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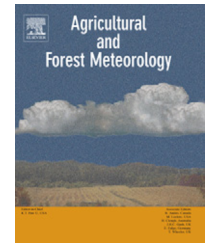

Analysis of rainfall onset, cessation and length of growing season for western Kenya

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ABSTRACT

Onset, cessation and length of growing season statistics are generated for both long and short rainy seasons in western Kenya. Onset identification is based on a daily analysis of the soil water balance over the initial growth stage (30 days) by identifying and quantifying the risk of failure of crop development. Cessation is based on a daily analysis of the soil water balance by identifying and quantifying the water stress in the root zone for maize. The length of growing season for a particular year is obtained from the difference between cessation and onset of that year. Historical daily climatic data of a 15–34-year period and soil data from 26 stations, spatially distributed in the study area, were considered. Results indicate that there exist organized progression of rainfall onset within the western Kenya region with the long rains showing a southerly progression while the short rains show a south-westerly progression. Cessation of rainfall for both seasons show strong localized influences, mainly surrounding Lake Victoria and forested areas, including orographic features. For stations with long length of growing season, the length varies more than the onset date.

1. Introduction

Lake Victoria Basin in western Kenya, is an area of high agricultural potential for both subsistence and plantation farming. The area is characterized by two rainfall seasons: the long rains and the short rains. The agricultural activities in this area are mainly rainfed. However, the rainfall characteristics in terms of length of growing season have always been uncertain due to high variability of onset and cessation of the rainy season. In some years the rains start early while in others it arrives late. The yearly variation makes the planning of sowing and the selection of the crop type and variety rather difficult. Generally yields may suffer significantly with either a late onset or early cessation of the growing season, as well as with a high frequency of damaging dry spells within the growing season. The ability to estimate effectively the actual start of the season therefore becomes vital. In order to plan rainfed agriculture, dependable probability levels of onset dates of the rainy period and length of growing season are important.

Previous work on rainfall onset has employed different techniques depending on the rain generating mechanisms of the region in question. Ilesanmi (1972) empirically formulated the onset, advance and cessation of the rains in Nigeria. Oshodi (1971), using a simple pentad method, arrived at similar isochrones of the onset of the rains in Nigeria. Nicholls (1984) used a wet season onset index in determining beyond reasonable doubt, the existence of the predictability of seasonal rainfall in Australia. Calooy (1981) used auto-regression models in predicting the seasonal rainfall of

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Bangladesh. Lineham (1983) used a water balance method in determining the onset and cessation of the rainy season in Zimbabwe. FAO (1978) defined the start of the growing season as the date when precipitation exceeds half of the potential evapotranspiration. Stewart and Hash (1982) evaluated the suitability of a given crop for a semi-arid location in Kenya using a water balance approach. Individual seasons were categorized according to date of rain onset and adequacy of rainfall for maize. This allowed recommendations on seed and fertiliser rates and thinning out of plants to be made and yield predicted for planning purposes. For bimodal rainfall regions of Kenya it was shown (Stewart, 1985), that if the onset of rains is early, maize could be grown, but in the case of delayed onset, which occurs in about half the number of years, sorghum and millet should be favoured over maize. Raes et al. (2004) carried out an evaluation of first planting dates in Zimbabwe by means of a soil water balance model and recommended the DEPTH (40 mm of rain in 4 days) criterion, based on the farmers' practices as an appropriate wet season sowing criterion.

The presence of a relationship between the onset and cessation dates and between the length of the season and the onset and/or cessation dates is also very relevant for planning activities in the season. Sivakumar (1988) carried out an analysis of long-term daily rainfall data for 58 locations in the southern Sahelian and Sudanian climatic zones of West Africa. The study showed that a significant relationship exists between the onset of rains and the length of the growing season. Oladipo and Kyari (1993) investigated the fluctuation in the onset, cessation and length of the growing season in Northern Nigeria and reported also that the length of the growing season is more sensitive to the onset of the rains than to the cessation. Reliable prediction of rainfall characteristics, especially the onset, is needed to determine a less risky planting date or planting method, or sowing of less risky types/ varieties of crops in responsive farming (Stewart, 1991).

In this study the two rainy seasons in western Kenya are analyzed with the objective to determine the patterns of rainfall onset, cessation and length of growing season and subsequently establish the relationships between these characteristics.

2. Materials and methods

2.1. Study area

The lake Victoria Basin which lies in the western part of Kenya between 1°30′N and 2°00′S and between 34°00′E and 35°45′E is considered in this study. The study area has close to 48,000 km^2 and is bordered by Uganda to the west, Tanzania to the south, and demarcated by the lake basin boundaries in the north and the east. Administratively, Nyanza and Western Provinces, and the western parts of Rift Valley province fall in this region (Fig. 1). The region is an area of high agricultural potential for both subsistence and plantation farming. The agricultural activities in this area are mainly under rainfed conditions.

The rainfall characteristics in the study area are influenced by several factors, which range from meso- to global-scale. These factors include; the meso-scale circulation induced by Lake Victoria, the Inter-Tropical Convergence Zone (ITCZ) and the Congo air mass (Ininda, 1994). There are two main rainfall seasons in the area, the 'long rains', which occur from mid March to May and the 'short rains', which occur from mid October to early December. The rains are usually associated with the northward/southward movement of the ITCZ.

Daily rainfall records and mean daily evaporation from 26 weather stations (Fig. 1) were collected for a period of 15–34 years from Kenya Meteorological Department (KMD) headquarters. The characteristics of the stations are presented in Table 1 with daily rainfall records spanning from 1970 to 2003 apart for Baraton University station, which spans from 1960 to 1987. Only eight stations had pan evaporation data (E_{pan}) based on class A pan. The estimation of evaporation data for the other stations was based on the homogeneous zonation of the Lake Victoria basin established by Ogallo (1980, 1989) and Agwata (1992). Spatially evaporation changes slowly and therefore this estimation was considered representative for the region. The eight stations were within the established homogeneous zones in the region and thus the evaporation data for the remaining stations was interpolated for these particular zones. Mean daily reference evapotranspiration (ETo) was derived from E_{pan} data by using a representative pan coefficient (Allen et al., 1998) for each of the eight meteorological stations.

Characteristics of the top soil for soil types found in the study area are indicated in Table 2. These are indicative values, which are obtained by means of a pedotransfer function (Saxton et al., 1986; Saxton, 2003) by considering the soil type.

2.2. Onset criteria

Onset is quantified by the DEPTH method described by Raes et al. (2004). It considers a cumulative rainfall depth that will bring the top 0.25 m of the soil profile to field capacity during a maximum of 4 days. The corresponding threshold rainfall quantifies the field inspection method by farmers to determine whether conditions are favourable for wet sowing. This is achieved by digging a test hole, usually a day after a rain event. The logic is to allow the rain to reach deeper layers of the soil, forming a recognisable wetting front. The total available soil water (TAW) during the initial stage for annual crops, for the major soils in the study area (Table 2) was used to determine the amount of rainfall required to raise the soil water content from wilting point to field capacity. Since TAW values in Table 2 do not vary widely from one soil type to another, with an exception of silt loam found in one station, an average TAW was considered. A mean threshold value of 40-mm rainfall is obtained by upgrading the TAW values (Table 2) by 20% to take care of losses by surface runoff, non-uniform wetting, and soil evaporation. Evaluation of onset criteria revealed that a threshold value of 40 mm rainfall during a maximum of 4 days is appropriate for the study area (Mugalavai, 2007; Kipkorir et al., 2007).

