Chapter 5

Climate

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1 THE CLIMATE OF KENYA

1.1 Introduction

A thorough understanding of climate characteristics and variation is important in agriculture including pastoralism, which plays a dominant role in the Kenyan economy. The main factors that control climate include latitude, altitude, characteristics of prevailing winds, distance from the sea or any form of sizeable water body and topography. Topography becomes significant especially when the area under study has diversity of relief, which can form the barrier to prevailing winds. Vegetal cover is also important but normally is a result of the previously mentioned factors. The pressure belts are also significant in controlling climate as the belts shift with the movement of the overhead sun resulting into seasons. The greatest insolation directly usually below the overhead sun creates a region of lowest pressure. The low pressure is also known as the heat trough or equatorial trough or the intertropical convergence zone. It is a point of convergence of air masses. An air mass is a large body of air covering hundreds of kilometres and that has a definite source region and marked uniformity in temperature or humidity throughout its entire length and width. As a body of air moves, it will be known by its source region, and as it moves across a section of the country, it transports and introduces its own particular climatic characteristics throughout the country over which it passes. Convergence of air masses normally results into an upward movement of air over the area of low pressure, thereby causing cooling, condensation and precipitation. Air masses, also referred to as air streams, are therefore important as carriers of moisture.

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2 AIR MASSES IN KENYA

Climate in the East African Region is influenced by three major air streams (Nicholson, 1996) which therefore determine the Kenyan climate. These airstreams are Congo air with westerly and south westerly flow, north east and south east trade winds. In the Eastern part of the country, the airstream which has Arabian source is known as the Arabian northeast trade winds. The northeasterly wind is the northeast monsoon that has crossed a stretch of the northern part of the Indian Ocean and brings some rain to the coastal regions during the period November to March. By about the month of April, the wind system has diverged and many of the central, southern and eastern parts of the country begin to gain the influence of the southeast trade winds from the Indian Ocean. Since these winds have crossed a large body of water over the southern Indian Ocean, they are the source of the major rains in Kenya. This air mass persists more or less with the same consistency until about August. From about the month of July, high winds penetrate from the west as the Congo airstream. This Congo airstream is completely unstable and storms easily form and develop. Its influence is felt mostly in the western parts of Kenya. The air masses are illustrated in Figure 1. Pressure patterns also have a major influence on the Kenyan Climate. Pressure belts shift with the movement of the overhead sun thereby causing seasons. The greatest insolation obtained

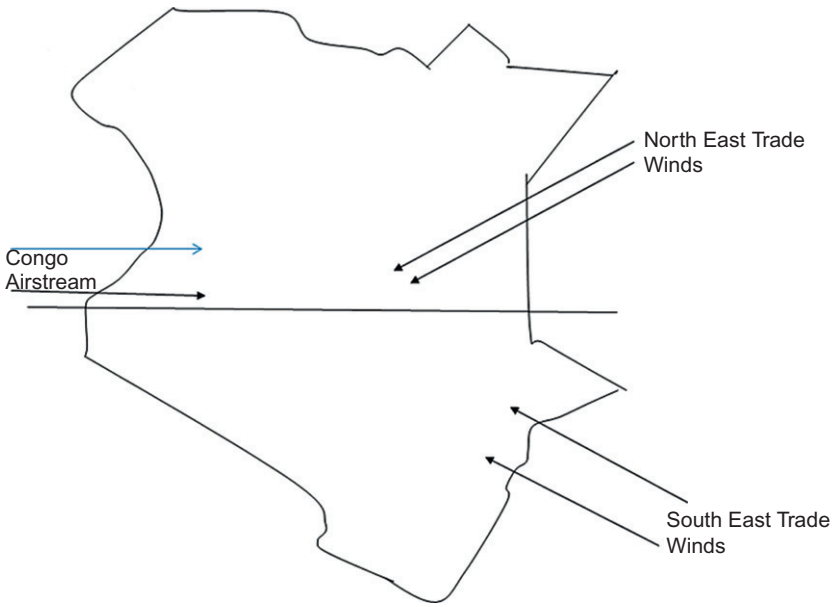


FIGURE 1 Air masses in Kenya. Harmattan—dry winds—November–March; Northeast trade winds—moist—November–March; Southeast trade winds—moist—April–August; Congo airstream—moist—July.

directly below the overhead sun creates lowest pressure which is known as a convergence zone. The Inter Tropical Convergence Zone (ITCZ) is an area of the atmosphere above the earth's surface where the two airstreams (The North East and South East trade winds) converge. It is characterised by warm air rising and the formation of clouds resulting into rainfall. It oscillates north and south across the equator as the earth revolves around the sun. The ITCZ intensifies the weather patterns for an area so that when an area expects rainfall when ITCZ is overhead, the rainfall is expected to be greater and more intense than when ITCZ is not passing over.

3 RAINFALL AND TEMPERATURE

3.1 Rainfall in Kenya

The climatic factor of greatest economic significance is rainfall. The average annual rainfall in Kenya ranges from 250 to 2500 mm. The distribution of rainfall in Kenya is irregular in time and space, that is, not uniform. The climate is characterized by alternating wet and dry seasons. Because of the great variability of rainfall received from one place to another, the mean annual rainfall is mostly considered. The percentages of land area receiving selected amounts of annual rainfall is illustrated in Table 1.

