Chapter 7

Challenges for Sustainable Water Resources Management in Botswana:
The Case of Data and Associated Uncertainty

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ABSTRACT

Like many semi-arid areas of Africa, Botswana continues to experience inadequate water supply particularly in the southern part of the country. In the last ten years, water restrictions have become part of water demand strategy aimed at maintaining sustainable water supply throughout the year. This has affected many economic sectors particularly small scale enterprises which directly rely on water for their business operations such as car wash and landscaping businesses. The issue of inadequate water availability and supply is more pronounced in Gaborone, the capital city of Botswana which relies on Gaborone dam as the main source of water to drive the economy. The dam was last filled to capacity in 2006 and has not spilled since then. While there are several factors affecting the inflows to the dams, rainfall is the principal candidate limiting water availability in the area. Past studies have shown a decline in rainfall and an increase in temperature since 1982. However, there are uncertainties associated with rainfall data, mainly regarding the presence of missing values which affect many hydrological modelling tools. In this chapter, we focus specifically on the effects of missing rainfall data and data infilling strategies on hydrological applications using rainfall and hydrological modelling tools. We also demonstrate the implications of these on spatial rainfall interpolation methods based on Geographic Information Systems (GIS). Our discussion focuses on the value of data as a priority developmental issue which should receive utmost attention particularly in the wake of climate change.

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INTRODUCTION

One of the challenges faced by most developing countries, especially Africa is the issue of systematic data collection and management. This is more pronounced in hydro-climatic data where many of the observation networks have either decreased in numbers or the quality of some datasets have deteriorated in the early 1990s (Westermeyer, 2011), or there is lack of electronically archived datasets for which observations have been made (Kaspar et al., 2015). Some of the reasons for the decrease had to do with reduced funding and technical assistance previously provided by international organisations that supported the establishment and improvement of climate observing networks. This has led to challenges with maintenance of old equipment, where in most cases the replacement parts are either obsolete or difficult to procure. There are several methods used to infill environmental data, and these are discussed in detail in the literature (e.g. Bárdossy, and Pegram, 2014). These methods, include (i) linear regression, (ii) nearest neighbourhood, (iii) Ordinary krigging, (iv) Multiple linear regression (MLR), (v) generalized linear regression methods (GLM) (Chandler and Wheater, 2002), Copular based estimation, (vi) MLR using the Expectation maximisation (EM) algorithm, among others. In this chapter, we focus specifically on the methods based on the generalised linear models for two reasons, i.e. (i) their ability to infill the missing values while accounting for uncertainty (Chandler and Wheater, 2002), (ii) they have been used to represent spatio-temporal rainfall distribution in various catchments, including semi-arid areas, and for various applications, i.e. for agricultural applications, water resources assessment, and flood forecasting, among others. Details of these applications and the review of associated models have recently been documented in Kenabatho et al (2012), Kenabatho et al., (2015, and the references there in. In this chapter, we revisit the application of these models, specifically looking at assessing the effects of uncertainty arising from the missing rainfall values. This is achieved by using the case study of Notwane catchment in Botswana. Section two briefly introduces the methods and data used in the study area, while section three presents the results and discussions. Conclusions drawn from this case study are presented in section four.

METHODS, DATA AND INTRODUCTION TO THE STUDY AREA

Generalised Linear Models (GLMs) for Rainfall Application

Details of theory and fundamentals of GLMs are well documented in the literature. The reader is referred to the earlier work of Chandler and Wheater (2002) in which GLMs were introduced for the first time regarding their application in spatial-temporal multi-sites rainfall modelling. Since then, the GLMs have been widely used for various applications, mainly for hydrological and climatic applications. In this chapter, only a brief introduction is made specifically for rainfall modelling. In general, the GLMs are used in two independent steps, i.e. on one hand, rainfall is considered to be made of the probability of occurrence, and on the other hand, the amount related to the non-zero occurrences. While there are many stochastic distributions that can be used within the GLM framework, for rainfall applications, rainfall occurrences are usually modelled using logistic regression (Equation 1), where the probability of having rainfall at a specified site is dependent on a number of predictors, such as location of the site (i.e. Northing, Easting and Elevation)-known as spatial predictors. Other predictors may include, seasonal characteristics of rainfall at specific sites (i.e. Seasonality such as wet and dry periods), or previous wet

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