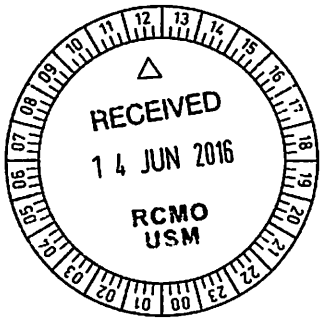
END OF REPORT

Program Title: Flood and flood disaster: Integrated assessment of extreme rainfall-runoff on flood hazard, water quality and microbial variability, and enhancement of standard operating procedures (SOP) for flood disaster awareness: Case study of Sungai Pahang River Basin

Project Title: Project 1 - Basin characteristics: Rainfall distribution in 5 states since 1967 flood until 2014 flood: Detecting the climate change effect



A. Project Information

Start Date	: 1/04/2015
End Date	: 31/03/2016
Extension Date	: RMC Level: 30/04/2016
Project Status	: Completed
Project Leader	: Nor Azazi bin Zakaria
I/C Number	: 630411-03-5045
University	: Universiti Sains Malaysia
Address	: REDAC, USM Engineering Campus, 14300 Nibong Tebal, Penang
Contact number	: (Office) 04-5995461 (H/p) 012-4070937
Project Members	: Aminuddin Ab Ghani
	Lee Lai Kuan
	Lau Tze Liang
	Chang Chun Kiat

B. Project Achievement

Project Progress	: 100%
Research Output	: Indexed Journal - 2 (1 - Accepeted, 1 - Under Review)
	Conference Proceedings – 2
Talent	: PhD student - Mazlina Alang Othman (IC No: 761015-08-6246) (Thesis write up)
	RA - Mohamad Afizi Jamadin (IC No: 850804-10-5969)

C. Expenditure

Budget Approved	: RM 133,100.00
Amount Spent	: RM 132,910.88
Balance	: RM 189.12
% of Amount Spent	: 99.86

SUMMARY OF RESEARCH FINDINGS

1.0 Introduction

Climate change can severely impact hydrological processes, including increase in precipitation, particularly during extreme events. Generally, in areas with increase in mean total precipitation, heavy and extreme precipitation events also increase with a large percentage (Dore, 2005). Changes in extreme events can effect environment and human activities, threatening to human health and safety.

Climate change has already begun to transform the rainfall patterns in Malaysia and extreme floods have become more severe in several states. Recently, extreme rainfall events in Malaysia are becoming more frequent and it revealed that heavy rain events on the east coast of Peninsular Malaysia have increased over 40 years (Mayowa et al. 2015). Various models also projected that rainfall will continue to increase, which will cause an increase of heavy rainfall events in the East Coast of Peninsular Malaysia (NAHRIM 2006).

There are a number of studies in extreme rainfall event over Malaysia but there are still large knowledge gap with regards to extreme events (Tangang et al. 2012). Syafarina et al. 2015 used non- parametric test to analyze rainfall trends and found that hourly extreme rainfall events in Peninsular Malaysia showed an increasing trend with notable increasing trends in short temporal rainfall. Given that these studies focus on the hourly extreme rainfall event, detailed study on short storm duration and long storm duration is needed. It is because of extreme rainfall in short storm durations potentially leads to an increase in the magnitude and frequency of flash floods in urban areas. Furthermore, extreme rainfall events in Malaysia frequently extend over two days due to the influence of monsoon seasons. Therefore, the main objectives of this paper are (a) to investigate changes in the annual maximum rainfall depth of 24 h duration over five major basins, and (b) to investigate the trend of extreme rainfall events in various storm duration by using Mann Kendall test and Sen's Slope Estimator.

2.0 Methodology

The trends of extreme rainfall event in five major basins: Perak, Kelantan, Terengganu, Pahang and Johor river basin are investigated in this study. Rainfall data for a period more than 25 years basins are obtained from Department of Irrigation and Drainage (DID), Malaysia. There are 34 rainfall stations from five major basins were examined in this study.

