Thick undergrowth in oak forests increases the water holding capacity. High porosity, poor stemflow, comparatively low throughfall, high interception loss, controlled surface runoff etc. generate low sediment loss. The soils are rich in nutrients (specially organic matter) and have poor erodibility.

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IMPLICATIONS OF RAINFALL FOR AGRICULTURAL AND URBAN DEVELOPMENT OF ELDORET, KENYA

by
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ABSTRACT

This paper examines the role of rainfall in the urban development of Kenya. The rainfall characteristics have been analysed and their influence on agricultural and urban development assessed. It is noted that since Eldoret is one of the rapidly expanding towns in Kenya located in highly potential agricultural region, variability of rainfall and drought can seriously affect urban development as farmers in the hinterland will abandon their farms and migrate to the town thus creating food shortage. Secondly, in times of drought, the water supply problems in the town will be exacerbated as it depends on surface water source. The tempo of rural-urban migration will be speeded up and this will create more socio-economic problems.

LOCATION

Eldoret is located on latitude 0°32'N and longitude 35°17'E (Fig. 1). It is located on the Uasin Gishu plateau at an altitude of about 2084 metres. It has a sub-humid climate. Altitude and aspect exert a great influence on temperature in Eldoret and its environs. As a result, mean temperatures are low. The mean annual maximum and minimum temperatures are 23.5°C and 10.3°C respectively. The coldest months are from June to September. High relative humidities are obtained in July and August. Mean annual pan evaporation is about 2000 mm. Eldoret has a mean annual water deficit of about 937 mm.

The most important geographical features which enhance the agricultural productivity of the region is its location and altitude. The climate is very ideal for large-scale production of crops and livestock. Its modified equatorial type of climate with double rainfall season and mild temperatures support the cultivation of both cash crops and timber. The fertility of the soil coupled with the favourable climate has made Eldoret and its environs a rich agricultural region. In consequence, most of the industries in the town are agro-based. The availability of raw materials has been the motivating factor in the town's industrialisation. Some of the industries include Raymond which is based on wool and cotton, Rivatex is based on cotton, Ken-Knit on wool and East African Tanning Extract company (EATEC) on timber products.

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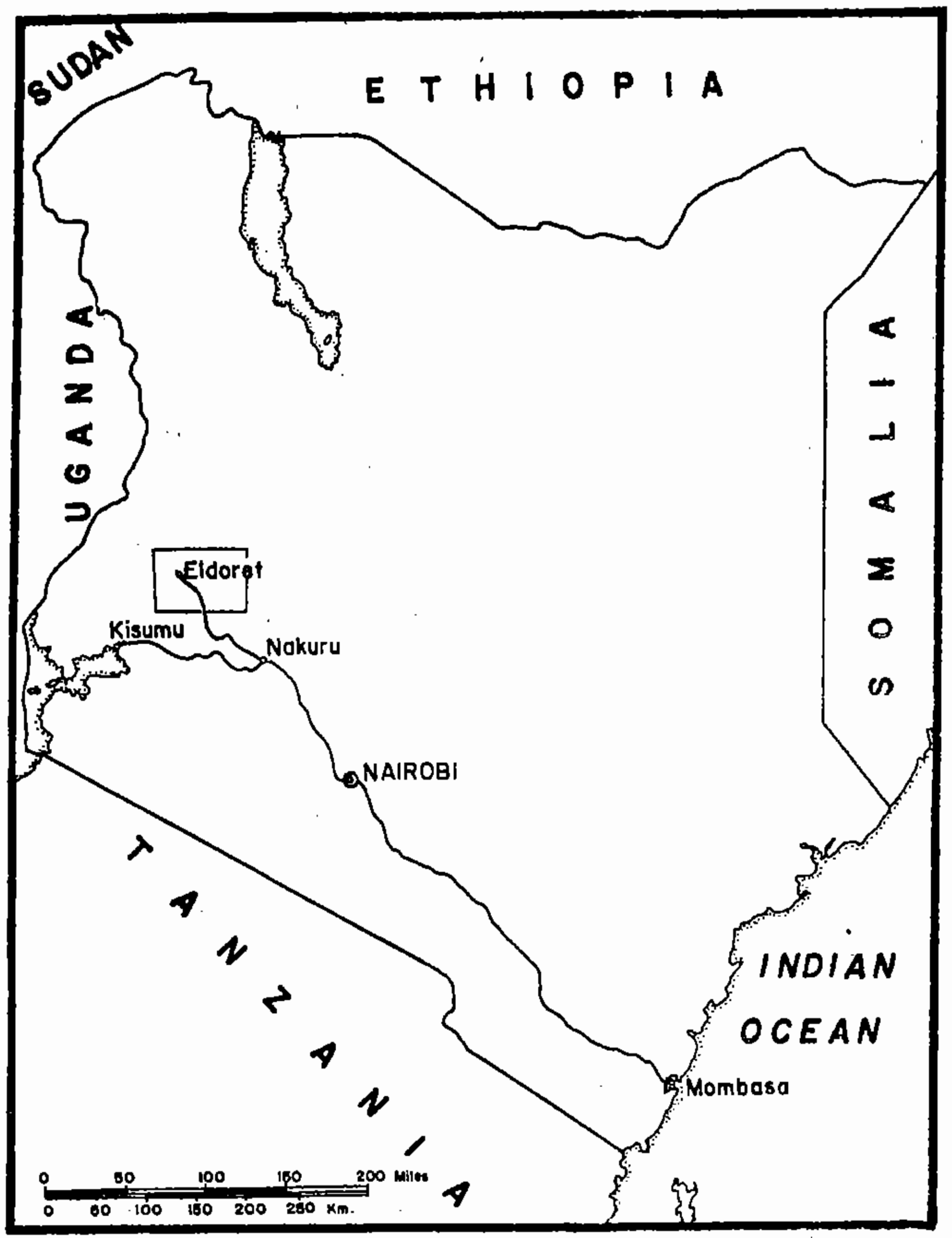

