THE PROBABILITY DISTRIBUTION OF ANNUAL MAXIMUM HOURLY AND DAILY RAINFALL IN KEMAMAN

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Banjir merupakan fenomena bencana alam yang seringkali terjadi dan mengancam dunia serta mempengaruhi, kesihatan, keselamatan, kebajikan dan ekonomi masyarakat. Malaysia telah mengalami banyak kejadian hujan sepanjang musim monsun, yang berpanjangan selama beberapa jam dan mengakibatkan banjir kilat. Kawasan kajian adalah daerah Kemaman, Terengganu, Malaysia kerana ia mengalami kerugian yang tidak dapat dielakkan dan terjejas setiap tahun disebabkan oleh hujan lebat yang melampau. Data hujan tahunan paling maksimum untuk setiap jam dan harian di sembilan stesen untuk daerah Kemaman dikumpulkan dan taburan kebarangkalian dianalisis untuk set data ini. Objektif kajian ini adalah: (i) untuk menjalankan analisis taburan kebarangkalian dengan menggunakan Taburan Log-Pearson Type III dan Taburan Gumbel untuk hujan tahunan paling maksimum setiap jam dan setiap hari di Kemaman, (ii) untuk menganggarkan taburan kebarangkalian yang paling sesuai untuk hujan tahunan paling maksimum untuk setiap jam dan harian di Kemaman dan (iii) untuk menganggarkan keamatan hujan setiap jam dan harian untuk kala kembali yang terpilih. Dalam kajian ini, kebaikan ujian patut untuk taburan diuji menggunakan ujian Kolmogorov-Smirnov dan Anderson-Darling. Berdasarkan keputusan yang dihasilkan, Log-Pearson Type III Distribution terbukti sebagai fungsi taburan kebarangkalian yang paling sesuai untuk hujan setiap jam dan harian untuk daerah Kemaman. Dianggarkan keamatan hujan yang melampau untuk pelbagai kala kembali boleh digunakan sebagai input asas dalam reka bentuk hidrologi seperti dalam reka bentuk pembetung air larian permukaan dan lain-lain struktur hidraulik serta input kepada model hujan dan air larian permukan.

ABSTRACT

The world's most catastrophic and repetitive event is known to be flood, which extremely affects the health, safety, welfare and economy of community. Malaysia has experienced uttermost rainfall events during the monsoon seasons that last for several hours and consequently lead to flash flood. The location of interest of this study is Kemaman district of Terengganu, Malaysia since it undergoes the unforeseeable loss and brunt every year due to extreme intensity of rainfall. Annual maximum hourly and daily rainfall data at nine stations in Kemaman district are collected and the probability distributions are analysed for these set of data. The objectives of this study are: (i) to perform the probability distribution analysis using Log-Pearson Type III Distribution and Gumbel Distribution for annual maximum hourly and daily rainfall in Kemaman, (ii) to estimate the most appropriate probability distribution for annual maximum hourly and daily rainfall in Kemaman and (iii) to estimate the annual maximum hourly and daily rainfall intensity for selected return periods. In this study, the goodness of fit test for the distribution are tested using Kolmogorov-Smirnov and Anderson-Darling tests. Based on the output generated for fitness tests, Log-Pearson Type III Distribution proves to be the most appropriate probability distribution function for annual maximum hourly and daily rainfall for Kemaman district. The estimated extreme rainfall intensity for various return period can be used as the basic inputs in hydrologic design such as in the design of storm sewers culverts and other hydraulic structures as well as inputs to rainfall runoff models.

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LIST OF SYMBOLS

y_H	High Outlier Threshold in Log Units
y_L	Low Outlier Threshold in Log Units
K_N	Coefficient for One-Sided 10 Percent Significance Level
$\overline{y}$	Sample Mean in Log Units
s_y	Standard Deviation in Log Units
$Q3$	Median of Upper Half of Data
$Q1$	Median of Lower Half of Data
α	Scale Parameter
α	Significance Level
β	Shape Parameter
γ	Location Parameter
Γ	Gamma Parameter
π	Pie
n	Number of Sample
μ	Mean
σ	Standard Deviation
λ	Euler's Constant
e	Exponential
E_i	Expected Frequency
O_i	Observed Frequency
χ	Chi
i	Number of Observation
k	Number of Data
x'	Sorted Data in Ascending Order
N	Sample size
∞	Infinity
y_H	High Outlier Threshold in Log Units
y_L	Low Outlier Threshold in Log Units
K_N	Coefficient for One-Sided 10 Percent Significance Level
$\overline{y}$	Sample Mean in Log Units

