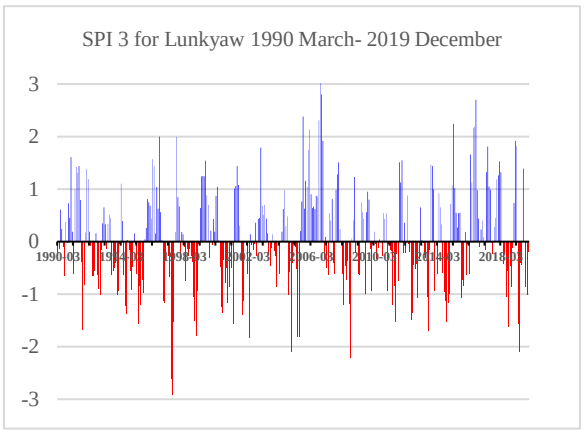

Figure (3) SPI-3 for Lunkyaw

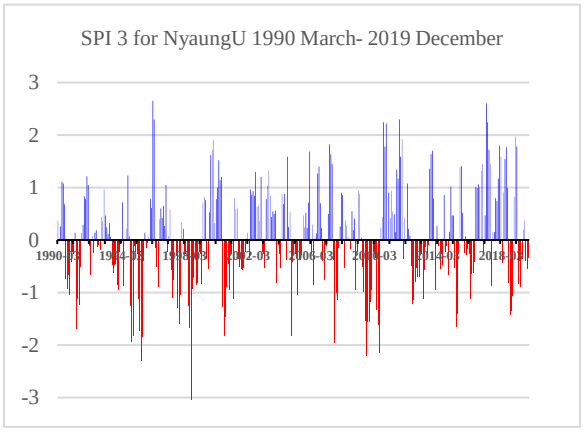

Figure (4) SPI-3 for NyaungU

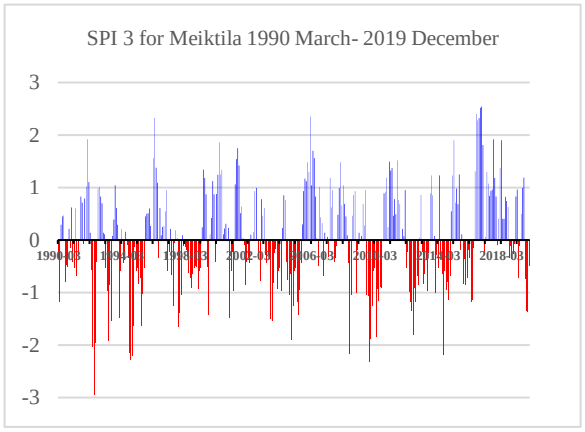

Figure (5) SPI-3 for Meiktila

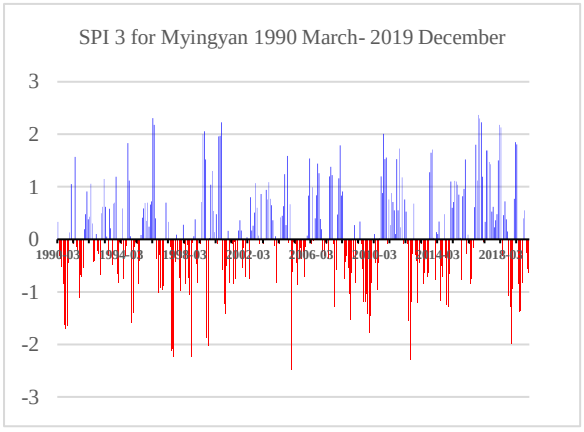

Figure (6) SPI-3 for Myingyan

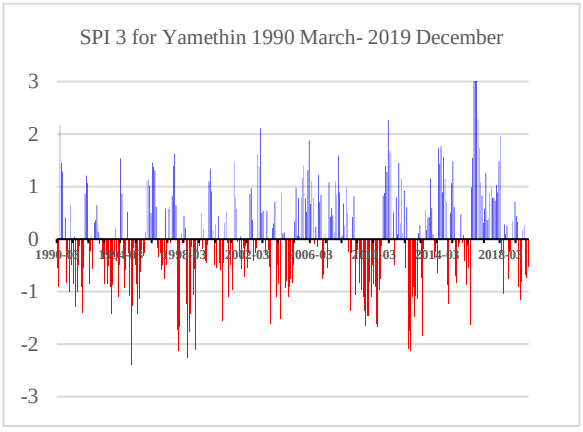

Figure (7) SPI-3 for Yamethin

Severe and Extreme Drought in Lower Sagaing Region

Sagaing, Monywa, Myinmu, Shwebo and YeU Stations are located in Lower Sagaing Region. **Sagaing** Station also hit by the severe drought in 1990 August, 1997 June, 1998 April, 2001 April and Sep, 2005 May and August, 2008 Sep, 2009 Nov, 2012 July, 2018 Nov and 2018 Dec. Extreme drought events were significant

in 1995 May-July, 2004 Dec and 2005 June-July and 2009 Dec. Figure (9).

Monywa Station had experienced severe drought by 1990 July, 1991 July, 1994 May, Nov and Dec,1995 April and June, 2004 Dec, 2008 Oct, 2009 Aug and 2019 Oct. According from the results in Monywa station, the extreme drought was more significant in the year of 1990 Aug, 1997 Nov, 1998 Aug, 2008 Sep, 2009 Sep and 2019 Nov-Dec. Figure (10). For **Myinmu** Station, the severe drought had occurred in the year of 1995 April, 1997 May-June, 1998 Oct, 2012 June and August and 2013 April. The extreme drought was more also observed in the year of 1998 Sep, Nov and Dec, and 2012 July. Figure (11). The