TRENDS OF RAINFALL IN SARAWAK FROM 1999 TO 2008

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ABSTRACT

An abiotic factor such as weather can be disruptive to certain businesses. Weather sensitive businesses (WSB) such as agriculture, construction, retail, transportation and tourism (travel and leisure) are often the first to feel the financial impact of severe or changing weather. Many WSB do not regularly quantify weather impact on performance, and such few have developed comprehensive strategies for managing weather risk. The impact of extreme weather on WSB occurs all over the world including Sarawak. Therefore, it is significant and necessary to conduct this study as a preliminary step to help businesses better understanding local rainfall patterns/trends to ensure good planning and risk mitigation for the future. Mann Kendall Test and time series plots were applied for this purpose. Rainfall data obtained from Drainage and Irrigation Department was the source of study. Prior to the above tests, regional and seasonal precipitations were determined using rainfall and rainy days. Any day with a collection of daily rain volume exceeding 6.35 mm is classified as rainy day.

Field of Research: Rainfall, precipitation trends, rainy days

1. Introduction

Many studies to analyse the changes in the amount of rainfall and its pattern of distribution have been conducted throughout the world. Many scientific papers and studies have concluded that most regional rainfall time-series have experienced fluctuations at different time-scales, rather than a notable or significant long-term trend (Folland et al. 1992, and Srikanthan & Stewart 1991). On the other hand, some evidence also showed consistent decreasing trends in some regions of the world (Nicholson and Palao 1993).

Malaysia’s climate can be classified as a typical tropical climate, hot and humid with temperature above 18°C throughout the year. The coastal plains temperature averaging 28°C, the inland and mountain areas averaging 26°C, and the higher mountain regions, 23°C. The area’s relative humidity is quite high, and ranges between 70 and 90 percent. The main variable of Malaysia’s climate is rainfall. Malaysia has extreme variations in rainfall that are influenced by the monsoons. The dry season usually starts from June to September, and the rainy season December to March. Western and northern parts of Malaysia experience the most precipitation, since the north- and westward-moving monsoon clouds are heavy with moisture by the time they reach these more distant regions.
Typhoons can sometimes hit Malaysia from July to mid-November, and can cause heavy damage, flooding and erosion (Weather Online). Even though many studies have been carried out globally and for specific regions, studies on rainfall pattern in Malaysia is very limited. Changes in long-term annual rainfall and its main characteristics for the whole of the country have not been studied comprehensively as yet.

As for this project, it uses the daily rainfall data as analysis parameters. Daily rainfall is defined as the quantity of water falling in a specific area in 24 hours, usually expressed in inches or centimetres of water. The area of study is inclusive of all divisions in Sarawak and the data covered ranges from January 1998 until December 2007.

2. Literature Review

Local Scenario

Many risk managers agree that the current business and financial planning paradigm around predictable and cyclical weather patterns is insufficient and may be further challenged in many regions by increasingly volatile climate. Businesses are typically prepared for rainfall norms and averages, but those averages are often the result of periodic extremes that can negatively impact business performance. Although precipitation forecasting can be extremely helpful to business in mitigating volatility and risk, it is worth noting that rainfall is among the most difficult weather elements to predict correctly (WeatherBill, 2007). In Malaysia, the climate is governed by the regime of the northeast and southwest monsoons. The northeast monsoon blows from October to March, and is responsible for the heavy rains which hit the east coast of the peninsular and frequently cause widespread floods. It also causes the wettest season in Sabah and Sarawak. The southwest monsoon period occurs between May and September, and is a drier period for the whole country. The period between these two monsoons is marked by heavy rainfall. The mean annual rainfall is 3,000 millimetres (mm). Sabah and Sarawak however experience more rainfall (3,000-4,000 mm) than the peninsular (Kundell, 2007).