LIST OF ABBREVIATIONS

KTM	Kereta-Api Tanah Melayu
MSMA	Urban Stormwater Management Manual for Malaysia
DID	Department of Irrigation and Drainage
IMD	India Meteorological Department
UK	United Kingdom
IQR	Interquartile Range
SPSS	Statistical Package for the Social Science
ANOVA	Analysis of Variance
MATLAB	Matrix Laboratory
ARI	Average Recurrence Interval
AM	Annual Maximum
LP3	Log-Pearson Type III

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Volcano eruption, tornadoes, hurricanes, earthquake, tsunami, typhoons, landslides, floods and others disasters caused by nature is known as natural disaster. United States Department of Health and Human Services (2009), stated that the health and welfare of human being can be either directly or indirectly effected by the cause of violent natural events. Among all the natural disasters, flooding is one of the most common and repeatedly occurring violent natural event all over the global.

Probability distribution of flood determination is one of the most interested part by engineers and planners in designing and planning water resources projects which including hydraulic structures such as dams, bridges, culverts and levees to control and manage flood water movement. Probability distribution analysis is one of the main approaches that is preferred compared to rational method, unit hydrograph method and rainfall-runoff models method to explain relationship between magnitude and frequency of the flood event. Pattern and distribution of rainfall is a main factor of water resources management of a country. Daily and hourly rainfall data is mostly needed especially in urban areas as the rainfall input is too quick to the sensitivity of storm water management system due to short time of concentration.

A land which is usually dry, is submerged by an overflow water from natural and artificial banks, is the condition known as flood. Flood is defined by The European Union (EU) Flood Directive as the covering of a land by flowing water. Wherefore, basically, flood becomes hazardous to the society and human life. In Malaysia, flood is the most frequent and common natural disaster which causes interruption and distraction to the normality of citizens in terms of daily routine, property, and economic. The repetitions

of this natural disaster annually in Malaysia, during the monsoon season from November to March, is due to the high intensity of rainfall which attributed by its topography and climate including northeast monsoon. It is proven when Resources and Environment, Malaysia (June 2007), stated that the basic cause of river flooding is the incidence of heavy rainfalls due to a monsoon season and the resultant of an excessive runoff of precipitation which exceeds river capacity. There are 89 river basins in peninsula Malaysia, 78 in Sabah and 22 in Sarawak flowing directly to South China Sea through main channels and 85 of them are lead to flooding.

Parts of Terengganu, annually experience damages and losses by flooding phenomena. Especially Kemaman, faced uncertainties and risk of flooding in consecutive years of 2014 and 2015. Many road links were disrupted and closed as roads submerged in flood where in November 2014, the connecting road from Kampung Pak Tuyu to city was completely unusable. High tide phenomenon of flood in December 2014, caused about 80 percentage of villages has been undergone damages and complete disruption of living neighbourhood, and fall apart economically in Dungun as overflow occurred in Sungai Dungun. This event consecutively has forced 4,209 residents of Terengganu vacate their homes (Sky News Australia, 2015). Besides that, facilities of transportation mainly train such as Kereta-Api Tanah Melayu (KTM) and intercity train was disconnected due to the occurrence of this natural disaster (The Malaysian Insider, 2014). Figure 1.1 shows the damages of road due to flood event in 2014 in Malaysia.

Figure 1.1 Road Damages

Source: Berita Harian (2014).

Studies and news has shown that the cause of flood is identified to be the extreme intensity of rainfall which resulted sever flood in the region of east-coast of Peninsula Malaysia, where state of Terengganu has endangered the worst effect. Besides the severe damages and disruption, loss of life was also unbearable due to exceeded rainfall depth about 600mm. In the basis of property losses, some of the residence of Terengganu was only able to secure partial parts of their belongings and some completely become empty handed. Nevertheless, government and non-government agencies as well encountered difficulties to protect flood victims, especially, in providing health and safety facilities such as, hospitals aids, clinical medicine, and quality foods. Damages of properties experienced by Malaysia is shown in Figure 1.2.

Figure 1.2 Damages of Houses

Source: Berita Harian (2014).

1.2 Problem Statement

There are multiple of human activities, being the influence of uncontrollable natural disaster which are can be listed as, sudden and rapid change of the land use, uncontrolled growth of construction development, improper plan of settlement development and excessive works of construction buildings. On the other hand, the other contributing factors of flood as explained by Khan (2014) are topography, geomorphology, drainage, engineering structures and climate. Moreover, not counting extreme rainfall, elevation and close proximity to the sea are physical factors of Dungun district of Terengganu in the monsoon period which is also influenced the overflow of water back in November 2014.

REFERENCES

Akasah, Z.A. and Doraisamy, S. V., 2015. 2014 Malaysia Flood: Impacts & Factors Contributing towards the Restoration of Damages. *Journal of Scientific Research and Development 2*, 2(14), pp.53–59.

