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Linkages between local knowledge drought forecasting indicators and scientific drought forecasting parameters in the Limpopo River Basin in Southern Africa

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ABSTRACT

This article aims at evaluating linkages between selected local traditional knowledge (LTK) indicators with meteorological drought forecasting parameters in the Mzingwane catchment area of Zimbabwe. In addition, the article investigates possible ways of integrating selected LTK indicators with the meteorological drought forecasting parameters to improve applicability of meteorological drought forecasts at local level.

LTK forecast data from trees and plants for 2012/2013 season was collected through structured questionnaires administered on 40 household heads. Monthly rainfall data spanning the period September 1999–May 2013 (14 years) were used for the calculation of Standard Precipitation Index (SPI) for the study catchment. The trends in drought severity scale were then compared to the results from local traditional knowledge drought forecasting (LTKDF) to find out the degree to which they could be correlated. The GEONETCast ten day composite, SPOT VEGETATION, normalized difference vegetation index (S10 NDVI) dataset with a 1 km resolution was used to evaluate vegetation condition and hence track drought occurrence and severity. The trends in drought severity scale from NDVI were then compared to the results from LTKDF to establish the level of correlation. The analyses carried out shows a good correlation between traditional plant and tree indicators with resulting conditions captured as NDVI and SPI. The challenge on the LKDF systems, however, was lack of historical data to ensure adequate analysis and comparison with meteorological data. The study therefore recommends continuous monitoring and standardisation of LTK data.

1. Introduction

Semi-arid southern Zimbabwe experiences frequent droughts and dry spells during the crop growing season, making rain-fed agriculture risky [6,16]. The knowledge of weather patterns and droughts is therefore an important aspect in the planning and management of agriculture and water resource systems. In Sub-Saharan Africa, resource-challenged national meteorological services are tasked with the responsibility of monitoring and predicting weather using complex tools. In recent years, meteorological science has made enormous progress in predicting climate at both global and regional scale. Scientific forecasting methods apply Global Circulation Models (GCMs) but downscaling to local level, have proved to be a huge challenge mainly because of inadequate calibration data, failure to accommodate local climate circulation systems and variations in geophysical conditions. The realization that sea surface temperatures (SSTs) influence global atmospheric circulation enables scientists to formulate forecasts of seasonal rainfall [26]. These “formal” rainfall forecasts are presented as the probability of the seasonal rainfall being in the above normal, below normal, or normal compared with historical trends. National meteorological services use well-calibrated weather stations that meet World Meteorological Organisation standards but the high cost of acquiring and installing the equipment has resulted in very limited spatial deployment of fully equipped stations [13]. Furthermore, the high monitoring and maintenance cost for isolated stations has resulted in a large number of the stations being abandoned. Despite these challenges, meteorological institutions continue to provide regular climate forecasts especially in the form of seasonal climate outlooks. In Zimbabwe the Meteorological Services Department (MSD) is the agency responsible for monitoring and predicting weather and climate,

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including forecasting seasonal rainfall for the whole country.

Rural farmers in Mzingwane catchment apply both meteorological and local traditional knowledge to forecast weather and droughts. However, the challenge is access by communities to location specific rainfall forecasts which would enable them to take appropriate decisions at the farm level is very limited [4]. The benefits of local traditional knowledge (LTK) within disaster risk reduction are gradually being identified and acknowledged [15]. However, despite this acknowledgement, LTK reaching the decision makers is not accompanied by the correct strategies for disaster risk reduction [15]. Traditional knowledge systems are generally defined by [2] as the knowledge of a people of a particular area based on their interactions and experiences within that area, their traditions, and their incorporation of knowledge emanating from elsewhere into their production and economic systems. LTK tends to be the result of cumulative experience and observation, tested in the context of everyday life, and devolved by oral communication and repetitive engagement rather than through formal instruction [29]). Local people, who live close to the natural resources, observe the activities around them and are first to identify any changes within their locality and adapt to them. Appearance of certain birds, mating of certain animals, or the nature of flowering of certain plants are all important signals of changes in time and seasons that are well understood by traditional knowledge. It is these indicators that are either located on one's farm or near one's home that have been used as indicative objects in making decisions of livelihood significance by farmers [3]. Traditional knowledge is the basis for local level decisions in such areas as food production, education, natural resources management, agriculture and health as well as a host of other livelihood activities in rural areas [30]. This ability to comprehend environmental clues and apply them to farming choices is performative knowledge that is intuitive and ingrained in practice, rather than articulated in a set of abstract principles or calculations [24]. LTK can help fine-tune weather and climate predictions for application at local level, much as traditional healing systems have provided many pharmaceuticals, techniques, information and ideas that Western biomedicine has adopted [21]. The United Nations Environment Programme (UNEP) recognizes the role of local traditional knowledge in the conservation of natural resources and management of natural disasters. Researchers on climate change in other regions [10,8] have recognized that despite the differences in the criteria used by local farmers and scientists to define seasonal phenomena, there is also significant overlap between them. This makes local traditional observations potentially useful to climate scientists. In Offon River basin in Ghana, farmers are able to predict well the onset of rains and plan their planting activities to coincide with the rains [7]. Findings from Zimbabwe suggest that some local indicators have predictive ability [25,28,3].

