Agricultural and Forest Meteorology 188 (2014) 24–32

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Length of growing season, rainfall temporal distribution, onset and cessation dates in the Kenyan highlands

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ARTICLE INFO

Article history:
Received 27 February 2013
Received in revised form
20 December 2013
Accepted 23 December 2013

Keywords:
Orographic rainfall
Spatial analysis
Homogeneity test
Central highlands of Kenya

ABSTRACT

Dependence on uncertain rainfall and exposure to unmitigated climate risk are major obstacles in efforts to sustainably intensify agricultural production and enhance rural livelihoods. There is generally enough seasonal total rainfall; the challenge is its poor distribution over time and across the season. The amount of water available to plants strongly depends on the rainy season's onset, length, temporal distribution and cessation and can indirectly indicate the climatic suitability of the crop and its chances of success or failure in a season. Thus, the objective was to determine rainfall pattern; temporal distribution, onset, cessation and length of growing seasons in the tropical sub-humid and a semi-arid regions with contrasting rainfall patterns and agricultural potential in central highlands of Kenya. The study was carried out in Maara and Meru South Sub-Counties in Tharaka Nithi County and Mbeere North and South Sub-Counties in Embu County of the central highlands of Kenya (CHK). Central highlands of Kenya cover both areas with high potential for crop production and low potential, attributed to rainfall differences. Meteorological data were sourced from Kenya Metrological Department (KMD) headquarters and research stations within the study areas. Length of growing season, onset and cessation dates for both Long (LR) and short (SR) rains seasons were determined based on historical rainfall data using RAIN software and derived using various spatial analysis tools in ArcGIS software and presented spatially. Generally there was high frequency of dry spells of at least 5 days length in all the sites with Kiamaogo site having the highest (84 occurrences during LR season) and Kiambere having the least (44 occurrences during LR season) in 10 years. The occurrence of dry spells longer than 15 days in a season was more rampant in the lower altitude parts (semi-arid regions) of the study area as reflected by the Kiambere, Kiritiri, Machang'a and Kamburu sites in both seasons. For the higher altitude regions, average LR onset, representative of the normal/conventional growing period, ranged from 22nd to 26th March to end of April in the region. For the lower altitude region, it ranged from 16th to 30th March. For SR, onset was generally earlier in the high altitude areas with Kiamaogo having the earliest on 13th October. In the low altitude region, onset was comparatively late compared to the higher potential region, but unlike the LR season, spatial and temporal variation was narrower. The high frequency of dry spells more than 15 days long, coupled with the generally low total amount of rainfall receive per season makes agriculture a risk venture. Homogeneity test revealed that the generated onset and cessation dates for the two rain seasons were homogeneous over the 10 years for each of the seven stations. This indicates that, there has been no shift in onset and cessation within the period under consideration. Dynamic derivation of the spatial onset and cessation data at a local scale can be useful in monitoring shifts in onset dates and hence advice small scale farmers and other stakeholders in agriculture sector accordingly in the quest for enhanced agricultural productivity.

1. Introduction

East Africa and Kenya in particular is characterised by high rainfall variability, part of which is caused by the El Niño/Southern Oscillation (ENSO) (Shisanya, 1996; Camberlin et al., 2001). Dependence on uncertain rainfall and exposure to unmitigated climate risk are major obstacles in efforts to sustainably intensify agricultural production and enhance rural livelihoods (Hansen

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0168-1923/$ – see front matter
http://dx.doi.org/10.1016/j.agrformet.2013.12.011

et al., 2009) in most sub-Saharan Africa (SSA) countries. Strong dependence on rain-fed smallholder farming practices has resulted in a quasi-linear relationship between grain yields, seasonal rainfall receipts, and food deficits (Funk et al., 2008). High rainfall variability coupled with low adaptive capacity makes farmers vulnerable especially because of dependence on rainfed agriculture (Osman-Elasha, 2007) given that rainfall amount and distribution is the most important environmental factor controlling successful germination and subsequent crop establishment. Hence, agricultural capacity multiplied by percent normal rainfall is strongly related to per-capita production (Funk et al., 2008). For instance, in four out of sixteen rainy seasons of the past eight years, rainfed agriculture failed in high potential areas of the central highlands of Kenya (Meru South Sub-County) and in the low potential areas (Mbeere Sub-County), total crop failure occurs every other season while rainfall is erratic in the remaining seasons. The amount of water available to plants strongly depends on the rainy season's onset, length, cessation (Ati et al., 2002) and rainfall temporal distribution, hence can determine a success or failure of a season. For example, the failure of consecutive rainy seasons of the East African short rains (typically October–December) and subsequent long rains (March–May) plunged much of the region into severe drought, impacting millions of people and triggering a humanitarian crisis in 2011 (Lyon and Dewitt, 2012).