Athens. 2015. Earth's natural cycles/ water hydrological cycle. IAASARS.

Azhar, M., Alias, B. and Alias, E.B., 2014. Extreme Rainfall Analysis on the December 2014 Flood, Pahang. , (December), pp.265–282.

Bhagat, N., 2017. Flood Frequency Analysis Using Gumbel â€TM s Distribution Method : A Case Study of Lower Mahi Basin , India. , 6(4), pp.51–54.

Blagojević, B., Mihailović, V. and Plavšić, J., 2014. Outlier Treatment In The Flood Flow Statistical Analysis. *Zbornik radova Gradjevinskog fakulteta u Subotici*, pp.603–609.

Burguefio, A., Codina, B., Redafio, A., and Lorente J., 1994. Basic Statistical Characteristics of Hourly Rainfall Amounts in Barcelona (Spain). Theor. Appl. Climatol. Springer Verlag, 49: pp. 175-181.

D/iya, S.G., Gasim, M.B., Toriman, M.E. and Abdullahi, M.G., 2014. Floods in Malaysia: Historical Reviews, Causes, Effects and Mtigations Approach. *International Journal of Interdisciplinary Research and Innovations*, 2(4), pp.59–65.

Dan'azumi, S., Shamsudin, S. and Rahman, a a, 2010. Probability Distribution of Rainfall Depth at Hourly Time-Scale. *World Academy of Science, Engineering and Technology*, 4(12), pp.760–764.

Department of Irrigation and Drainage, Malaysia 2007, 2010, 2015.

Department of Irrigation and Drainage Malaysia (2009). Flood management manual vol 1

Department of Irrigation and Drainage Malaysia (2011).Flood phenomenon, flood mitigations publication & Ministry of Natural Resources and Environment.

Department of Irrigation and Drainage Malaysia. 2012. Urban Stormwater Management Manual for Malaysia, (MSMA2). Percetakan Nasional (M) Berhad.

Eslamian, S.S. and Feizi, H., 2007. Maximum monthly rainfall analysis using L-moments for an arid region in Isfahan Province, Iran. *Journal of Applied Meteorology and Climatology*, 46(4), pp.494–503.

Fikre, A., 2017. Selection of Best Fitted Probability Distribution Function for Daily Extreme Rainfall of Bale Zone, Ethiopia. Civil and Environmental REsearch, 8 No 12(January 2016), pp.13–21.

Firdaus, M., Saad, M., Latif, A.A. and Othman, M., 2017. the 2014 Flood Disaster in Kemaman, Terengganu : Lessons From the Kemaman Experience. , (133), pp.628–635.

Haddad, K. and Rahman, A., 2011. Design Rainfall Estimation for Short Storm Durations Using L-Moments and Generalised Least Squares Regression-Application to Australian Data. *Int. J. Water Resour. ...*, 1(3), pp.210–218.

Hanson, L.S. and Vogel, R., 2008. The Probability Distribution of Daily Rainfall in the United States. *World Environmental and Water Resources Congress 2008*, pp.1–10.

Hosking, J.R.M. L-moments: Analysis and Estimation of Distribution Using Linear Combinations of Order Statistics. J. R. Statist. Soc. B 1990, 52, 105-124.

Huang, Y., Lee, C. and Ting, C., 2008. Improved estimation of hydrologic data using the chi-square goodness-of-fit test. *Journal of the Chinese Institute of Engineers*, 31(3), pp.515–521.

Hutjes, R. W. A., Kabat, P., Running, S. W., Shuttleworth, W. J., Field, C., Bass (1998, December). Biospheric aspects of the hydrological cycle. Journal of Hydrology, 212–213(1–4), 1–21.

Hydrology Subcomittee Bulletin #17B. 'Guidelines for determining flood flow frequency', Interagency Advisory Committee on Water Data,, available from Office of Water Data Coordination, U.S. Department of the Interior Geological Survey, Reston, VA, 1982.

Kroll, C.N., Croteau, K.E. and Vogel, R.M., 2015. Hypothesis tests for hydrologic alteration. *Journal of Hydrology*, 530, pp.117–126.

Kuchment, L. S. 2004. The Hydrological Cycle and Human Impact on it. In H. H. G. Hoekstra, Arjen Y. ; Savenije (Ed.), Water Resources Management, Encyclopedia of Life Support Systems (EOLSS). Retrieved from http://www.eolss.net/ebooks/Sample Chapters/C07/E2-16-10-01.pdf

Lala I.P.Ray, P. K. Bora, A. K. Singh, N. J. Singh, R. Singh and S. M. Feroze., 2013. Estimation of Annual Maximum Rainfall for Central Meghalaya, 26(1), pp. 47-51.

