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Evaluation of criteria for use in determining growing season onset dates in the Kenyan Lake Victoria Basin

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Abstract
This paper presents evaluation of criteria to be used in advising farmers on the planting dates in Lake Victoria Basin. The criteria were evaluated using relative yield over a 30 days period following sowing computed by means of soil water balance technique. Crop failure or a false start to the season is indicated by a relative yield rate of less than 35%. Due to the high ratio of computed relative yields in the region, the threshold values were varied from 35% to 75% in order to capture the failure rates. Using this method, onset dates were determined for 26 stations spatially distributed in the basin. Daily rainfall and mean daily evaporation data for a period of 20-30 years starting from 1970 were used. The criteria for accumulated rainfall depth over a specified period were evaluated. The tested criteria using RAIN software included; the accumulation of 20 mm of rainfall in 3 days, accumulation of 40 mm in 4 days and accumulation of 60 mm in 6 days. Comparison made between the accumulated depth criteria and those based on root zone depletion equal to readily available water (RAW) in 4 days and the soil moisture content at field capacity (SMC) in 4 days showed that the accumulation of 40mm in 4 days criterion compared well with (RAW) criterion but the SMC criterion gave delayed onsets in most cases. Results reveal that the accumulated depth criterion of 40mm in 4 days can be used as an operational criterion.

Key words: onset criteria, rainy season, evaluation, Lake Victoria Basin

1. INTRODUCTION

In the tropics food is raised mainly under rainfed agriculture to feed the rapidly growing population. The Kenyan Lake Victoria basin, which is located within the tropics, has a high agricultural potential for both subsistence and plantation farming. The agricultural activities in this region are mainly dependent on rainfall occurrence. For rainfed agriculture, problems for farmers arise in the yearly variation of onset, cessation and duration of the growing 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 dates of onset of rains and the length of the growing season. This analysis has important

applications in crop planning as well as disaster planning and forms an initial step in concepts such as "Response farming" or "Weather responsive crop management tactics" for drought prone West Africa. Oladipo and Kyari (1993) investigated the fluctuation in the onset, cessation and length of the growing season in Northern Nigeria. The results indicated that the trends in the length of the growing season are more sensitive to large inter-annual fluctuations in the start of the rains than to variations in the cessation dates.

In order to promote rainfed agricultural planning, the normal dates of onset of rainy period in particular regions in the tropics would be quite vital. 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 pentade method, arrived at similar isochrones of the onset of the rains in Nigeria. Various criteria have been employed in different parts of the world to predict the onset of the growing season in the respective regions. 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 autoregression models in predicting the seasonal rainfall of Bangladesh and India respectively. In the determination of onset of the growing season, the (FAO, 1978) bases the beginning of the growing period on the start of the rainy season. This occurs when the first rains fall on soil, which is generally dry at the surface and has a large soil moisture deficit. Lineham (1983) used 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 the precipitation exceeds half the potential evapotranspiration. Matari (1993) carried out a study aimed at predicting the seasonal rainfall from the onset, cessation and length of the growing season in Tanzania. The results of his study indicated that it is possible to estimate with reasonable accuracy the average onset date, length of growing season and the seasonal rainfall of Tanzania. Raes *et al.* (2004) carried out an evaluation of first planting dates recommended by criteria used in Zimbabwe by means of a soil water balance model. The criteria included: the AREX criterion of the Agricultural Research Extension (25 mm rainfall in 7 days), and the MET criterion of the Department of Meteorological services (40mm in 15 days). A third criterion DEPTH (40 mm in 4 days), based on the farmers' practices was introduced and recommended for operational use by the farmers. In this study an evaluation of criteria for determining growing season onset dates is done using the relative yield over the initial growth stage of 30 days from sowing (Allen et al., 1998). The results are then used to determine the onset dates for the long and short rains.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out in the Lake Victoria Basin which lies in the western part of Kenya in latitude between 1^0 30'N and 2^0 00's and in longitude between 34^0 00'E and 35^0 45'E with a total area of about 48,000 Km^2. The region is bordered by Uganda in the West and by Tanzania in the South, and demarcated by the water divides in the North and the East. Administratively, Nyanza and Western Provinces, and the Western Parts of Rift Valley province fall in this region (Figure 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. There area two main rainfall seasons, the long rains which occur from mid march to May and the short rains which occur from mid October to early December are experienced in most parts of Kenya. The rains are usually associated with northward/southward movement of the inter-tropical convergence zone (ITCZ).

