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CLIMATIC SEASONALITY IN KENYA WITH SPECIAL REFERENCE TO COAST PROVINCE

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ABSTRACT

This article deals with climatic seasonality in Kenya in two ways. First, rainfall seasonality is discussed in terms of a measurable variable, with reference to that part of Kenya which is of importance for arable farming. Secondly, the concept is related to agricultural potential as well as actual land use in one particular region, notably Kwale and Kilifi Districts.

Key words: *climatic seasonality, land use Kenya, Coast Province.*

INTRODUCTION

Kenya's agricultural potential is rather low. Official statistics using the annual amount of precipitation as a criterion, classify only 13 per cent of the country's total rural land area as high-potential, 6 per cent as medium-potential, and the remaining 81 per cent being of low-potential, most of which is unsuitable for arable farming (CBS 1991, 93).

Most of Kenya's population is concentrated in the 19 per cent of the country with high and medium potential land. Due to the high population growth, land suitable for rain-fed farming has become very scarce in Kenya. Already in 1979, population densities in many rural areas were high. With 400 and 300 people per square kilometre, densities were highest in (the then) Kisii and (the then) Kakamega Districts, respectively. These figures however, hide that in certain areas, densities were even higher than 600 people per square kilometre (CBS, 1981). That means that only slightly more than 0.1 ha of agricultural land was available per person (Jaetzold & Schmidt, 1983 A:97,372). Although when writing this article, population figures of the 1989 census were not yet available, it is certain that in some rural parts of the country, densities will have risen to over 1000 persons per square kilometre, implying less than 0.1 hectare of agricultural land per person.

One of the consequences of this process of ever increasing pressure on arable land is a continuous migration from areas where this pressure is relatively high to areas where land is less scarce. Roughly two flows can be discerned. The first one concerns migration to the former white farmers' areas in the highlands. Many farmers have been able to acquire a piece of land on a former large farm, often with government assistance by means of settlement schemes. The second flow is directed towards areas with only marginal agricultural potential (semi-arid lands). For instance, arable farmers in the Eastern Foreland Plateau, largely consisting of (former) Machakos and Kitui Districts, as well as the lower parts of (former) Meru and Embu Districts have to a large extent penetrated into the marginal, semi-arid zone. The cultivated area in Kilifi District and to a lesser extent the one in Kwale District nowadays, also reaches into the semi-arid hinterland with its low agricultural potential (Kliest 1985:39).

The agricultural potential is largely determined by soil characteristics on the one hand and climatological characteristics on the other. Of the latter, three aspects play a crucial role, notably temperature (and hence evaporation), annual rainfall and seasonal distribution of rainfall. The agro-ecological zonation made by Jaetzold & Schmidt (1982:13) was based on these three elements. Both temperature and annual rainfall have been measured and studied in detail. Seasonal distribution of rainfall is a much less known variable.

expressed as a percentage of annual rainfall. The formula reads as follows:

$$DRS = \frac{(\bar{x}_{max1}+\bar{x}_{max2}+\bar{x}_{max3}) - (\bar{x}_{min1}+\bar{x}_{min2}+\bar{x}_{min3})}{\bar{R}} \; 100\%$$

in which: $\bar{x}_{max1}$ = mean rainfall of the wettest month

$\bar{x}_{max2}$ = mean rainfall of the second wettest month

$\bar{x}_{max3}$ = mean rainfall of the third wettest month

$\bar{x}_{min1}$ = mean rainfall of the driest month

$\bar{x}_{min2}$ = mean rainfall of the second driest month

$\bar{x}_{min3}$ = mean rainfall of the third driest month

$\bar{R}$ = mean annual rainfall

Values range from 0% (all months with an equal amount of rainfall) to 100% (all rainfall in three months). This index has two advantages. First, an index in percentages is easier to 'understand' than an index with a theoretical maximum of 1.83. Secondly, because the maximum value is reached when annual rainfall is concentrated in three months instead of one, this maximum is not solely a theoretical maximum. DRS-values can indeed reach values of over 90%.

CLIMATIC SEASONALITY IN KENYA

Figures 1 and 2 show the spatial pattern of the seasonality index and the degree of rainfall seasonality, respectively, for the southern half of Kenya. The area covered coincides largely with the part of the country suitable for arable farming. The information is derived from the rainfall data presented in Jaetzold & Schmidt (1982, 1983). Of 250 rainfall stations, both the seasonality index and the degree of rainfall seasonality have been calculated. Only stations with an uninterrupted period of at least 20 years of rainfall recording have been used. Of these, 63% covered 30 years or more. The spatial distribution of the measuring points over the districts is not very equal. Especially in the former areas of 'white' farming, rainfall recordings date far back. Table 1 shows the relevant data per district.

The two maps reveal a clear east-west gradient. Rainfall seasonality is fairly high along the coast line, particularly the northern coast. Going inland, values drop quickly in the immediate coastal hinterland, but then start to rise again, reaching maxima in Kitui District. Going further west, rainfall seasonality declines, the lowest levels being found in the border area of Kisumu, Kericho, Kisii and Southeast Narok. Finally, moving in the direction of Lake Victoria and Uganda, values start rising again. As far as the degree of rainfall seasonality is concerned, this gradient is made visible in Figure 3 for the line Lamu Town to Kisumu Town (Figs. 1,2, & 3).

As mentioned above, according to Walsh' map covering the whole of Sub-Saharan Africa, the seasonality index in Kenya ranges from 0.40 to 0.79. Moreover, it is indicated that roughly the northern half of Kenya falls in the 0.40-0.59 class and the southern half in the 0.60-0.79 clash (Walsh 1981:26), suggesting a north-south gradient. Figure 1 shows that both images are wrong. In the first place, the range of rainfall seasonality is much wider than what Walsh indicates, the highest SI being 1.02 and the lowest 0.19. Secondly, the spatial pattern not only shows an east-west instead of north-south gradient, but is also far more varied than a simple division in two classes.

The spatial patterns of Figures 1,2 and 3 can be considered as a refinement of the findings of Braun (1985). Braun made a rough distinction between the region west of the Rift Valley and the region east of the Rift Valley. Although in both areas a bimodal rainfall regime can be discerned, this is very weak in the former area and very pronounced in the latter. The maps show that the Rift Valley is not a sharp dividing line, however.

Figure 4 shows the monthly distribution (in percentages of total mean annual rainfall) for the two extreme cases, notably Mui in Kitui District, with the highest calculated degree of rainfall seasonality (70.5%), and Kilgoris in Narok District, where the lowest DRS-value was found (15.2%). Mui has a very clear bimodal climate, with rainfall peaks in April and November. From June to September there is very little rainfall. In Kilgoris, rainfall is somewhat equally distributed throughout the year. Although a very weak bimodal rainfall regime may be discerned, the 'peaks' are very modest indeed.

