FLOOD FREQUENCY ANALYSIS: BEST DISTRIBUTION FOR KUCHING AND KOTA SAMARAHAN

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Universiti Malaysia Sarawak
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14.5.1999

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Allahyarhamah Nur Azura Binti Puteh

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Abstract

Flood frequency analysis was performed on selected gauging stations in Kuching and Kota Samarahan. The selected gauging stations were located on nine different rivers. The data that consist of maximum annual flood from each gauging station was analyzed statistically with four frequency distribution. The analysis was done by using spreadsheet and computer programme. A frequency distribution was recommended for each gauging station that fitted the data. The recommendation of frequency distribution was made by using the comparison of results which were obtained from spreadsheet and computer programme that gave the smallest standard deviation. By using the recommended frequency distribution to the gauging station, the magnitude and return period of a particular flood can be predicted.

Abstrak

Analisa kekerapan banjir telah dilakukan ke atas stesyen stesyen cerapan sungai yang dipilih di Kuching dan Kota Samarahan. Stesyen stesyen tersebut terletak di sembilan sungai yang berasingan. Data yang mengandungi kadaralir maksimum tahunan bagi setiap sungai untuk stesyen stesyen tersebut dianalisa secara statistik dengan menggunakan empat taburan kekerapan. Analisa dilakukan dengan hamparan elektronik dan program komputer. Taburan kekerapan yang sesuai telah dicadangkan pada setiap stesyen cerapan sungai tersebut. Taburan kekerapan dicadangkan pada setiap stesyen berdasarkan perbandingan keputusan-keputusan analisa yang diperolehi daripada hamparan elektronik dan program komputer, dimana sisihan piawai minimum diperolehi. Dengan menggunakan taburan kekerapan yang telah dicadangkan pada setiap stesyen tersebut, magnitud dan tempoh berulang sesuatu banjir dapat diramal.

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Chapter 1

Introduction

1.0 General

One of the major problems in civil engineering field is the occurrence of floods. Engineers and planners must consider the factor of flood occurrence in their design. Although the technology in weather forecasting is developing, man still cannot very well predict the occurrence of floods and its magnitude in advance.

With the aid of the concept of probability, the frequency of floods occurrence can be analyzed statistically. Frequency analysis is a technique to analyze the occurrence of hydrologic events within statistical framework, i.e. by using compiled data and statistical laws.

1.1 Flood Frequency Analysis

Frequency analysis is commonly used to calculate flood discharges and known as flood frequency analysis. Flood frequency analysis is the most common procedure

for analysis of data of a gauged station (stream). Generally the data that will be analyzed from the gauging station is the available streamflow records.

1.2 Regional Frequency Analysis

Due to some obvious reasons, gauging station cannot be set up to certain streams. A regional frequency analysis is performed to the catchments where the streamflow data are insufficient or does not exist. From the flood frequency analysis of gauged stations within the region, mathematical relations will be developed such that the information from the gauged stations can be used to the ungauged stations with similar hydrologic characteristics.

1.3 The Concept of Probability

The very basic concept of a probability for a particular event is a number telling us how likely that event is to occur. This number is the ratio of the number of ways the outcome may occur to the number of total possible outcomes for the event. For the simplest example, the outcome of drawing an ace card from a regular deck of 52 cards. The probability to draw an ace is four out of 52. This will result the ratio of 1 out of 13.

1.4 Objective

The broad objective of the study is to recommend a flood frequency distribution for each gauging station in Sarawak especially for Kuching and Kota Samarahan divisions. This study will attempt to contribute towards the fundamental studies for regional flood frequency analysis for Sarawak.

Chapter 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discuss briefly the methods that have developed and used by hydrologist in the study of flood frequency. The method in flood frequency analysis has developed as hydrologists and scientists grew interest in conducting the study throughout the world. Figure 2.1 shows the general procedure to be followed in studying the flood.

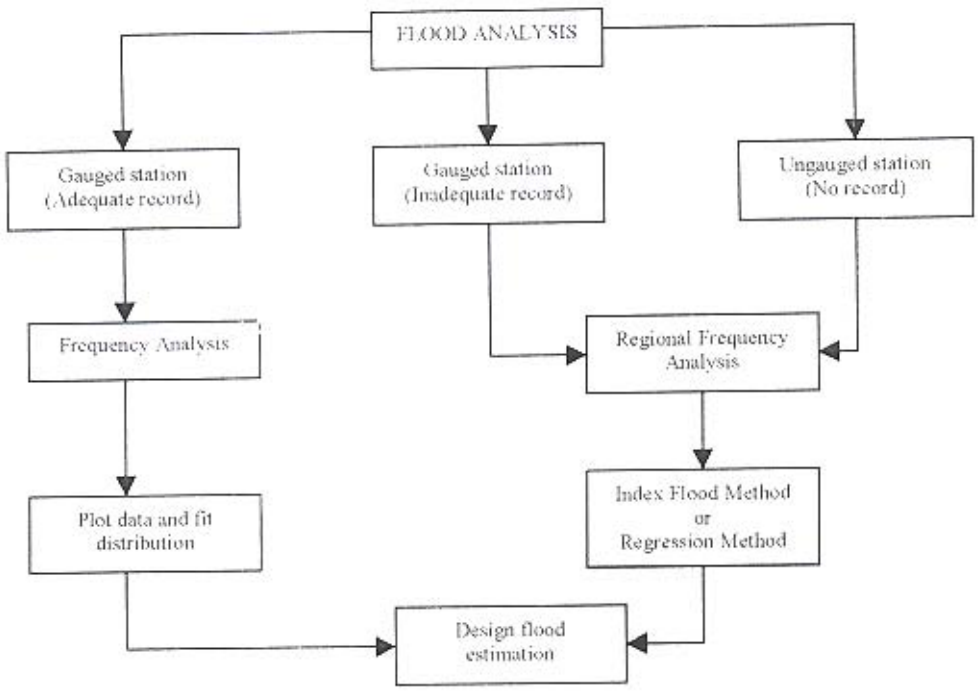

Figure 2.1 General Procedure for studying the flood

2.1 The Concept of Probability in Hydrology Engineering

The return period T is the time elapsed between successive peak flows exceeded or equaled in a period of time. Statistical analysis of hydrological events considers the average elapsed time between occurrence of hydrologic event. The chance of occurrence of a flood of a return period T is known as probability of occurrence. The probability of flood is expressed as the percent probability of annual exceedence (unit percentage). The relationship between probability and return period is shown as:

