ANALYSIS OF METEOROLOGICAL DATA AND DROUGHT IN THE LOWER NORTHERN PART OF THAILAND

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Abstract: The study areas include Phitsanulok, Nakhon Sawan and Khamphang Phet. The meteorological data between 1986 and 2015, was collected from the meteorological rain gauge stations situated in the Lower Northern part of Thailand. This study involves the analysis of the meteorological data and drought trends in the northern region of Thailand from 1986 to 2015. The study used the Meteorological Drought Monitor software (MDM) to analyze the drought trends through the Standardized Precipitation Index (SPI). From this analysis, we then presented the results through graphs representing the trends in meteorological parameters and drought index. The results showed that, the annual rainfall measurement of the regions analyzed continues to reduce consistently as the temperature increase. The drought trends in these provinces observed to considerably lean towards dry conditions. Nakhon Sawan, for instance, experienced extreme drought in 1977(SPI =-2.5) and moderate wetness in 2013. Kampheang Phet recorded moderately wet conditions (SPI =1.5) in 2013 and 2014 years, and near normal conditions (SPI = -1.1) in 1996. Lastly, Phitsanulok was majorly comprised of moderately dry and severely dry, especially for 2015(SPI =-22). From the findings, awareness should be created to foster the need for environmental conservation, besides to improve environmental protection and the levels of precipitation.

***Keywords*: SPI index, MDM software, Drought**

1. Introduction

It is considered that Thailand has sufficient water sources and high volume of water catchment. The drought problem in Thailand is more frequent and severe combined with increasing of water requirement, causing the effects to normal livelihood and destroying ecology and environment system. Understanding the variability of rainfall and the pattern of extreme high or low precipitation are very important for the agriculture as well as the economy of the country. It is well established that the rainfall is changing on both the global [1, 4, 8] and the regional scales [2, 5] due to global warming. Rising average temperatures, frequent and more intense heat waves due to climate change are affecting human health in several ways. Warmer temperatures diminish air quality by increasing exposure levels of ground-level ozone. Analysis of the trends of temperatures occurring across in Lower Northern part of Thailand has would help in finding trends with the aim of predicting the average temperatures. Evaporation from the land surface includes evaporation from open water surface, soil, shallow groundwater, and water stored in vegetation along with transpiration through plants. Determining evaporation rates is essential for efficient management of reservoirs and water resources.

Drought, by many considered to be the least understood of all major natural hazards, has also been shown to be the most costly [15]. Drought has many effects on man's economic activities, human lives and various elements of the environment such as the Earth's ecosystems [16]. A number of drought monitoring indices have been used over the years. However, the Standard Precipitation Index (SPI), recommended by [3], remains a popular choice among researchers because it is simple, spatially consistent in its interpretation, probabilistic so that it can be used in risk management and decision analysis, and can be tailored to periods of user's interest. In Thailand, water is insufficient and drought originated from long delay of rainfall affected to outside irrigated areas. The farmers cultivate their farmland during rainy season except the farmland in watershed area or small scale irrigated areas.

This study will focus in the Lower Northern Part of Thailand, which include Phitsanulok, Khampaeng Phet and Nakhon Sawan. The area is affected by recurrent drought and it has not been covered by many previous studies; hence, this research will focus on this area and make vital analysis. The current research thereby intends to conduct a grounded analysis of the meteorological data present in the lower northern provinces of Thailand. Such analysis of data collection methodologies, as well as the implications of the data in informing the drought and precipitation trends in the country, will advise policy on the need for better conceptual approaches to address the persistent climate inconsistencies in the regions. The need for such a grounded study in the area prompted by continuing severity of drought in the regions modern times.

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2. Research Methodology

This section comprises research objectives, data collection and data analysis.

Research Objectives

The objectives of this study were

1) to analyze the meteorological data in the Lower Northern part of Thailand and

2) to analyze drought severity level in the Lower Northern part of Thailand.

Collection of data

The research utilized meteorological data (Rainfall, Temperature, and Evaporation) between 1986 and 2015 collected from the meteorological rain gauge stations that situated in the Lower Northern Part of Thailand.