For each of the 26 stations, and for each of the 15–34 years of the period that daily rainfall data was available, RAIN software (Kipkorir, 2005) was used to determine the actual onset and cessation dates for each year. RAIN is a software

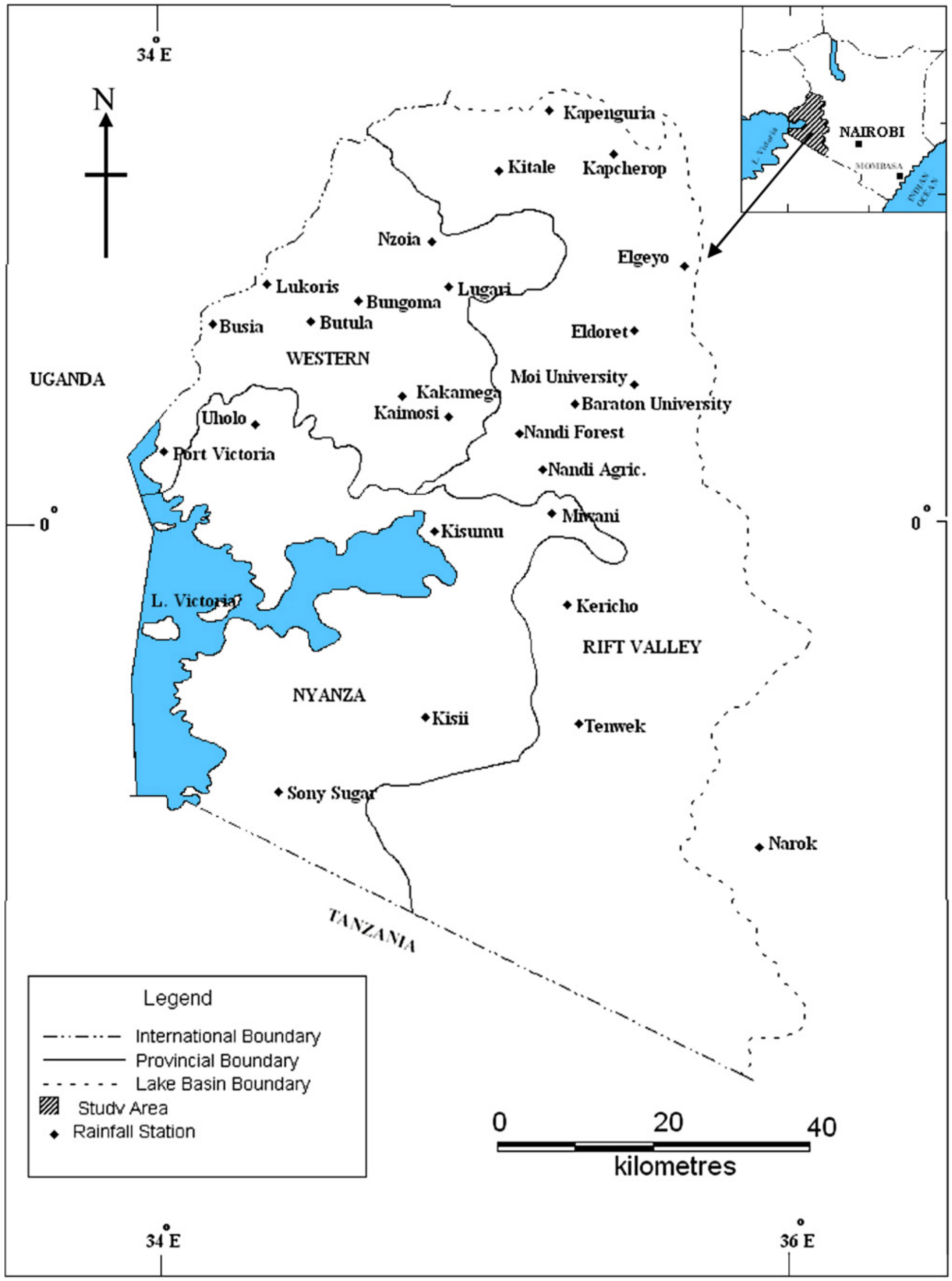

Fig. 1 – Location of the study area and the meteorological stations.

package designed for determination of onset, cessation and length of the growing season and to execute a frequency analysis of the above three parameters, which are important variables in planning rainfed agriculture. To eliminate problems of early showers, which are followed by long dry spells, an appropriate initial search date and the corresponding onset window (Fig. 2) were selected, with the help of the RAIN software (Kipkorir, 2005). For each station, the date having a probability of at least 20% that the root zone has adequate soil moisture was regarded as the date after which the onset criteria apply. The 20% probability level is commonly considered as acceptable when evaluating rainfed agriculture (Kipkorir et al., 2007). Starting from the initial search data the onset was taken to be the date on which the criterion was first satisfied or exceeded (Stewart, 1990; Kipkorir et al., 2004).

2.3. *Cessation criteria*

Cessation is quantified by considering the date on which the water stress in the root zone of a maize crop exceeds a threshold value. For each of the 26 stations, and for each of the 15–34 years of period that daily rainfall data was available the soil water content in the root zone was simulated with help of the soil water balance module in the RAIN software (Kipkorir, 2005). The maize crop was selected since it is the staple food for the majority of people in western Kenya. The maximum

Table 1 – Characteristics of the 26 meteorological stations used in the study

Station name	Latitude	Longitude	Altitude (m)	Record (years)	Mean annual rainfall (mm)	Climate	Soil type	Data
Narok	1°06′S	35°52′E	1576	34	779	Semi-humid	Silt loam	P, E_{pan}
Sony-Sugar	0°54′S	34°32′E	1455	18	1806	Humid	Clay	P
Tenwek	0°45′S	35°22′E	2000	33	1451	Humid	Clay loam	P
Kisii	0°41′S	34°47′E	1761	34	2106	Humid	Clay	P, E_{pan}
Kericho	0°22′S	35°16′E	1965	30	1956	Humid	Clay loam	P, E_{pan}
Kisumu	0°06′S	34°45′E	1142	34	1354	Humid	Clay	P, E_{pan}
Miwani	0°03′S	34°59′E	1200	26	1418	Humid	Clay	P
Nandi Agric	0°07′N	35°11′E	1988	25	1480	Humid	Clay	P
Port Victoria	0°09′N	34°01′E	1212	20	776	Transitional	Clay	P
Uholo	0°11′N	34°20′E	1212	34	1731	Humid	Clay	P
Nandi Forest	0°12′N	35°04′E	1970	26	1822	Humid	Clay	P
Kaimosi	0°13′N	34°57′E	1697	29	1809	Humid	Clay	P
Baraton University	0°15′N	35°05′E	1970	28	1639	Humid	Clay	P
Kakamega	0°16′N	34°45′E	1585	34	1926	Humid	Clay	P, E_{pan}
Moi University	0°17′N	35°20′E	2240	15	1252	Humid	Sandy loam	P, E_{pan}
Butula	0°20′N	34°21′E	1288	34	1930	Humid	Clay	P
Busia	0°28′N	34°06′E	1182	34	1891	Humid	Clay	P
Eldoret	0°32′N	35°17′E	2120	32	1063	Sub-humid	Sandy loam	P, E_{pan}
Bungoma	0°35′N	34°34′E	1394	34	1511	Humid	Clay	P
Lukoris	0°38′N	34°15′E	1212	30	1443	Humid	Clay	P
Lugari	0°40′N	34°54′E	1680	34	1371	Humid	Sandy clay loam	P
Elgeyo	0°43′N	35°31′E	2303	34	1302	Humid	Sandy loam	P
Nzoia	0°45′N	34°56′E	1812	34	1291	Humid	Clay	P
Kitale	1°00′N	34°59′E	1840	25	1256	Humid	Clay	P, E_{pan}
Kapcherop	1°03′N	35°19′E	2212	34	1211	Humid	Sandy loam	P
Kapenguria	1°14′N	35°07′E	2121	25	1223	Humid	Sandy loam	P