$$P = \frac{1}{T} \tag{2.1}$$

As an example, if T=100 years, the probability of occurrence is 0.01 or 1% in 100 years time.

2.2 The Data Series

A complete duration series is a record of streamflows at a gauging station. It is necessary to select a flood series in performing a frequency analysis. The data of the streamflows should be representative of the total population of floods which are likely to occur on the stream. The data must be based on consistent set of stream, catchment and climatic condition. For a reliable computation of a flood frequency analysis curve, Gupta (1989) outline the following requirements to be met by the data:

i) Stationariness of data. The meaning of stationary data is that properties of the data do change with time.

ii) Homogeneity of data. Homogeneity is an indicator that all data of a series belong to the same population. At some point the streamflows might be disturbed because of development at the stream i.e. land used for man made pond. A change in location of the station may lead to a non-homogeneous record.

The data series also must be adequate. Longer record will represent analysis that is more reliable. Researchers suggest many length of record for statistical analysis of maximum flows as the most desirable is considered 25 years.

2.2.1 Annual Maximum Series

The annual maximum series includes the largest values recorded each year. This series only considered the peak flow of the stream for every year. The flows are normally determined from instantaneous water level at the stream.

2.2.2 Partial Duration Series

A partial duration series is a series that is selected from the flood record so as to include all floods higher than a specified base discharge. The discharges are to be independent with each other.

A partial duration series composed of flows above some "threshold level". Shaw (1988) described that a special case of the partial duration series is the annual exceedance series, where the N highest peaks within the N years of data are chosen, irrespective of when they occur. Figure 2 shows the peak flood peak data series as mentioned by Shaw (1988)

Figure 2.2 Flood peak data series

Researchers and hydrologists throughout the world nowadays have more interest in performing flood frequency analysis with data of streamflows based on partial duration series.

2.3 Flood Frequency Analysis

Flood frequency analysis refers to the application of frequency analysis to study the occurrence of floods. From a flood frequency analysis, a curve that indicates the magnitude of floods of various probabilities of occurrence. There have been many probability distributions introduced for the purpose of flood frequency analysis. Some of the probability distributions will be discussed later in this Chapter.

2.3.1 Plotting Positions

The data will be plotted on probability graph paper. The data will be ranked in descending or ascending order. The data then will be plotted at the appropriate coordinate on the probability graph paper.

A general plotting formula is as followed:

$$\frac{1}{T} = P = \frac{(m-a)}{(n+1-2a)} \qquad (2.2)$$

which,

n = number of values in the series

m = the rank of descending values, with the largest equal to 1

a = parameter

In hydrologic application, the most common plotting formula used was introduce by Weibull,

$$P = \frac{m}{n+1} \qquad (2.3)$$

Gringorten formula is used in connection with the Gumbel distribution. Others plotting position formula as shown in Table 2.1.

Table 2.1 Plotting position formulas

Method	Formula
Hazen	$\frac{m-0.5}{n}$
California	$\frac{m}{n}$
Beard	$\frac{m-0.31}{n+0.38}$
Chegodayev	$\frac{m-0.3}{n+0.4}$
Blom	$\frac{m-0.375}{n+0.25}$
Gringorten	$\frac{m-0.44}{n+0.12}$
Cunnane	$\frac{m-0.4}{n+0.2}$
Adamowski	$\frac{m-0.25}{n+0.5}$

2.3.2 Fitting the Curve

A curve is to be fitted through the plotted points on the probability graph paper. There are four methods to accomplish the curve fitting.

i) Graphical Method

This method is perhaps the easiest one where a function is fitted to data visually. Linsley (1975) recommend that a curve can be fitted by an eye if one intends to use the frequency analysis for information on floods with recurrence intervals less than N/5.

ii) Method of Least Square

In this method, the sum of the squares of the differences between observed data and fitted values is minimized. This will lead to a set of m normal equations, where m is the number of parameters to be estimated. This method is usually used in regional flood frequency analysis.

iii) Method of Moments

A distribution is selected before applying the method of moments. The moments of the distributions then calculated based on the data. This method provides an exact theoretical fitting. The disadvantage of this method is the uncertainty due to the adequacy of the chosen probability distribution.

iv) Method of Maximum Likelihood

The distribution parameters are estimated in such way that the product of probabilities is maximized. This method is the most difficult to apply compare to the other three methods.

From this four method, the method of moments is the most commonly used in practice for the curve fitting.

2.3.3 Frequency Factors

Any value of random variables may be represented in the following form:

$$x = \bar{x} + \Delta x \tag{2.4}$$

which,

x = value of random variable

$\bar{x}$ = mean of the distribution

Δx = departure from the mean, a function of return period and statistical properties of the distribution.

The departure from the mean can be expressed in terms of the product of the standard deviation S and a frequency factor K such that,

$$\Delta x = KS \tag{2.5}$$