Mann Kendall (MK) test is a statistical test widely used to assess the trend in hydrological time series. The test statistic of MK test, S, is computed as follows:

$$S=\sum_{k=1}^{n-1}\left[\sum_{j=k+1}^{n} sign\left(x_j-x_k\right)\right] \tag{1}$$

$$sign\left(x_j-x_k\right)=\begin{cases}1, & x_j-x_k>0\\ 0, & x_j-x_k=0\\ -1, & x_j-x_k<0\end{cases} \tag{2}$$

Where x_j and x_k are the sequential data values, n is the number of observations. In the MK test, the positive test statistic, S indicates increasing trend, whereas the negative test statistic indicates decreasing trends. The variance for the S statistic is defined by:

$$Var(S)=\frac{n(n-1)(2n+5)}{18} \tag{3}$$

$$z=\begin{cases}\frac{S-1}{Var(s)}, S>0\\ 0, S=0\\ \frac{S+1}{Var(S)}, S<0\end{cases} \tag{4}$$

The test statistic Z is used to measure of significance of the trends. The magnitude of the trend was calculated using the Sen's slope approach. Sen's non-parametric method estimates the magnitude of the trends in the time series data:

$$T_i=\frac{x_j-x_k}{j-k} \tag{5}$$

In this equation, x_j and x_k correspond to data values at time j and k. Consider

$$Q_i=\begin{cases}T_{\frac{N+1}{2}}\\ \frac{1}{2}\left(T_{N/2}+T_{N+2/2}\right)\end{cases} \tag{6}$$

A positive value represents an increasing trend and a negative value represents a decreasing trend over time. Software used for performing the statistical MK test and homogeneity test is Addinsoft's XLSTAT 2016. The null hypothesis is tested at 95% confidence level.

3.0 Results and Discussion

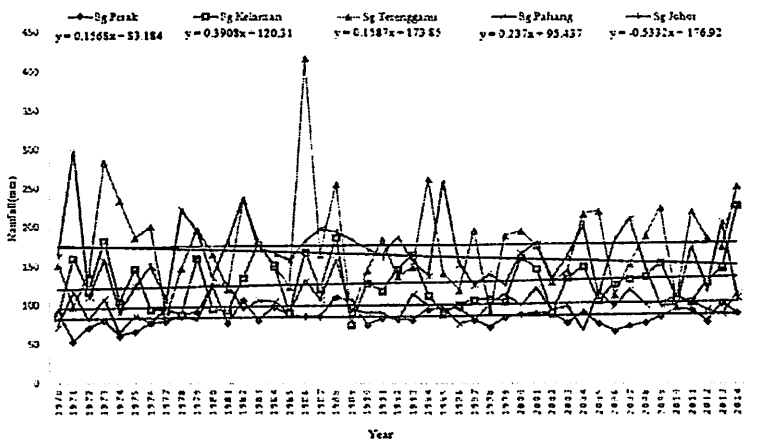
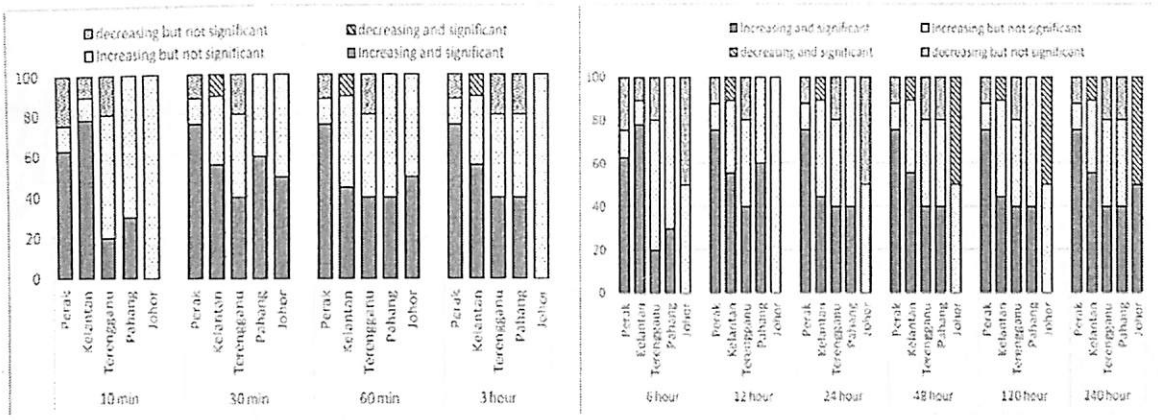


FIGURE 2. Annual maximum daily rainfall

Based on the graphs in Figure 2, a clear increasing trend in annual maximum daily rainfall was observed for Perak, Kelantan, Terengganu and Pahang river basins and decreasing trends in Johor river basin. Fitting trend lines show positive magnitude in slope for increasing trend and Kelantan River Basin recorded higher magnitude compared to the others. Negative magnitude was detected at Johor river basin showing decreasing trends in annual maximum daily rainfall. It is noteworthy that only two stations were studied in this area. As a result from increase in annual maximum daily rainfall, flood risk will also increase, which in turn can trigger landslide events.