TABLE 1: Rainfall Seasonality by District

District*	Rainfall stations N	Rainfall stations Years of recording	Rainfall stations Average altitude (m)	Average annual rainfall (mm)	Seasonality index (SI)	Degree of rainfall seasonality (DRS)
Kwale + Mombasa	15	33	146	1079	0.50	39.7
Kilifi	9	38	105	942	0.52	40.7
Tana River	1	67	3	947	0.70	52.4
Lamu	4	45	7	870	0.79	61.7
Taita Taveta	8	40	860	660	0.72	50.5
Embu	4	38	1509	1366	0.74	53.1
Meru	7	27	1690	1399	0.78	56.2
Machakos	19	40	1348	791	0.78	58.3
Kitui	14	26	865	755	0.94	67.2
Kirinyaga	2	30	1385	1231	0.76	52.4
Nyeri	8	35	2013	1230	0.57	40.6
Murang'a	11	42	1552	1282	0.70	51.2
Kiambu	14	44	1815	1039	0.63	48.0
Nyandarua	8	39	2380	1055	0.38	29.7
Laikipia	3	42	1902	664	0.38	27.6
Samburu	3	31	1244	538	0.71	51.7
Baringo	8	36	1767	1036	0.34	31.3
West Pokot	3	27	1585	1001	0.47	35.6
Trans Nzoia	8	44	1993	1152	0.44	32.7
Uasin Gishu	8	36	2342	1113	0.44	32.3
Elgeyo Marakwet	5	31	2249	1326	0.37	28.7
Nandi	10	38	1937	1591	0.33	24.7
Kericho	13	45	2051	1398	0.34	25.4
Nakuru	20	46	2098	904	0.40	30.6
Narok	3	36	2193	1100	0.36	25.9
Kajiado (S.E.)	1	30	1960	821	0.73	55.5
Kisii	7	34	1667	1767	0.29	22.6
South Nyanza	8	27	1346	1293	0.40	30.0
Kisumu	4	44	1262	1442	0.31	23.1
Siaya	5	30	1271	1455	0.36	26.4
Busia	4	30	1246	1487	0.39	30.1
Bungoma	2	27	1555	1623	0.34	28.2
Kakamega	11	39	1622	1718	0.37	28.0
Average**	250	38	1506	1137	0.53	39.6

* The recent division of certain districts is not included

** The average totals are for the 250 rainfall stations and not for the 33 districts.

Source: Jaetzold & Schmidt 1982, 1983.

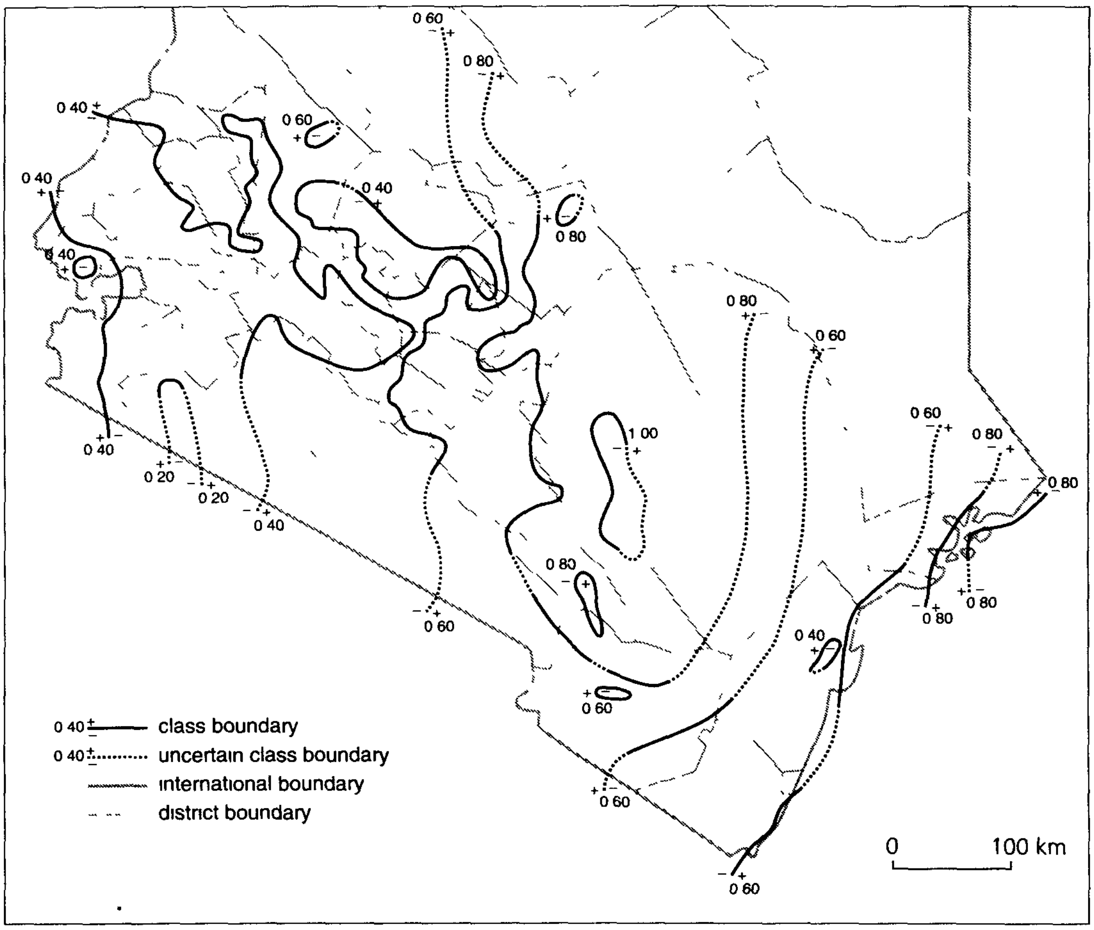

FIGURE 1: Rainfall Seasonality in Kenya I: the "Seasonality Index" (SI)
(Based on Jartzold & Schmidt, 1982 and 1983)

CLIMATIC SEASONALITY IN COAST PROVINCE

In this and the following section, one region in Kenya is analyzed in somewhat more detail, notably Coast Province, and Kwale Districts in particular. The data were obtained during a number of socio-economic and nutritional studies that were carried out between 1985 and 1987, as part of the Food and Nutrition Studies Programme (a joint Dutch-Kenyan research programme). Unless stated otherwise, both sections are based on two sources, i.e. Foeken & Hoorweg 1988 and Foeken et al. 1989.