From Table 1 earlier, it is observed that only 15% of Kenya area receives reliable rainfall of over 760 mm (30 in.) per annum (Griffiths, 1972). The areas with over 1270 mm (50 in.) mean annual rainfall include most of the catchment areas and are relatively small. This emphasizes the vital need for strict acceptable hydrological, agricultural and forestry conservation practices if the rivers are to have dry season flow. In Kenya, the regions with good reliable rainfall are confined to the narrow coastal belt and the highlands. The transition from humid to dry areas is particularly sharp and is related to the sharp changes in topography especially east of the Rift Valley where there are two distinct wet seasons. The longer rainy season of the highlands west of the Rift Valley offers a more reliable growing season for annual crops and this has long been the nucleus of agricultural production in Kenya. A summary of annual rainfall from various rainfall stations in major towns in Kenya is tabulated in Table 2.

TABLE 1 Areal Proportions of Rainfall Received in Kenya

Rainfall Received	Percentage Area
$\leq$508 mm (20 in.)	72%
508–760 mm	13%
760–1270 mm	12%
$\geq$1270 mm	3%

TABLE 2 Summary of Mean Annual Rainfall and Periods for Various Locations on Kenya

Location	Mean Annual Rainfall	Average No. of Rainy Days Annually
Nairobi	879	120
Mombasa	1204	145
Nakuru	871	137
Eldoret	973	134
Nyeri	922	100
Wajir	249	29
Kisumu	1278	139
Magadi	378	67
Lodwar	165	23

The reason for the large rainfall variation (Table 2) is partly because of the tremendous topographical contrasts including the great altitude range and partly the distribution and presence of large water bodies such as Lake Victoria and Indian Ocean.

3.2 Temperature

The average annual temperatures in Kenya range from <10 to 30 °C. Elevation and relief are the two factors that have the greatest influence on the temperatures in Kenya; however, at the coastal areas and around Lake Victoria, the influence of land and sea breezes is more important. The highland areas in the country are the regions with low temperature, while the low-lying areas stand out as areas with higher temperatures. As is expected, there is a large range from below freezing point in the snow-capped mount Kenya to over 40 °C in some parts of north and northeastern Kenya. The low-lying northern plains are the hottest and generally the maximum temperatures commonly exceed 35 °C with March as the hottest month. Night temperatures in these areas are generally above 25 °C. Nyanza and western province mostly show great variations from hot low-lying plains to cool temperatures in the hills surrounding Kakamega, Kericho and Kisii areas. The rift valley, including the adjoining highlands, shows a large diurnal range in temperature of over 20 °C. The hottest parts are the low-lying rift valley floor with Magadi frequently recording over 40 °C. The central areas of Kenya including Nairobi generally enjoy pleasant temperatures with a daily range of about 15 °C. The coastal belt is an area of fairly high temperatures ranging 26 °C to

TABLE 3 Temperature and Sunshine Data for Selected Locations in Kenya

Station	Elevation	Mean Max.	Mean Min.	Ave. Sunshine Hours
Low-lying areas				
Lodwar	506	34.9	23.7	3582
Lamu	30	29.2	24.1	3242
Mombasa	16	30.1	23.4	2987
Kisumu	1146	29.4	17.1	2842
Highlands				
Nairobi	1798	23.6	11.6	2503
Nanyuki	1946	23.7	8.5	2172
Nakuru	1836	26.4	10.1	2584

32 °C on average with a very small diurnal range of between 7 and 9 °C. The coolest months are July and August where afternoon temperatures may average 28 °C and night temperatures of 20 °C. The mean maximum and minimum temperatures recorded in the various locations are tabulated in Table 3.

Table 3 shows that the low-lying areas and coastal regions have higher temperatures and more hours of sunshine than the highlands.

4 CLIMATIC REGIONS IN KENYA

There are seven climatic regions in Kenya.

4.1 Modified Equatorial Climate of the Coast

As the other equatorial climate in this region, this region has no dry season but has a well-developed double maximum rainfall in May and October. There is high average temperatures and humidity throughout the year. The Kenyan coast differs from the equatorial climate being well known for its high annual rainfall totals in that it receives much lower totals.

4.2 Modified Tropical Climate of the Kenya Highlands

The modification is caused by the high varied relief. The resulting climate is therefore cooler than a tropical continental climate. The amount of rainfall received at different places depends very much on the position of the station in relation to the rain-bearing winds. For example, Meru on the northeastern slopes of Mount Kenya receives about 1320 mm of rain per year, while Nyeri

on southwestern Kenya only receives 737 mm a year. This region has the best climate in the country. Day temperatures are cool and nights may be chilly.

4.3 Modified Equatorial Climate of Lake Victoria Basin

In this region, modification results from relief and influence of the lake. The rainfall totals in the region show considerable variations and are in any case much lower than a typical equatorial climate. The enclosed basin of Lake Victoria tends to increase temperatures, although the lake itself exerts a cooling influence on the surrounding areas.