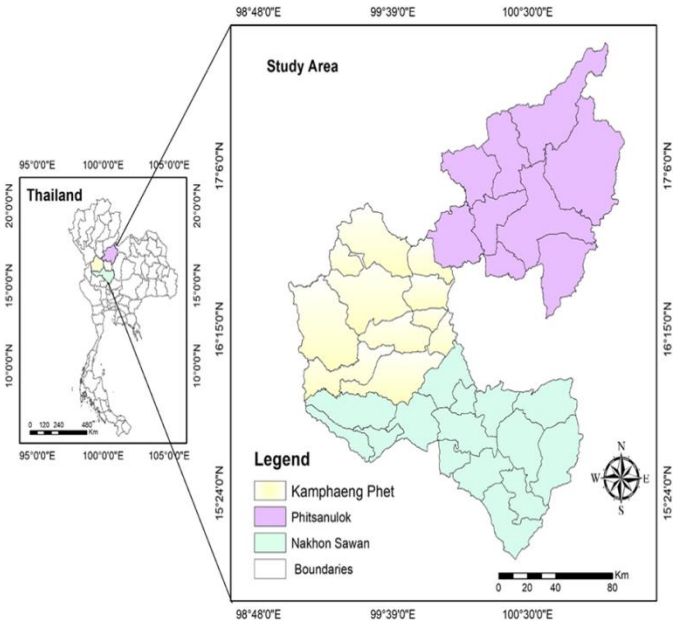

Figure 1: Location map of the Study Area

Data analysis

The main variables used in this study were temperature, evaporation and rainfall. The correlational analysis then helps to begin the analysis of their sustained fluctuations in the past thirty years in the three selected provinces in Lower Northern part of Thailand. After the correlation study of the aggregated meteorological data for the three variables, the analyst then used SPI meteorological index to characterize the meteorological drought according to the three variables. The main index used for this analysis was the Standardized Precipitation Index (SPI). These results then presented using tables and graphs showing trends in the meteorological parameters as well as their correlations and the value of the index. Meteorological Drought Monitor (MDM) software used for calculating the Standardized Precipitation Index (SPI). MDM is a software by Agricultural and Meteorological Software (AgriMetSoft) that is available free to download from the organization's website. We used the 2018 version of MDM – the MDM 1.0 version for this study.

Analysis of meteorological data

1) Analysis changing and trend of each meteorological data

The tendencies of meteorological statistics, for example, evaporation, temperature, and rainfall scrutinized basing on the data collected from the meteorological rain gauge stations from 1986 to 2015. The research established, checked and analyzed the relationship between the meteorological data on temperature, rainfall, and evaporation. The trends of temperature, evaporation and rainfall from 1986 to 2015 offers a chance for monitoring the respective changes from the years.

2) Correlation between the meteorological data and drought severity level.

The connection linking the change and tendency of the meteorological statistics analyzed and scrutinized based on the results about the level of severity of drought. The Standardized Precipitation Index, employed to calculate and get reliable data.

3) Drought analysis

This work selected the SPI index for drought monitoring in the Lower Northern Part of Thailand and calculated using an MDM (Meteorological Drought Monitor) software. This index used to measure the extent of dryness within Thailand, to understand the varied levels of precipitation for the past years. Furthermore, the change in the rates of dryness are also evident from the calculations, giving a picture of the weather conditions in the three provinces, from the meteorological rain gauge stations that are situated in the Lower Northern Part of Thailand.

3. Result

1) Trend and relation of meteorological data

The research checked and analyzed the relationship between the meteorological data on temperature, rainfall, and evaporation; calculated together with the trends graphs over the period for the three stations namely Nakhon Sawan, Phitsanulok and Kampheang Phet.

1.1) Nakhon Swan

For the Nakhon Sawan station (as for each of the two other stations), we shall investigate the aggregated measurements and the trends of the rainfall, temperature and evaporation for the period between 1986 and 2015. The distribution of rainfall, temperature and evaporation through the years shall assist in recognizing the wetness and drought levels in each year. Such a trend analysis allows the analyst to gain a trend precipitation and evaporation indices for the measurement period. The detail of each stations explained below.

Rainfall

The rainfall in Nakhon Sawan province found to experience a changing trend. In 1991, for instance, recorded the lowest rainfall in the three-decade duration. The mean average annual rainfall receives in Nakhon Sawan was 1135.6mm. The rainfall was decreasing in the last 5 years before 2016. 1988 had the highest annual rainfall value (1618.3 mm) and 1991

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recorded the lowest amount of rainfall value 608.5 mm. The Range value was1009.8 mm (Figure 2).

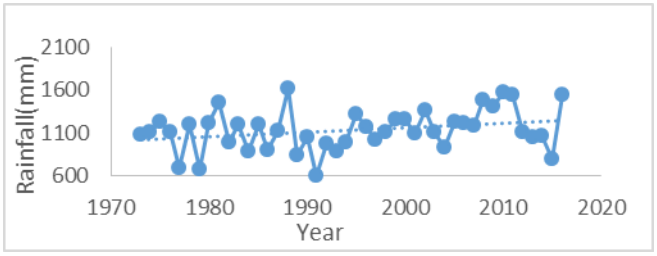

Figure 2. Trend graph of rainfall for Nakhon Sawan.

Maximum temperature

The mean average temperature was 36.860C and the range value was 30C. More than 56% of the years' experienced annual temperature below the mean average while the remaining 44% of the years experienced annual temperature above the mean average. The last ten years experienced higher maximum temperature than the first ten years. 2015 had the highest recorded maximum temperature with value of 38.550C. 1973, recorded the lowest maximum temperature value of 35.550C (Figure 3).

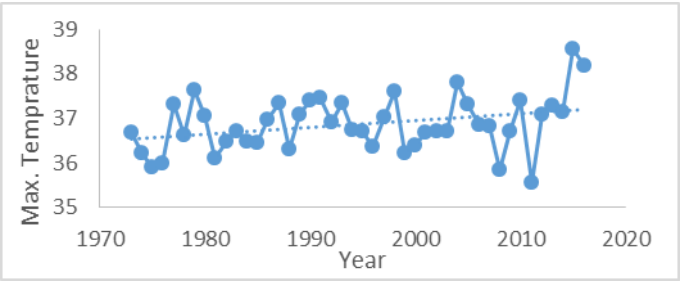

Figure 3. Trend graph of maximum temperatures for Nakhon Sawan.

Evaporation

The average evaporation between 1973 and 2015 in Nakhon Sawan was 1892.534mm, while the range was 886.23mm. More than 51% of the years' experienced annual evaporation below the mean average while the remaining 49% of the years experienced annual evaporation above the mean average. The first ten years experienced higher maximum evaporation than the last ten years. 1979, was the highest recorded evaporation with value of 2380.7 mm and 2011 recorded the lowest evaporation value of 1494.47 mm. From the graph, it can be observed that evaporation was decreasing (Figure 4).