P indicates that rainfall data were available; E_{pan} indicates that pan evaporation data were available.

rooting depth for maize of 0.70 m and a readily available soil water (RAW) of 50% of TAW were considered in this study. Water stress was assessed by means of the water stress coefficient K_s (Allen et al., 1998). As long as a fraction of RAW remains available in the root zone, there is no water stress and K_s is 1. When water stress occurs, K_s decreases linearly with the soil water content and becomes zero when wilting point is reached. The cessation of the rainy season is assumed when K_s drops below 0.40 within the cessation window (Fig. 2). At that moment the crop experiences severe water stress and early canopy senescence is likely to be triggered. This simple approach eliminates the unrealistic long back-ends to the growing season. The cessation was taken to be the date on which the criterion was first satisfied or exceeded.

The simulation period is specified as between the derived onset date and the latest cessation date (Fig. 2). To avoid negative length of the growing season, the difference between the earliest cessation and latest onset is set at a minimum of 10 days. To eliminate problems of late showers, which are followed by long dry spells, an appropriate late cessation search date had to be chosen. The date having a probability of at least 20% that the root zone has adequate soil moisture (i.e., K_s is 1) was regarded as the date before which the cessation criteria apply.

Table 2 – Soil water contents and the corresponding total available water (TAW) in the 0.25-m soil profile for soil types used in the study

Soil type	Field capacity (vol.%)	Wilting point (vol.%)	TAW (mm/0.25 m soil depth)
Silt loam	33.8	9.2	62
Clay loam	40.0	26.4	34
Clay	42.4	29.8	32
Sandy clay loam	23.4	10.7	32
Sandy loam	23.8	10.0	35

2.4. *Length of growing season*

The length of the growing season (days) for a particular year is taken as the difference between the Julian day numbers of the

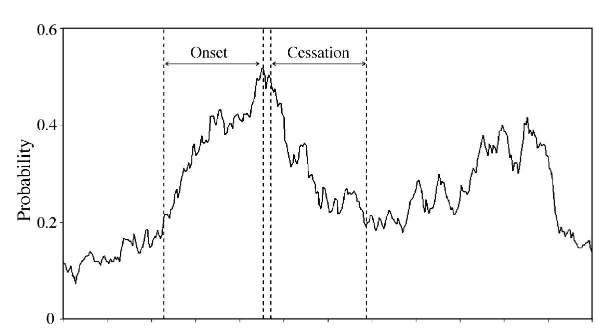

Fig. 2 – Probability on a day with adequate root zone soil moisture for Lukoris climatic station with indication of the onset and cessation search windows for long rainy season.

determined cessation date and the determined onset date for that year.

2.5. Statistical analysis

Probabilities of exceedance of the onset and cessation dates (specified as Julian day numbers) and of the length of growing season were calculated using the frequency analysis module in the RAIN software (Kipkorir, 2005). The frequency analysis in RAIN is based on ranking the data values in a descending order and assigning a serial rank number to each value to obtain a plotting position. The plotting position corresponds with frequency of exceedance on probability scale of probability plot. After selecting the distribution assumption, data values are plotted and a theoretical distribution line drawn. In RAIN normal probability distribution function is used, however, the data can be transformed using log, square or square root functions. Instead of drawing the theoretical line, a straight line can be fitted through the data points by the method of least squares and information on the goodness of fit (R^2) is displayed. If the R^2 value is acceptable, it may be assumed that the data can be approximated by the assumed distribution. After selecting the type of distribution with the best fit, the 80, 50 and 20% probabilities of exceedance were determined and used as indicators of early, normal and late onset and cessation dates, respectively. For the length of growing season analysis, the 80, 50 and 20% probabilities of exceedance were determined and used as indicators of short, normal and long season. To confirm that the selected onset and cessation dates for each station are representative of the current climatic conditions, a homogeneity test based on cumulative deviation from the mean was done.

3. Results and discussions

Many studies have indicated the existence of three rainfall peaks within western Kenya. This has led to the categorization of the seasons as: March–May, June–September and October–December (Beltrando, 1990). In this study only two seasons used for crop production under rainfed system were considered and therefore, for stations that showed three peaks, the first two peaks (March–September) were considered as the long rains and the last peak (October–December) as short rainy season. The calculated early, normal and late onset and cessation dates and the calculated short, normal and long length of growing season for the long and short rainy seasons are presented in Tables 3 and 4 for all the 26 stations considered in this study. For some selected probability levels the onset and cessation dates and the length of growing season are plotted as isochrones in Figs. 3–8.

The results for the homogeneity test revealed that the generated onset and cessation dates for the two rain seasons are homogeneous over the past 15–34 years for each of the 26 stations. This indicates that there is no shift in onset and cessation in the past 15–34 years, however, continuous monitoring should be done to detect any shift if it arises in the future.

Table 3 – Early (80% probability of exceedance), normal (50%) and late (20%) onset and cessation dates (day/month) and long (20% probability of exceedance), normal (50%) and short (80%) length of growing season (days) for long rains for various stations in the study area

Station	Onset			Cessation			Length		
	Early	Normal	Late	Early	Normal	Late	Long	Normal	Short
Narok	4/12	12/1	22/2	17/5	29/5	10/6	177	146	106
Sony-Sugar	6/3	20/3	5/4	15/5	6/6	3/7	107	73	50
Tenwek	17/2	7/3	25/3	10/5	2/6	24/6	162	134	110
Kisii	7/3	17/3	29/3	20/6	5/7	19/7	183	155	131
Kericho	6/3	19/3	4/4	3/6	12/6	21/6	226	191	161
Kisumu	22/3	30/3	5/4	13/5	31/5	19/6	81	62	43
Miwani	5/3	21/3	10/4	13/5	29/5	15/6	92	71	49
Nandi Agric	21/3	30/3	7/4	9/6	7/7	9/8	196	158	127
Port Victoria	24/3	29/3	2/4	12/5	26/5	7/6	66	53	41
Uholo	7/3	17/3	29/3	2/6	21/6	10/7	116	98	78
Nandi Forest	18/3	2/4	18/4	12/6	22/7	31/8	199	171	146
Kaimosi	20/3	4/4	22/4	13/6	30/6	19/7	108	83	61
Baraton	15/3	28/3	13/4	15/6	18/7	24/8	213	183	157
Kakamega	7/3	21/3	7/4	11/6	26/6	9/7	119	103	83
Moi Univ	17/3	1/4	20/4	10/5	14/6	9/8	177	161	146
Butula	11/3	22/3	2/4	9/6	25/6	10/7	109	92	75
Busia	21/3	28/3	4/4	30/5	15/6	29/6	89	76	60
Eldoret	28/3	13/4	30/4	14/5	1/6	18/6	172	161	150
Bungoma	14/3	29/3	16/4	2/6	21/6	12/7	106	79	56
Lukoris	10/3	27/3	17/4	29/5	18/6	11/7	115	91	58
Lugari	19/3	3/4	22/4	24/4	8/6	23/7	186	150	121
Elgeyo	18/3	3/4	22/4	23/5	20/6	23/7	176	149	127
Nzoia	18/3	4/4	25/4	11/9	3/10	26/10	217	187	157
Kitale	20/3	5/4	24/4	23/8	30/9	3/11	201	162	109
Kapcherop	27/3	13/4	30/4	20/5	20/6	28/7	163	106	49
Kapenguria	17/3	3/4	24/4	5/6	5/7	11/8	170	132	93