severe drought had occurred in **Shwebo** Station during 2000 Aug-Oct, 2001 Sep, 2012 May, 2018 Sep and 2019 Oct. The extreme drought had occurred in the year of 2004 Dec, 2005 May and 2019 May and Dec. Figure (12). Severe drought had occurred in **YeU** during 1995 April-May, 1996 Dec, 2000 Aug, 2005 Aug, 2007 Aug and Oct, 2012 May, 2016 Dec, 2018 Sep and 2019 Nov. And extreme drought was observed in the year of 2005 May-July, 2007 Sep, 2012 June-July and 2016 Nov. Figure (13).

Severe and Extreme Drought in Magway Region

Magwe, Minbu and Chauk Station are located in Magway Region. Severe drought in **Magwe** Station had occurred in 1991 Aug, 1994 July and Nov, 1995 April, 1998 June, July and Nov, 2014 July, 2016 April, 2018 Nov and 2019 May. The extreme drought had occurred in 1991 July, Sep-Oct, 1994 Oct and Dec, 1998 Aug, Oct and Dec, 2005 May, 2014 May-June. Figure (14). The severe drought had occurred in **Minbu** during 1994 June, Nov and Dec, 1998 June-July, Oct and Dec, 2009 Nov. The extreme drought had occurred in 1991 Sep-Oct, 1994 July, 1998 Aug, 2005 May and 2019 May. Figure (15). **Chauk** Station had experienced severe drought in 1991 Sep, 1998 Dec, 2001 Nov, 2005 May and Aug, 2009 Sep-Oct, 2012 May, 2014 Oct, 2018 Nov and 2019 June. And the extreme drought had occurred in the year of 1991 Oct, 2004 Dec, 2005 June-July, 2012 June-July, and 2019 May. Figure (16).