The uncertainty associated with rainfall variability is a disincentive to investment and adoption of agricultural technologies and market opportunities. It prompts the risk-averse farmers to favour precautionary strategies that buffer against climatic extremes over activities that are more profitable on average (Hansen et al., 2009) as available soil water in drought years limits returns on investment, for instance, the fertilizer. Dry spell analysis of weather data from a site in Machakos district with similar characteristics as low potential areas of the central highlands of Kenya reveals that, maize on a sandy soil is exposed to a dry spell exceeding 15 days in more than three out of five seasons (Barron et al., 2003). Analysing rainfall data from a nearby Murang'a district in central province, Ovuka and Lindqvist (2000) found that, farmers' perception that rainfall has decreased over the last 40 years is not reflected in a decrease of the total rainfall amounts, but there were indications for more frequent dry spells towards the end of the short rains season. This has considerable impact on agricultural productivity, market dynamics and hampers incentives for investments in agriculture.

Furthermore, future adaptations in response to climate change and rapid population growth are expected to intensify dependence upon rainfall in most smallholder farming systems in SSA (Mélanie et al., 2010). Besides rainfall variability, Kenya's extensive arid and semi-arid lands, characterised by dependence on low (690 mm year^{-1}) and unreliable rainfall, are representative of the extensive dryland regions of sub-Saharan Africa (Hansen et al., 2009). Given that food security critically hinges on investments in agricultural water management, with an emphasis on locally adapted rain water management measures (Hoff et al., 2010) there is need to understand the rainfall pattern. Onset and cessation are important variables to which all the other seasonal variables are related (Stewart, 1991). Onset seldom occurs abruptly and is often preceded by short isolated showers with intermittent dry spells of various lengths, which are often misinterpreted as the start of the rains (false starts) (Laux and Kunstmann, 2008). Knowledge of the onset, cessation, and, thus, of the length of the growing/rainy season significantly supports the timely preparation of farmland, mobilisation of seed/crop, manpower, and equipment, and most likely reduces the risk of planting and sowing too late or too early (Omotosho et al., 2000).

Uneven seasonal distribution of rainfall may expose agricultural practices to a range of mild to severe intra-seasonal dry spells, which may subsequently affect the agricultural productivity adversely. Different types of water limitation can seriously affect crop production. Dry spells are prolonged periods between rain events within the season (Fox and Rockström, 2005). According to Barron et al. (1999) and Fox and Rockström (2000), the period length of a dry spell will, for grain cultivation in semi-arid tropical conditions in Sub-Saharan Africa, generally range between 5 and 15 days. Dry spells affect crop production depending on their timing and magnitude with respect to crop growth stages and sensitivity to water stress (Ngigi et al., 2005). This implies that, understanding the nature and occurrence of dry spell is of importance especially for the rainfed farmers who has less access to irrigation facilities as they search for mitigation (Makurira et al., 2009).

Information about growing season characteristics in relation to rainfall pattern can help small scale farmers in making informed decisions in designing strategic planting management options that increase the chance for a successful and profitable season. Therefore, understanding the rainfall distribution within and between seasons as well as the onset and cessation of the rain contributes to knowledge of the length of growing period and indirectly indicates the climatic suitability of the crop (Araya et al., 2010). Hence, the objective of the study was to determine rainfall pattern; quantity, temporal distribution, onset, cessation and length of growing season.

2. Methodology

The study was conducted in the Central highlands of Kenya (CHK) covering four Sub-Counties: Maara and Meru South Sub-Counties in Tharak Nithi County and Mbeere North and Mbeere South Sub-Counties in Embu County. The CHK produces about 20% of the country's maize, cover both areas with high potential for crop production on inherently fertile Nitisols, and those of low potential attributed to lower rainfall and/or less fertile soils (Ferralsols, shallow and sandy soils) (Jaetzold et al., 2006). Rainfall pattern of CHK is bimodal with long rains (LR) coming from mid March to June and short rains (SR) from mid October to February, hence two cropping seasons per year. Just like rainfall patterns over much of East Africa, the bimodal rainfall regime moderated by coastal and topographic influences (Mutai et al., 1998).

Mbeere North and South Sub-Counties in Embu County lie on the South-Eastern slopes of Mount Kenya in the Lower Midland Agro-ecological Zone 3, 4 and 5 (LM3, 4, and 5). The LM 3 is a cotton (*Gossypium hirsutem*) zone while LM4 and LM5 are Marginal Cotton and livestock-millet zones, respectively, characterised by a short to very short cropping season (Fig. 1a). These zones are suitable for common beans (*Phaseolus vulgaris*), Dry land Composite and hybrid maize (*Zea mays*), sorghum (*Sorghum bicolour*) green grams (*Vigna radiata*), cowpeas (*Vigna unguiculata*), chick peas (*Cicer arietinum*) among other pulses (Jaetzold et al., 2006). Mean annual temperature ranges from 20.7 to 22.5 °C with average annual rainfall ranging between 700 and 900 mm. The Sub-Counties are characteristic of marginal region with low agricultural potential. Currently, it is experiencing increase in population pressure resulting from an influx of immigrants from the over-populated neighbouring high potential areas. It is representative of semi-arid agro-climatic conditions with relatively low agricultural production potential. Although the region is more suitable for drought tolerant crops and livestock rearing (Jaetzold et al., 2006), major crops grown by most households are maize (*Zea mays*), cowpeas (*Vigna unguiculata*), pigeon peas (*Cajanus cajan*) and common beans (*Phaseolus vulgaris*).

Meru South and Maara South Sub-Counties lie on the eastern slopes of Mount Kenya and are representative of the densely populated high potential humid area (Fig. 1a). Annual mean temperature