Table 4 – Early (80% probability of exceedance), normal (50%) and late (20%) onset and cessation dates (day/month) and long (20% probability of exceedance), normal (50%) and short (80%) length of growing season (days) for short rains for various stations in the study area

Station	Onset			Cessation			Length		
	Early	Normal	Late	Early	Normal	Late	Long	Normal	Short
Narok	–	–	–	–	–	–	–	–	–
Sony-Sugar	19/7	19/8	25/9	1/12	12/12	23/12	141	118	88
Tenwek	25/8	30/8	3/9	18/11	2/12	16/12	106	95	84
Kisii	31/7	24/8	19/9	5/12	13/12	21/12	127	112	94
Kericho	3/8	11/8	19/8	21/11	2/12	13/12	133	116	95
Kisumu	7/11	9/11	11/11	23/11	30/11	8/12	30	20	13
Miwani	30/10	4/11	8/11	16/11	27/11	8/12	36	19	10
Nandi Agric	27/10	31/10	5/11	23/11	28/11	4/12	37	26	18
Port Victoria	9/11	10/11	11/11	23/11	24/11	26/11	21	15	0
Uholo	24/7	16/8	5/9	20/11	29/11	7/12	120	105	89
Nandi Forest	18/10	21/10	23/10	3/11	16/11	30/11	37	24	16
Kaimosi	8/7	23/7	8/8	15/10	5/11	26/11	127	102	82
Baraton	29/7	6/8	13/8	18/10	3/11	21/11	106	88	74
Kakamega	9/7	26/7	14/8	9/11	23/11	8/12	140	117	98
Moi Univ	8/10	17/10	27/10	10/11	18/11	25/11	44	31	18
Butula	4/8	26/8	18/9	16/11	26/11	5/12	105	94	80
Busia	9/8	30/8	22/9	12/11	22/11	2/12	108	89	64
Eldoret	3/10	15/10	26/10	14/11	21/11	27/11	54	41	23
Bungoma	15/8	25/8	3/9	28/10	9/11	21/11	102	77	53
Lukoris	17/10	25/10	3/11	19/11	27/11	4/12	48	33	17
Lugari	10/10	15/10	19/10	6/11	13/11	20/11	39	29	20
Elgeyo	21/10	28/10	3/11	20/11	28/11	7/12	42	30	21
Nzoia	7/8	11/8	15/8	17/9	6/10	27/10	73	55	40
Kitale	11/10	19/10	28/10	15/11	28/11	12/12	58	45	25
Kapcherop	11/10	16/10	21/10	12/11	20/11	27/11	46	32	22
Kapenguria	14/10	17/10	21/10	27/10	11/11	26/11	35	23	15

– indicates non-existence of short rains season at the station.

For the long rains, onset ranges from early March to end of April in the region (Table 3). In a year with an early onset for the long-rainy season, the onset over the region generally shows a gradual progression from the southern part of the basin towards the north, however, it shows a general south-westerly progression from the Lake Victoria area. Since this is the period when the south-east (SE) monsoon sets in, there is a south-easterly progression of the onset and the stronger south-westerly progression and gradually, both arms move northwards (Fig. 3). Onset results indicate availability of homogeneous zones and examples are the northeasterly moving ridge covering Uholo, Busia and Bungoma and around Nandi Forest and Nandi Agriculture stations (Fig. 3). These findings are in agreement with those of Barring (1988) who analyzed the spatial patterns of daily rainfall from 73 stations in Kenya, and defined 11 major regions partly linked to orographic features. The results indicate an organized progression of the rain belt which, contradicts the observation by Alusa and Mushi (1974) that dismissed the existence of such organized movement of rain belts within Kenya except at the Coast. This could primarily be attributed to the poor coverage of data up to that time.

Results indicate that cessation of the long rains is generally slow from the south but as it progresses northwards its speed increases due to the orographic effects around Kisii, Kericho and Sony-Sugar (Fig. 4). Cessation generally shows an increasing pattern from south to north. However, around Kisumu and Miwani stations, the pattern suddenly changes. The area around Kisumu gets an early cessation because it is a lowland channel between the high grounds north and south of it. The air within the channel undergoes horizontal divergence as it flows. This divergence causes an early cessation in the area since it does not favour formation of rains. From the channel towards the high grounds in the north, progress is faster up to July, but beyond that meso-scale factors take control of the cessation. The divergence that is prevalent in this region between June and September delineates the lake basin into two with the lowland channel around Kisumu acting as a transition zone. This creates different patterns of cessation north and south of the channel. In the southern part, cessation progresses from late May (30) to early July (5). From the channel towards the north, cessation also occurs faster starting from late May (30) to early July (5). Beyond that the cessation tends to follow localized patterns with some form of closed isochrones, for example the area around Nzoia and Kitale. This pattern is attributed to the presence of Nzoia forest, which influences the microclimate of the area. It is, however, clear that cessation generally progresses from the southern part to the northern part, although this pattern is interfered with in the lowland channel. However, after the channel the pattern increases northwards although creating some closed patterns due to meso-scale factors (Fig. 4).

The normal lengths of the long rains growing season results (Fig. 5) indicate that there are stations with shorter