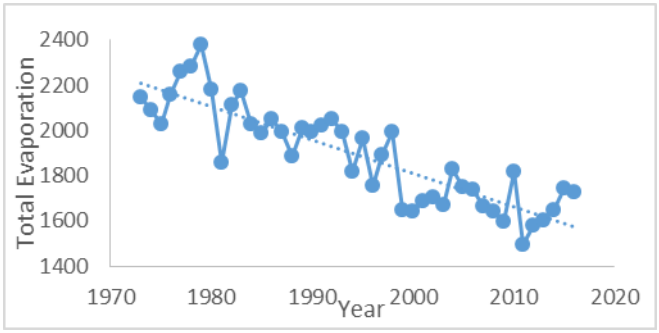

Figure 4. Trend graph of evaporation for Nakhon Sawan.

Correlations among the variables

As the entire study aims to understand the correlation between the meteorological conditions that propagate drought in the three provinces, this section correlates the meteorological parameters. The relationship between the three variables over the three-decade period allows linking the co-occurrence of period variables.

Rainfall vs maximum temperature

Rainfall also had a negative correction with rainfall and maximum temperature evaporation (y= -168.32x + 7341.5, R2=0.1898). On Figure 4, an increase in the maximum temperature leads to a decrease in total rainfall amounts. Subsequently, a decrease in the total rainfall in the region, based on the data leads to a decrease in the rates of evaporation (Figure 5).

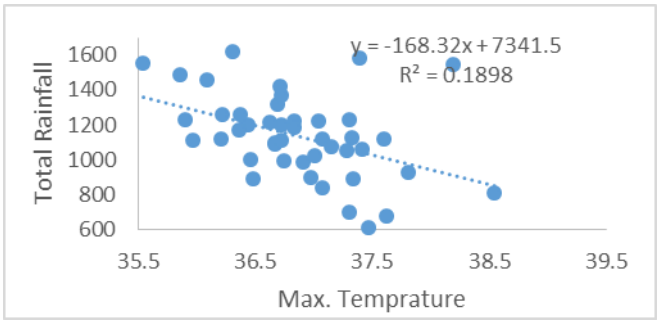

Figure 5. Scatterplot of total rainfall versus maximum temperature for Nakhon Sawan.

Rainfall vs evaporation

Rainfall also had a negative correction with evaporation. On Figure 5, an increase in the total rainfall leads to decline in total evaporation levels. Subsequently, a decrease in the total rainfall in the region, based on the data leads to a decrease in the rates of evaporation. The last 10 years and the first 10 years' rainfall and evaporation (Figure 6).

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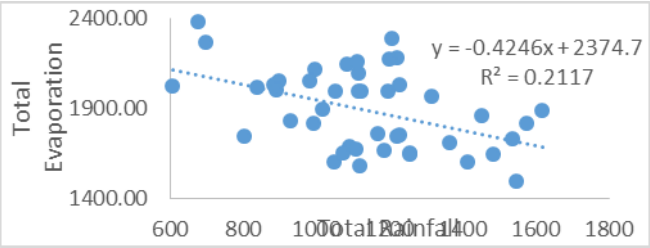

Figure 6. Scatterplot of total evaporation versus total rainfall for Nakhon Sawan.

Evaporation vs maximum temperature

Evaporation had a positive correlation with maximum temperature. On Figure 6, an increase in the temperature leads to an increase in the evaporation levels. Consequently, a decrease in the temperatures within the region, based on the meteorological data leads to a decrease in the rates of evaporation. On the equation, maximum temperature increases the rates of evaporation (Figure 7).

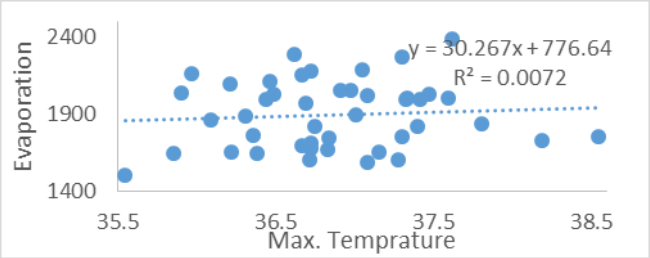

Figure 7. Scatterplot of evaporation versus maximum temperature for Nakhon Sawan

1.2) Phitsanulok

The next target for interrogation for the meteorological parameters is the Phitsanulok station. In this weather, the trend analysis covers the period between 1981 and 2016. A changing trend in rainfall, temperature, and evaporation noted.

Rainfall

This analysis indicates a steady increase in the rainfall parameter through the years with an annual average rainfall of about 1315mm and highest rainfall recorded was 1853.6mm in the year 2011. The maximum and the minimum annual rainfall of Phitsanulok meteorological station for the study period (1981–2016) were 1853.6 mm and 891.3 mm respectively. The range between the highest and lowest rainfall during the specific period was 962.3 mm (Figure 8).

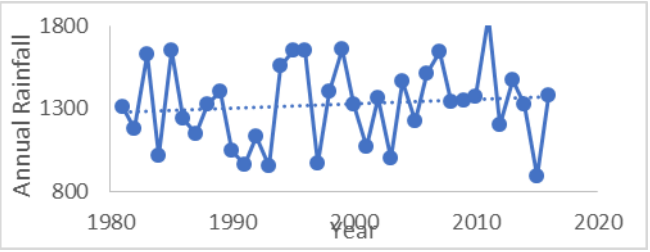

Figure 8. Trend graph of annual rainfall for Phistanulok.