In general, the annual precipitation in the district varies with the distance to the coast. Along the coastline, rainfall changes from 900-1100 mm per year in the northeast of Kilifi District to more than 1300 mm per year in the southeast of Kwale District. About 40 to 50 km inland, the 700 mm isohyet can be found. However, this general picture is slightly disturbed by the relief of the two districts. Only slightly, because the four major topographical zones which can be discerned also run southeast-northeast. These zones are:

I) The *Coastal Plain*, a narrow belt along the coast, with maximum altitude of about 60 metres. This zone extends to 10 km inland in the area stretching from Lunga-Lunga on the Tanzania border to the town of Kilifi. North of Kilifi town, the plain widens until it reaches some 30 km inland near Malindi town.

II) The *Foot Plateau*, the western extension of the Coastal Plain. This plateau has an altitude of 60 to 120 metres, although it is characterised by a relatively flat surface, alternated with a number of hills.

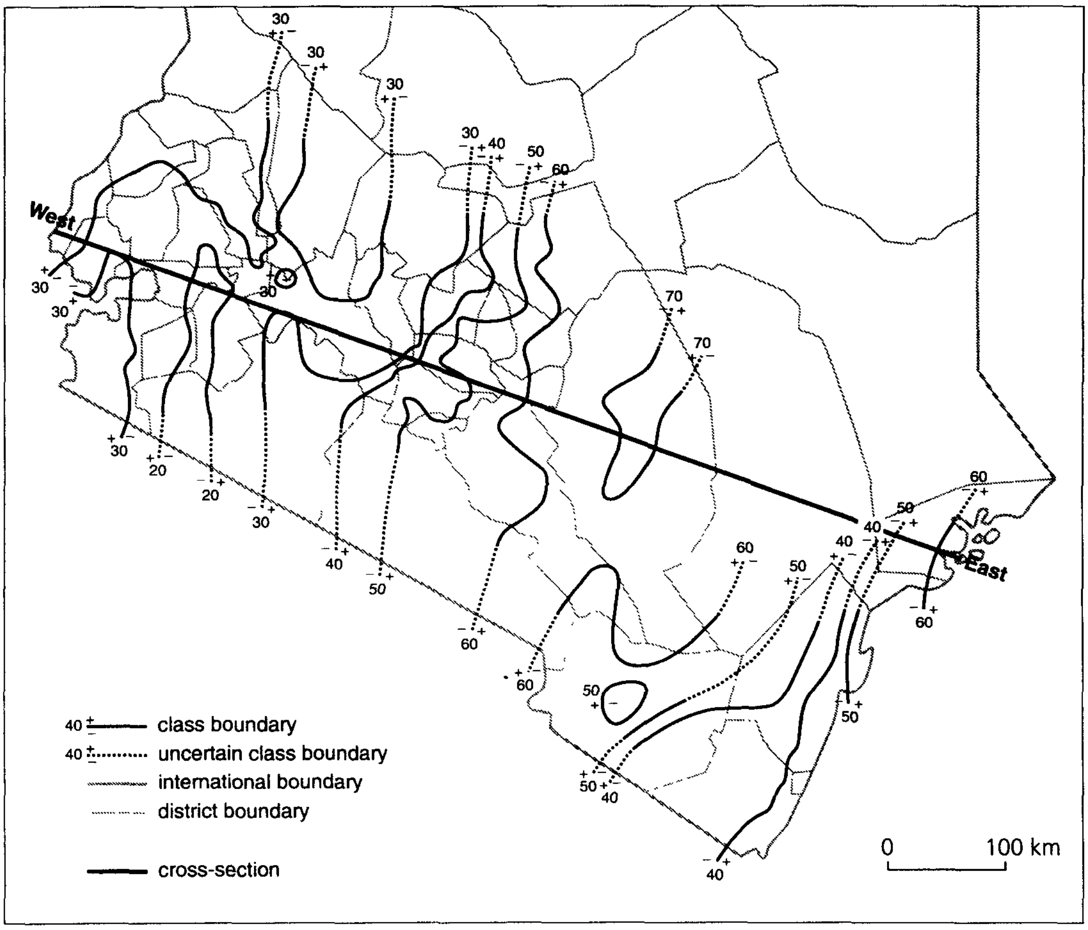

FIGURE 2: Rainfall seasonality in Kenya II: the "Degree of Rainfall Seasonality" (DRS)
(Based on Jaetzold & Schmidt, 1982 and 1983)

III) The *Coastal Range*, rather steeply rising inland from the Foot Plateau. This zone includes hills complexes, such as the Shimba Hills in Kwale District and the hilly country of the Mazeras-Kaloleni-Kitsoeni area in Kilifi District, as well as a number of isolated hills.

IV) The *Nyika Plateau*, extending to the west of the Coastal Range. It has gently rolling relief and an altitude of 200 to 300 metres.

At the transition between the Foot Plateau and the hilly Mazeras-Kaloleni-Kitsoeni area of the Coastal Range, steep, eastern facing slopes promote rainfall, causing the "wet islands" in the interior. Thus, as Figure 5 shows, average annual precipitation does not show a perfect east-west continuum because of differences in relief. Figure 6 offers insight into the distribution of rainfall throughout the year, based on data from 16 selected stations. Along the narrow coastal strip, a unimodal climate prevails, i.e. with one rainfall peak around May, Malindi being the clearest example. More inland, a weak bimodal regime is found, with two wet seasons, one in April-May and one in October-December. This is the intermediate region between the unimodal type at the coast and the real bimodal type further inland (Braun, 1985:8). As shown in Figure 4, Mui is a good example of the latter, with two rainy peaks and very dry periods in between. In Kwale and Kilifi, the period between the first rains and the second rains is not totally dry. For that reason, the majority of the rainfall stations have a degree of rainfall seasonality between 30 and 50%, with the exception of Malindi where 58% was calculated. The only real 'dry' months are January and February.