Climate variability in Malaysia is very much influenced by Madden-Julian Oscillation (intra-seasonal oscillation), ENSO (El Nino Southern Oscillation), and IOD (Indian Ocean Dipole) (inter-annual oscillation) modes. Consistent with other places, generally temperature in Malaysia is rising. Long term trends of precipitation appears to be more varying, with some stations showing positive trends and others showing negative trends. It is not certain precisely how global warming alters local rainfall distribution or extreme events, thus this relationship needs further investigation (Tanggang 2007). A preliminary result from a study on trend analysis of monthly rainfall in certain areas in Malaysia indicated that the trends increased in certain areas but decreased in other areas (Lai et al. 2009).

During the National Seminar on Socio-Economic Impacts of Extreme Weather and Climate Change held by the Ministry of Science, Technology and Innovation lately at Putrajaya, Malaysia, it has been concluded that the future climate scenario will be warmer based on the projections of the Intergovernmental Panel on Climate Change (IPCC). It was noted that the IPCC scientists have interpreted the increase in climate variability and extreme weather events as signals of the impacts of climate change due to global warming. It is imperative that all necessary steps be taken to better prepare ourselves against the impacts of such changes. There is no doubt that global warming is real and happening. Modelled results have also forecasted the occurrences of extreme events. There is urgent need to understand our vulnerability and risks to formulate the needed adaptation measures. In this respect, there is need to understand the scientific aspects of climate variability and climate...
change, in particular, the climate variability at local levels and its impact on social and economic sectors (MOSTI, 2007).

Climate and day-to-day weather variations affect a wide range of economic activities. Climate influences the spatial distributions of population and of industrial, agricultural, and resource-based production activities, while weather can affect levels of production and production costs. In addition, severe weather can damage or destroy properties.

3. Methodology

A. Selection of Station

Rainfall data at eleven rainfall stations were identified based on the availability of data. These stations are the nearest stations relative to the main towns in all divisions. The rainfall data of Betong, Bintulu, Kapit, Kuching, Limbang, Miri, Mukah, Samarahan, Sarikel, Sibu and Sri Aman regions for the past ten years (year 1999 to 2008) were obtained from the resources of Meteorological Department as well as Irrigation & Drainage Department.

B. Rainfall Patterns and Trends Study

By focusing into regional and seasonal aspects, average rainfall and rainy days were determined. All these parameters provide a platform towards the identification of rainy area quarterly and yearly. After completing all the above stated, statistical tools were applied as means to test the significance of monthly and quarterly precipitation trends in both rainfall and rainy days. Time series plots and Mann-Kendall test for trends were the two desired statistical methods.

The first step involved the usage of graphical representations or better known as time series plots. Time series plot are important in revealing long-term trends.

Next, XLSTAT Mann-Kendall test was employed to analyse the monthly and quarterly precipitation trends in both rainfall and rainy days for all eleven stations. The test is to identify whether or not a statistically significant decreasing or increasing trend or none could be found in a data set. Mann-Kendall test is a nonparametric test for identifying trends in a series of data. Confidence levels of 90 and 95 percent were taken as thresholds to classify the significance of precipitation trends. p-values smaller than 0.05 or 0.1 must be fulfilled before the trend test was concluded to be significant.

As to further supporting the trend analysis, least squares method was used in order to determine the equation of trend line that best describes data behaviour.

4. Finding

A. Divisional Precipitation
Precipitation for eleven divisions in Sarawak over the period of ten years beginning from year 1999 was studied by analysing the total millimetres of rainfall and the number of rainy days. Day of a week is considered as rainy or wet if the amount of rain collected exceeds 6.35 mm.

Figure 4.1  Average Annual Rainfall and Rainy Days > 6.35 mm

Northern Region Division Miri displayed the smallest amount of rainfall with a percentage of 7.26% over the total divisional average (Figure 4.1). On the other hand, Kapit demonstrated the highest amount of rainfall, at 10.93% of the total divisional average.
B. Seasonal Precipitation

In this section, rainfall and rainy days data were divided into clusters term as quarter.