Fig.1.

Figure 1. Location of Eldoret Kenya

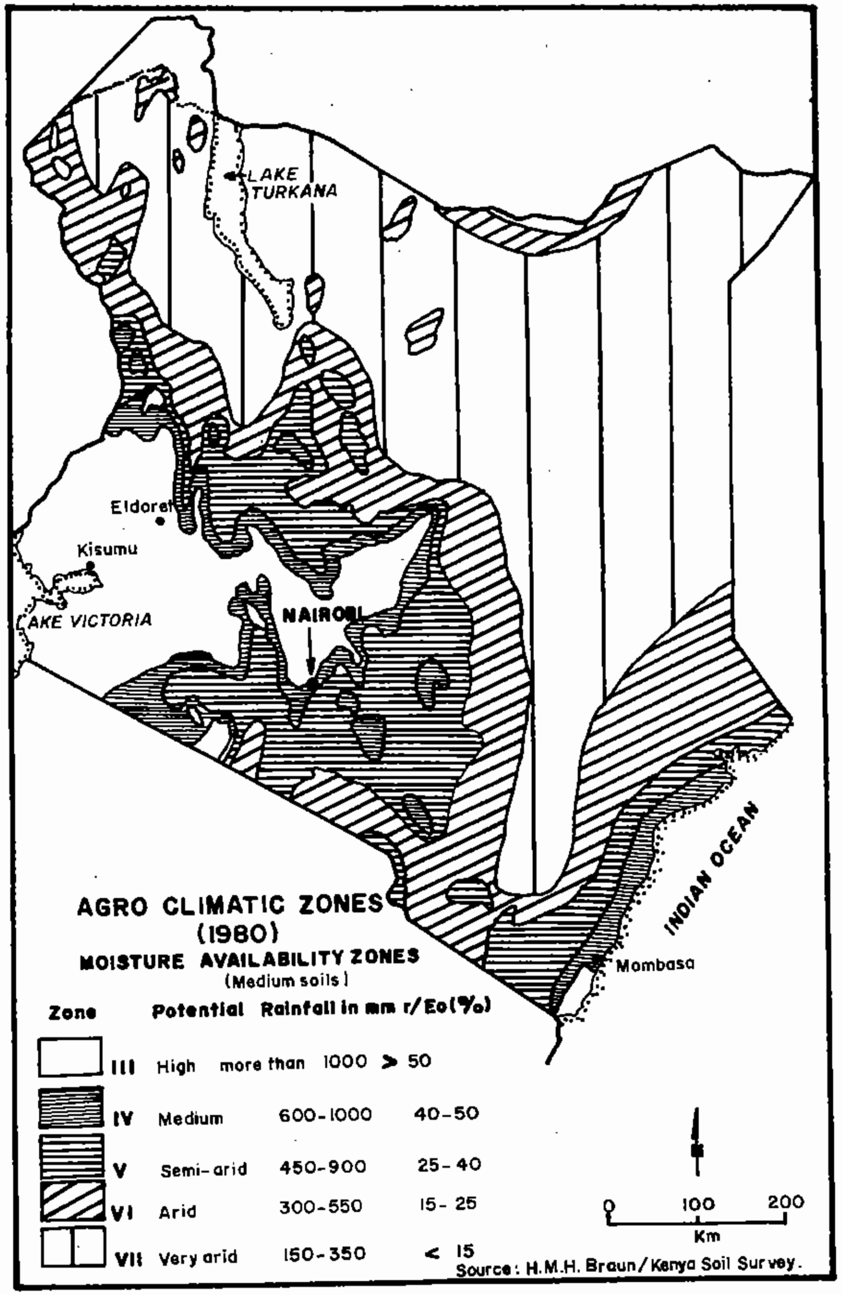

Figure 1. Kenya-Arid and Semi-Arid Lands

METHODOLOGY

The data used in the analysis of the nature of rainfall in Eldoret were obtained from the Eldoret Meteorological Department. Although the station was set up in 1972, the existing records span from 1977. The rainfall data used here cover a period of 12 years; thunderstorm records 9 years and rain days 11 years.

