

RAINFALL INTENSITY DURATION FREQUENCY CURVE FOR SUNGAI
LAYANG CATCHMENT UNDER CLIMATE CHANGE

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To my beloved parents and family members

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ABSTRACT

This paper study on the development of intensity duration frequency (IDF) curve at study area of Sungai Layang catchment by using the annual maximum rainfall data (mm) for 20 years rainfall data from 1980 to 1999 years by using the observed rainfall data and the simulated rainfall data obtained from Global Climate Models (GCMs). The frequency analysis was conducted by using the rainfall data in determining the best suited type of data distribution by using empirical and theoretical (Normal, Lognormal and EV1- Gumbel) distribution which applied the frequency factor method for obtaining the magnitudes of extreme events. These distributions were been used to fit rainfall data with 2, 5, 10, 20, 50 and 100 years return periods. Two global climate models which consist of ECHAM5 and CCSM3 models were involved in this study to determine the best model that was suitable for rainfall analysis in this study area. The study shows that EV1 Gumbel distribution was the most fitted distribution to describe the daily rainfall patterns in study area. Besides, the study also resulted that ECHAM5 model was more suited to be used with lower RMSE value compared to CCSM3 model. Therefore, for future research involving climate change study using global climate models, the rainfall simulation using ECHAM5 was validated to be used for rainfall analysis.

Keywords: *GCMs, Frequency Analysis, Probability Distribution, Return Period, Frequency Factor*

ABSTRAK

Tujuan kajian ini adalah untuk membina lengkung keamatan tempoh kekerapan (IDF) di kawasan tadahan Sungai Layang dengan menggunakan data hujan maksimum tahunan (mm) untuk tempoh data 20 tahun dari tahun 1980 sehingga 1999 dengan menggunakan data hujan cerapan dan data hujan simulasi yang diperoleh daripada model iklim global (GCMS). Analisis kekerapan telah dijalankan dengan menggunakan data hujan tersebut untuk menentukan jenis taburan yang sesuai untuk taburan hujan di kawasan kajian dengan menggunakan kaedah empirikal dan teoritikal iaitu yang menggunakan kaedah Normal, Lognormal dan EV1- Gumbel. Kaedah ini telah digunakan untuk menyesuaikan data hujan berdasarkan 2, 5, 10, 20, 50 dan 100 tahun tempoh pulangan hujan. Dua model iklim global yang terdiri daripada model ECHAM5 dan CCSM3 telah digunakan dalam kajian ini untuk menentukan model yang terbaik untuk analisis hujan di kawasan kajian ini. Hasil kajian ini menunjukkan bahawa taburan EV1 Gumbel adalah taburan yang paling sesuai untuk menggambarkan corak taburan hujan harian di kawasan kajian. Di samping itu, kajian ini menunjukkan bahawa ECHAM5 model adalah lebih sesuai untuk digunakan dengan nilai RMSE yang lebih kecil berbanding nilai RMSE daripada model CCSM3. Oleh itu, untuk penyelidikan yang melibatkan perubahan iklim kajian menggunakan model iklim global di masa hadapan, simulasi hujan dengan menggunakan ECHAM5 adalah lebih sesuai berbanding model CCSM3.

Kata kunci: *Model Iklim Global, Analisis Kekerapan, Kaedah Empirikal, Tempoh Pulangan Hujan, Faktor Kekerapan*

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Climate change has always been one of the crucial environmental global issues that is highly anticipated by many researchers. The change in climate generally includes aspects of rising temperatures, shifting seasons, rising sea-levels, disappearing Arctic sea-ice and more intense heat waves that occur globally. The issue has arisen throughout history but the severity of this problem increases uncontrollably in a few recent years due to various factors that are mainly contributed by excessive burning of fossil fuel from industrial activities. This issue not only affects human beings, but also biodiversity, environment, and global economy growth.