- Q1: January – March
- Q2: April – June
- Q3: July – September
- Q4: October – December

Ten of the eleven Sarawak divisions exhibited a significantly higher rainfall in Q1 and Q4 (Figure 4.2). There is an obvious pattern while comparing these two quarters whereby among all the divisions, only Kuching and Samarahan recorded a higher number of rainy days in the first quarter.

C. Precipitation trends

Sections below emphasize on the quarterly and monthly precipitation trends of eleven divisions in Sarawak. Time series plots and the Mann-Kendall test for trends were used in determining the trend associated rainfall and rainy days for each division. Results obtained show a significant trend at 90 and 95 percent confidence level for certain divisions. As such, least squares method was performed on all the time series plot of these divisions in order to develop a trend line equation for each. By graphical presentation, trend line was drawn using weighted black line. The upright direction represents positive trends while negative trends are exemplified by direction heading to the lower left. Statistically, a positive trend indicates an augmentation in both rainy days and amount of rainfall from year to year.

i) Monthly precipitation trends of rainfall
Figure 4.3 Monthly Rainfall Precipitation Trends (Rainfall Monitoring) – Significant Changes in Ten Years

Figure 4.3 illustrates the order of magnitude of the investigated trends. The significant positive monthly precipitation trends (from January 1999 to December 2008) at 90 percent confidence levels were detected in four divisions namely Bintulu, Kapit, Limbang and Miri.

ii) Monthly precipitation trends of rainy days

a. Miri (at 95% significance level),
   \[ T = 8.294818 + 0.012758t \]

b. Limbang, \[ T = 10.05014 + 0.009226t \]

Figure 4.4 Monthly Precipitation Trends (Rainy Days Monitoring) – Significant Changes in Ten Years

It is observed that both Miri and Limbang divisions displayed a momentous positive monthly precipitation trends in rainy days. Significance level for Miri Division is slightly higher at 95% as compared to the level for Limbang which is positioned at 90%.

iii) Quarterly precipitation trends of rainfall

a. Bintulu, \[ T = 872.3188 + 4.418837t \]

b. Kapit, \[ T = 997.2673 + 3.908424t \]
c. Miri, \( T = 665.4381 + 2.459606 \ t \)

Figure 4.5 Quarterly Precipitation Trends (Rainfall Monitoring) – Significant Changes in Ten Years

As seen in Figure 4.5, divisions such as Bintulu, Kapit and Miri showed significant positive quarterly precipitation trends in rainfall.

iv) Quarterly precipitation trends of rainy days

a. Miri, \( T = 25.05 + 0.104878 \ t \)

b. Mukah, \( T = 28.19615 + 0.102627 \ t \)

Figure 4.6 Quarterly Precipitation Trends (Rainy Days Monitoring) – Significant Changes in Ten Years

Two divisions showed significant quarterly precipitation trends in rainy days (Figure 4.6). The significant increment in rainy days were noted in Miri and Mukah.

5. Concluding Remark

As demonstrated by the finding, several northern divisions namely Kapit, Bintulu, Miri, Limbang and Mukah epitomized positive significant precipitation trends. Positive precipitation trends serve as strong proofs that rainy days incidence and rainfall volume for northern along with central regions...
are going to elevate every year. There is no doubt that these data will help to encourage the inclusion of proper flood mitigation measures in the future town development projects. Other northern and central divisions whilst not categorized as flood prone areas, flood preparation projects like redirecting flood run off and upgrading of irrigation system could still be implemented so as to prevent severe damage if floods were to happen in the future.

Interestingly, trends generated show that universities have a role to play in understanding the scientific aspects of climate variability and climate change at broad and local scales. In particular, the climate variability at local level is critical to formulate the needed adaptation measures as well as to generate regional climate models, which is useful for good planning for the future. Broader data investigations are highly recommended in an attempt to realize a more comprehensive visual analysis.

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