VARIABILITY EFFECTS OF RAINFALL EVENTS ON SOIL EROSION IN NORTHERN REGION OF PENINSULAR MALAYSIA

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VARIABILITY EFFECTS OF RAINFALL EVENTS ON SOIL EROSION IN NORTHERN REGION OF PENINSULAR MALAYSIA

by

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LIST OF ABBREVIATIONS

8R	8 Rubber
AR4	Fourth Assessment Report
BR	Buishand range
CCl	Commission for Climatology
CDD	Continuous dry days
CLIVAR	World Climate Research Program's Project on Climate Variability and Predictability
COV	Coefficient of Variation
CWD	Continuous wet days
DID	Department of Irrigation and Drainage
EPA	Environmental Protection Agency
ETCCDI	Expert Team on Climate Change Detection and Indices
GHGs	Greenhouse Gases
EI_{ROM}	Erodibility Index (Roslan and Mazidah)
IPCC	Intergovernmental Panel on Climate Change
MFI	Modified Fournier index
MK	Mann- Kendall
MOSTI	Ministry of Science, Technology and Innovation
N_2O	Nitrous Oxide
NAHRIM	National Hydraulic Research Institute of Malaysia
NASA	National Aeronautics and Space Administration
PRCPTOT	Annual total precipitation in wet days
R	Software Environment for Statistical Computing and Graphics

RMSE	Root Mean Squared Error
RUSLE	Revised Universal Soil Loss Equation
SNHT	Standard Normal Homogeneity Test
SPSS	Statistical Product and Services Solution
SSE	Sen’s Slope Estimator
TM	Tilt Meter
USLE	Universal Soil Loss Equation
WHO	World Health Organisation
WMO	World Meteorological Organization
VNR	Von Neumann ratio

LIST OF SYMBOLS

σ	Standard deviation of parameter
CFCs	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
E	Break year
F	Fournier index
f	Function
H_2O	Water vapour
i	year from 1 to n
i	Day
j	Time period
K	year
m	Median
N	Von Neumann test statistic
n	Total number of parameter
n	Number of values in a time series
N	Von Neumann ratio statistic
p	Precipitation in the wettest month
P	Total annual rainfall
Q_i	Sen's slope test statistic
r	Correlation
r	Rank
R	Rescaled adjusted range

r^2	Coefficient of determination
RR	Daily precipitation amount
R10mm	Annual count of days when ≥ 10mm
R20mm	Annual count of days when precipitation ≥ 20mm
Rx1day	Monthly maximum 1-day precipitation
Rx5day	Monthly maximum consecutive 5-day precipitation
R95pTOT	Annual total precipitation when RR > 95p
R99pTOT	Annual total precipitation when RR > 99p
RR	Daily precipitation amount on a wet day
s	Skewness
S	Mann-Kendall tau-b test statistic
S^*	Cumulative deviations from the mean
SDII	Simple precipitation intensity index
sgn	sign
T_0	Test statistic
T (k)	Standard normal homogeneity test statistic
$\mathrm{Var}(S)$	Variance
X	Pettit test statistic
x	Rainfall event
x	Concentration of parameter
$\bar{x}$	Mean
X_k	Pettitt statistic
$\bar{Y}$	Mean of Y_i
Y_i	Series of data
Z_s	Mann-Kendall test statistic

KESAN KEBERUBAHAN KEJADIAN HUJAN TERHADAP HAKISAN TANAH DI RANTAU UTARA SEMENANJUNG MALAYSIA

ABSTRAK

Lebih banyak hujan lebat disebabkan oleh perubahan iklim terbukti memburukkan lagi kehakisan dan akhirnya hakisan. Kajian terdahulu telah mengemukakan sistem hamparan 8R yang boleh menambah baik kestabilan cerun dan kawalan hakisan. Objektif kajian ini adalah pertama untuk mendapatkan trend hujan dan indeks iklim ekstrem, kedua untuk menentukan kehakisan hujan menggunakan indeks Fournier terubah suai dan akhir sekali untuk mengenal pasti hubungan di antara kelebatan hujan dan kestabilan system hamparan 8R. Empat lokasi bertempat di rantau utara semenajung Malaysia dipilih. Variasi hujan tahunan dan monsun jangka masa panjang (30 tahun) dikaji. Daripada plot siri masa dan analisa trend variasi purata tahunan, hanya Kangar memberikan trend negatif yang signifikan menunjukkan Kangar akan menjadi lebih kering. Analisa iklim ekstrim menunjukkan semasa monsun barat daya, Kangar menjadi lebih kering dari tahun ke tahun. Sementara itu, Simpang Ampat menjadi lebih lembab pada monsun timur laut. Stesen lain menunjukkan trend iklim ekstrim yang tidak signifikan. Kajian keseluruhan tentang kehakisan hujan menggunkan indeks Fournier terubah suai menunjukkan rantau kajian ini dibawah impak kehakisan hujan sederhana dan rendah. Kajian pada tahap hakisan menggunakan kehakisan hujan dan kebolehhakisan tanah di tapak pembinaan sistem hamparan 8R menunjukkan rantau ini berada dibawah tahap tinggi empat (HL4) tahap hakisan mendorong tanah runtuh. Akhir sekali didapati bahawa tiada hubungkait yang signifikan di antara kelebatan hujan dan kestabilan sistem hamparan 8R diperolehi.

