Chapter 18
Geomorphic Modelling Application for Geospatial Flood Hazards and Flash Flood Thresholds Forecasting

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ABSTRACT

In this chapter, a geomorphic modelling is presented and as a tool for geospatial flood hazard and flash flood thresholds forecasting in drainage basins. The flash flood thresholds have been estimated in terms of flash flood guidance values for the various tributary watersheds of a drainage basin considered. It has been demonstrated using the Limpopo drainage basin in southern Africa. This transboundary basin was chosen because of its importance to water supply for the growing population and water demands in its four riparian states. The basin is also subject to frequent flood and drought hazards. Even though, well established hydrological and flood frequency models do exist for flood forecasting, the purpose of this manuscript is to produce indicative flash flood guidance from a drainage basin of diverse regional development and intensive catchment land-use land cover dynamics by shading light on the geospatial portrayal of flood producing determinants. This will be important in lieu of the need for designing flood forecasting and flood early warning systems for this basin which is subject to frequent flooding hazards. Recommendations on flood forecasting and mitigation of flood hazards is provided considering the technical, human capital and institutional challenges that exist in this part of Africa.

INTRODUCTION

Floods are among the most common hazards facing human existence in different parts of the world occurring at different places with extreme magnitude and frequency. The most recent flooding events and their damaging effect in the world witnessed the continued flood hazards the world is frequently facing from time to time, including Bangladesh in 1987, 1988 and 1998 (Islam and Sado 2002), Hurricane

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Katrina in the USA Gulf Coast (Ilan 2008), Mississippi River in 1993 (Kunel and Angel 1994; Kolva 1993), Zambezi and Limpopo Rivers in 2000 (Guleid et al. 2004).

The Limpopo basin is subject to frequent flood and drought hazards. The basin is also facing increasing threats of droughts affecting water availability and access to meet growing water demands for its population inhibited by the four riparian counties viz-a-vis Botswana, Mozambique, South Africa and Zimbabwe. The runoff hydrograph of the Limpopo basin is influenced by a the drainage characteristics of the basin as it traverses the relatively high elevations in Botswana, South Africa and Zimbabwe from the main headstreams as it flows down descent towards the main Limpopo basin swiping a relatively flat plains in Mozambique as it descends to its outlet in the Indian Ocean.

Since the 1990s, there is a proliferation of tools and models for flood forecasting, flood management, and social mobilization (Sweeney et al. 1993; Carpenter et al. 1999; Pelling 1999). The two most prominent flood foresting modeling approaches are the distributed physically-based and lumped hydrological forecasting models (Pelling 1999; Nash and Sutcliffe 1970). Recently, distributed GIS-based models that take into account of direct runoff and topography driven stream flow generation have been developed (Abbott et al 1986; Wise 2000; Fairfield and Leymarie 1991; Gupta et al 1980; Rodriguez-Iturbe and Veldez 1979).

Extreme weather conditions, flood events and flood risk levels are complicated by the El Nino Southern Oscillation (ENSO) phenomenon. The southern Africa region, including the Limpopo basin, is particularly affected by this phenomenon (Jury and Pathack 1993; Ropelewski and Halpert 1987; Alemaw and Chaoka 2006). Climate change also has contributed to the occurrence of extreme events such as floods in this part of Africa (Ngongondo et al. 2013). The availability and assurance of water resources can also be influenced by, and manifested in terms of, the natural variability of rainfall that results in exaggerated variations in river runoff (Alemaw and Chaoka 2002).

Flood transport in the hydrologic response of travel time distributions over watersheds and in rainfall-runoff modelling using Geomorphic Instantaneous Unit Hydrograph (GIUH) has been developed and applied over years by various researchers in the hydrologic community. A brief overview of Geomorphic Instantaneous Unit Hydro- graph (GIUH) theories and analyze their successful application such as Rainfall-runoff modelling (e.g. Beven 2011; Botter et al. 2011) and in hydrologic response of travel time distributions over watersheds (e.g. Botter et al. 2010; Comola et al. 2015; Botter and Rinaldo 2003).

In this manuscript it is attempted to discuss results of investigation that address flood hazard and the geospatial characteristics of geomorphology of the Limpopo basin. The specific objectives of the paper are: (a) To forecast and determine the flooding in the Limpopo basin; (b) To establish Flash Flood Guidance (FFG) values for all the major sub-catchments of the basin (c) To assess the geospatial hydrographical and morphological characteristics of the basin; and (d) To provide recommendations for a comprehensive flood forecasting and early warning system for the basin.

Further recommendations on flood forecasting and mitigation of flood hazards are provided in lieu of the technical, human capital and institutional challenges in the basin.