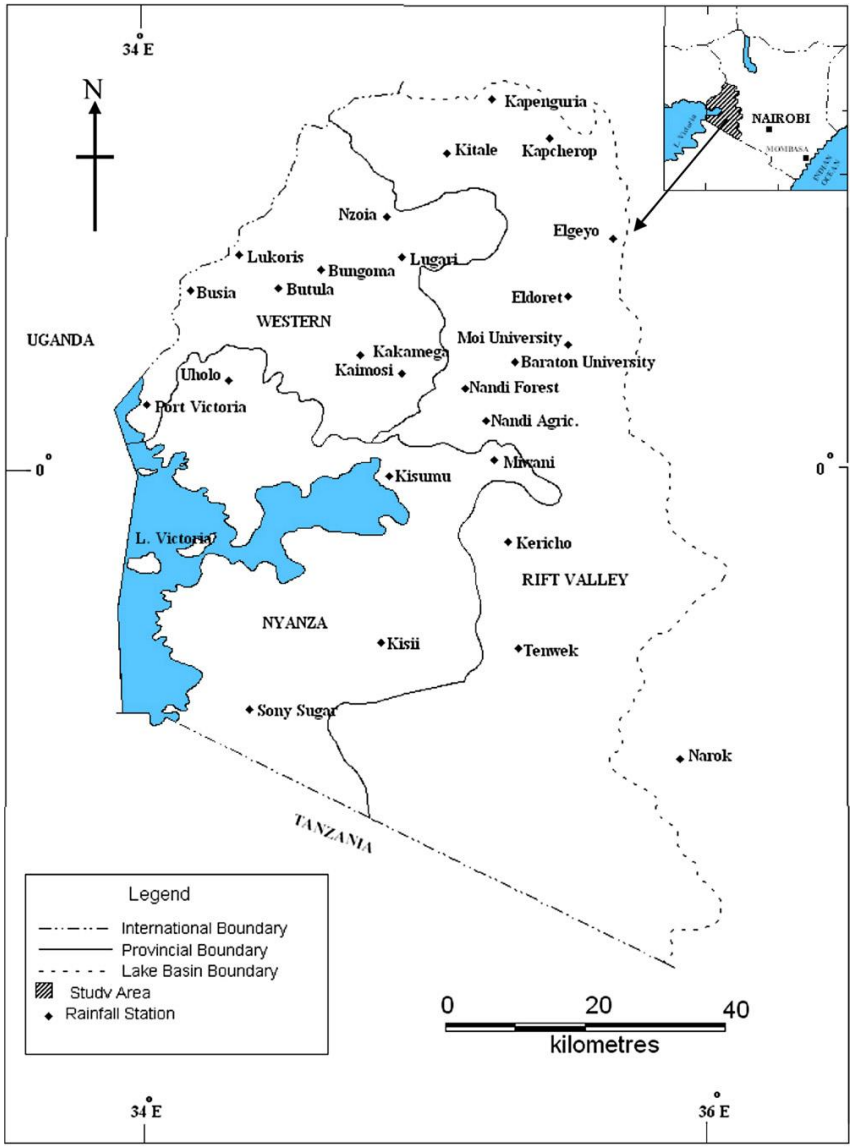

Figure 1- Location of study area

2.2 Climatic data

Daily rainfall records and mean daily evaporation from 26 meteorological and rainfall stations were collected for an average period of 20-30 years from the Kenya Meteorological Department headquarters. The location of the stations is indicated in Figure 1. Moi University (15 years) and South Nyanza Sugar Factory (18 years) were incorporated to enhance the stations network. The records spanned from 1970 to 2003 apart from Baraton University station, which spans from 1960 to 1987. The mean

monthly reference evapotranspiration (ET_0) was derived from class A pan measurements (E_{pan}) by using a representative pan coefficient for each of the eight meteorological stations which had evaporation data (Allen et al., 1998). Since only 8 stations provided pan evaporation data, it was necessary to estimate data for the other stations. The estimation of data was based on the homogeneous zonation of the Lake basin established by Ogallo (1980), Ogallo (1989) and Agwata (1992). Evaporation data is conservative and therefore this estimation was representative for the region.