Penggunaan batu terhancur sebagai bahan pemenuh dan pembinaan longkang membantu air dari memberi kesan kepada kestabilan sistem ini.

VARIABILITY EFFECTS OF RAINFALL EVENTS ON SOIL EROSION IN NORTHERN REGION OF PENINSULAR MALAYSIA

ABSTRACT

More intense rainfalls caused by climate change proven to worsen erosivity and ultimately erosion. A previous study has come up with 8R mat system that can improve slope stability and erosion control. The objectives of this study are first to obtain the trend for rainfall and climate extreme indices, second to determine the rainfall erosivity using Modified Fourneir Index and lastly to identify the relationship between rainfall intensity and the stability of 8R mat system. Four stations located in the northern region of Peninsular Malaysia were chosen. The yearly and monsoonal variations of long-term rainfall (30 years) data were studied. From the time series plot and trend analysis of mean yearly variations, Kangar provides negative significant trend indicates that Kangar will be drier. The climate extreme indices analysis shows that during southwest monsoon season, Kangar becomes drier year by year. Meanwhile, Simpang Ampat are getting wetter in northeast monsoon season. Other stations show insignificant trend of climate extreme indices. The overall studies of rainfall erosivity using Modified Fournier index show that the study area is under the moderate and low impact of rainfall erosivity. The study on erosion level using rainfall erosivity and soil erodibility at 8R mat system construction site shows that the area is under High Level 4 (HL4) level of erosion induced landslide. Finally, it is found that no significant correlations between rainfall intensity and horizontal movement of the 8R mat system. The usage of crusher run as the filling material and the construction of drain helps to prevent water from affecting the stability of this system.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

These days, climate change had received great attention across the world. Climate change plays a big part in creating problems on world food supply (Rosenzweig and Parry, 1994), human health (Patz et al., 2005), water resource (Wilby, 2005), economy (Mendelsohn and Neumann, 2004) and other fields throughout the world. Intergovernmental panel on climate change (IPCC, 2007) define climate change as a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that continue for a prolonged period, typically decades or longer. Previous researchers have concluded that human activities have been recognized as the dominant cause of the earth atmosphere rapid warming. Human activities such as burning of fossil fuels and changing land cover are modifying the concentration of atmospheric properties of the Earth’s surface that absorb radiant energy (Sivakumar and Ndiang’ui, 2007)

Hydrologic variables such as rainfall and surface water are an important indicator of climate change. These variables tend to reflect climate change and can help in understanding the relationship between hydrology and climate (Burn and Elnur, 2002). There have been many studies in recent decades that have examined changes in monthly, seasonal, and annual climate means for the purpose of capturing the fingerprints of climate change due to anthropogenic modification of atmospheric chemistry. For example, study on observations of climate change impacts are focused on elements of the hydrological systems and cycle such as: changing precipitation/rainfall patterns, intensity and extremes; increasing atmospheric water vapor; increasing evaporation; and changes in soil moisture and runoff has been done by Trenberth (2005). Trenberth (2005) conclude that climate change has a direct impact on changes in precipitations and heavy rains. Increased surface temperature leads to greater evaporation and consequently surface drying, as a result of that increase in intensity and duration of drought.

1.2 MALAYSIAN CLIMATE CONDITION

Situated in the western part of the Maritime Continent, the Malaysian climate is strongly dominated by the Southeast Asia Maritime Continent monsoon – an important component of the larger Asia-Australia monsoon system. Figure 1.1 illustrates all countries in Southeast Asia. These countries are influenced by the monsoon which is a ‘large-scale seasonal reversals of the wind regime’ (Serreze and Barry, 2010). Malaysia is located near the equator line with tropical climates which receives the high intensity of rainfall. The average annual rainfall is 2400mm for Peninsular Malaysia, 3800mm for Sarawak, and 2600mm for Sabah (Ching et al., 2015). Regionally, Malaysian surface climate is influenced by two monsoon regimes namely the southwest monsoon and the northeast monsoon. The southwest monsoon, characterized by low-level southwesterly winds, commences in May and usually lasts between 3-4 months up to August. On the other hand, the northeast monsoon is dominated by northeasterly winds that cross over the South China Sea. The season usually commences in November and ends in February the following year. Intermittently during this period, strong pulses of wind known as cold surge penetrate to the most southern region of the South China Sea (Chang et al., 2005). The region is usually wetter during the northeast monsoon when the Inter-tropical Convergence Zone is located close to the equator. However, the annual cycle of precipitation shows spatial variations due to the complex distribution of land, sea and terrain in the region (Chang et al., 2005).