The degree of variability of rainfall was computed on the basis of the coefficient of variability formula which states as:

$$Cv = \frac{S}{\bar{X}} \times 100$$

Where Cv = Coefficient of variability
S = Standard deviation
X = Mean annual rainfall

In order to examine the seasonality of rainfall, the precipitation concentration index (PCI) was used:

$$PCI = 100 \left(\frac{\Sigma x^2}{(\Sigma x)^2} \right)$$

Where x = mean monthly rainfall for each month of the year

Theoretically, the PCI ranges from 8.3 for equal monthly increments to 100 for extreme monthly distribution (Oliver, 1980). A PCI of less than 10 indicates uniform distribution and values between 11 and 20 show a tendency for seasonal distribution and values, beyond 20 indicate marked seasonal difference with increasing values evident of monthly concentration.

Rainfall intensity is vital to an undestanding of rainfall regimes. Unfortunately, data are few stations equipped with reliable pluviograph and in Eldoret this instrument is not available. Rainfall intensity was therefore calculated using the formula:

$$I = \frac{A}{n}$$

Where A = total rainfall over a given period
n = total number of rain days or total number of hours of rain.

For Eldoret, the number of rain days was used instead of total number of hours of rain.

AIR MASS

The climate of Eldoret reflects circumtances not only peculiar to itself but also to the rest of Kenya. The climate of Kenya is greatly influenced by three main air masses. Very dry winds which originate from tha Sahara Desert dominate the entire western protion of Kenya between November and March. This air mass is dusty and is reffered to as harmattan or Egyptian air. The northeast trade winds from India affect the eastern parts of Kenya. This is the northeast monsoon which owing to its long tract over the Indian Ocean brings rainfall to the Coastal parts of Kenya.

In April, most of the central, southern and eastern parts of the country experience the southeast monsoon which originates from the Indian Ocean. As a result of its long sea track, it is the major source of rains in the country.

From July, Kenya comes under the influence of the Congo airstream which is associated with high winds. The instability of this air mass causes convectional storms to develop. The airstream affects the climate of western Kenya. The climate seasons of Eldoret and the rest of the country are therefore basically dependent upon the foregoing air masses.

ANNUAL RAINFALL

The mean annual rainfall computed for 12 years data is 1058.2 mm. Figure 2 shows the annual percentage departures from mean rainfall. Twelve years of rainfall records 6 year experienced rainfall below average. In other 6 out of 12 years experienced drought. Five years received rainfall above average while one year almost had average rainfall. The lowest rainfall recorded so far was in 1984 when Eldoret received 624.9 mm which was 59 percent of the long term average. This gave a rainfall deficit of 41 percent. Another significant drought year was 1986. Eldoret received 770.6 mm (73 percent of long term average). The coefficient of variability of rainfall in Eldoret is 23 percent but during some of the wet dan dry years, variability exceeded the mean (Figure 2).

The wettest year was 1977 during which Eldoret received a total rainfall of 1612.7 mm. This was 52 percent above average. Another wet year was 1983. The annual rainfall recorded was 1289.8 mm which was 22 percent above average. Figure 2 shows that inter- annual variability of rainfall is quite high.

Figure 3 depicts the number of mean annual rain days. The mean number of rain days is 107. In Kenya, a rain day is regard as a day with 5 mm of rainfall. The distribution of rain days over the 11 year period shows some anomalies. The lowest number of rain days ever recorded was in 1984 which was the year with the lowest rainfall. A total rainfall of 624.9 mm was distributed over 82 days. Generally, the belief is that the higher the rainfall the greater the number of rain days. However, it can be identified from Figure 2 and 3 that in 1980 Eldoret received 930.8 mm over 83 days while in 1986 it had 770.6 mm within 96 days. Similarly, in 1987 an amount of 1148.3 mm fell within 105 days while in 1988, 991.1 mm fell over 124 days. This therefore shows that more number of rain days does not indicate higher rainfall.

MEAN MONTHLY RAINFALL

The mean monthly rainfall is an arithmetic means of total rainfall for each month over a period of 12 years. The monthly means are useful for depicting the average distribution of rainfall throughout the year at a station. Figure 4 illustrates the mean monthly rainfall for Eldoret. The peak of the first rainy season occurs in April with a short break in June. August is the peak of the second rainy season. Rainfall declines sharply after August but picks up slightly in November and then falls off to its