Some studies on the contributions of LTK to climate change research also show that LTK and science can complement each other [12,22] through the different types of data collected and the different scales of analysis. However, LTK is location-specific and can be very detailed. Formal scientific forecasts are mainly regional and global. The temporal scales at which both forms of knowledge (LTK and scientific) are generated is also different. LTK is generated continuously; while scientific forecasting depends on frequency of data capture and analysis for events and the results are then presented at time scales such as hourly, daily, monthly or yearly. According to Roncoli et al. [26], comparison between forecasts can also help generate important theoretical insights into the relationships between different knowledge systems. Roncoli et al. [26] suggests that a comparison between local and scientific forecasting knowledge leads to the following two key questions: Firstly, are local knowledge forecasts accurate and secondly are LTK forecasts reliable? Lack of historical and quantitative data hinders adequate evaluation of LTKs. Scientific and LTKs weather and climate forecasts have strengths and weaknesses and the major challenge is how to bring these two forms of knowledge together in a way that acknowledges their limitations, while building upon their respective strengths [9].

This study was therefore undertaken with the following objectives; firstly to evaluate linkages between selected LTK indicators with meteorological drought forecasting parameters (mainly vegetation), and secondly, to analyse possible ways of integrating selected LTK with meteorological parameters. The study focuses on analysis of the impacts of drought on vegetation. This was done by analysing changes in vegetation activity and greenness (leaf cover density, healthy and population of plants or tees) using both LTK and NDVI. Possible linkages between vegetation based LTK indicators and NDVI parameters were also analysed.

2. Description of the study area

The research was carried out in the southern part of Zimbabwe in the Mzingwane catchment. This catchment forms a portion of the Limpopo River Basin. The location of the study area is shown in Fig. 1. It is divided into four sub-catchments, namely; Upper Mzingwane; Lower Mzingwane, Shashe and Mwenezi. The catchment is characterised by low, erratic rainfall ranging from 450 mm to 650 mm/annum [11]. The Mzingwane catchment has an area of 63,000 km^2. Major water uses in the catchment are for domestic, industrial, mining and agricultural purposes. Droughts are frequent in the Mzingwane catchment. According to Nyabeze [18,19], the 1:10 four-year drought affects the whole of Mzingwane while the 1:15 four-year drought would achieve 91% coverage of the catchment. The 1991/1992 drought in Mzingwane was somewhere between these two droughts. A period of 4 moderately dry years can occur in a block of 5 years [17]. This means that there is only one wet season that period. The rainfall season stretches from October to April. Intra-season dry spells are very common even in good seasons. These dry spells range between 10 and 20 days, mainly in January. The mean minimum temperature is 5 °C and the mean maximum temperature is 30 °C [11]. Of the total population in the Mzingwane catchment, 66% lives in rural areas. Most of the smallholder farmers in the catchment rely on rainfed agriculture, and because the rainfall is usually erratic, low, and the length of dry spells long, crop failure is common. This often leads to food insecurity among the smallholder farmers. The main crops grown in the area are maize and sorghum, while cattle and goats are the main livestock kept. Environmental degradation is also common in the catchment, gold panning being the main driver.

2.1. Research design

The focus of this research was to establish linkages that may exist between selected meteorological and LTK parameters in mapping droughts. Seasonal rainfall prediction using *acacia* and *colophospermum mopane* trees (flowering and leaf production) was compared with seasonal rainfall prediction using meteorological forecast. Changes in leaf and flower density as observed by the communities were compared to SPI results and NDVI trend. The respondents were allowed to make observations and assign a percentage of density relative to the normal fruiting and flowering of the specific tree species. Fourteen years of monthly rainfall data collected from the MSD was used to calculate SPI for 3 and 6 month periods (SPI3 and SPI6). The use of SPI3 and SPI6 makes it possible to try and match the forecasting time scale of tree and plant LTK forecasts which is mainly seasonal. *Acacia* and *colophospermum mopane* species were selected for comparison