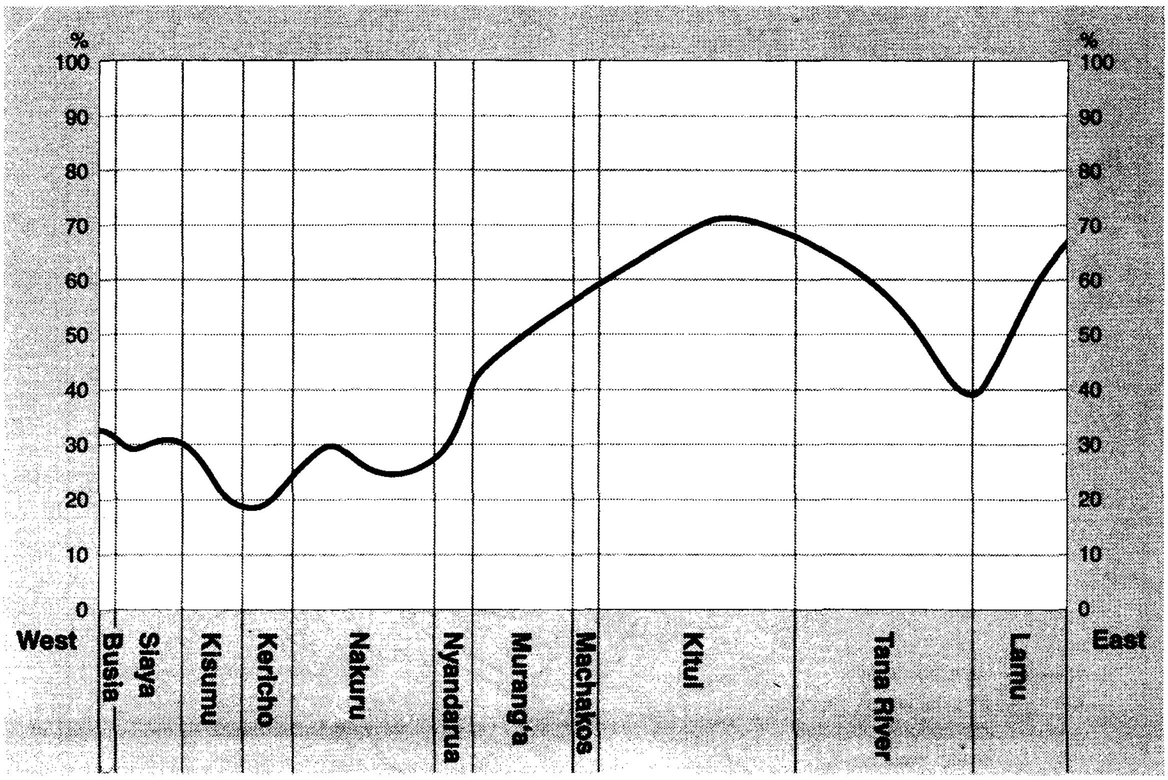

FIGURE 3: Degree of Rainfall Seasonality along the Lamu-Kisumu cross-section (Source: Figure 2)

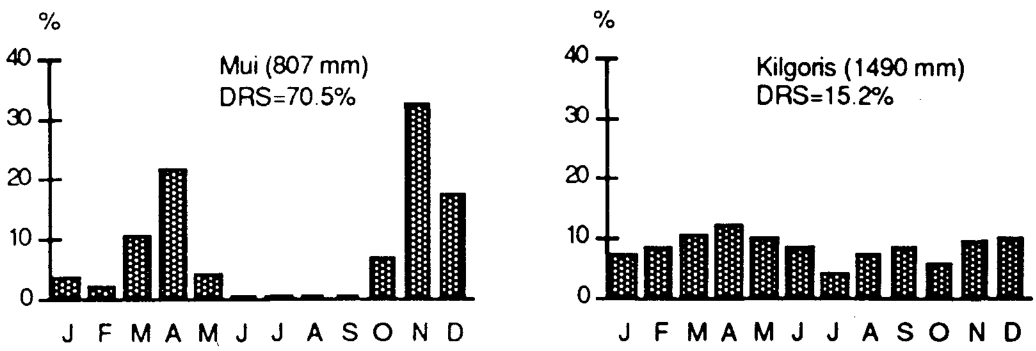

FIGURE 4: Mean monthly rainfall as percentage of mean annual rainfall for two Kenyan rainfall stations with a high (left) and a low (right) Degree of Rainfall Seasonality.
(Based on Jaetzold and Schmidt, 1982 and 1983)

Another important rainfall feature, especially in the drier climates, is the international variability, measured as the yearly deviation from the average annual rainfall. Table 2 shows - for six rainfall stations closest to the areas where the research took place - the number of years in which the total annual rainfall deviates at least 20% from the average annual rainfall.

In Kinango, Muhaka and Kaloleni this occurs in six out of every ten years, in Mariakani and Bamba once in every two years. In five of the six stations, a deviation of no less than 40% occurs once in every four or five years. One cannot conclude from the data in the table that the lesser the annual rainfall the greater the interannual variability.

When rainfall shows such large yearly fluctuations, monthly rainfall also varies substantially. Some extreme deviations from the average in the wettest month. (May) and in the driest month (January) will serve as examples. The absolute peak in May is +269% in Kinango in 1947 when 627 mm was measured instead of the 'normal' 170 mm. On the other hand, very dry May months occurred in 1969 (-90% in Kinango and -80% in Muhaka), while in 1962 there was no rain at all in Mariakani in this 'wettest' month. The mean rainfall in January ranges from 20 to 30 mm in the different stations and deviations of -100% (no rain at all) occur regularly. Sometimes, however, there is a considerable rainfall during this month, as in 1979 when Muhaka, Chonyi and Bamba recorded 123, 150 and 121 mm (i.e. four to five-fold the average) respectively. Again Kinango ranks first, measuring 182 mm in 1978 or a deviation of +550%.

Monthly rainfall can also vary between years with the same overall rainfall, as the four examples in Figure 7 illustrate. For each of the four stations, two years have been selected with a total rainfall slightly above or below the average annual rainfall. Nevertheless, the monthly distributions are highly different. In the one year there is a clear rainfall peak during the first rains, in the other year durng the second rains. This variations reflects that even in years with 'normal' or 'above-normal' rainfall, the monthly distribution does not necessarily coincide with the needs of the agrarian cycle (Fig. 7).

The last type of rainfall fluctuation that is briefly discussed here concerns the spatial variability. Kinango and Muhaka are two stations which are only 30 kilometres apart as the crow flies. Although the yearly rainfall shows a high degree of correlation between the two stations, there are also some marked differences. In 8 out of the 32 years for which figures are at hand, the difference between their respective deviations from mean annual rainfall was 25% or more. In Kinango and Bamba, the two 'dry' stations in our sample, this happened in four out of eleven recorded years in the 1972-1985 period.

In review, it is striking how rainfall fluctuates, not only intra-annually and inter-annually but also between the same months in different years, as well as between places. In other words, it is highly unpredictable when the rains will start, how much rain will fall and how the rain will be distributed over the seasons. Since rainfall determines the agricultural calender, this make the crop cycle equally uncertain.