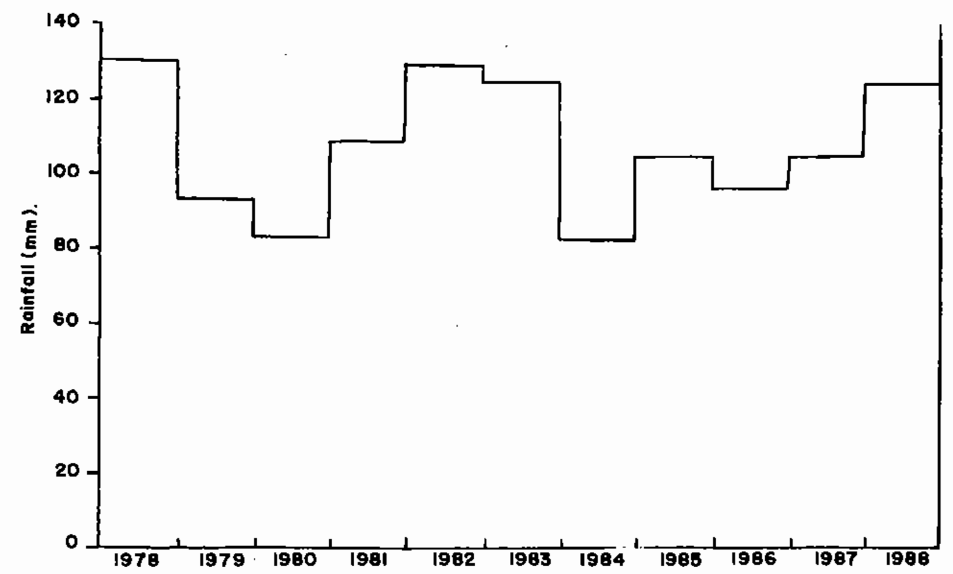

Figure 3. Annual Rain Days (1978-1988)

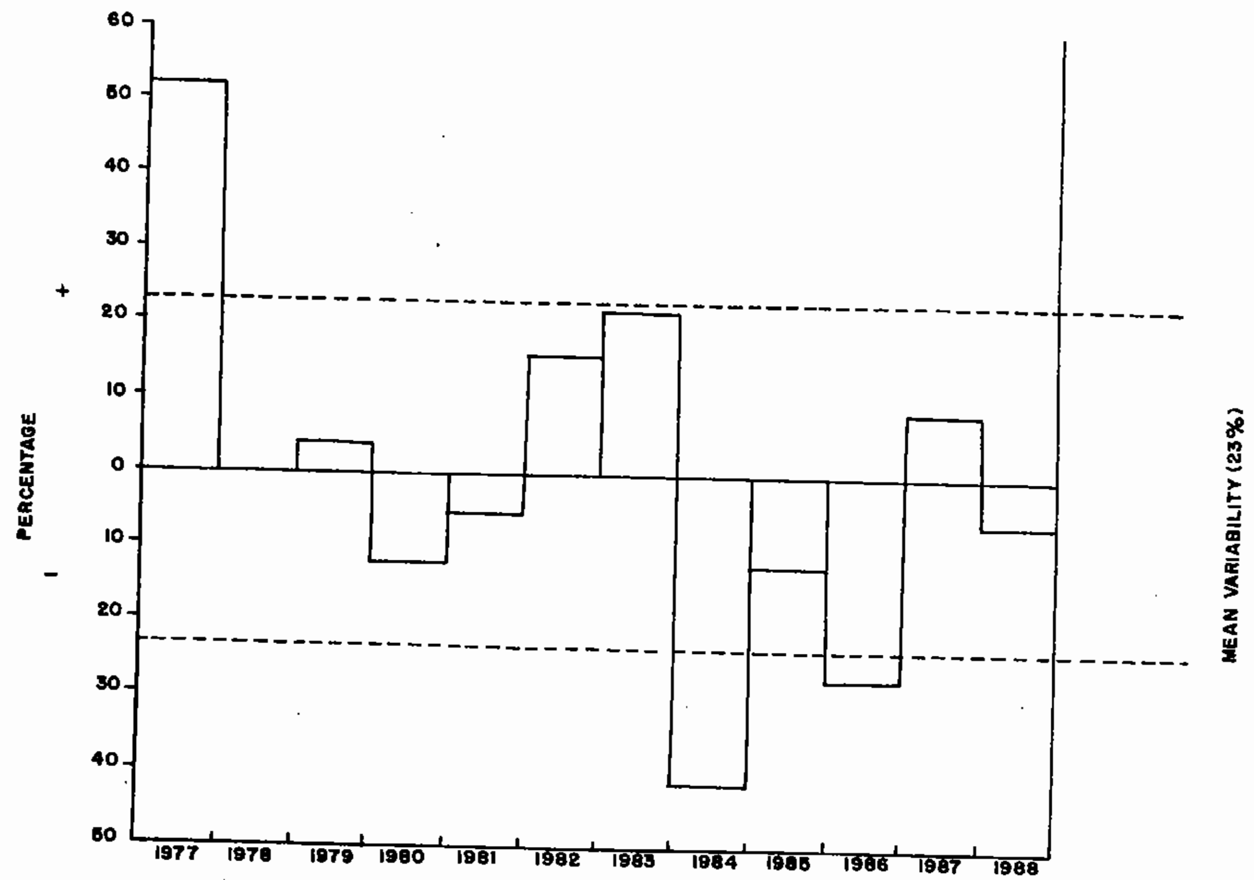

Figure 2. Annual Percentage Departures from Mean Rainfall (1977-1988)