Maximum temperature

The maximum temperature achieved through the measurement period ranged between 32 and 34.5 degrees celsius. The average maximum temperature for Phitsanoluk as observed on the graph in Figure 12 was 33.44670C while the range was 2.10C. This indicates that 53.3% of the years experienced maximum temperatures above average while the remaining 46.7% of the total number of years experienced a maximum temperature below the average temperature (Figure 9).

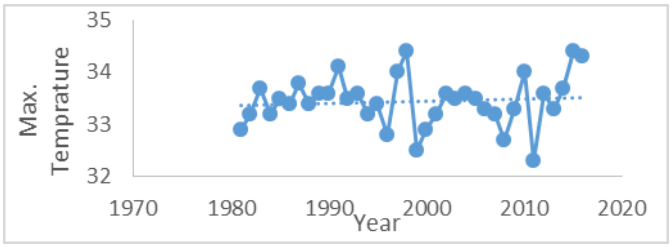

Figure 9. Trend graph of maximum temperature.

Evaporation

It is noted a somewhat random trend in evaporation between 1982 and 2016. The evaporation ranged between 1229 mm and 1887.9 mm, hence the range was 658.9mm. Evaporation was observed to decrease gradually through the measurement period. The average annual evaporation in Phitsanoluk was 1557.347mm. More than 53% of the years' experienced annual evaporation below the mean average while the remaining 47% of the years experienced annual evaporation above the mean average. The first ten years experienced higher annual evaporation than the last ten years but I had also been increasing in the last five years (Figure 10)..

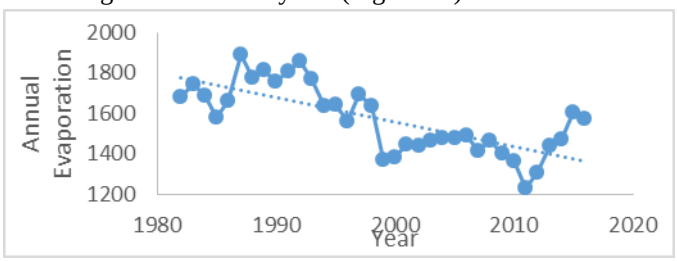

Figure 10. Trend graph of annual evaporation for Phitsanulok.

Correlations among the variables

The correlation between the three meteorological parameters in this station was variable. As described in more in-depth details, maximum temperature and rainfall, as well as rain and evaporation, are both slightly negatively correlated while temperature and evaporation are positively correlated.

Rainfall vs maximum temperature

Rainfall also had negative correlations with the maximum temperature. The correlation between rainfall and maximum temperature (y= -238.65x + 9306, R2=0.2195). A negative correlation indicates that when rainfall increases the maximum temperature falls. The low R2 value also shows rainfall and maximum temperature in the province were not dependent on each other (Figure 11).

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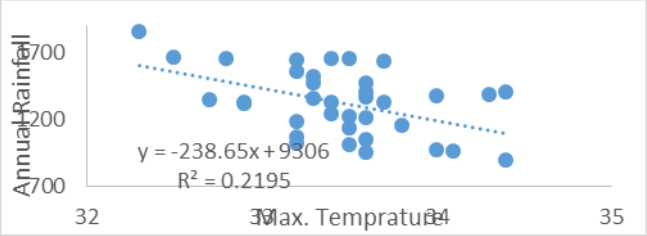

Figure 11. Scatterplot of annual rainfall versus maximum temperature.

Rainfall vs evaporation

Rainfall also had negative correlations with the evaporation. The correlation between rainfall and evaporation (y= -0.6061 x + 2275.8, R2=0.1698). A negative correlation indicates that rainfall increases when the evaporation falls (Figure 12).

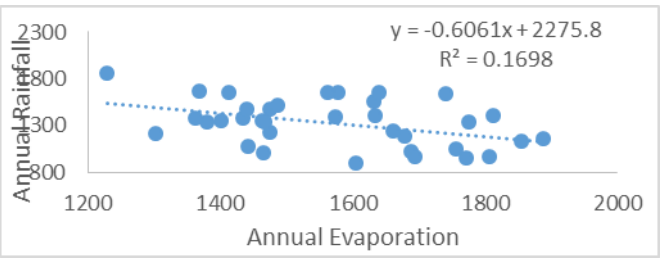

Figure 12. Scatterplot of annual rainfall versus annual evaporation for Phitsanulok

Maximum temperature vs evaporation

Maximum Temperature had weak and positive correlations with evaporation. The correlation between maximum temperature and evaporation was (y= 149.27x - 3424.4, R2=0.1787) (Figure 13).

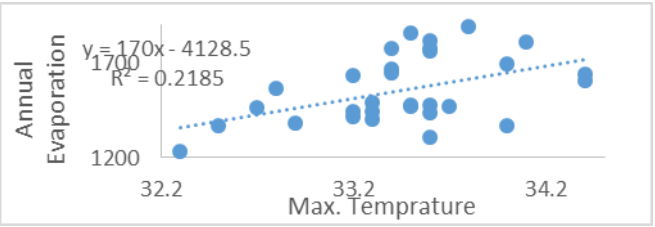

Figure 13. Scatterplot of maximum temperature versus annual evaporation for Phitsanulok

1.3) Kamphaeng Phet

The Kamphaeng Phet station is the third and final station that the analyst gathered meteorological data. From this station data, the analyzed the trends and the correlation factors for the three meteorological parameters between 1982 and 2015. This section describes the data from such a measurement period and a somewhat random trend over the years. Out of the three locations, Kamphaeng Phet experienced the steepest decreasing trend in the parameters, especially in the evaporation variable.