In contrast with rainfall, average annual potential evapotranspiration shows a much more regular pattern, both geographically and throughout the year. From east to west, it ranges from about 2,000 mm a year along the coast line to more than 2,300 mm in the hinterland, with only the Shimba Hills forming a disturbance (Michieka *et al.* 1978). Comparing mean annual rainfall with mean annual evapotranspiration, it is clear that on a yearly basis there is a considerable water deficit. But, while evaporation is fairly equally distributed throughout the year, rainfall is not. As shown, there is "a pronounced concentration of rainfall at the beginning of the April-June rains, particularly in the hinterland" (Smaling & Boxem, 1987). This means that only during relatively short periods there is a water surplus in the soil. These periods determine the length of the growing seasons, which are generally short in Coast Province.

LAND USE IN COAST PROVINCE

As mentioned above, agricultural potential and growing periods of crops are largely determined by the following factors: (a) temperature, (b) annual rainfall, and (c) seasonal distribution of rainfall. Based on these three elements, Jaetzold & Schmidt have constructed their agro-ecological zonation for the different districts of Kenya.

Firstly, *zone groups* are based on temperature belts, "defined according to the maximum temperature limits within which the main crops in Kenya can flourish"

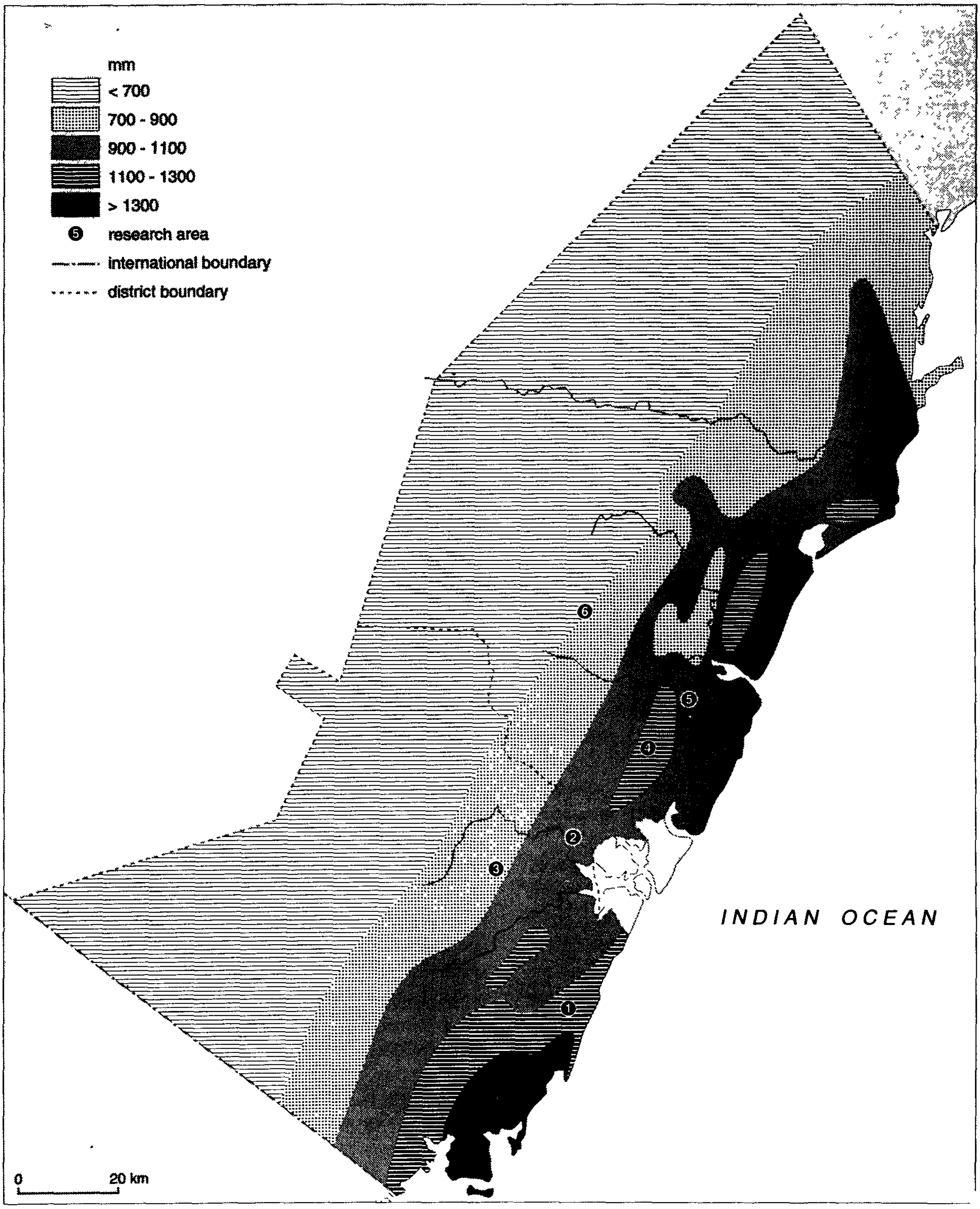

FIGURE 5: Mean annual rainfall for Kwale and Kilifi Districts
(Based on Jaetzold & Schmidt, 1983)