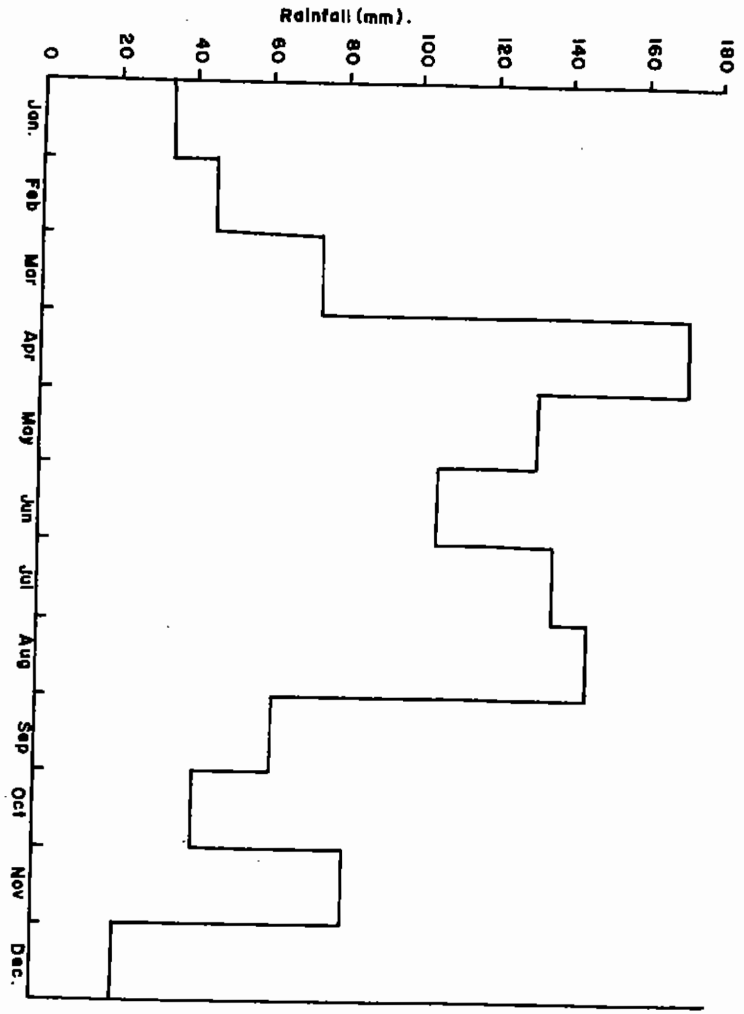

Figure 4. Mean Monthly Rainfall (1977-1988)

lowest level in December. Seasonality of rainfall at Eldoret was determined by using the precipitation concentration index (PCI). The index gave a value of 10.8 percent which indicates that rainfall is fairly uniformly distributed throughout the year.

Figure 5 shows the distribution of rainfall during the drought year 1984. As mentioned earlier on, the lowest rainfall on record was in 1984 when a deficit of 41 percent was registered. A catholic examination of Figure 4 shows that it was only in July and December that above average and this accounted for 24 percent of the total rainfall recorded in the year. Rainfall between January and June was grossly inadequate as it was far below average. This might have disrupted the growing season which normally commences in April and May. There was a heavy decline in rainfall after July and August which is the peak of the second rainy season received only 30 percent of average rainfall.

Figure 6 shows the seasonal distribution of rainfall in the wettest year 1977. The onset of the rains was early as rainfall exceeded average in January and February. However, in March it fell below average and picked up considerably in April but fell in May. In the former month, the amount of rainfall received was 380.9 mm which was 120 percent above average. There was a sharp decline in June, August and September but October and November received above average rainfall.

A cursory look at Figure 6 shows that most of the rainfall was concentrated within four months, April, July, October and November as they accounted for 66 percent of the yearly total. One can infer from the diagram that runoff was very high in 1977. The substantial rainfall deficit which was recorded in August and September might have affected the yield of annuals cultivated in that year. Annuals such as maize, wheat, potatoes, rice etc. respond to variations in available soil moisture. In the case of maize, soil moisture during flowering and early grain formation seems particularly critical in determining yield and any water shortage during these periods is likely to affect yield (Salter and Goode, 1967; Fuehring, 1966; Wrigley, 1969). However, in East Africa there are three periods when water is most needed - germination, fertilization and grain filling (Semb and Garberg, 1969).

Inspite of 1977 being the wettest year on record at Eldoret, the seasonal distribution of rainfall was quite poor. It should be realised that in the tropics, it is the seasonal distribution of rainfall that determines the cycle of farming activities.