2.3 Onset Criteria

In this study three appropriate criteria using RAIN software (Kipkorir, 2004) for analysis are considered. The first is based on accumulated rainfall of at least 40 mm received during a maximum of 4 successive days from new rains (Raes *et al.*, 2004). Sensitivity analysis was performed for the criteria by varying the accumulated rainfall in the range of 20 to 60 mm for a maximum period in the range of 2 to 6 successive days. The second is based on root soil moisture content being at field capacity (SMC), during a maximum of 4 successive days from new rains. The third is based on root zone depletion being less than or equal to readily available soil water (RAW) in the root zone during a maximum of 4 successive days from new rains. RAW is considered equal to 50% of the total available water (TAW) in the root zone and the root zone depth is 25 cm.

2.3.1 Evaluation of rainfall onset criteria

Before applying any of the criteria for the current study, evaluation to determine the suitable criteria was done. This was done for the three cases, which included the accumulation of 20 mm over 3 days (Sivakumar, 1988), 40 mm over 4 days (Raes, et.al., 2004) and 60 mm in 6 days. In the analysis relative yield linked to the initial growth stage of 30 days from planting was used to determine the crop performance (Doorenbos and Kassam, 1986). The relative yield is computed using daily soil water balance model in the RAIN software. Simulations for the three criteria showed that the lowest relative yield index for most stations was high, over 0.5 apart from Elgeyo- Forest and Eldoret Met stations, which was less than 0.5.

As a result of this observation, the threshold relative yield values were varied from 35 to 75 % in order to determine crop failures at the different threshold levels. The selection of a criterion for particular stations was based on the number of failures linked to the tested criteria. Less failure qualified the criterion under consideration. Adjusting threshold values up to 75% was only done to enable the selection of the suitable criteria for different stations. A period of 30 days is the average length for the initial growth stage of several annual crops (Allen et al, 1998). The length of the period is further justified by the fact that farmers often make final adjustments to plant population (by thinning) and add fertilizers when they are sure that the crop is likely to survive the critical stage. These adjustments are made approximately 30days following crop germination (Stewart, 1990).

3. RESULTS AND DISCUSSIONS

3.1 Evaluation of onset criteria

The selection of suitable criteria for each station was done as described earlier. It was however observed that in some cases either two or all the three criteria tied. In such cases the criteria that qualified was based on the relative yield ratio. The one that had the

highest relative yield was selected. However in cases where this was inapplicable, the criteria that came next to the one with the highest failure rate in ascending order was selected. This was done mainly in cases where both the accumulation of 40 mm in 4 days and 60 mm in 6 days qualified, and then the 40mm in 4 days criterion was selected. These results are summarized in Table 1.

Table 1: Evaluation of the criteria using threshold relative yield at the end of initial stage