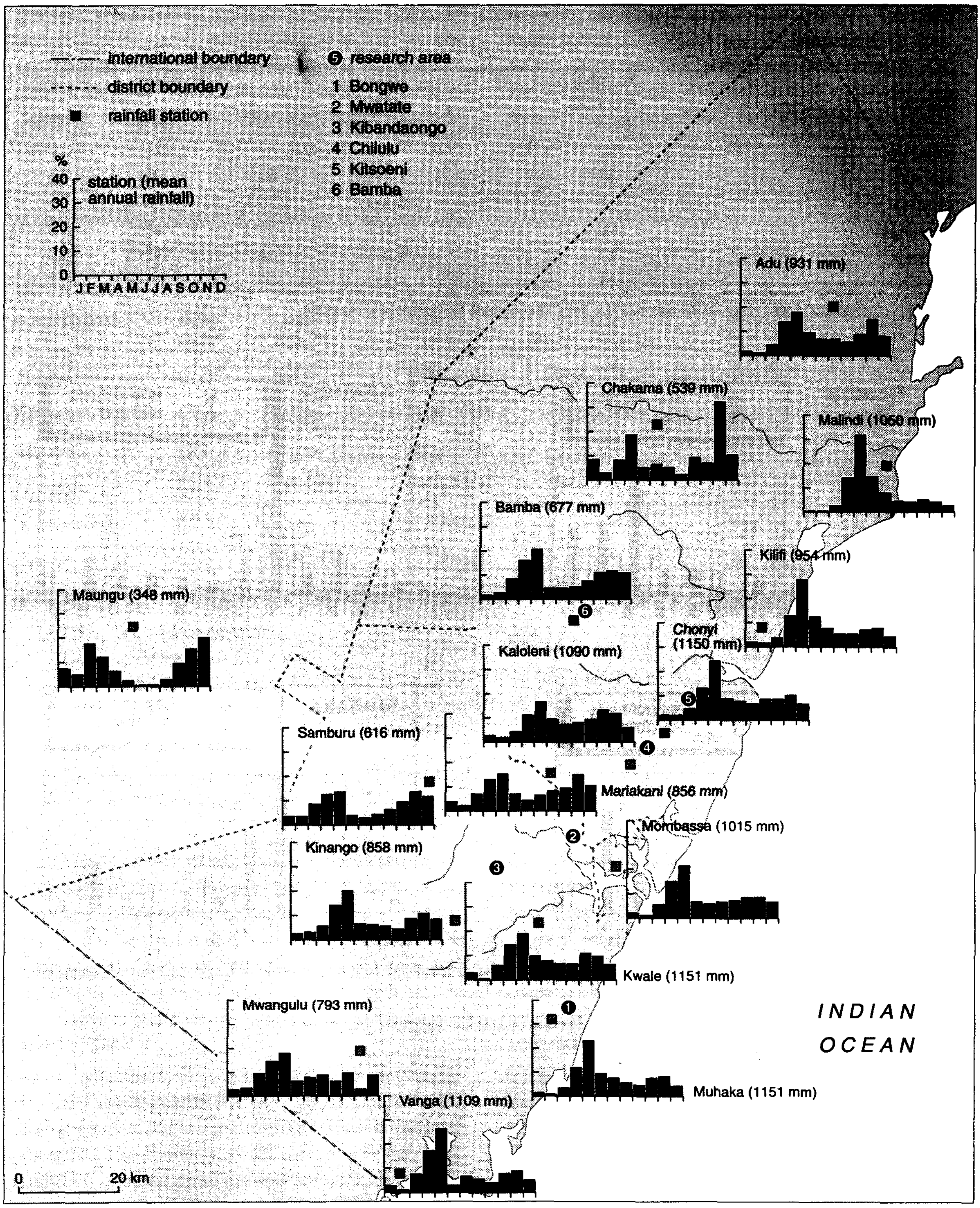

FIGURE 6: Mean monthly rainfall as percentage of mean annual rainfall for selected stations in Kwale and Kilifi Districts
(Based on Jaetzold & Schmidt, 1983)

TABLE 2: Number of Deviating Years From Mean Annual Rainfall, by Degree of Absolute Deviation, for Selected Stations

Station	Number of recorded years	Mean annual rainfall	deviation >20%	>30%	>40%
Kinango	42	835	62	38	21
Muhaka	33	1151	61	36	12
Kaloleni	19	1069	58	37	26
Mariakani	10	822	50	40	40
Chonyi	13	1163	38	31	23
Bamba	11	657	55	45	27

Source: Calculated from data from the Kenya Meteorological Department, Nairobi.

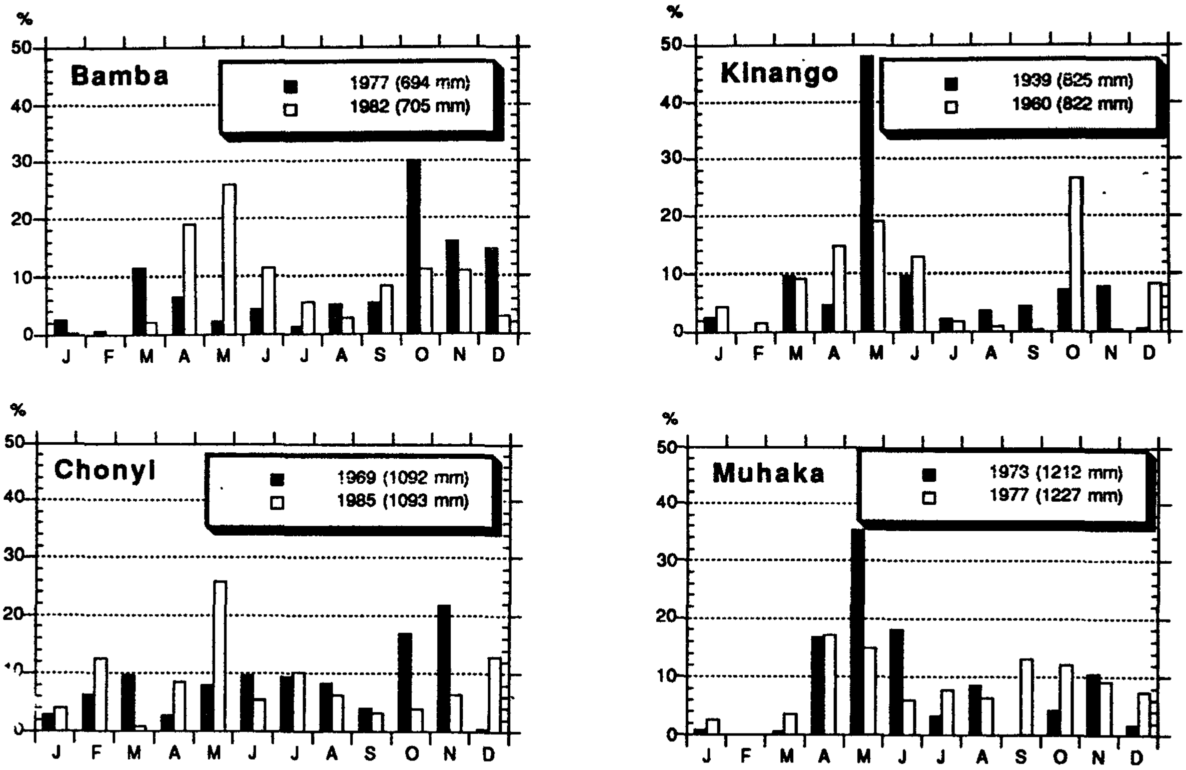

FIGURE. 7: Kenya: Monthly rainfall as percentage of year total for two selected years at four rainfall stations in Coast Province.
(Based on data from the Kenya Meteorogical Department, Nairobi)

(Jaetzold & Schmidt 1983/C:9. Kwale and Kilifi belong to one temperature belt, with mean annual temperature higher than 24°C and mean maximum temperature lower than 31°C. This zone group is denoted as CL, i.e. Coastal Lowlands, with cashewnuts and coconuts being the characteristic main crops. Secondly, within these zone groups, *main zones* are distinguished, determined by the mean annual rainfall. These main zones are based on "their probability of meeting the temperature and water requirements of the main leading crops". In Kwale and Kilifi Districts, there are five main agro-ecological zones, ranging from CL2 (where '2' stands for 'sub-humid') to CL6 ('arid'), characterised by the leading crops and/or agricultural activities in each of them.