Rainfall

This analysis indicates a changing trend in the rainfall parameter through the years with an annual average rainfall of 1306.5 mm. The maximum and the minimum annual rainfall of Kamphaeng Phet meteorological station for the study period (1982–2015) were 1704.4 mm and 795.3 mm respectively, hence the range of 909.1 mm. More than 53% of the years' experienced annual rainfall below the mean average while the remaining 47% of the years experienced annual rainfall above the mean average. The last ten years experienced higher annual temperature than the first ten years (Figure 14).

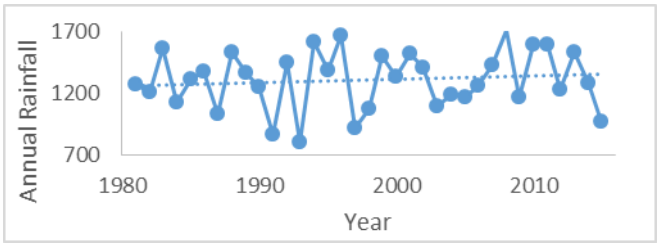

Figure 14. Trend graph for annual rainfall for Kamphaeng Phet

Maximum temperature

The Maximum temperature in Kampheang Phet had a changing trend over the three decades. 1998 had the highest maximum temperature value 34.5oC. 2011 had the lowest recorded value of 32.2 oC. The mean average temperature for Kamphaeng Phet was 33.470C, while the range was 1.030C. More than 56% of the years' experienced annual maximum temperature below the mean average while the remaining 44% of the years experienced annual maximum temperature above the mean average. Most of the years experienced a maximum temperature falling below the average temperature (Figure 15).

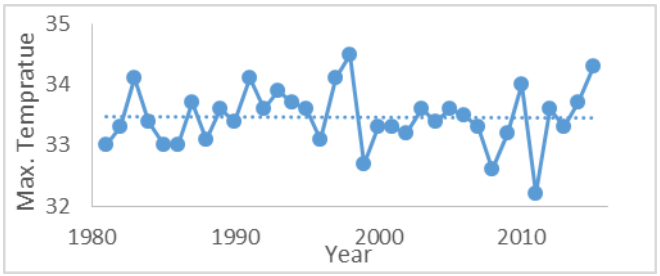

Figure 15. Trend graph of maximum temperature for Kamphaeng Phet

Evaporation

The evaporation in Kampheang Phet experienced the steepest decreasing trend for more than two decades but show an increase for the years between 2011 to 2015. 1987 had the highest evaporation recorded value of 1576.8mm. 2011 had the lowest evaporation recorded value of 1229. The average annual evaporation was 1350.25mm, the range was 347.8mm. More than 59% of the years' experienced annual evaporation below the mean average while the remaining 41% of the years experienced annual evaporation above the mean average (Figure 16).

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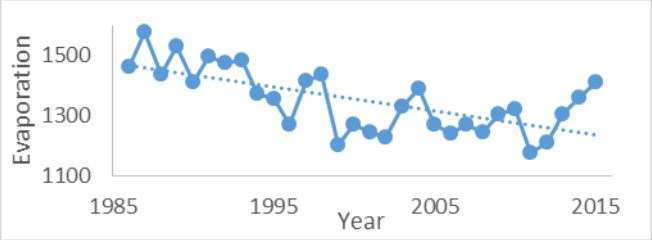

Figure 16. Trend graph of evaporation for Kamphaeng Phet

Correlations among variables

Rainfall vs maximum temperature

Rainfall had weak and negative correlations with maximum temperature. The correlation between rainfall and maximum temperature was the weakest (y= -268.96x + 10305, with low R2 value of 0.3037) (Figure 17).

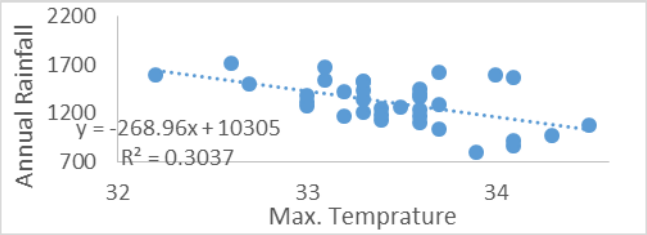

Figure 17. Scatterplot of rainfall versus maximum temperature for Kamphaeng Phet

Rainfall vs evaporation

Rainfall also had weak and negative correlations with the evaporation. The correlation between rainfall and evaporation (y= -1.1637x + 2879.9, R2=0.2535). A negative correlation indicates that rainfall increases when the evaporation falls (Figure 18).

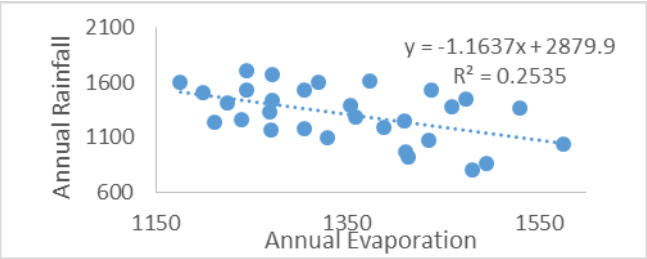

Figure 18. Scatterplot for annual rainfall versus annual evaporation

Maximum temperature vs evaporation

Evaporation had a weak and positive correlation with maximum temperature. The correlation between maximum temperature and evaporation was (y= 120.3x – 2676.5, R2=0.3064) (Figure 19).