Station	Criteria days.mm	Lowest Y_a/Y_m	No. of Failures for various threshold (Ya/Ym) 35%	55%	75%	N (Events)	Selected Criteria
Baraton	3, 20	0.753	0	0	0		
	4, 40	0.675	0	0	1	25	3,20
	6, 60	0.563	0	0	5		
Kaimosi	3, 20	0.504	0	1	2		
	4, 40	0.797	0	0	0	24	4,40
	6, 60	0.752	0	0	0		
Bungoma Water	3, 20	0.631	0	0	5		
	4, 40	0.831	0	0	0	34	4,40
	6, 60	0.930	0	0	0		
Butula Mission	3, 20	0.772	0	0	0		
	4, 40	0.831	0	0	0	32	4,40
	6, 60	0.831	0	0	0		
Busia Farmers Training	3, 20	0.537	0	1	2		
	4, 40	0.804	0	0	0	32	4,40
	6, 60	0.904	0	0	0		
Eldoret Met.	3, 20	0.418	0	4	14		
	4, 40	0.258	1	7	17	29	3,20
	6, 60	0.381	0	6	16		
Elgeyo Forest	3, 20	0.251	4	10	19		
	4, 40	0.291	1	4	10	32	4,40
	6, 60	0.253	3	7	18		
Narok Met.	3, 20	0.600	0	0	4		
	4, 40	0.595	0	0	4	33	4,40
	6, 60	0.595	0	0	4		
Moi University	3, 20	0.544	0	2	4		
	4, 40	0.491	0	2	4	15	3,20
	6, 60	0.531	0	1	5		
Kakamega Met.	3, 20	0.510	0	1	2		
	4, 40	0.746	0	0	1	32	4,40
	6, 60	0.734	0	0	1		
Kisii Met.	3, 20	0.726	0	0	1		
	4, 40	0.922	0	0	0	32	4,40
	6, 60	0.922	0	0	0		
Kitale Met.	3, 20	0.738	0	0	1		
	4, 40	0.738	0	0	1	24	4,40
	6, 60	0.723	0	0	1		
Kapcherop	3, 20	0.308	1	5	5		
	4, 40	0.488	0	1	5	30	4,40
	6, 60	0.569	0	0	6		
Kapenguria	3, 20	0.454	0	3	8		
	4, 40	0.514	0	2	6	15	4,40
	6, 60	0.510	0	2	5		
Kisumu Met.	3, 20	0.722	0	0	3		
	4, 40	0.722	0	0	1	34	4,40
	6, 60	0.925	0	0	0		
Lugari Forest	3, 20	0.408	0	3	8		4,40
	4, 40	0.669	0	0	3	31	
	6, 60	0.712	0	0	2		
Lukoris Disp.	3, 20	0.603	0	0	2		4,40
	4, 40	0.803	0	0	0	23	
	6, 60	0.700	0	0	1		
Miwani Mill	3, 20	0.632	0	0	3		4,40
	4, 40	0.788	0	0	0	16	
	6, 60	0.760	0	0	0		
Nandi Agric.	3, 20	0.768	0	0	0		4,40
	4, 40	0.735	0	0	1	23	

	6, 60	0.855	0	0	0		
Nandi Forest	3, 20	0.772	0	0	0		4,40
	4, 40	0.914	0	0	0	21	
	6, 60	0.770	0	0	0		
Nzoia Forest	3, 20	0.616	0	0	1		4,40
	4, 40	0.892	0	0	0	24	
	6, 60	0.723	0	0	1		
Port Victoria	3, 20	0.589	0	0	3		
	4, 40	0.589	0	0	2	18	6,60
	6, 60	0.703	0	0	2		
Sony- Sugar	3, 20	0.701	0	0	1		
	4, 40	0.847	0	0	0	10	4,40
	6, 60	0.847	0	0	0		
Tenwek	3, 20	0.433	0	2	10		
	4, 40	0.638	0	0	3	30	4,40
	6, 60	0.638	0	0	3		
Uholo-Camp	3, 20	0.632	0	0	1		
	4, 40	0.512	0	1	1	33	3,20
	6, 60	0.541	0	1	1		
Kericho-Hail	3, 20	0.553	0	0	2		
	4, 40	0.797	0	0	0	26	4,40
	6, 60	0.797	0	0	0		

The established onset criterion for each station was then used to determine the onset dates for the respective stations and the results tabulated as shown in Table 2. These results indicate the expected onset dates for the long and short rains at the various stations within the lake basin region.