Since, as described earlier, considerable variations in rainfall distribution over the seasons exist, the main zones can be divided into sub-zones, "according to the yearly distribution and the lengths of the growing periods". Using as criteria the length of the first and second rainy seasons and the existence of intermediate rains, a range of combinations is possible (Jaetzold & Schmidt, 1983/C:9). Table 3 lists the various sub-zones in which the six research areas are located (the research sites were selected in the three most important main zones: CL3, CL4 and CL5), including their major characteristics and the explanations of the various denotations. Although in each main zone two research sites were selected, each research area appears to represent a different sub-zone.

TABLE 3: Agro-ecological zub-zones by research area (Based on Jaetzold & Schmidt, 1983)

research area	main zone*	sub-zone**	mean annual rainfall (mm)	length 1st growing period (days)	intermediate rains	length 2nd growing period (days)
Bongwe	CL3	m/l,i	1100-1200	155-174	yes	-
Chilulu	CL3	m/l,i,s	1100-1200	155-174	yes	85-104
Kitsoeni	CL4	m,i,vs	1000-1100	135-154	yes	40-54
Mwatate	CL4	m/s,i,vs	1000-1100	115-134	yes	40-54
Kibandaongo	CL5	s,i,vs	800-900	85-104	yes	40-54
Bamba	CL5	vs/s,vs	700-800	55-74	no	40-54

* main zones:
- CL3 coconut-cassava zone
- CL4 cashewnut-cassava zone
- CL5 livestock-millet zone

** sub-zones (growth periods):
- m/l medium to long
- m medium
- m/s medium to short
- s short
- vs/s very short to short
- vs very short
- i intermediate rains

Mean annual rainfall, length of the first growing period, possible intermediate rains, and length of the second growing period determine the types of crops which can be grown and - to a lesser extent - the average yield potential (obviously, the latter is also influenced by soil characteristics such as depth, texture and chemical and physical structure). An overview is given in Table 4.

There are sharp contrasts between relatively wet areas like Bongwe and Chilulu on the one hand, and relatively dry regions like Kibandaongo and Bamba on the other. First, while in the CL3 sub-zones many permanent crops (fruits, cassava, etc.) offer good yields, in the CL5 sub-zones only a few of such crops will grow. Secondly, the growing period during the first rains in the CL3 sub-zones is so much longer than in the CL5 sub-zones, this is only the case with some drought-resistant grains (sorghum, millet) and vegetables (green grams, gourds). Other crops give at best 'fair' yields. The CL4 sub-zones have only a slightly shorter growing period than the CL3 sub-zones, but the difference regarding crops and crop yield potentials is nevertheless remarkable. Thirdly, in most areas the growing period during the second rains is very short. In Bongwe, for instance, there is not even a second cropping period. However, the long intermediate rains explain why many year-round crops mature well in that area. In the other areas, a second growing period exists (at least, in 'normal' years), but rainfall is only slightly above what has been labelled as intermediate rains. No more than a few drought-resistant crops can be grown then, but at best with 'fair' results.

TABLE 4: Potential crop yields by agro-ecological sub-zone and by season (Based on Jaetzold and Schmidt, 1983/c)

RESEARCH AREA:		BONGWE	CHILULU	KITSOENI	MWATATE	KIBANDAONGO	BAMBA
A.E. sub-zone:		CL3 m/l,i	CL3 m/l, i,s	CL4 m,i,vs	CL4 m/s, i,vs	CL5 s,i,vs	CL5 vs/s,vs
Mean annual rainfall		1100-1200mm.	1100-1200mm	1000-1100mm	1100-1100mm	800-900mm	700-800mm
WHOLE YEAR	GOOD	FR coconut, mango, banana, pawpaw avocado, guava pineapple, citrus VEG: - VEG: - MISC: cassava, bixa,	FR: coconut, mango, banana, pawpaw avocado, guava VEG: - VEG: - MISC: bixa, sisal	FR: cashewnut, mango, avocado, pineapple VEG: m.beans, gourds MISC: sisal, castor	FR: cashewnut mango VEG: m.beans, gourds MISC: cassava, sisal	FR: - MISC: -	FR: - MISC: -
	FAIR	FR: cashewnut VEG: - MISC: sugar cane, curcuma	FR: cashewnut, pineapple, citrus VEG: - MISC: cassava, curcuma	FR: pawpaw, guava VEG: - MISC: cassava, bixa	FR: pawpaw VEG: - MISC: bixa	FR: - VEG: - MISC: cassava, sisal, castor	FR: - VEG: - MISC: cassava, sisal castor
1st RAINS Growing period:		155-174 days	155-174 days	135-154 days	115-134 days	85-104 days 55-74 days	
	GOOD	GR: C.C. maize, P.H. maize, sorghum VEG: sw. potato, cow peaschicken peas, eggplant, simsim, kales, gr. grams, bl. grams chillies, m.beans, tomato, gourds MISC: -	GR: C.C. maize, P.H. maize, sorghum VEG: sw.potato, cow-peas, chicken peas, egg plant, kales, green grams, bl. grams, chillies, m.beans MISC. -	GR: C.C. maize, sorghum VEG sweet potato egg plant, kales, chillies MISC -	GR: sorghum VEG: sweet potato egg plant, kales, chillies MISC: groundnuts, bamb, ground-nuts	GR: sorghum, millet VEG: green grams MISC: -	GR: sorghum, millet VEG: gourds MISC: -
	FAIR	GR: rice VEG: - MISC. cotton	GR rice VEG simsim MISC cotton	GR P.H. maize VEG: cowpeas, simsim, tomato MISC groundnuts	GR: C.C. maize, P.H. maize VEG: cowpeas, tomato MISC cotton	GR: - VEG: sw.potato cowpeas, chicken peas, bl.grams MISC: bamb.ground-nuts,castor	GR: - VEG: cowpeas, chickpeas, green grams bl.grams MISC: bamb.ground-nuts,castor
2nd RAINS Growing period		-	85-104 days	40-54 days	40-54 days	40-54 days	40-54 days
	FAIR	GR. - VEG -	GR: sorghum VEG sw.potato	GR: sorghum,millet VEG cowpeas	GR: millet VEG cowpeas,chicken	GR: - VEG: cowpeas,chicken	GR: - GR: -
	POOR	GR: - VEG: -	GR C.C. maize VEG -	GR C.C.maize VEG sw.potato	GR. sorghum VEG: -	GR: sorghum, VEG sw.potato	GR: sorghum millet VEG: green grams

EXPLANATIONS

AGRO-ECOLOGICAL ZONES

• main zones:
- CL3 coconut-cassava zone
- CL4 cashewnut-cassava zone
- CL5 livestock-millet zone