The intensity of rainfall at Eldoret was found to be 0.90. This figure was arrived at on the basis of the formula stated in the methodology. Using the same formula, the intensity of rainfall at Boston (USA) and Cherrapunji (Assam), the rainiest at Eldoret is quite erosive. Most of the rainfall at Eldoret is associated with thunderstorms which reach their maximum frequency in August (Figure 7). The explanation for the highest frequency of thunderstorms in August can be put down to the influence of the Congo airstream which arrives in Kenya in July. This airstream is associated with high winds which are unstable and as a result gives rise to the development of convectional thunderstorms which affect western and other parts of Kenya.

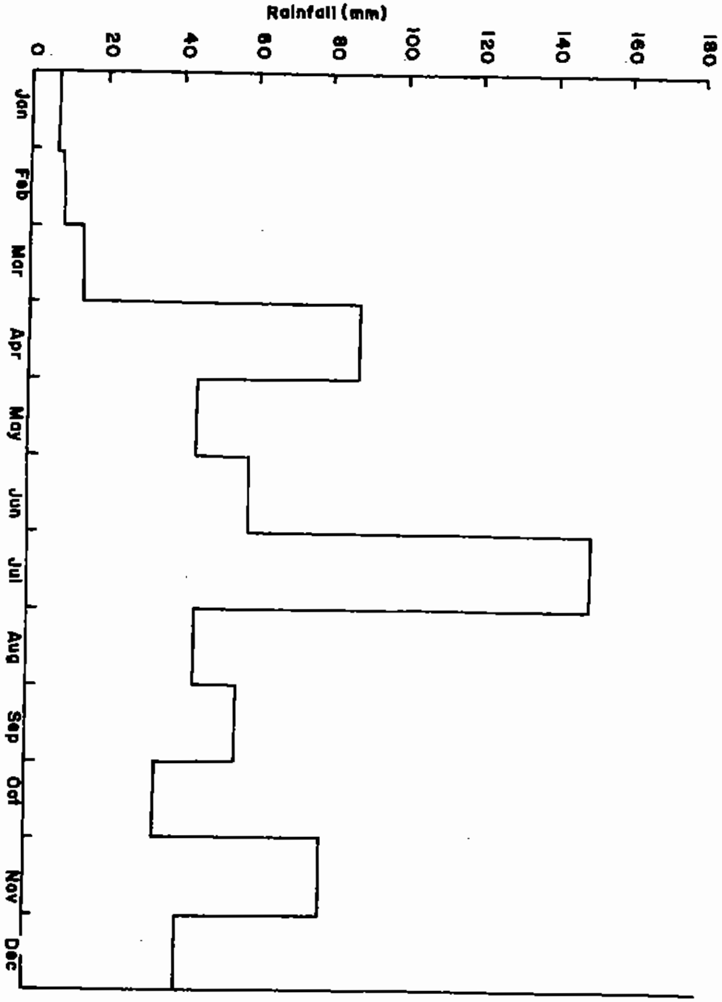

Figure 5. Rainfall Distribution in a Drought Year (1984)