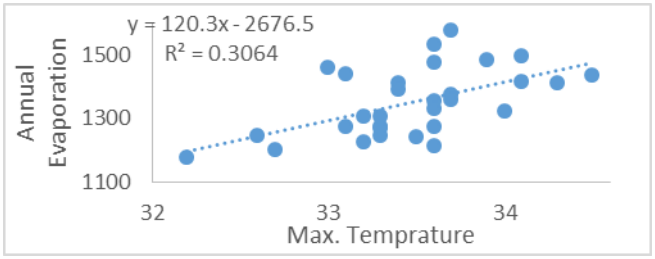

Figure 19. Scatterplot of annual evaporation and maximum temperature

2) Drought Analysis

2.1) Nakhon Sawan drought analysis using SPI

In Nakhon Sawan, there has been a series of wetness and droughts for the past decade. According to the index, the province experienced considerable wetness in recent times. As opposed to the meteorological drought experienced back in the 1990s, the 2010s appeared to suffer less and less of the drought conditions. As each of the index shall show, the region has had a range of drought index Figures in the past three decades that range from negative indices to positive ones and that extend beyond the moderate and average wetness and drought conditions. The decade beginning 1986 to 1996 presents a period of severe drought in 1990 (SPI = -2.71). It also present years showing 1988 and 1992 showing moderate drought (SPI = -1.4 and -1.15) respectively. 1989, 1991 and 1993 showed near normal conditions (SPI = -0.4, -0.71 and -0.67). Overall, 1987 recorded highest SPI with a maximum of 1.71 while the lowest SPI was recorded in 1990 with a value of -2.71. The SPI range was -1. (Figure 20).

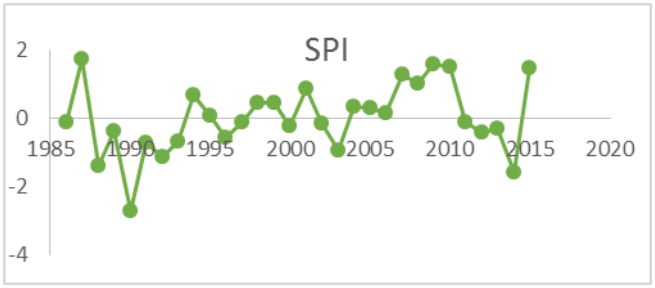

Figure 20. SPI for Nakon Sawan

2.2) Phitsanulok drought level using SPI

This second analyzed province offers results that are considerably different from the first one. In Phitsanulok, we noted several areas experience moderately dry to, dry conditions. 2015, was, for instance, the driest year in the measurement range. However, other years in recent times have bought severe wetness in the province, When we interpolate a little over two decades ago (the late 1990s), we realize that wetness had been the predominant condition according to the SPI Figures. Overall, most years between 1997 and 2007 experienced near-normal drought indices. We shall describe these Figures briefly below.

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According to SPI-12 months' time scale, at the Phitsanulok area, 2015 and 1993 were the worst drought years and 1988 was a normal year (Figure 21).

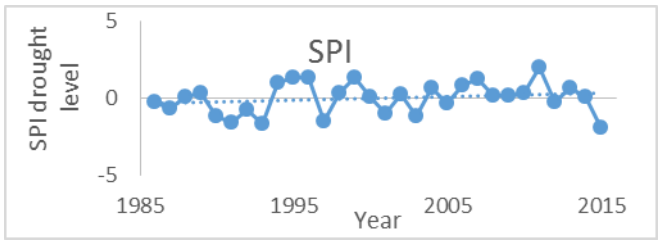

Figure 21. SPI for Phitsanulok

2.3) Kamphaeng Phet drought analysis

Lastly, Kampheang Pher province experienced the highest score on wetness in 2008. The trend in the province however, has been considerably consistent and moderate through the years. While the area initially experienced moderate drought, it changed the fortunes to significantly weak drought ratings. According to the standardized precipitation analysis, Kampheang phet recorded moderately wet (SPI =1.5) in 2013 and 2014 years, near normal (-1.1) in 1996 (Figure 22).

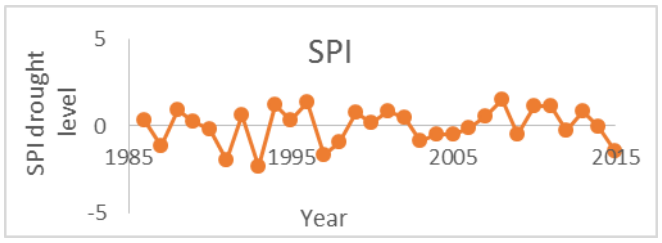

Figure 22. SPI for Kamphaeng Phet

On the annual SPI, Kamphaeng Phet recorded moderately wet (SPI=1.5) in 2013 and 2014 years, near normal (-1.1) in 1996. This implicates evidence of average levels of precipitation experienced in the region, hence limited levels of dryness witnessed in the region.

3) Metrological Data Vs SPI

In this section, we will look at the correlation between each meteorological data and SPI.

3.1) SPI correlation with meteorological data for Nakhon Sawan

The results indicated that the region has experienced average precipitation over time. There was severe drought in 1990 since it has an SPI of less than -2. From 2008 to 2015, there has been a considerable amount of precipitation compared to a period between 1988 to 2006. The R2 value relationship of SPI with evaporation, rainfall and max. temperature is 0.0549, 0.0368 and 0.0057, respectively (Figure 23).