Legates, D.R. and McCabe, G.J., 1999. Evaluating the use of "goodness-of-fit" measures in hydrologic and hydroclimatic model validation. *Water Resources Research*, 35(1), pp.233–241.

MACHIWAL, D. and JHA, M.K., 2008. Comparative evaluation of statistical tests for time series analysis: application to hydrological time series / Evaluation comparative de tests statistiques pour l'analyse de séries temporelles: application à des séries temporelles hydrologiques. *Hydrological Sciences Journal*, 53(2), pp.353–366.

Markus, M., Vernon Knapp, H. and Tasker, G.D., 2003. Entropy and generalized least square methods in assessment of the regional value of streamgages. *Journal of Hydrology*, 283(1–4), pp.107–121.

Matulessy, E.R., 2015. Quantile Regression with Partial Least Squares in Statistical Downscaling for Estimation of Extreme Rainfall. , 9(90), pp.4489–4498.

Meneghini, R., and J. A. Jones., 1993. An approach to estimate the areal rain-rate distribution from spaceborne radar by the use of multiple thresholds. J. Appl. Meteor., 32, pp.386–398.

Mohita Anand Sharma and Jai Bhagwan Singh. 2010. Use of Probability Distribution inRainfall Analysis. New York Science Journal 2010;3(9):40-49]. (ISSN: 1554-0200).

Papalaskaris, T.K. and Emmanouloudis, D.A., 2015. a Probability Distribution of Annual Maximum Daily Rainfall of Ten Meteorological Stations of Evros River Transboundary Basin ,. , (September), pp.3–5.

Raghunath, H. M. 2006. *Hydrology: principles, analysis and design*. New Age International.

Rakhecha, P., & Singh, V. P. 2009. *Applied hydrometeorology*. Springer Science & Business Media.

Reddy, P. J. R. 1997. *Stochastic hydrology*. Laxmi Publications, Ltd..

Reddy, P. J. 2005. A textbook of Hydrology.

Sharma, M.A. and Singh, J.B., 2010. Use of Probability Distribution in Rainfall Analysis. *New York Science Journal*, 3(9), pp.40–49.

Shiklomanov, I.A. ed., 2009. The hydrological cycle. Eolss Publishers Company Limited.

Subramanya, K. 2013. *Engineering Hydrology, 4e*. Tata McGraw-Hill Education.

Taib, Z.M., Jaharuddin, N.S. and Mansor, Z., 2016. a Review of Flood Disaster and Disaster Management in. *International Journal of Accounting, Business and Management*, 4(2), pp.97–105.

Topaloglu, F. Determining Suitable Probability Distribution Models for Flow and Precipitation Series of the Seyhan River Basin. Turk. Journal of Agric. 2002;26: 189-194.

Vivekanandan, N., 2015. Flood frequency analysis using method of moments and L-moments of probability distributions. *Cogent Engineering*, 2(1).

Vojinovic, Z. and Abbott, M.B., 2012. Flood risk and social justice. IWA Publishing.

V.T. Chow, D.R. Maidment, and L.W. Mays, Applied Hydrology, McGraw-Hill, Inc., 1988.

Waichler, S.R. and Wigmosta, M.S., 2003. Development of Hourly Meteorological Values From Daily Data and Significance to Hydrological Modeling at H. J. Andrews Experimental Forest. *Journal of Hydrometeorology*, 4(2), pp.251–263.

Wan, Z., Hong, Y., Khan, S., Gourley, J., Flamig, Z., Kirschbaum, D. and Tang, G., 2014. A cloud-based global flood disaster community cyber-infrastructure: Development and demonstration. Environmental Modelling & Software, 58, pp.86-94

Win, N.L. and Win, K.M., 2014. The Probability Distributions of Daily Rainfall for Kuantan River Basin in Malaysia. *International Journal of Science and Research*, 3(8), pp.977–983.

Yuanfang, C., Qingrong, W. and Gelder, V., Application of Regional Flood Frequency Analysis Based on L-moments in the Region of the Middle and Lower Yangtze River. *GIS & RS in Hydrology, Water Resources and Environment*, 1, pp.1–8.

Yusof, F., Hui-Mean, F., Suhaila, J., Yusop, Z. and Ching-Yee, K., 2014. Rainfall characterisation by application of standardised precipitation index (SPI) in Peninsular Malaysia. Theoretical and applied climatology, 115(3-4), pp.503-516.

Zeng, X., Wang, D. and Wu, J., 2015. Evaulating the Three Methods of Goodness of Fit Test for Frequency Analysis. *Journal of Risk Analysis and Crisis Response*, 5(3), pp.178–187.