Stochastic Drought Forecasting Exploration for Water Resources Management in the Upper Tana River Basin, Kenya

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Chapter 54

Stochastic Drought Forecasting Exploration for Water Resources Management in the Upper Tana River Basin, Kenya

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ABSTRACT

This chapter presents the trend of drought as a stochastic natural disaster influenced by the climate variability for the upper Tana River basin in Kenya. Drought frequency, duration and intensity in the upper Tana River basin have been increasing over the years. To develop measures for mitigating impacts of drought, the influencing hydro-meteorological parameters and their interaction are necessary. Drought definitions, fundamental concepts of droughts, classification of droughts, types of drought indices, historical droughts and application of artificial neural networks in analyzing impacts of drought on water resources with special focus on a Kenyan river basin is presented. Gaps for more focused research are identified. Although drought forecasting is very vital in managing key sectors such as water, agriculture and hydro-power generation, drought forecasting techniques in Kenya are limited. There is need therefore to develop an effective drought forecasting tool for on-set detection, classification and drought forecasting. The forecasting is necessary for decision making on matters of drought preparedness and proper water resources planning and management.

1. INTRODUCTION

Drought is a stochastic natural disaster that adversely affects water resources within river basins (Jahangir *et al*., 2013). It may be defined as a hydro-meteorological epoch on land characterized by temporary and recurring water scarcity. The drought magnitude is measured by the extent with which it falls below a defined threshold level over an extended period of time (Morid *et al*., 2007). Drought has been identified as one of the most complex natural hazards due to its detection difficulties. In addition, drought develops slowly and impacts negatively on numerous sectors within a region (Morid *et al*., 2007). Effective drought preparedness and mitigation will depend upon timely information on its onset, and propagation in terms of temporal and spatial extent. Such information is usually obtained via effective and continuous drought monitoring using drought indices. Study on spatial and temporal drought conditions is therefore fundamental in offering a wide range of solutions that are geared towards management and planning of water resource systems. For instance, assessment of drought conditions is critical for planning water supplies, irrigation systems, crop and food security programmes, hydropower generation, water quality management and waste disposal systems (Abad *et al*., 2013).

On a global scale, drought has become more frequent and severe. This is mainly associated to climate variability with different regions experiencing droughts at varying scales and times (GoK, 2012). Consequently, global impacts of drought on environmental, agricultural and socio-economic aspects need to be studied. As such, four distinct types of droughts namely; meteorological, agricultural, hydrological and socio-economic are recognised. These droughts have either direct or indirect impacts on river basins. The former include degradation of water resources in terms of quantity and quality, reduced crop productivity, increased livestock and wildlife mortality rates, increased soil erosion and land degradation, and increased plant diseases and insect attacks (UN, 2008; Scheffran *et al*., 2012).

Severe drought impacts have been experienced in other regions of the world leading to food insecurity and general increase in world food prices. For instance, very notable recent droughts of 2009 and 2011 in Kenya adversely affected the agricultural sector where crop yields were drastically reduced. Due to the problems mentioned above, river basin managers often have a challenge of addressing water risks, conflicts and balancing economic development while at the same time maintaining reliable water resources (Okoro *et al*., 2014). To manage drought impacts, it is important to provide information on its characteristics in different forecasting ranges. Researchers have developed a number of tools to assist in drought forecasting such as the Artificial Neural Networks (ANNs) tool. The ANN tool is an information processing system developed with a structure and operation similar to that of a human brain (Maier *et al*., 2010) as described in section 6.1. The ANNs tool can offer numerous solutions to drought studies.

2. BACKGROUND

African countries are among the most vulnerable to impacts of drought and climate variability. The impacts adversely affect the well-being of human population. These impacts are compounded by numerous factors such as vast arid and semi-arid lands (ASAL) in the region, high levels of poverty, high population density, and recurrent of diseases. This is expected to multiply the demand for water, food and forage for livestock within the area in the next decades (Okoro *et al*., 2014). In East Africa, it has been projected that water availability will decline in future due to drought. In addition, there is a likeli-

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