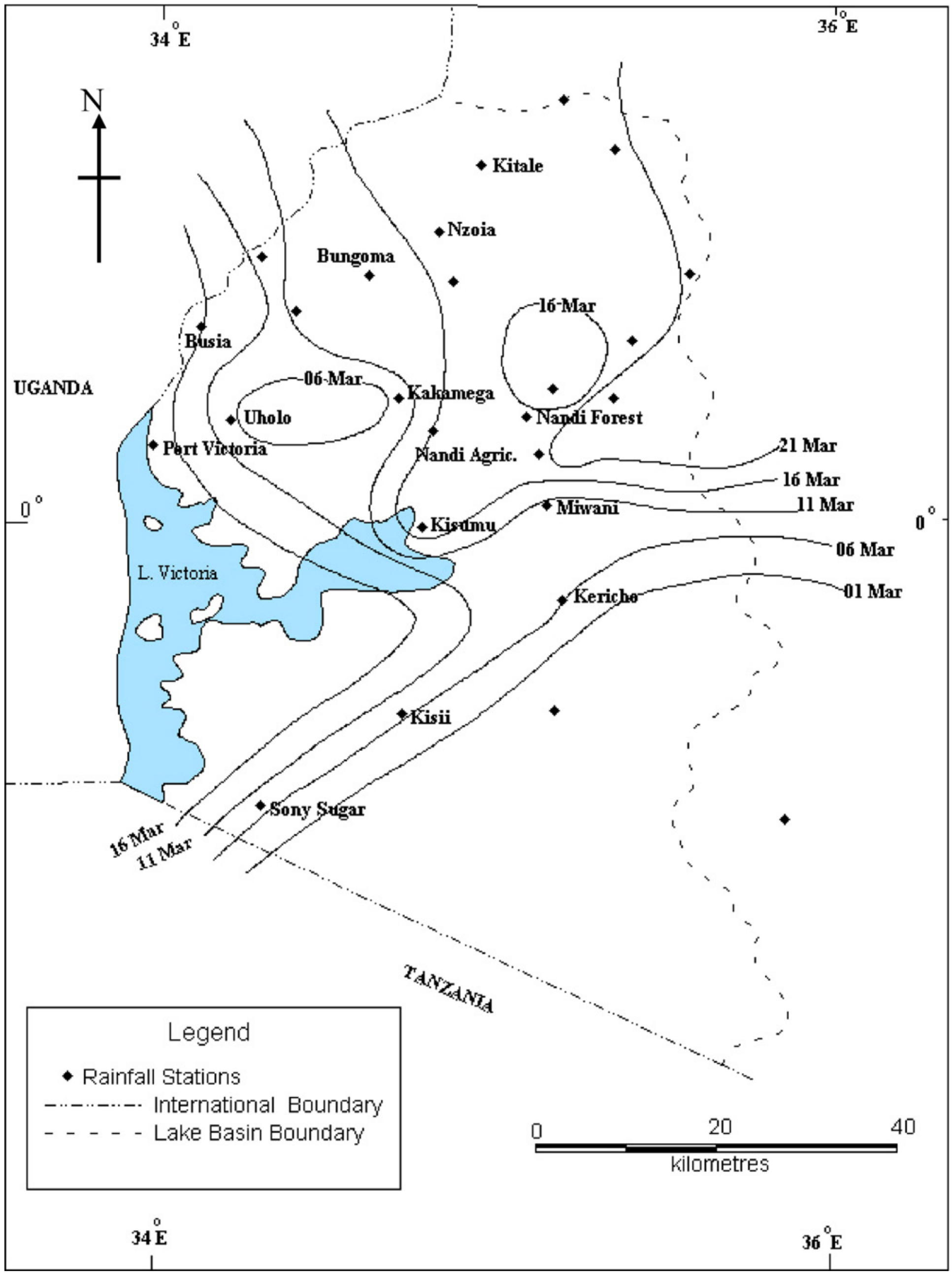

Fig. 3 – Early (80% probability of exceedance) onset dates (day/month) for long rains for various stations in the study area.

lengths (≤140 days) and others that have longer lengths (>140 days). Therefore the whole region can be delineated into two by use of the determined lengths of growing season (Fig. 5). Results indicated that the stations that grow crops with short growing lengths (≤140 days) are mainly situated to the western part of the Kenyan Lake Victoria basin with normal onset, cessation and length of 27 March, 15 June, and 80 days, respectively. Stations that grow crops with long growing lengths (>140 days) are situated to the eastern part of the Lake Victoria Basin region with normal onset, cessation and length of 25 April, 27 September and 155 days, respectively.

To determine the strength of the relationships between the onset and cessation dates and the length of growing season for the long rains a correlation analysis was done. The stations were divided into two groups: those with a short (≤140 days) and those with a long length (>140 days) of growing season. Results indicate a positive correlation between the length of the growing season and the cessation of the long rains. The correlation is strong ($r = 0.9$) for stations with a short length of season, and weak ($r = 0.3$) for stations with a long length of the long rainy season. Similarly a negative correlation exists between the length of the growing season and the onset of the long rains. The correlation is strong ($r = -0.6$) for stations with a short length of season, and weak ($r = -0.3$) for stations with a long length of the long rainy season. The noted difference in strength of the correlation can be attributed to the fact that the

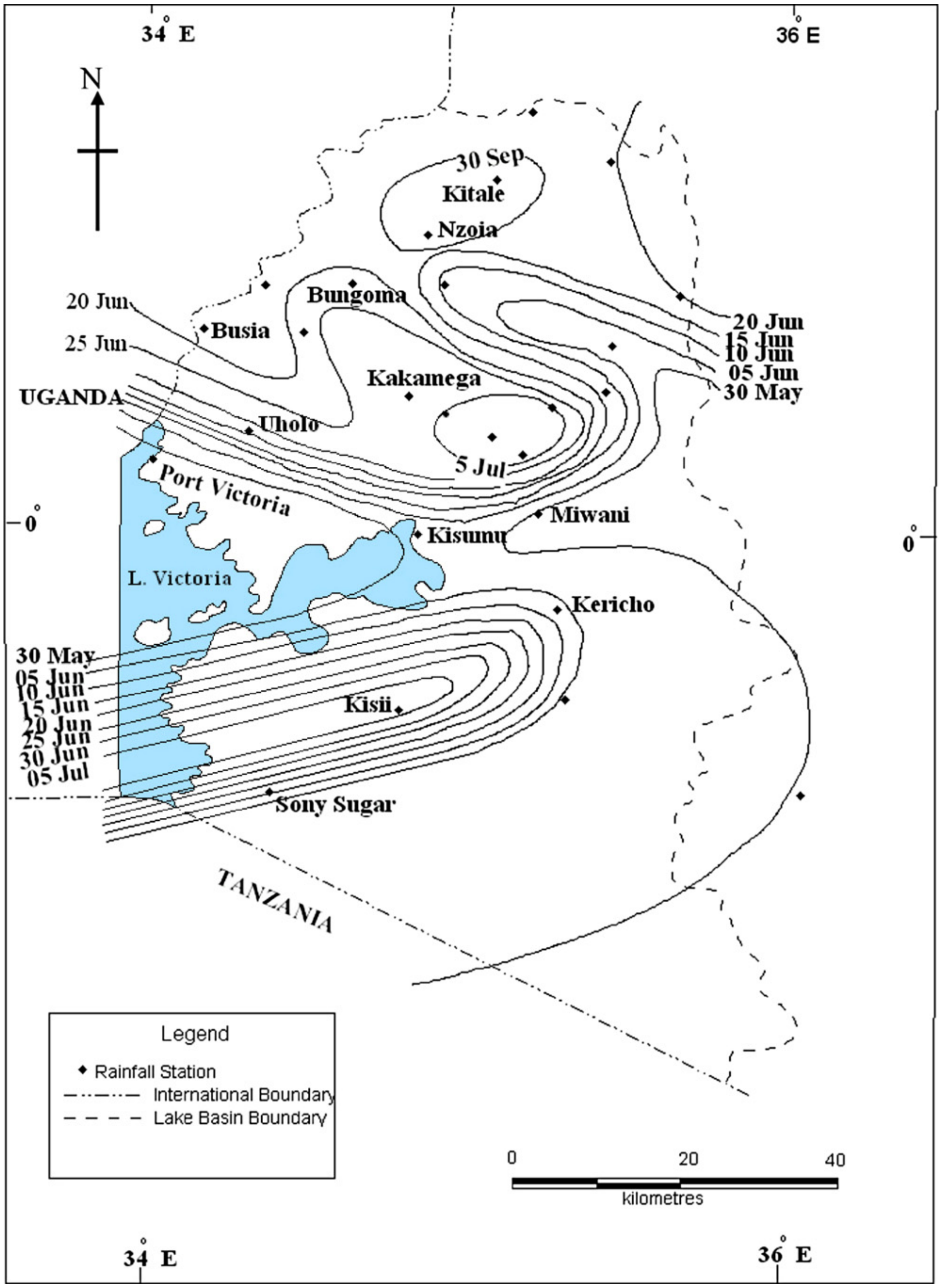

Fig. 4 – Normal (50% probability of exceedance) cessation for long rains for various stations in the study area.

longer the lengths of the growing season the larger the variations between stations.