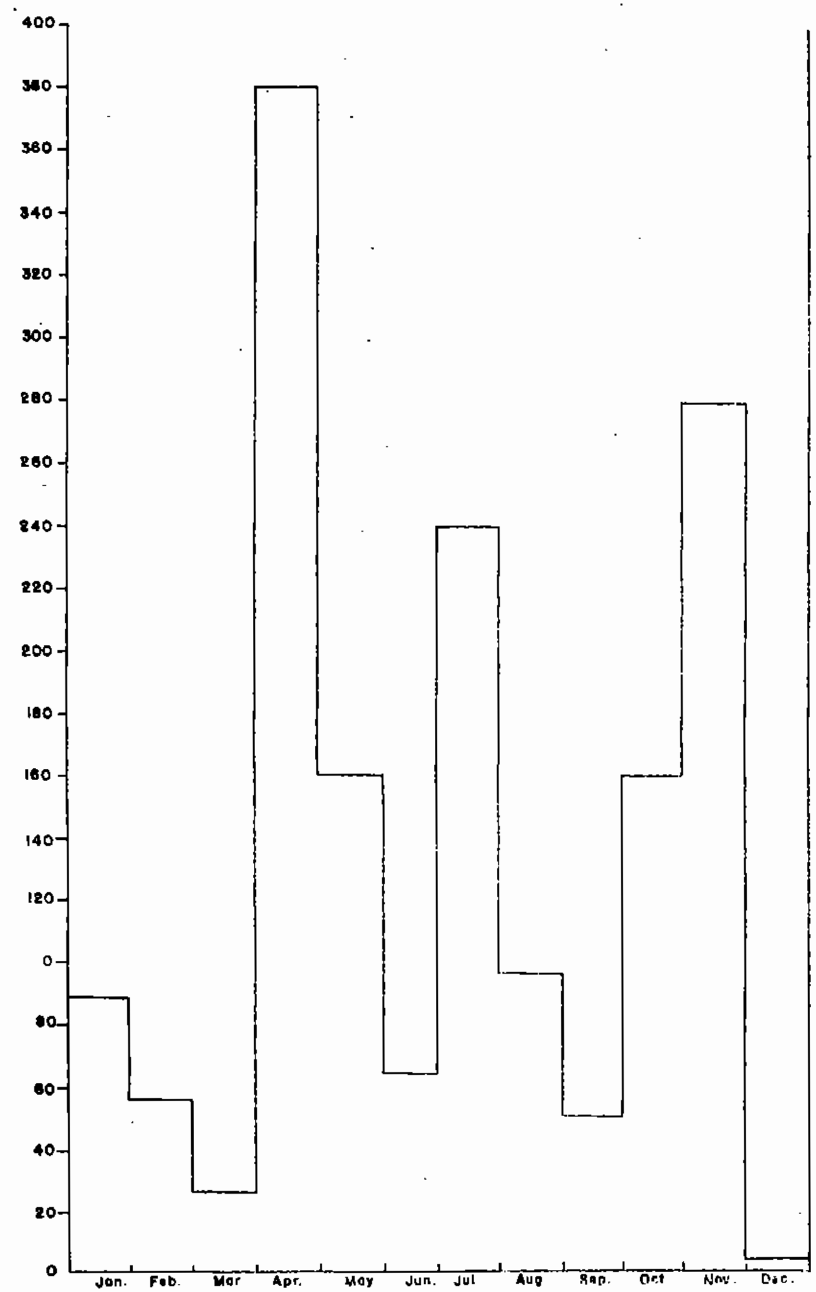

Figure 6. Rainfall Distribution in a Wet Year (1984)

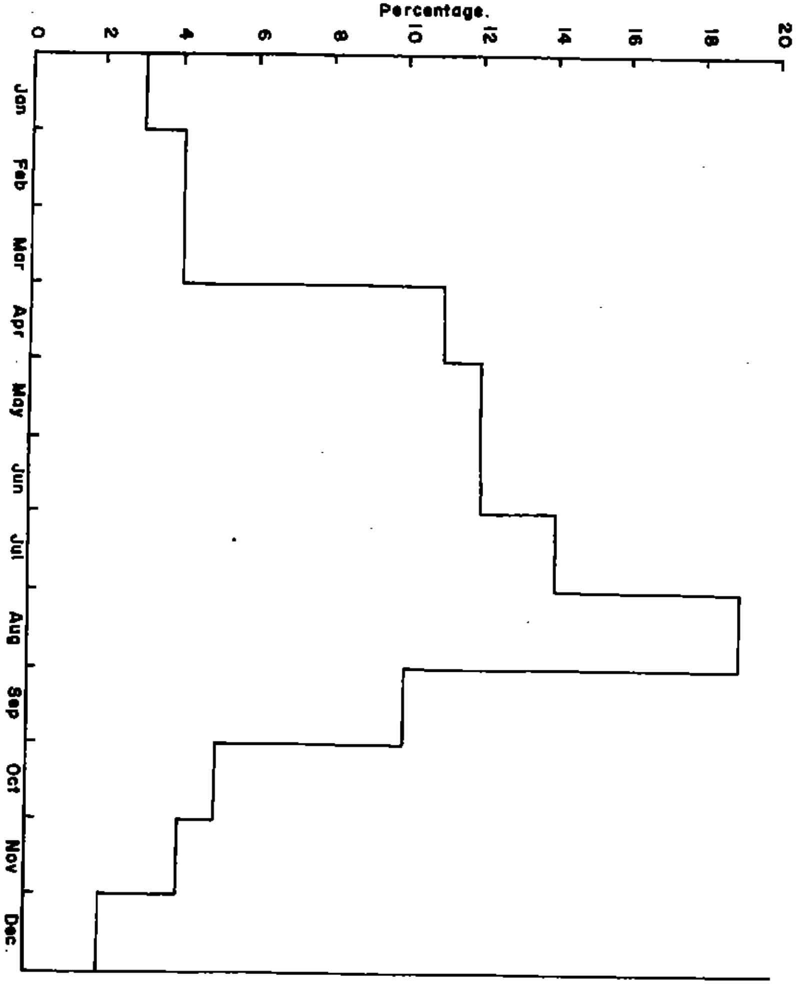

Figure 7. Percentage Frequency of Thunderstorms (1980-1988)

IMPLICATIONS OF RAINFALL FOR DEVELOPMENT

Eldoret is located in an agricultural region where the most important crops grown are wheat, maize, potatoes and vegetable. Dairy farming is also very intensive here. Agriculture is therefore the mainstay of the economy. Climate and for that matter rainfall plays a crucil role in the development of agriculture. Any variation in weather is likely to affect food, cash crop and livestock production.