Table 2: Long rains and short rains onset Julian days for the study area

Station	Long Rains					Short Rains				
	VL	L	N	E	VE	VL	L	N	E	VE
Baraton	96	86	82	79	71	225	220	218	215	210
Bungoma	106	93	88	83	73	246	239	237	234	227
Busia Far.	94	90	87	85	80	265	249	242	235	221
Butula Mis.	92	85	81	78	70	261	244	238	231	216
Eldoret	108	96	91	86	76	299	291	288	284	276
Elgeyo For.	103	96	93	90	81	307	302	301	299	294
Kaimosi	112	99	94	89	79	220	208	204	199	189
Kakamega	97	85	80	76	66	226	213	207	202	190
Kapcherop	117	105	99	94	82	294	290	289	287	284
Kapenguria	114	99	93	87	76	294	291	290	289	287
Kisii	88	79	76	73	66	262	244	236	229	212
Kisumu	95	91	89	87	81	315	314	313	313	311
Kitale	110	97	91	87	76	301	295	292	290	284
Lugari	109	97	92	87	78	292	289	288	286	283
Lukoris	107	92	86	80	69	307	301	298	296	290
Miwani	100	85	80	75	64	312	309	308	306	303
Moi Univ	106	98	95	91	84	300	293	290	288	281
Nandi Agr.	97	92	89	87	80	309	306	304	303	300
Nandi For.	108	96	92	87	77	296	294	294	293	291
Narok	53	24	12	0	338	-	-	-	-	-
Nzoia For.	115	100	94	89	77	227	224	223	222	219
Port Vic.	92	89	88	86	83	315	314	314	314	313
Soni Sugar	95	83	79	74	65	268	242	231	221	200
Tenwek	84	71	66	61	48	246	243	242	240	237
Uholo	88	80	76	73	66	248	234	228	221	205
Kericho	94	83	78	74	65	231	225	223	221	215

Onset Departures: very early (VE-80%), early (60%), normal (N-50%), late (L-40%), very late (VL-20%)

NB: Narok experiences one rainy season

3.1.1 Comparison of onset dates obtained using the three criteria

A comparison of onset dates obtained using the three criteria (accumulated rainfall of 40mm in 4 days, RAW and SMC) showed that the results obtained from the accumulated 40mm in 4days rainfall compared well with those obtained from RAW. The onset dates obtained from the two criteria agreed in most cases or were within a difference of one week (7-10 days). However the onset dates obtained from SMC generally came later. This shows that the use of this criterion generally gives delayed onsets of up to 3 weeks, which would shorten the length of the growing season. The results also reveal that in some cases all the three criteria gave the same dates of onset, further strengthening the selection of the accumulated rainfall criterion for use as an operational criterion for the region. These results are presented in Table 3.

Table 3: Comparison of dependable onset dates (day/month) obtained using three criteria