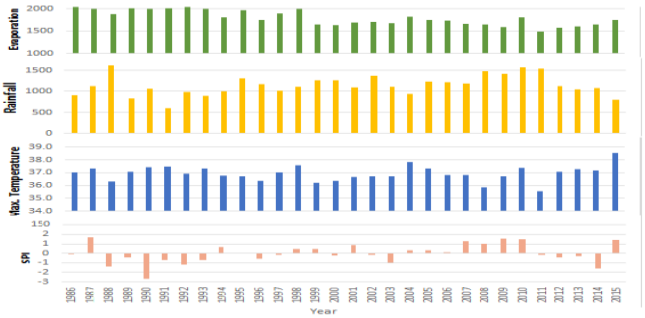

Figure 23. SPI correlation with meteorological data in Nakhon Sawan

3.2) SPI correlation with meteorological data in Phitsanulok

The region majorly comprised of moderately dry and severely dry especially for 2015 and 1993 years on monthly analysis. Several areas showed near normal, extremely wet, and very wet categories. The region majorly comprised of moderately dry and severely dry, especially for 2015 and 1993 years on annual analysis (Figure 24).

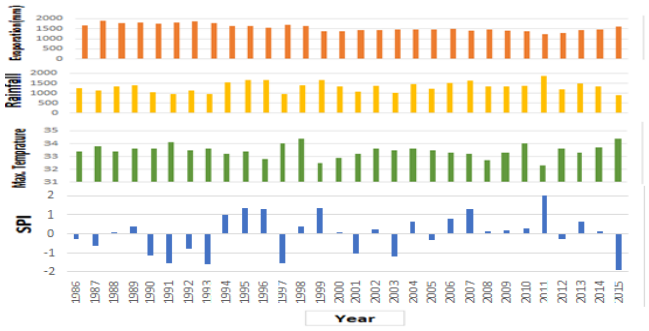

Figure 24. SPI correlation with meteorological data in Phitsanulok

3.3) SPI correlation with Meteorological Data in Kampheang Phet

On the annual SPI, Kamphaeng Phet recorded moderately wet (SPI=1.5) in 2013 and 2014 years, near normal (-1.1) in 1996. This implicates evidence of average levels of precipitation experienced in the region. Hence limited levels of dryness witnessed in the area. 1993 was severely dry while 2008 experienced wetness. Throughout the years, there were varied weather experiences, with fluctuations of drought and precipitation (Figure 25).

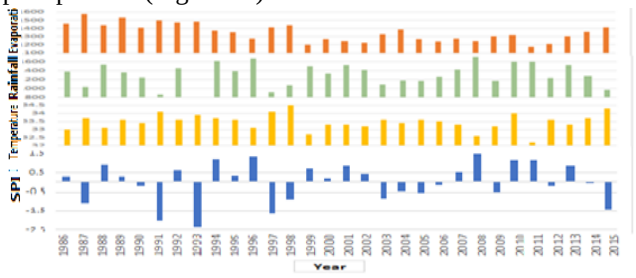

Figure 25. SPI correlation with meteorological data in Kampheang Phet

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4. Discussion

1) Meteorological weather patterns in Nakhon Sawan

The evaporation trends in Nakhon Sawan agree with the findings and the projection of the future reductions proposed by various studies [9]. The minimum and maximum annual rainfall of Nakhon Sawan meteorological station for the years 1973 to 2016 were 608.5 mm and 1618.3 mm, respectively. The highest and lowest values of maximum temperatures of Nakhon Sawan for the study period, 1973 to 2016, were 38.550C and 35.550C, respectively. The highest and lowest evaporation of Nakhon Sawan station for the period, 1973 to 2016, were 2380.7 and 1494.47, respectively.

2) Meteorological weather patterns in Phitsanulok

The data indicated that evaporation reduced during the study period. Studies agree with the reduced rainfall reading of 2015 in Phitsanulok [7]. The research postulated that the annual rainfall (2015-2039) in Phitsanulok would continue to decrease significantly [7]. Water demands however, would continue to increase during the same period, thus requiring innovative agricultural practices like irrigation to ensure sustained production [7]. The global temperature of the earth's surface is estimated to have risen by 0.74 ± 0.18oC since the start of the 20th Century [7]. In Southeast Asia, the temperature rise has been estimated to reach as high as 45oC. As such, the tropical Asian regions are vulnerable to extreme climate changes [7]. While staying with the context in Thailand, we notice a consistent shift in annual temperature by around 0.04oC annually. The climate trend in the two Northern Thailand locations agree with the scientific consensus on Temperature rises through the measurement age (1981-2015). One research proposed that the decreasing rainfall will continue in the near future, while the temperature continues to increase [9].

3) Meteorological weather patterns in Kampaeng Phet

In Kampheang Phet, it is notable that the average temperature has consistently risen while the annual rainfall has changed irregularly. Again, we may refer to the findings by [6-7], who recognize the continued rise in temperature levels in Asian country. As already stated, the scholars claim that the regions of Thailand and the globe will continue to experience a rising temperature status and a decreasing rainfall. Trends in pan evaporation in Thailand indicate that the meteorological factor has been reducing narrowly over the past 37 years [9]. This reduction comes despite the continuous increase in temperatures. Some factors that the authors associate with the decrease in evaporation may include lowered sunshine durations and decreased wind speeds. This study thereby appears to generally replicate the national and international Figures in evaporation rates indicating that the pan evaporation rates usually are falling through the new century. The maximum and the minimum annual rainfall of Kamphaeng Phet meteorological station for the study period (1982–2015) were 1704.4 and 795.3 mm respectively. The highest and lowest values of maximum temperature of Kamphaeng Phet for the study period (1981-2015) were 34.5oC and 32.2oC respectively. The highest and lowest evaporation of Kamphaeng Phet station for the period, 1982 to 2016, were 1887.9 and 1229 respectively.