Figure 3 show the percentage of rainfall stations which presented increasing (significant or not) or decreasing (significant or not) with statistical significance of 95% in various storm durations (i.e. 10, 30 and 60 minutes, 3, 6, 12, 24, 48, 120 and 240 hours). Storm durations were classified into two groups: (i) as a short storm duration for duration less than or equal to 3 hours; and (ii) as a long storm duration for a duration equal to or greater than 6 hours. With regards to short storm durations, an increasing trend was identified for all basins which percentage of stations more than 80%. The most marked trend has been detected in 10, 30 and 60 minutes for Pahang and Johor river basin with 100% of the rainfall stations showing increasing trends. Statistically increasing trends more than 40% were notified in short storm duration except for Terengganu, Pahang and Johor (10 mins) and Johor (3 hours). In contrast, there are statistically decreasing trend in 30 mins, 60 mins and 3 hours storm durations for Kelantan river basin but in a very small percentage. The increasing trend also evidenced at long storm duration for all river basins. However, decreasing trends were more noticeable at long storm durations compared with short storm durations especially for the Johor river basin. 50% of rainfall stations in the Johor river basin showing statistically decreasing trend in 48, 120and 240 hours. Given that there are only two stations represent this area, the results can be improved by analyzing more stations.



(a) (b)

FIGURE 3. Trend of extreme rainfall event in (a) short storm duration and (b) in long storm duration expressed as percentage of rainfall stations of the basins

The results of percentage of stations showing significant and insignificant trend were summarized in Table 2. From the hypothesis test, percentage of stations showing significant increasing trends were more higher in short storm duration for Perak, Pahang and Johor river basin. However, Kelantan and Terengganu river basins show higher percentages in significant increasing trends for long storm durations. As mentioned before, extreme rainfall in short durations potentially leads to flash floods in urban areas. Therefore, particular attention must given to the short storm duration rainfall event in Perak, Pahang and Johor river basin. Increase in the frequency of flash flood occurrence in the western and southern region, particularly because of an increase in a number of very wet and extremely wet of a rainfall station in that area. (Syafarina et al. 2015). Significant increasing trends in long storm duration also give an impact to Kelantan and Terengganu river basin. Given that North East Monsoon brings about heavier rainfall in this area, the probability of getting extreme rainfall in long duration storm is very high in this area. Although the percentage of decreasing trend is small,Kelantan river basin recorded 11% of significant decreasing trend in short storm duration. Whereas, Pahang and Johor river basin recorded significant decreasing trend in long storm duration at 10% and 50% respectively.

TABLE 2: Results of a percentage of the stations showing trends

Basin	Durations	Increasing		Decreasing	
		Significant	Insignificant	Significant	Insignificant
Perak	Short storm	75	12.5	0	12.5
	Long Storm	62.5	25	0	12.5
Kelantan	Short storm	67	22	11	0
	Long Storm	78	11	0	11
Terengganu	Short storm	40	40	0	20
	Long Storm	60	20	0	20
Pahang	Short storm	50	50	0	0
	Long Storm	30	30	10	30
Johor	Short storm	50	50	0	0
	Long Storm	0	50	50	0

4.0 Conclusion

Important findings of the study are summarized as follows.

i. Annual maximum daily rainfall in Perak, Kelantan, Terengganu and Pahang River basin increase throughout 45 years, meanwhile decreasing trend were detected in Johor river basin. Increasing of annual maximum daily rainfall will increase flood risk and indirectly decrease the water quality related to sediment movement. Increasing intensities of rainfall will also lead to increases in soil loss and major landslide events.

ii. Percentage of stations showing significant increasing trends were more higher in short storm duration for Perak, Pahang and Johor river basin. However, Kelantan and Terengganu river basins show higher percentages in significant increasing trends for long storm durations. It should be noted that the increasing trend in short storm duration rainfall gives an impact on urban drainage and stormwater facilities. Studies dealing with extreme rainfall in urban areas in Malaysia is still rather limited, and detailed studies related to extreme rainfall in short storm durations should be taken into consideration in the future.

References

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