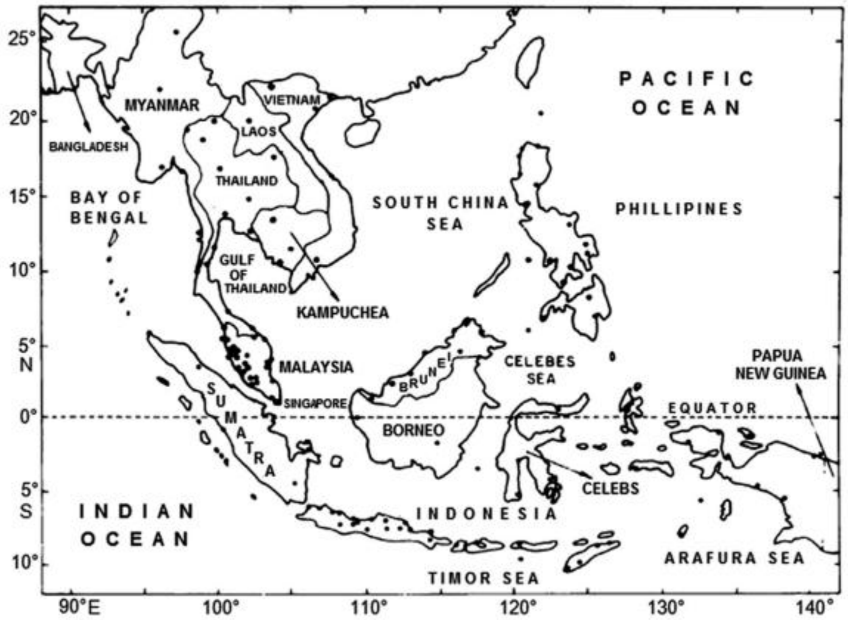

Figure 1.1: Southeast Asia region (Kripalani and Kulkarni, 1997).

Malaysia's climate contain uniform temperature, high humidity, numerous rainfall and light wind. A report by MOSTI (2009), shows that it is rare to have continuous days with entirely no sunshine during the Northeast monsoon season. Meanwhile, it is also hard to have a whole day with entirely clear sky even in periods of drought during the Southwest monsoon season.

Tangang et al. (2007) showed that for several locations in Malaysia, the rates of warming for the last 40 years were as high as 0.4°C per decade. Moreover, observed climatic change in Malaysia was pointed out by NAHRIM (2013) that mean surface temperature recorded an increment and varies from 0.6°C to 1.2°C in 1969 to 2009. In addition, data from 1993 to 2010 showed that the sea level has risen and varies from 4.6cm to 11.9cm. Meanwhile, 1-hour rainfall intensity showed an increase by 17% in 2000 to 2007 compared to 1970's values. Meanwhile, as identified by Sang et al. (2015), generally, the Peninsular Malaysia and Sarawak has been getting increased maximum consecutive dry spells durations while Sabah has been seeing increased maximum continuous wet spells.

Given the background, the increase in rainfall amount and frequency in certain areas will worsen erosion problem in Malaysia. Rainfall is of major direct importance as the main agent in causing erosion. Roslan and Tew (1996) pointed that in Malaysia, water erosion is a major problem because the amount and intensity of rainfall are high.

1.3 8R MAT SYSTEM

In order to overcome the problem of the scrap tyres disposal, researchers around the world start to analyse the properties of the tyres and proposed a new method of reusing the scrap tyre in a new way. A study had been carried out to see the probability of the tyres to be used in the construction area (Huat et al., 2008). Because of it high in tensile strength, low deformation and high durability, tyre give desired properties in geotechnical field.

To cope with erosion problem, by using scrap tyres Safari (2012) has developed the 8R mat system for slope stabilization and also can act as erosion control mechanism. The constructed 8R mat system is shown in Figure 1.2. The usage of crusher run as the filling material are expected to help the drainage of the 8R mat system and prevent erosion to occur.

Figure 1.2: Construction of 8R mat system for slope stabilization and erosion control (Safari, 2012)

1.4 PROBLEM STATEMENT

Climate change has causes many problems into almost every aspect of living. The main concern of climate change impact in this study is on rainfall patterns and intensities. According to IPCC (2007), a warmer atmosphere can hold more moisture, and globally water vapor increases by 7% for every degree celcius of warming and total volume of precipitation is likely to increase by 1-2% per degree of warming. IPCC (2007) also mention that there's evidence to show that regions that are already wet are likely to get wetter, but details on how much wetter and what impacts there will be on a local scale are more difficult to ascertain. The dry regions of the subtropics are likely to get drier and will shift towards the poles. Moreover, in a warmer climate