4) Drought in Nakhon Sawan, Phitsanulok and Kampheang Phet

On SPI for Nakhon Sawan, the region showed extremely dryness in 1997 (SPI=-2.5), with extremely wetness evident in 2013 (SP1=2.2). In 2012, three districts in Nakhon Sawan, were declared drought zones. The drought situation could be predicted by extreme dryness and drought conditions in the leading up to the 2010s, as shown by both this meteorological data analysis and governmental reports [12].

Phitsanulok region was majorly comprised of moderately dry and severely dry especially for 2015 and 1993 years on annual analysis. Current studies and national meteorological data postulate that the Phitsanulok region is vulnerable to drought. Recently, for instance, the Thai Government declared the Drought situation in Phitsanulok to be headed for disaster status. Drought has furthermore, been declared a disaster in Thailand. According to the various studies, Phitsanulok is among the several areas in the nation that require immediate intervention to the ravaging drought crisis [10]. This study goes on to provide further evidence through the SPI values that the region is vulnerable to extreme drought.

According to the standard precipitation analysis, Kamphaeng Phet recorded moderately wet (SPI=1.5) in 2013 and 2014 years, near normal (-1.1) in 1996. The trend in wetness however, has paved the way for weak drought conditions in recent times. One research found moderate to weak drought episodes in some areas of Thailand, including the Sakae Krang River basin in their analysis of the rainfall and meteorological drought indicators on 2015 [14]. Such previous analysis thereby endorse the suggestions in this analysis that various regions in the country, including Khampheang Phet, maybe prone to extended periods of drought and wetness with inconsistent expressions of such conditions.

This shows that in terms of dryness, Nakhon Sawan was the highest followed by kampheang Phet as the least dry region being Phitsanulok from SPI of drought analysis. The trends in meteorological parameters through the years in Northern Thailand indicates an overall trend in drought and wetness that will continue for the next few decades. While the temperature is projected to increase considerably over the next few decades, rainfall is expected to decrease. This inverse proportionality of temperature and rainfall in the northern regions of Thailand maybe be projected to further the trend in global warming. Various policy and scientific research output in Thailand and globally thereby continue to present possible propositions for solving such unusual changes in the meteorological parameters.

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Generally, Phitsanulok had the highest rainfall amounts at 1853.6mm with a minimum of 891.3mm. Kamphang Phet came second on rainfall amounts with the highest at 1704.4mm and the least being 795.3mm. Nakhon Sawan had the least rainfall amounts with the highest of 1618.3mm and a lowest of 608.5mm. On evaporation, Kamphang Phet and Phitsanulok had the same lowest rates, with the highest value at 1887.9 with the lowest values of 1229. Nakhon Sawan had the highest amounts of evaporation with its highest being 2380.7 and a minimum of 1494.47. On the temperature differences, Nakhon Sawan had the highest at 29.3oC followed by Kamphang Phet showing 29.0oC and the least being Phitsanulok at 28.7oC.

In this analysis, we observed a trend of drought across lower northern part of Thailand through a dive through the recent history of the meteorological parameters. The aggregate data from up to thirty years ago reveal a continued trend towards drought disaster in northern Thailand that is accompanied by unpredictable climatic determinants. The comparative instrumental approach in this study enabled the results to possess improved consistency and validity while making the drought severity analysis objective and predictive.

5. Conclusion

According to the analysis, there exists differences from the three weather stations; Kamphang Phet, Nakhon Sawan and Phitsanulok, based on the weather elements measured. This clearly shows differences in weather patterns across this area, from the past meteorological data.

The findings emphasize the need to address the trend in declining rainfall and growing temperature. The drought trends in these provinces through the years were observed to considerably lean towards dry conditions. Nakhon Sawan, for instance, faced extreme drought in 1977(SPI =-2.5) and moderate wetness in 2013. Kampheang Phet recorded moderately wet conditions (SPI =1.5) in 2013 and 2014 years, and near normal conditions (SPI = -1.1) in 1996. Lastly, Phitsanulok region was majorly comprised of moderately dry and severely dry, especially for 1993 and 2015 years on annual analysis. Awareness should be created to nurture the need for environmental conservation, in a bid to improve environmental protection, and to improve the levels of precipitation.

From such a rising trend in dryness and drought, we recommend that the government develop policies for minimizing the impacts of environmental degradation. Furthermore, the government should install measures that enhance the amount of precipitation in the near future. Global environmental organizations must also assist local government in such initiatives, such as tree planting, to assist in environmental conservation. Monitoring and evaluation of the past environmental conservation data using such methods as SPI allow the government to predict trends in a meteorological drought that then assists in determining the other types of drought that accompany meteorological drought. Recommendation for further study: Monitoring and evaluation of the past environmental conservation measures should be checked, in relation to the changes in the levels of precipitation, to gauge for their effectiveness. Improvement in weather measuring instruments within the weather stations from Kamphang Phet, Nakhom Sawan and Phhitsanulok to develop sensitive instruments to check on the slight changes in precipitation, temperature and evaporation rates.

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