• sub-zone (growth periods):
- m/l medium to long
- m medium
- m/s medium to short
- s short
- vs/s very short to short
- vs very short
- i intermediate rains

YIELD POTENTIAL

Good: average 60% of optimum
FAIR: average 40-60% of optimum
POOR: average 20-40% of optimum

CROPS

FR: fruits
GR: grains
VEG: vegetables
MISC: miscellaneous crops
C.C.maize: Coast Composite maize
P.H. maize: Pioneer Hybrid maize
sorghum: early maturing varieties
millet: early maturing bulrush millet
sw.potatoes: sweet potatoes
gr. grams: green grams
bl. grams: black grams
m. beans; marama beans
bamb. groundnuts: bambara groundnuts

Table 4 deals with potential yields of crops that are considered to thrive more or less well in the various agro-ecological settings. Table 5 shows what the farmers' houselholds actually cultivated during the long rains and the short rains of 1985. Comparing the two tables reveals some notable differences. The most important one concerns the cultivation of cereals. Maize - i.e. the traditional varieties 0- is cultivated by most of the households, also in the sub-zones where the potential yield of this crop is regarded 'fair' or even less. Cereals like sorghum and millet are hardly cultivated, also not in the relative dry areas in the hinterland. This is caused by taste preferences: although the cultivation of maize is more risky than the cultivation of sorghum and millet (millet needs more moisture), people do grow this crop because they like it better. As far as vegetables are concerned, Table 5 shows that despite promising yields for a whole variety of crops, particularly in the CL3 areas, relatively few crops are actually cultivated and always by less than half of the households.

TABLE 5: Agricultural activities by research area (% of households; long + short rains 1985)
Source: Foeken *et al.*, 1989: 97, 109.

Research area: A.E. sub-zone: N:	Bongwe CL3 m/l,i 50	Chilulu CL3 m/l,i,s 50	Mwatate CL4 m,i,vs 48	Kitsoeni CL4 m/s,i,vs 50	Kibandaongo CL5 s,i,vs 49	Bamba CL5 vs/s,vs 50
food crop cultivation						
• maize	32	78	90	92	94	62
• sorghum/millet	2	-	-	-	-	10
• rice	38	14	-	8	-	-
• beans/cowpeas/gr. grams	42	44	38	24	27	46
• cassava	92	88	85	80	73	24
• bananas	70	80	69	34	59	2
• pigeon peas	10	-	8	-	20	4
cash crop cultivation						
• coconuts	82	92	56	58	61	12
• cashewnuts	82	56	73	50	49	14
• citrus/improved mango	72	62	71	26	43	4
• sw.soursop/guava/mango	26	20	75	16	47	-
• pawpaw/passion fruit	40	32	50	12	35	-
• pineapple	20	4	4	-	2	-
• sugar cane/pepper/bixa	12	-	21	-	10	-
livestock rearing						
• cattle	6	12	13	4	29	42
• goats/sheep	20	48	35	34	49	58

Cash crops mainly concern tree crops and long coconuts prevail in this category. Good yields can only be expected in the CL3 sub-zones, but nevertheless many households in the other zones have coconut palms at their disposal. This does concern trees in the wetter zones, however, which are leased. Selling coconuts, copra and palm wine has always been an important mechanism in Coast province to see households through seasonal stress and periods of famine (Herlehy 1983). It is important to note that leasing applies to coconut palms only. Moreover, land ownership or access to land in different agro-ecological zones was practically absent among the surveyed households (Foeken et al. 1989:95). In general then, as far as cash crops are concerned the figures in Table 5 more or less fit into the pattern described in Table 4, in the sense that cash crops are fairly common in CL3 sub-zones and somewhat less in the CL4 sub-zones. Still there are some notable deviations, in particular in Kibandaongo (CL5) where many more households cultivate certain cash crops that might be expected from Table 4. It can be added, however, that the average number of producing plants in this area is very modest indeed (Foeken et al. 1989:105).

Two of the research areas located in the CL5 zone, i.e. in the livestock-millet zone. Hence, one would expect most households to possess cattle and other livestock. Table 5 reveals that only about half of the households in this zone kept goats/sheep, and even fewer kept cattle (local breed).

CONCLUSIONS

Besides temperature and soil characteristics, annual rainfall and the seasonal distribution of rainfall are important determinants of the agricultural potential of the land and largely determine the length of the growing period(s). Most high potential of the land in Kenya is to be found in areas with relatively high altitudes and fairly abundant rainfall. Since the climate in Kenya is mainly bimodal, with two rainy seasons per annum often two harvests are possible in these areas.

However, due to migration from very densely populated high potential areas and to natural increase, more and more households have to make a living in areas where annual rainfall is hardly sufficient to permit arable farming and where growing seasons tend to be very short. The relatively dry hinterland in Coast Province is such an area. Not only is the average annual precipitation rather modest, rainfall also shows a strong annual, monthly and spatial variability. Hence, climatic circumstances put strong limitations on the use of the land. It is therefore noteworthy that actual land use in the six described research areas appears to be rather different from what is regarded as the optimum land use in the sense of types of crops and the choice between arable farming and livestock rearing.

This observation leads to at least two important questions. First, how reliable is the agro-ecological zonation as presented by Jaetzold and Schmidt? Although all important determinants for assessing the agro-ecological potentials have been included in their analysis, it was an impossible task to cover each district in detail. Hence, many boundaries on their agro-ecological maps are at least "uncertain" as they call it. Moreover, boundaries between zones are no clear dividing lines but indicate a transitional area between zones. Hence, locations near agro-ecological 'boundaries' are likely to show characteristic s of two zones. Another factor is that local climatological variations can not be included in an agro-ecological zonation as carried out by Jaetzold and Schmidt. All this may partly explain the observed differences between 'potential' and 'actual' land use.

Secondly, are farmers always inclined to use their land in the most optimum way? Although one would expect so, it is beyond doubt that maize is a rather risky crop in Coast Province. It was mentioned already that maize is preferred above more drought-resistant crops like millet and sorghum for reasons of taste. One can also wonder why only about half of the households in an area which is located in the livestock-millet zone (Bamba) owns cattle and or goats/sheep. Perhaps, here lies a government task, in particular as far as the promotion of livestock rearing is concerned. Livestock is not only important for mild production but also as capital investment to be drawn on in times of stress. For the growing number of households who moved in the semi-arid parts of Coast Province, with all its prevailing uncertainties concerning rainfall and arable farming, this might be the most optimum way of securing a reasonable livelihood - the more so as nearby possibilities for non-agricultural income generation are very limited.

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