

## Regional flood estimation for ungauged basins in Sarawak, Malaysia

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**Abstract** Design flood estimation is an important task that is required in the planning and design of many civil engineering projects. In this study, the flood records of more than 23 gauged river basins in Sarawak, Malaysia, are examined using an index-flood estimation procedure based on L-moments. Two homogeneous regions were identified and the Generalized Extreme Value and the Generalized Logistic distributions are found to describe the distribution of extreme flood events appropriately within the respective regions. A regional growth curve is subsequently developed for each of the regions. These curves can be used for the estimation of design floods in ungauged basins in Sarawak within the limitations identified for the method. The results presented herein are useful for practicing engineers in Sarawak while the general methodology may be used in any other regions, provided flood records are available.

**Key words** regional flood frequency; design flood; L-moments; homogeneous region; cluster analysis; index flood; growth curves; Sarawak, Malaysia

### Estimation régionale des crues de bassins non jaugés de Sarawak en Malaisie

**Résumé** L'estimation de crues de projet est une tâche importante, nécessaire dans la planification et le dimensionnement de nombreux ouvrages de génie civil. Dans cette étude, nous analysons les données de crues de plus de 23 bassins versants jaugés à Sarawak en Malaisie grâce à une procédure d'estimation d'un indice de crue basée sur les L-moments. Deux régions homogènes ont été identifiées et il est démontré que les distributions généralisée de valeurs extrêmes et généralisée logistique sont respectivement les plus appropriées pour décrire les distributions des valeurs de crues extrêmes dans ces régions. Une courbe régionale d'accroissement est ensuite élaborée pour chacune de ces régions. Les courbes obtenues peuvent être utilisées, dans les limites identifiées de validité de la méthodologie, pour l'estimation des crues de projet de bassins non jaugés de Sarawak. Les résultats présentés dans cet article sont utiles pour les ingénieurs œuvrant à Sarawak, tandis que la méthodologie générale peut être utilisée dans d'autres régions à condition d'y disposer de données de crues.

**Mots clefs** fréquence de crue régionale; crue de projet; L-moments; région homogène; analyse de groupe; indice de crue; courbes de croissance; Sarawak, Malaisie

## INTRODUCTION

The accurate estimation of design floods remains one of the major challenges for many engineers and planners who are involved in project design where hydrological data and information are limited. This is typical of the case in the eastern State of Sarawak, Malaysia, where many of the rivers remain ungauged. A number of gauged stations in operation also face problems, such as shortness of records, incomplete records, and

inaccuracy of flow rating curves, among others. However, where there is a sufficient number of reliable gauging stations, regionalization can be very helpful in pooling flood data such that design flood estimations can be made at ungauged basins. At present no current regional flood frequency curves are established for the whole of Sarawak. With such circumstances and limitations in mind, regional flood growth curves for the state are developed herein using an approach that is able to minimize the bias due to outliers and shortness of record length. This study strives to provide useful results that can be used by those who need to estimate design floods for non-tidally influenced ungauged basins in Sarawak.

## DESIGN FLOOD ESTIMATION PROBLEMS IN SARAWAK

The purpose of design flood estimation is to make predictions on the magnitude of flood discharges at a particular section of a river of interest corresponding to a risk level that is acceptable to the design of structures. The risk is normally taken to be a probability of nonexceedence expressed as a certain return period ( $T$ -year) or annual recurrence interval (ARI). With sufficient length of flow observations at a particular site of interest, one can make statistical inference on the flood discharges corresponding to various acceptable risk levels.

In the absence of any relevant authoritative guidelines, many practicing engineers in Sarawak are relying on rainfall intensities to generate flood peaks using a simple classical method called the rational method for flood estimations. Despite the fact that the rational method is intended for very small basins, its application in some large basins without any modification is common practice. There are many circumstances where flood estimation procedures applicable to Peninsular Malaysia, published by the Department of Irrigation and Drainage (DID), Sarawak, Malaysia, are adopted for use in Sarawak with the assumption that the basins characteristics are similar. The approach becomes absurd when a particular region in Peninsular Malaysia has to be chosen arbitrarily as similar to Sarawak. The dilemma can be understood in view of the fact that no specific regional flood estimation procedures have been developed for Sarawak. Some rainfall-runoff simulation programs have been used and there are attempts to apply simulation programs using default values of internal parameters without actual comprehensive calibration of regional basins. There are also circumstances where calibrations are done on common flood events and then extrapolated to make estimations for extreme floods.

## REGIONAL FLOOD FREQUENCY ANALYSIS

### Rationale for regionalization

Regionalization is still a favourite approach in estimating parameters in hydrology compensating for the lack of long hydrological time series and the lack of information. These can be seen in recent papers by Burn & Goel (2000), Cunderlik & Burn (2002), and Pfister *et al.* (2002). It is well accepted that using a regional approach in flood frequency analysis is effective in extending the flood information at a site to sites within a homogeneous region. The extension enables flood quantile estimates for any