The correlation between the onset and cessation date is very weak ($r = -0.1$) for the stations with a short growing length but very strong ($r = 0.9$) for the stations with long growing length. Therefore there is no significant relationship between onset and cessation for the stations with short growing lengths. For the stations with a long growing length, an early onset translates to an early cessation during the long rainy season.

The western Kenya region experiences a rainfall peak during July/August, which is associated with the westerly influx of moisture from the Atlantic Ocean and moist Congo air masses. This study considered this period to constitute the onset of the short rains. During this period the lake basin region is located south of the ITCZ and the rains occur mainly as thunderstorms in the deep monsoon air originating from the Congo Basin. The results reveal that onset of the short rains generally show a southwesterly progression (Fig. 6) confirming that the Congo Basin, which lies to the west of this region, plays an important role in the occurrence of short rains.

The contribution of the Congo air masses is enhanced by the convergence of the NE and SE monsoon winds which

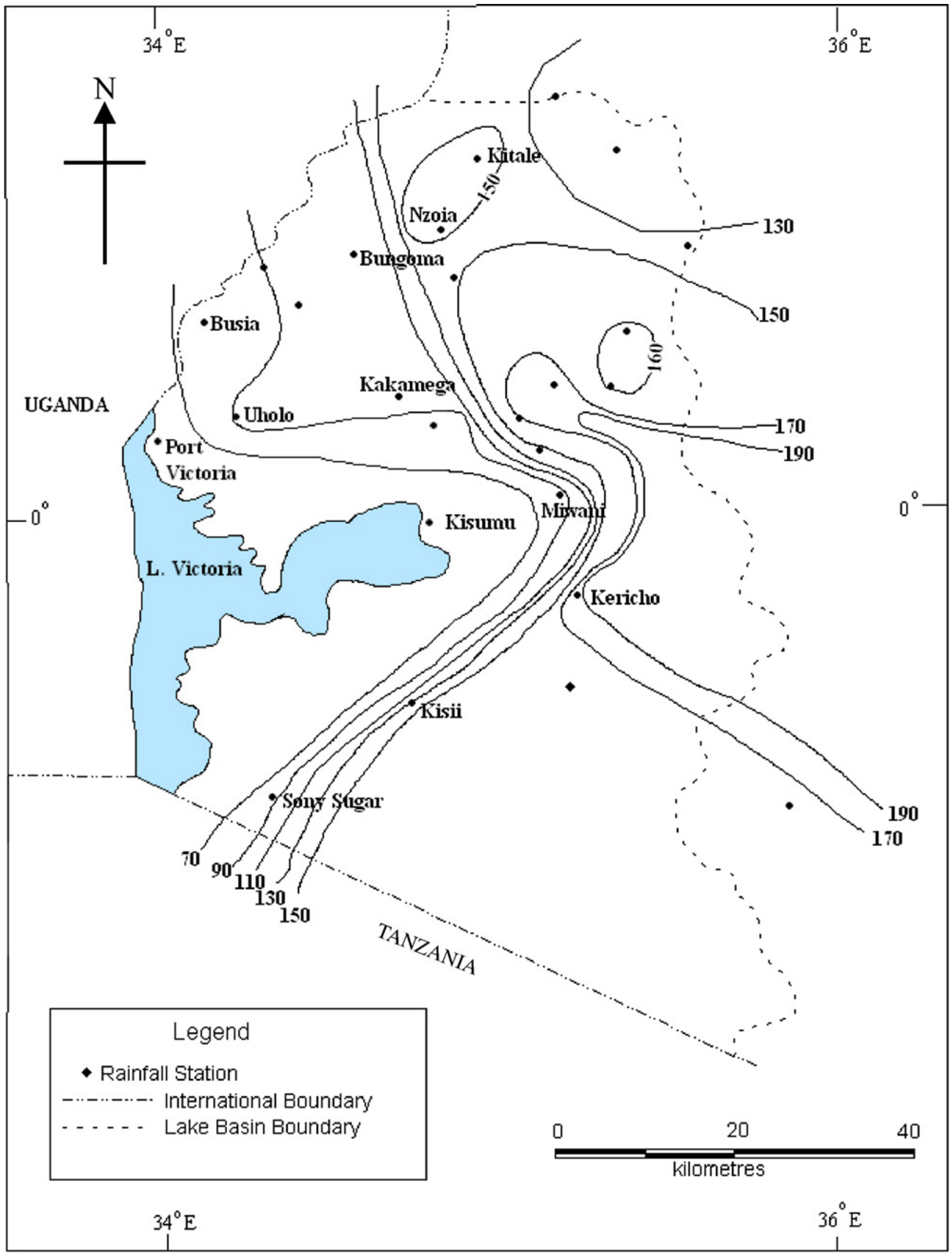

Fig. 5 – Normal (50% probability of exceedance) length of growing season (days) for long rains for various stations in the study area.

converge over the area in October just after the passage of the ITCZ as it moves southwards. Activities intensify in October since the ITCZ normally lags behind the seasonal movement of the overhead sun by about 3–4 weeks. The onset of the short rains do not indicate a direct progression from south to north but clearly reveal a southwesterly progression of the onset with two arms: one to the north and another to the south revolving around the Kisumu lowland channel. Both arms show that the onset progresses from mid-late August and extends to late October. However, the strong localized effects of the Kakamega forest causes an early onset that is indicated by the closed isochrones around the forested area (Fig. 6). The closed isochrone emphasizes the influence of Kakamega forest, which is a remnant of the tropical rain forest. For this station, the onset occurs in July and spreads out to other areas.