The increment of concentration of carbon monoxide in the atmosphere due to industrial activity in the past and recent times has been identified as the major cause of global warming and climate change. The normal balance of the earth's hydrological cycle has been altered due to the changes in the temperature and precipitation patterns. The worsening condition by time has triggered the increasing awareness among researchers that resulted in more studies on climate change related areas. Few studies have come out with few conclusions of increasing annual total precipitation in the second half of the century along with an increment in the number of wet

days and also the prediction of unexpected pattern for extreme wet and dry events in recent and upcoming years.

The unpredictable wet and dry day in recent years had caused the water resource issue in Malaysia. The extreme dry events eventually led to water shortage problem in some regions of Malaysia that occur frequently since past few years. This problem includes the severe water shortage issue in year 2015 in Sungai Layang dam in district of Pasir Gudang, Johor that affected 580 000 users. Generally, the issue water shortage due to decreasing of rainfall in Sungai Layang catchment was a prolonged issue faced by authority and residents but the issue was worsened starting in 2015.

Therefore, in the planning of water resource design for future purposes, the rainfall analysis in the study area that included the aspect of climate change issue was conducted in ensuring the water resource in this study area through development of Intensity Duration Frequency (IDF) curve. This is because the generation of IDF curve acts as the most vital consideration in hydrologic designs purposes and can be used in determining the design rainfall for water resource analysis. An IDF curve can give the expected rainfall intensity of a given duration of storm having desired frequency of particular rainfall occurrence.

1.2 Problem Statements

In Malaysia, the issue on water shortage due to decreasing rainfall intensity had been discussed in detail by government after water shortage issue that strike several parts of Malaysia starting in year 2015. Malaysia receives 2500 mm/year rainfall but the value decreased in few recent years that subsequently contributed to water shortage issue in several parts of Malaysia. Therefore, this study is to conduct the analysis of rainfall pattern in Sungai Layang catchment located at Pasir Gudang district by using observed historical rainfall data and also the simulated rainfall produced by Global Climate Models (GCMs) that focuses on climate change parameters of daily rainfall data produced by National Hydraulic Research Institute of Malaysia (NAHRIM).

1.3 Objective of Study

The objectives of study are as following:

- (1) To develop IDF curves using frequency analysis for Sungai Layang catchment by using historical and simulated GCMs rainfall data.
- (2) To determine the most fitted distribution curve among Normal, Lognormal and EV1 Gumbel distribution for rainfall data at study area.
- (3) To determine the most fitted global climate models of ECHAM5 and CCSM3 for rainfall analysis in study area.

1.4 Scope of Study

This study covers the rainfall analysis and the construction of intensity duration frequency (IDF) curve at Sungai Layang catchment in Pasir Gudang district for 2, 5, 10, 20, 50 and 100 years return periods. It consists of historical and simulated historical rainfall data produced by Global Climate Models (GCMs) that consists of ECHAM5 and CCSM3 models for 20 years period from year 1980 until 1999. The rainfall data was collected from rainfall station at Station Loji Sungai Layang where the historical and simulated GCMs rainfall data for both models were obtained from Department of Irrigation (DID) Malaysia and National Hydraulic Research Institute of Malaysia (NAHRIM) respectively. Hyetos software was used in this study to disaggregate the daily into hourly rainfall data.

1.5 Significance of Study

The study area of Sungai Layang catchment was selected due to the report released by Suruhanjaya Air Johor (SAJ) (2015) on problems related to water shortage issue in Sungai Layang Dam in 2015. The water crisis has affected not only clean water supply to residents but also the surrounding agricultural activities around the catchment. The study will enable us to analyze the rainfall pattern at study area by developing intensity duration frequency (IDF) curves. In this process, it determines the type of distribution for the rainfall data involved in this study. The analysis on several global climate models consists of ECHAM5 and CCSM3 in this study can be used in order to widen the understanding on effect of climate change on rainfall pattern in study area since these models were mainly associated with climates parameters.

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