Station	40mm in 4days Criteria					RAW Criteria					SMC Criteria				
	VE	E	N	L	VL	VE	E	N	L	VL	VE	E	N	L	VL
Baraton	6/3	16/3	23/3	31/3	14/4	12/3	23/3	31/3	7/4	18/4	16/3	28/3	5/4	14/4	27/4
Bungoma	7/3	19/3	29/3	9/4	27/4	11/3	24/3	2/ 4	9/4	19/4	15/3	27/3	4/ 4	14/4	30/4
Busia Farmers	17/3	24/3	28/3	2/4	8/4	7/3	19/3	28/3	7/4	23/4	7/3	2/4	9/4	12/4	28/4
Butula Mission	6/3	16/3	22/3	29/3	8/4	5/3	18/3	26/3	2/4	12/4	5/3	18/3	26/3	2/4	12/4
Eldoret Met.	11/3	23/3	1/ 4	11/4	29/4	12/3	28/3	6/4	15/4	27/4	11/3	25/3	3/ 4	12/4	25/4
Elgeyo Forest	15/3	27/3	3/ 4	10/4	18/4	7/3	18/3	26/3	5/4	20/4	8/3	19/3	27/3	6/4	22/4
Kaimosi	13/3	25/3	4/ 4	15/4	3/5	14/3	26/3	5/4	15/4	3/5	20/3	1/ 4	9/4	18/4	1/5
Kakamega Met.	1/3	12/3	21/3	31/3	17/4	2/3	16/3	24/3	31/3	9/4	4/3	17/3	26/3	6/4	21/4
Kapcherop	14/3	30/3	9/4	20/4	13/5	18/3	28/3	4/ 4	12/4	25/4	23/3	1/ 4	8/4	15/4	27/4
Kapenguria	9/3	23/3	3/ 4	15/4	6/5	7/3	21/3	30/3	9/4	22/4	1/3	20/3	30/3	11/4	1/5
Kericho	1/3	11/3	19/3	29/3	13/4	7/3	14/3	19/3	25/3	2/4	2/3	13/3	21/3	31/3	15/4
Kisii	2/3	10/3	17/3	24/3	5/4	23/3	6/3	15/3	25/3	11/4	27/2	5/3	18/3	28/3	13/4
Kisumu	20/3	25/3	30/3	3/ 4	9/4	6/3	18/3	27/3	4/4	17/4	9/3	21/3	28/3	5/4	17/3
Kitale	10/3	23/3	1/ 4	13/4	1/5	20/3	30/3	6/4	12/4	20/4	20/3	2/4	11/4	18/4	29/4
Lugari	12/3	24/3	2/ 4	12/4	29/4	22/3	1/ 4	8/4	14/4	22/4	20/3	1/ 4	11/4	20/4	5/4
Lukoris	3/3	16/3	27/3	9/4	30/4	14/3	21/3	26/3	30/3	5/4	10/3	20/3	26/3	1/ 4	9/4
Miwani	26/2	11/3	21/3	2/4	22/4	4/3	16/3	25/3	4/4	21/4	12/3	23/3	31/3	6/4	15/4
Moi University	21/3	29/3	5/4	11/4	22/4	7/3	20/3	30/3	8/4	22/4	8/3	21/3	31/3	9/4	23/4
Nandi Forest	12/3	23/3	2/ 4	12/4	29/4	2/3	15/3	25/3	8/4	22/4	9/3	22/3	31/3	10/4	26/4
Nandi Agric.	16/3	25/3	30/3	4/4	11/4	6/3	20/3	30/3	9/4	26/4	8/3	22/3	31/3	11/4	27/4
Nzoia Forest	11/3	24/3	4/ 4	16/4	7/5	13/3	25/3	4/4	14/4	29/4	13/3	28/3	9/4	21/4	9/5
Port Victoria	22/3	26/3	29/3	1/ 4	4/4	24/3	3/ 4	9/4	15/4	23/4	16/3	24/3	29/3	3/ 4	10/4
Sony- Sugar	28/2	11/3	20/3	29/3	15/4	3/3	13/3	20/3	29/3	11/4	3/3	13/3	20/3	29/3	11/4
Uholo –Camp	4/3	11/3	17/3	24/3	4/4	10/3	20/3	27/3	5/4	19/4	12/3	21/3	28/3	5/4	18/4
Tenwek	8/2	24/2	7/3	18/3	¾	28/2	10/3	18/3	26/3	7/4	4/3	17/3	25/3	2/4	11/4
Narok	29/10	19/12	12/1	3/2	16/3	21/11	20/12	10/1	1/ 2	8/3	26/11	4/1	28/1	21/2	24/3

Onset Departures: very early (VE-80%), early (60%), normal (N-50%), late (L-40%), very late (VL-20%)

4. CONCLUSION

The study has identified suitable criteria for determining the rainfall onset for the lake basin region. The evaluation of the criteria indicated that the use of the accumulation of 40 mm of rainfall in 4 days from new rains is suitable for determining rainfall onset in the region and can be used as an operational criterion. To formulate practical guidelines for farmers, the 40 mm in 4 days criterion is transformed into a wetting front criterion in terms of linear depths for different soil types. The farmer will therefore be expected to observe the wetting front, which should approximate to the initial rooting depth for the crop in question (25 cm for maize crop). When these conditions are achieved, sowing can be done. This could reduce the risk taken by farmers during early sowing, that results from false insets.

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