During the month of November–December (northern winter), the NE monsoon is predominant over the Lake Victoria basin region. The NE monsoon air current has its roots in the high-pressure centre over the Arabian and Indian subcontinent. Since this air current has a continental origin, it is dry and it has also been observed to be divergent over eastern Africa (Findlater, 1971; Anyamba, 1983). This explains why cessation occurs during this period. The plot for the cessation dates (Fig. 7) suggests strong micro- to meso-scale

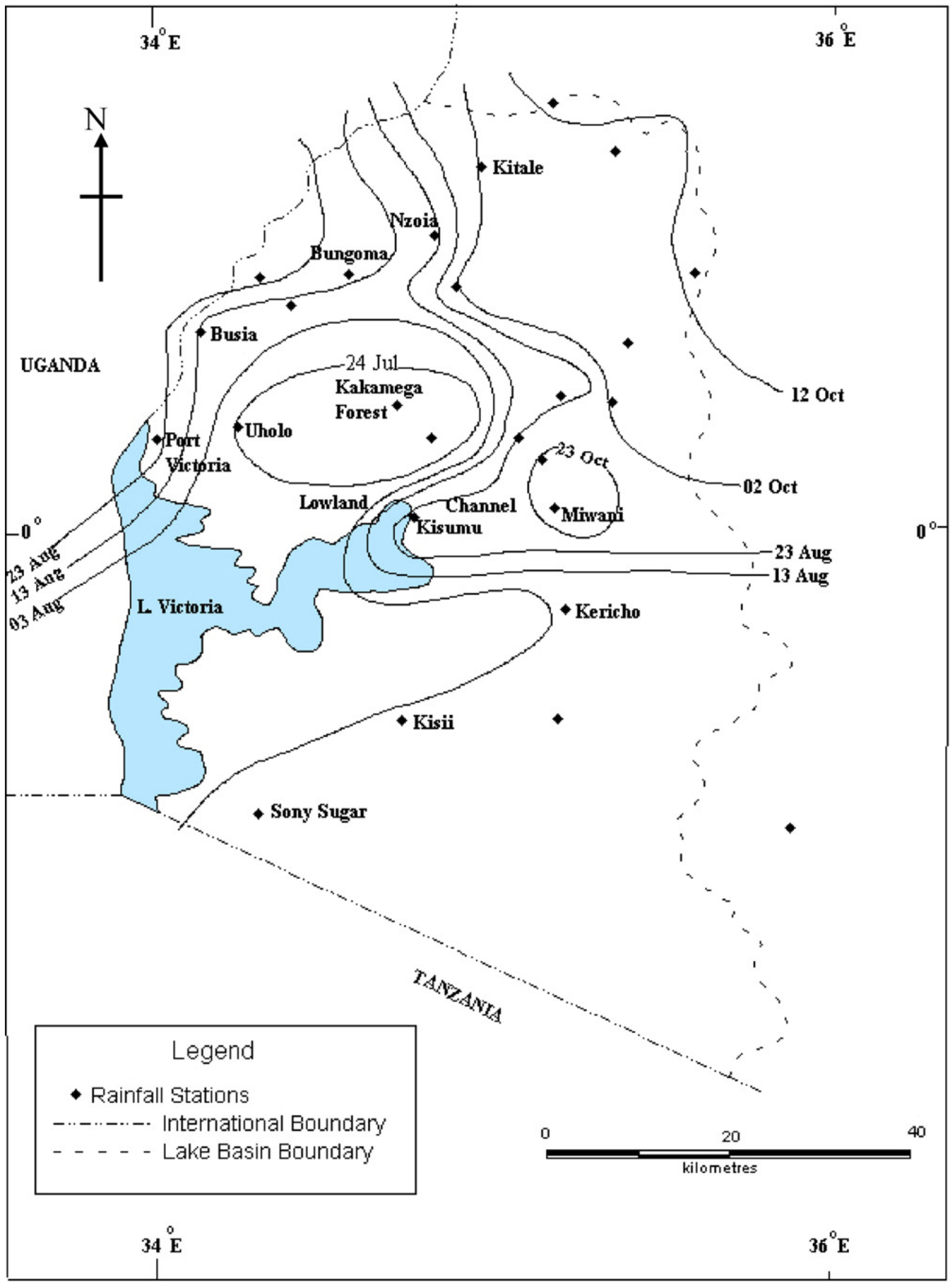

Fig. 6 – Early (80% probability of exceedance) onset dates (day/month) for short rains for various stations in the study area.

influences to the cessation of short rains indicated by the closed isochrones both to the north and south of the lowland channel which sweeps over Kisumu all the way to Uholo and finally to Port Victoria. The conventional rule for maintaining the interval between isochrones has not been strictly followed (Fig. 5) due to patterns surrounding certain features such as forests.

Results for analysis of the length of growing season, indicate that out of the 11 stations that have well-defined short rains, only 7 can successfully grow a second short maize crop. These stations include Bungoma, Butula, Kaimosi, Kakamega, Sony-sugar, Uholo and Busia. Most of these stations are located to the western part of Lake Victoria basin (Fig. 8). The length of the growing seasons for these stations range from 77 days (2.5 months) to 118 days (4 months), which are sufficient for a second maize crop. However, the remaining stations, including Port Victoria, Miwani, Lukoris and Kisumu have a very short length of growing season. Their lengths range from 15 days (Port Victoria) to 33 days (Lukoris), which are not sufficient for a second maize crop (Table 4). For these stations, irrigation is recommended during the short rains as a way of supplementing the limited rainfall.

Results for the correlation analysis for the short rainy season revealed a weak positive relationship (r = 0.22) between