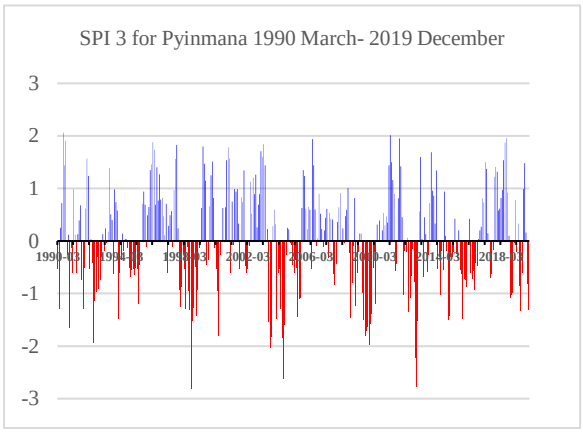

Figure (8) SPI-3 for Pyinmana Station

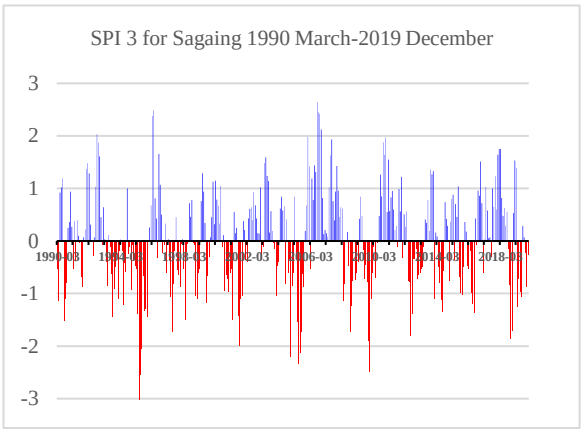

Figure (9) SPI-3 for Sagaing Station

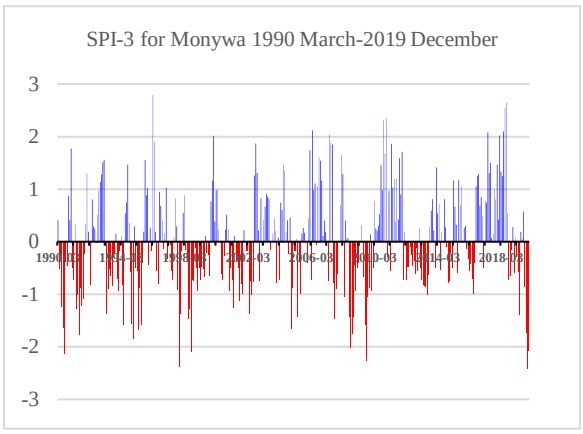

Figure (10) SPI-3 for Monywa

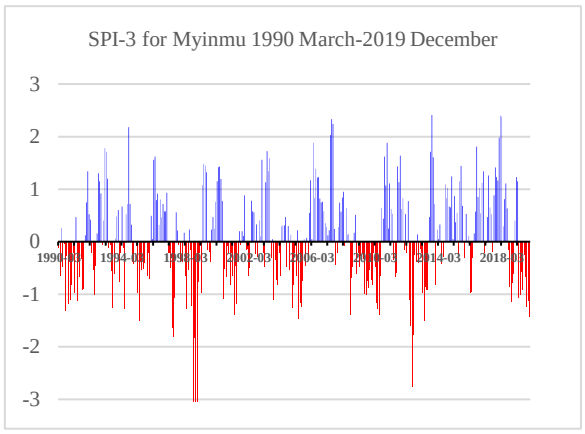

Figure (11) SPI-3 for Myinmu Station

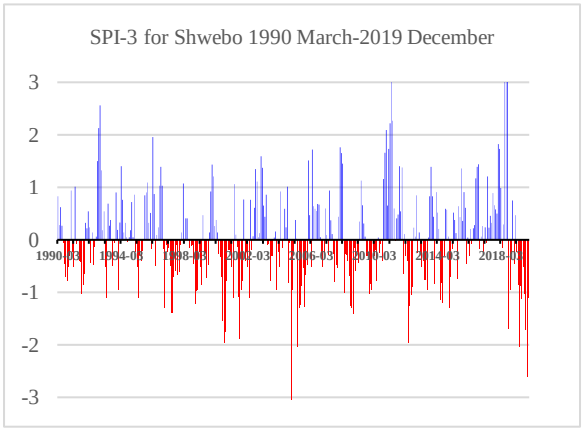

Figure (12) SPI-3 for Shwebo Station

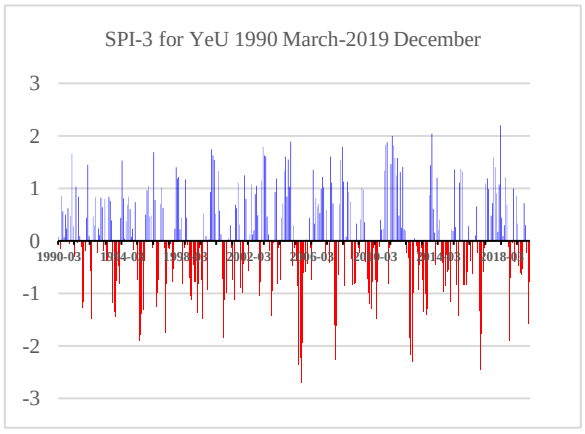

Figure (13) SPI-3 for YeU Station

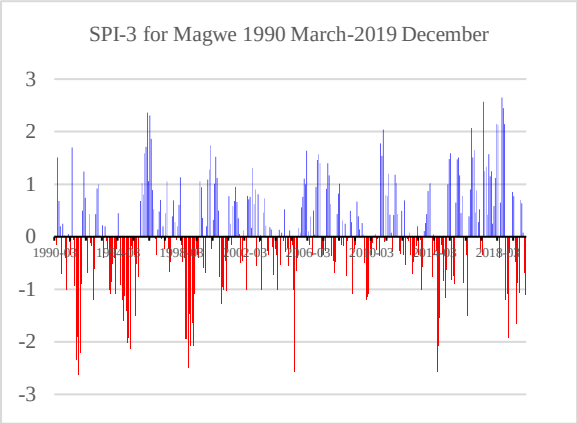

Figure (14) SPI-3 for Magwe Station

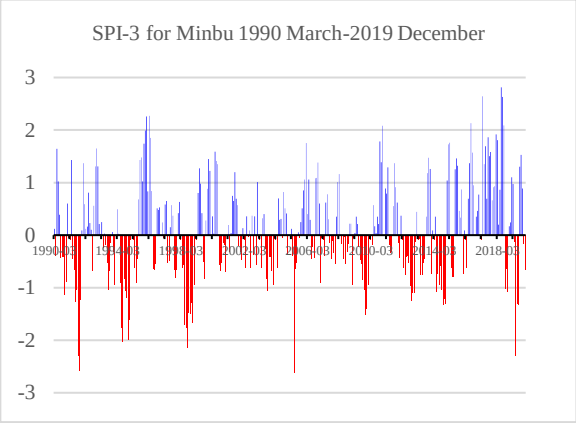

Figure (15) SPI-3 for Minbu Station

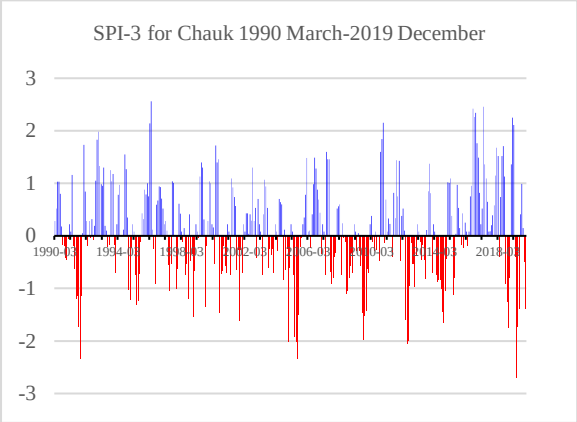

Figure (16) SPI-3 for Chauk Station

Discussions

Present study found that the clear evidence for severe and extreme drought in Central dry zone of Myanmar. The results of the present study are very likely to be support for developing climate risk management, climate change adaptation activities, drought hazard mapping, and formulating local drought policy. But, more research activities in drought conditions with different time scales is required for detail characteristics of local drought conditions. There is no doubtful about the changing climate in the past and it is very likely to continue to experience the warming and significant variation of rainfall in our future. So, it is time to take actions against the climate change with climate information and climate knowledge and following strategic action plans to implement the gaps, needs, challenges, potential adaptive capacities, opportunities to the climate sensitive sectors.

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