Chapter 5
Flood Frequency Analysis Using Bayesian Paradigm: A Case Study From Pakistan

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ABSTRACT

At-site flood frequency analysis (FFA) of extreme hydrological events under Bayesian paradigm has been carried out and compared with frequentist paradigm of maximum likelihood estimation (MLE). The main objective of this chapter is to identify the best approach between Bayesian and frequentist one for at-site FFA. As a case study, the data of only two stations were used, Kotri and Rasul, and Bayesian and MLE approaches were implemented. Most commonly used tests were applied for checking initial assumptions. Goodness of fit (GOF) tests were used to identify the best model, which indicated that the generalized extreme value (GEV) distribution appeared to be best fitted for both stations. Under Bayesian paradigm, quantile estimates are constructed using Markov Chain Monte Carlo (MCMC) simulation method for their respective returned periods and non-exceedance probabilities. For MCMC simulations, as compared to other sampler, the M-H sampling technique was used to generate a large number of parameters. The analysis indicated that the standard

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errors of the parameters' estimates and ultimately the quantiles' estimates using Bayesian methods remained less as compared to maximum likelihood estimation (MLE), which shows the superiority of Bayesian methods over conventional ones in this study. Further, the safety amendments under two techniques were also calculated, which also show the robustness of Bayesian method over MLE. The outcomes of these analyses can be used in the selection of better design criteria for water resources management, particularly in flood mitigation.

INTRODUCTION

Hydrologists, over the years, have preferred to use best estimation methods and the most suitable probability distribution for extreme events through at-site FFA (Ahmad et al., 2015). Selection of suitable probability distribution not only provides the best fit to the selected site(Ahmad et al., 2013), but also provides efficient and accurate quantiles estimates corresponding to different returned periods (Ahmad et al., 2016). After finding the most suitable distribution for extreme events in FFA the next step is parameters estimation. Different approaches are utilized to estimate parameters of the respective distribution such as Method of Moments (MOM), MLE, and Method of Linear Moments (MLM). Exception of these methods, Bayesian approach based on the theorem by Thomas Bayes in 1763 (Keynes, (1921), is also intensively studied and applied now days in FFA(Coles et al.,1996) and (Gelman et al.,1997). One of the major differences between traditional approaches and Bayesian approach is that the parameters of interest have their own probability distributions and are treated as random variable rather than fixed as in traditional methods. In Bayesian approach, the sample information and prior knowledge are combined to get the posterior knowledge that provides a hypothetically consistent structure of hydrological information in the estimation of uncertainties and flood frequency models. It allows the explicit uncertainties due to flood frequency model and its parameters (Vicens et al., 1975) and (ZhongMin et al., 2011). In this context, Wood and Rodriguez-Iturbe evolved the procedures useful for dealing with the uncertainties resulting from flood frequency competing models and their parameters estimation and also compared these results with Bayesian paradigm (Wood and Rodriguez, 1975). Tang practiced a Bayesian regression analysis to estimate the resulting probability distribution of flood level (Tang et al., 1980). Van Gelder et al. the extension to Tang's work, adopting the procedure of Bayes factor in selection of suitable probability distribution and declared that this procedure provides better results than Tang's work (Van et al., 1999). Kuczera introduced the empirical Bayes technique to deduce hydrological quantities by joining site-specific as well as regional information. A Monte Carlo