The rainfall pattern shows that in times of negative departures from the average, the degree of variability exceeds the coefficient of variability. It is also self-evident that drought is endemic in Eldoret and its environs. Out of 12 years data, 6 years experienced rainfall below average. This confirms Tomsett's (1969) assertion that rainfall may be expected to be below average in more years than it is above it in East Africa. There is also the tendency for drought to occur in succesion (Figure 2). For example Eldoret had 3 successive years of drought between 1984 and 1986 and also 2 years of drought in 1980 and 1981. Though Eldoret has sub-humid climate it lies in a precarious position. Actual (AE) and potential evapotranspiration (PE) axceed the annual mean rainfall. AE is 1083 mm compared with annual mean rainfall of 1058.2 mm, while PE is greater than 1500 mm. The mean water deficit is 333 mm compared with mean water surplus of 34 mm (Obasi and Kiangi, 1973).

The occurrence of drought in succession can create serious food crisis which will affect the urban development of Eldoret (Ofori-Sarpong, 1983, 1986; Toupet, 1977; Oguntoyimbo and Richards, 1977). It should be realised that drought has caused the collapse of several ancient civilizations and cities such as Mycenae in 1200 BC, Mill Creek in AD 1200 (Bryson, 1977; Ladurie, 1971) and Mesa Verde in Colorado between 1271 and 1285 (Ladurie, 1971). These cities collapse due to drought.

With Eldoret having one of the highest urban growth rates in the country, there wiil be a great demand for water. Water supply will be needed for a variety of uses which include residential, commercial, industrial, public and others. Domestic water uses include drinking, cooking, bathing and so forth. Climate and for that matter rainfall is one of the major factors which influences the amount of water used. Eldoret takes its water supply from surface water source (a stream). As more people continue to stream into Eldoret from rural areas and as total water use continues to increase with increase in population, demands for water would rise. The population of Eldoret rose from 24,900 in 1969 to 58,000 in 1980 and further increased to 108,000 in 1989 (1989 Population Census). Consequently, the water demand for the town rose from 5,000 cubic m/day in 1969 to 18,400 cubic m/day in 1980 and it is estimated that by 1995 the water demand would be 43,500 cubic m/day (Eldoret Water Resources Investigation, Final Report, Vol.1). Due to seasonal and annual variations in rainfall, stream do not flow uniformly throughout the year. In times of drought, it is possible that these streams may dry up and create an acute water shortage in Eldoret. Such a situation can have a far reaching consequences on the urban development of Eldoret.

One of the sequels of drought is migration. In the throes of acute food shortage as a result od drought, the tempo of rural- urban migration tends to increase and this poses social and economic problems for the urban dwellers (Caldwell, 1977; Boutrais, 1977). In the event of severe drought, Eldoret can face this problem as the peasant farmers would abandon their farms in search of jobs in the city. Acute food shortage can lead to acute malnutrition and kwashiorkor. Other communicable diseases that can afflict the community are Chlorela and parasitic infestation. The rainfall trend shows that is possible for Eldoret to experience about four or more droughts in succession. Such a situation can lead to the closure of all the agro-based industries in the city due to shortage of raw materials from its hinterland. This situation was experienced in Northern Nigeria during the 1968-1973 Sahelian drought (Apeldoorn, 1981).

The intensity of rainfall at Eldoret and its environs can cause extensive gully and sheet erosion in wet years. This is exemplified by 1977. During that year, April alone recorded about 380 mm of rainfall. It might be possible that greater proportion of this amount resulted in run off and hence erosion. Such high intensity of rainfall is capable of reducing the productive capacity of the land particularly in areas where open structured ecosystem of Eldoret if erosion becomes pronounced.

CONCLUSION

The foregoing analysis of rainfall at Eldoret provides a lot of insight into the vulnerability of the city and its environs to drought. Drought is a recurrent climatic phenomenon whose incidence in space and time cannot be predicted with accuracy. Its occurence is imperfectible and indefinite and can destroy the facbric of any society. Drought has been found to be endemic at Eldoret even though the lenght of the data is short. Drought coupled with high rainfall variability can destroy every form of development progress. Agriculture can be ruined in times of severe drought and the peasant farmers may be compelled to migrate to Eldoret for jobs. This can lead to socio-economic problems.

Agro-based industries can be jeopardised as a result of shortage of raw materials produced in the hinterland in drought years. The water supply problems of the town will be exacerbated.

High rainfall intensity associated with storms is capable of rendering fertile agricultural lands of Eldoret unproductive due to erosion and this can affect the planning of the city.

Any development planning in Eldoret must therefore take due cognizance of the climatic constraints inherent within the environment. Drought which is unpredictable must be regarde as part of the normal climate and should be planned for (Landsberg, 1975). There must be a comprehensive and integrated plan to contain drought. Such a plan should include the intensive and large scale development and conservation of both the surface and underground water resources of the area. Besides water resources development and concservation, the programme should take in agro- forestry methods.

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