

The characterisation of rainfall in the arid and semi-arid regions of Ethiopia

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Abstract

In order to plan effective agricultural and water resource projects, it is necessary to understand the spatial and temporal variability of rainfall. Although it is one of the most drought-hit countries in the world, almost no study has ever been conducted in characterising the rainfall pattern of the arid and semi-arid regions of Ethiopia. In this study, rainfall data of the past 50 years was used to study the basic statistical characteristics of the rainfall of this region. Annual and monthly rainfall was fitted to the theoretical probability distributions and the best distributions describing the data at respective stations were determined. Probability of wet days and dry periods of different durations was determined. It has been found that both annual and monthly rainfall at different stations was described by different probability distributions. There is high variation of rainfall pattern among the stations. Heavier rainfall events are infrequent but they make up a significant percentage of the total rainfall. In arid and semi-arid regions where both the amount and frequency of rainfall occurrence is low, it is essential to take into account the unique rainfall characteristics in such regions.

Keywords: arid; dry period; Ethiopia; probability distribution; semi-arid; wet period

Introduction

Rainfall is the most important environmental factor limiting agricultural activities in the arid and semi-arid regions of the tropics. Although irrigation is believed to be an important strategy in alleviating the current food crisis, rain-fed agriculture is still the dominant practice in most developing countries. Soil moisture management in semi-arid and arid areas of the tropics is faced with limited and unreliable rainfall and high variability in rainfall pattern (Kipkorir, 2002).

It is very hard for hydrologists to measure, collect and store hydrological data such as rainfall and runoff. In most cases, the available data are limited and may also contain some gaps in the series. The gaps in the data can be filled or the series extended to a longer period using mathematical equations. It is generally assumed that a hydrological variable has a certain distribution type. Some of the most common and important probability distributions used in hydrology are the normal, lognormal, gamma, Weibul and Gumbel (Aksoy, 1999). The normal distribution generally fits to the annual rainfall and flows of rivers. The lognormal distribution is also used for the same purpose. In hydrology, the gamma distribution has the advantage of having only positive values. The Weibul and Gumbel distributions are used for extreme values of hydrological variables.

Generally only few studies of rainfall characteristics of arid and semi-arid regions of the tropics have ever been conducted. A review of research on tropical rainfall reveals that most detailed studies have been concerned with the more humid areas, a reflection of the distribution of both population and rainfall stations (Jackson, 1977; Oguntoyinbo and Akintola, 1983; Rowntree, 1988). The few published studies available from semi-arid areas tend to be from outside of the tropics (Sharon and Kutel, 1986) and the results are not necessarily representative of tropical areas. The Ethiopian arid and semi-arid region is no exception with almost no study to characterise the climatic pattern of this area. A recent study by Segele et al. (2005) tried to analyse the onset of *Kiremt* (rainy season), the rainy season of Ethiopia over the highlands of Ethiopia.

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This study tries to characterise daily, monthly and annual rainfall distributions of the arid and semi-arid region of Ethiopia. The resulting information is essential for several research programmes, rehabilitation projects, irrigation scheduling, and hydrological studies in the area.

Data and method of data analysis

The study area and data

The study area encompasses the arid and semi-arid region of Ethiopia found in the southern, southern-eastern, eastern, and north-eastern parts of the country (Fig. 1). The selection of the stations was restricted to eight stations due to unavailability of stations with complete data. Daily data of rainfall, temperature, humidity, wind speed, and sunshine hours was obtained from the National Meteorological Services Agency (NAMSA) of Ethiopia. As presented in Table 1, the length of data record for all the stations was greater than the 30 years of climatic data needed to do accurate climatic analyses in the tropics (Stewart, 1988; Aldabadh et al., 1982).

Method of data analysis

Monthly reference evapotranspiration was calculated using the FAO Penman-Monteith equation (Allen et al., 1998) given as:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma[900/(T + 273)]u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

where:

ET_o is the reference evapotranspiration (mm d⁻¹)

R_n is the net radiation at the crop surface (MJ·m⁻²·d⁻¹)

G is the soil heat flux density (MJ·m⁻²·d⁻¹)

T is the air temperature (°C)

u_2 is the wind speed at 2 m height (m·s⁻¹)

e_s is the saturation vapour pressure (kPa)

e_a is the actual vapour pressure (k Pa)

$(e_s - e_a)$ is the saturation vapour pressure deficit (k Pa)

Δ is the slope of vapour pressure curve (k Pa^o·C⁻¹)

γ is the psychrometric constant (k Pa^o·C⁻¹)