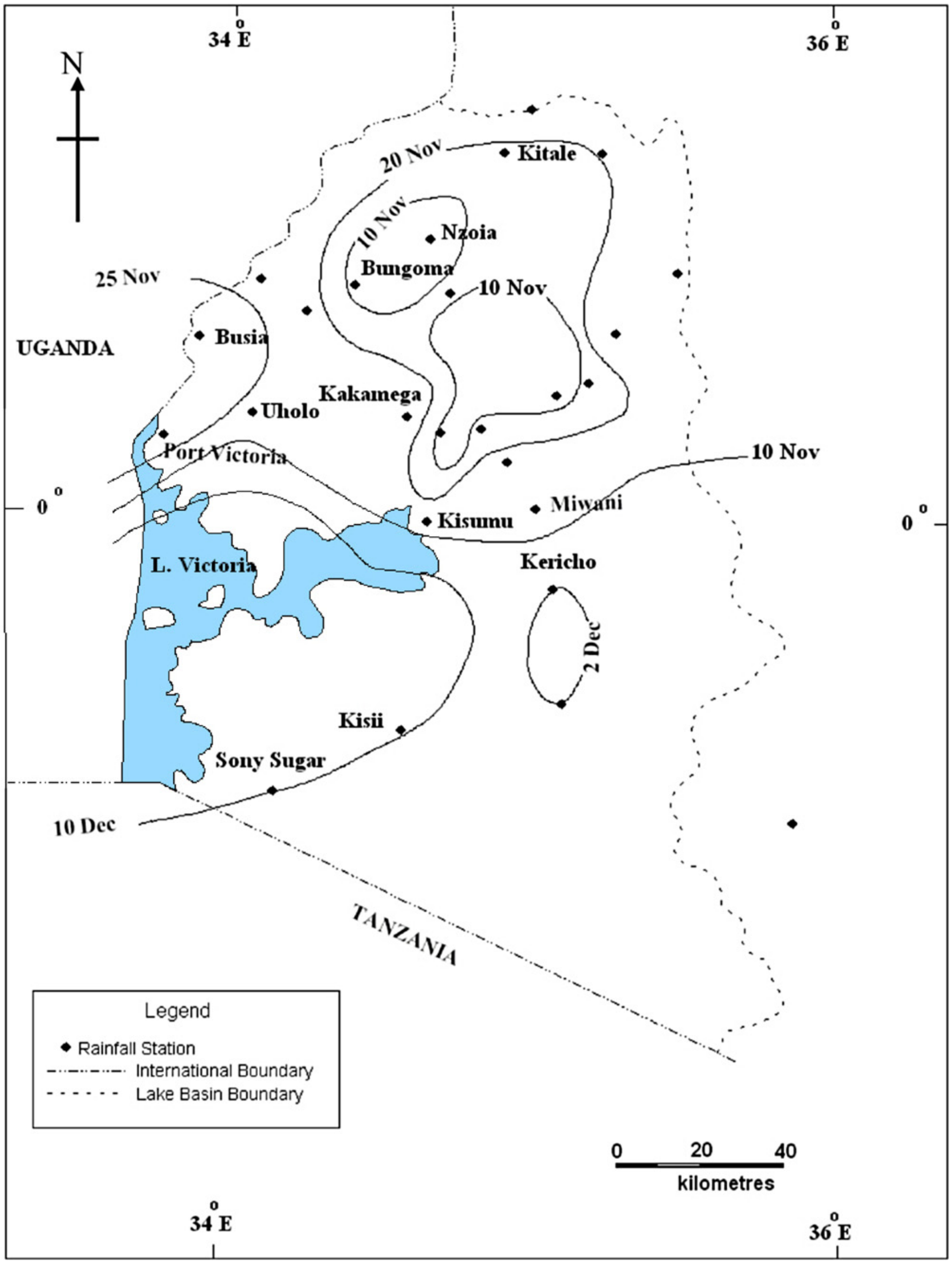

Fig. 7 – Normal (50% probability of exceedance) cessation for short rains for various stations in the study area.

the onset and cessation date and a strong negative correlation ($r = -0.94$) between the onset and the length of the growing season. This indicates that an early onset translates to a long length of growing season for short rains.

To be able to operationalize the findings of this study there is need for collaborative approach between the scientist, agricultural extension staff and farmers. This paper addresses the potential contributions of agricultural meteorology to agricultural planning and development. These contributions can take the form of agro-meteorological forecasting (WMO, 1981) and weather advisories (Stigter, 1984). If this approach can be made operational it will be the most powerful tool to meet the needs of low input agriculture. Since the paper has established the rainfall characteristics of the region based on a determined criterion (Mugalavai, 2007), there is need for the criterion to be used in identifying the onset dates for the ongoing season to enable the farmers to better plan their seasonal cropping activities (Ati et al., 2002). For the short rains for example, if the onset of the rains is early crops with long length of growing season can be grown, but in the case of delayed onset crops with short length of growing season should be favoured.

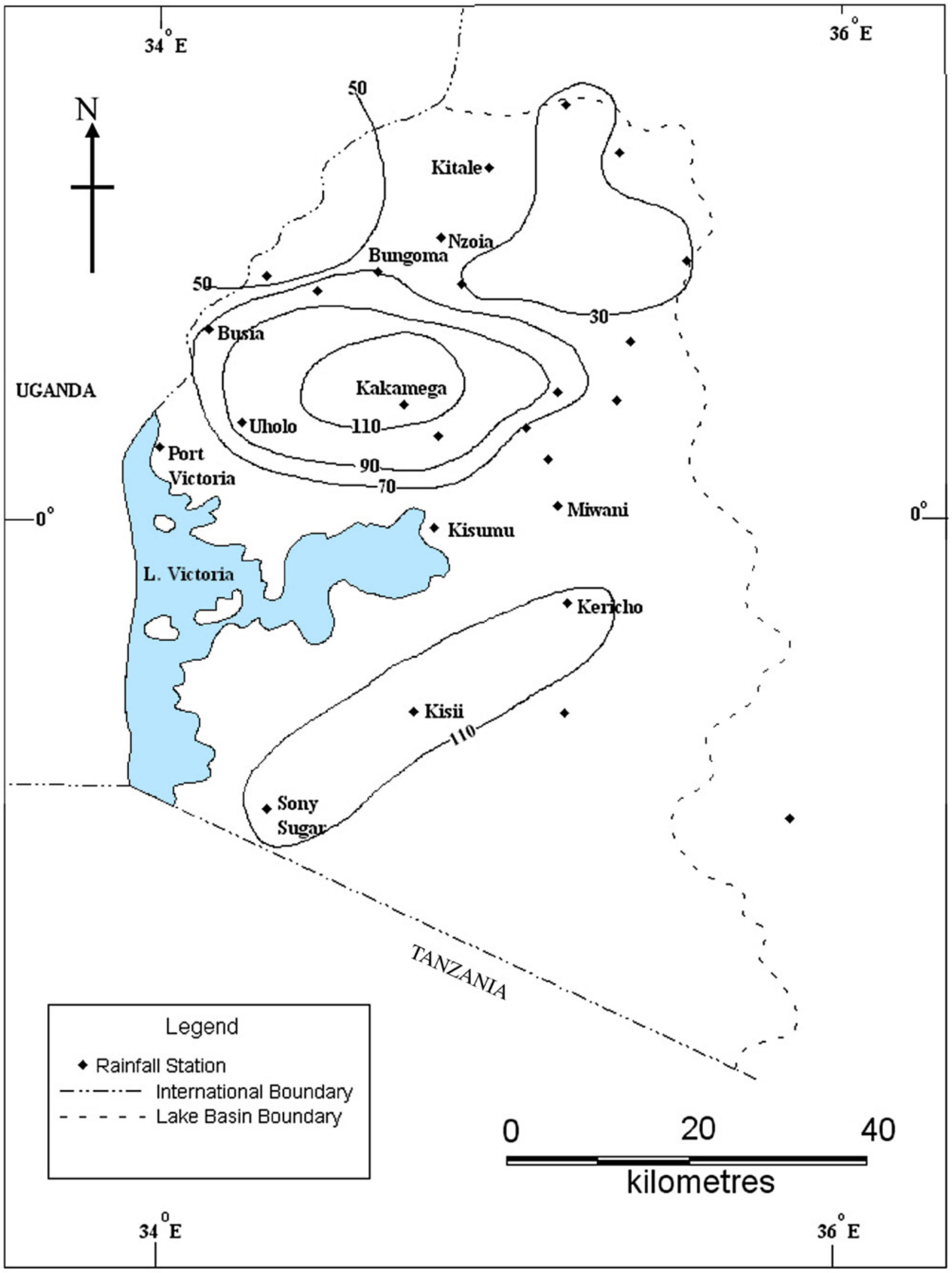

Fig. 8 – Normal (50% probability of exceedance) length of growing season (days) for short rains for various stations in the study area.

4. Conclusion

The onset and cessation dates were identified by using water balance techniques for 26 stations spatially distributed in western Kenya. The identified onset and cessation dates and the lengths of the growing season are presented in form of dependable probability of exceedance levels, which are quite valuable for planning of rainfed agricultural activities. Analysis of onset results indicate that there exist organized progression of rainfall onset within the western Kenya region with the long rains showing a southerly progression while the short rains show a south-westerly progression, indicating that the Congo air mass has influence on the short rainy season. However, the cessation of rainfall for both seasons show strong localized influences, mainly surrounding Lake Victoria and forested areas, including orographic features. Correlation analysis of onset and cessation for long rains indicate that for the stations with longer length of growing season, early onset translates to early cessation, while, for the short rains, early onset translates to a longer length of growing season. This information is very important to farmers in the region in deciding on crop types to be cultivated and on planning sowing dates as a function of observed onset dates.

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