4.4 Modified Equatorial Climate of Northwestern Kenya

This is a continuation of the climate of Eastern and North Uganda. High relief lowers the temperature in parts of the region.

4.5 Tropical Climate of the Narok and Southern Taita/Kwale Areas

This is part of the tropical climate that dominates the central mainland of Tanzania. The high relief of some localities exerts a cooling effect so that taken altogether, the climate here is more tolerable than the semi-desert climate of eastern Kenya.

4.6 Tropical Continental Semi-Desert Climate of Eastern Kenya

This vast region receives <500 mm of annual rainfall. The mean annual temperature is between 22 and 27 °C with a very wide daily range of about 11 °C. The skies are generally clear and great variations in the mean annual rainfall can be expected.

4.7 Desert Climate of Central Northern Kenya

A considerable stretch of northern Kenya receives <250 mm of rainfall and its climatology may be regarded as desert. The aridity of this area is a continuation of that of Arabia. In this region, the skies are cloudless and visibility is only hindered by sandstorms, which are of common occurrence.

5 CLIMATE AND AGRICULTURE

The relation between climate and agricultural potential in Kenya has been recognized. Crop growth is influenced by the balance between rainfall, evaporation and temperature. The length and intensity of rainy and dry seasons are more important than the annual variations.

5.1 Climatic Zones in Relation to Crop Production

The major climates in the world (FAO Bulletin 52, 1984) show broad climatic divisions defined in terms of monthly mean temperatures, seasonality of rainfall and temperature regimes during the growing period. The suitability for each of the major climates in consideration for particular crop adaptability group is also discussed. The agro-climatic zones consist of two major components, the moisture availability zones and temperature zones. The ratio of average annual rainfall and average annual evaporation determines the moisture availability zones. The temperature zones are based on the average annual temperature. The agro-climatic zones are tabulated in Table 4.

The agro-climatic zones have a direct bearing on potential for land use. The ratio of average annual rainfall to average annual potential evaporation has been used in delineating the agro-climatic zones in Kenya. The agro-climatic zones provide a tool for assessing which areas are suitable for various land-use alternatives, with emphasis on suitability for crop production. Table 5 illustrates the classification with respect to potential for crop production (Biamah and Cherogony, 1995).

The boundary criteria for the temperature zones are illustrated in Table 6. The moisture ranges and corresponding suitability for various crops and animal production as well as forestry are illustrated in Table 7. The crops that can be produced in the indicated temperature ranges for the various zones are shown in Table 8. Agro-climatological crop list details are well documented in Jaetzold and Schmidt (1982), detailing crop growing periods, crop varieties, average number of days to maturity and rainfall required.

TABLE 4 Criteria for Establishing Boundaries for Moisture Availability Zones

Zone	R/E_o Ratio	R/E_o (%)	Climate Designation
I	>0.8	>80	Humid
II	0.65–0.80	65–80	Sub-humid
III	0.5–0.65	50–65	Semi-humid
IV	0.4–0.5	40–50	Semi-humid to Semi-arid
V	0.25–0.40	25–40	Semi-arid
VI	0.15–0.25	15–25	Arid
VII	<0.15	<15	Very arid

R, average annual rainfall.
E_o, average annual potential evaporation.

TABLE 5 Agro-Climatic Zones and Potential for Crop Production in Kenya

Zone	R/E_o (%)	Classification	Risk of Maize Crop Failure
I	>80	Humid	Extremely low (0–1%)
II	65–80	Sub-humid	Very low (1–5%)
III	50–65	Semi-humid	Fairly low (5–10%)
IV	40–50	Semi-humid to semi-arid	Low (10–25%)
V	25–40	Semi-arid	High (25–75%)
VI	15–25	Arid	Very high (75–95%)
VII	<15	Very arid	Extremely high (95–100%)

TABLE 6 Boundary Criteria for Temperature Zones

Zone	Altitude (ft)	Mean Annual Temperature	Climate Designation
1	0–3000	24–30	Fairly hot to very hot
2	3000–4000	22–24	Warm
3	4000–5000	20–22	Fairly warm
4	5000–6000	18–20	Warm temperate
5	6000–7000	16–18	Cool temperate
6	7000–8000	14–16	Fairly cool
7	8000–9000	12–14	Cool
8	9000–10,000	10–12	Very cool
9	>10,000	<10	Cool to very cold

6 CLIMATE EXTREMES

6.1 Overview

Kenya is affected by a range of hazards emanating from extremes of climate that often translate into natural disasters arising from drought, severe storms, tropical cyclones and floods. The most catastrophic events in recent times have been the droughts of the early 1980s, the late 1980s, early 1990 and 2002/2003. The 1997/1998 El Niño, the strongest in the century, caused a lot of damages in East Africa, with heavy floods washing away roads, bridges and railway tracks and destroying many hectares of crops. The National Meteorological Services (NMSs) in the region have the responsibility of the protection of life and property of the community. Each NMS contributes to disaster

TABLE 7 Range of Crops, Types of Animal Production Systems and Forest Species Suited for Various Moisture Ranges

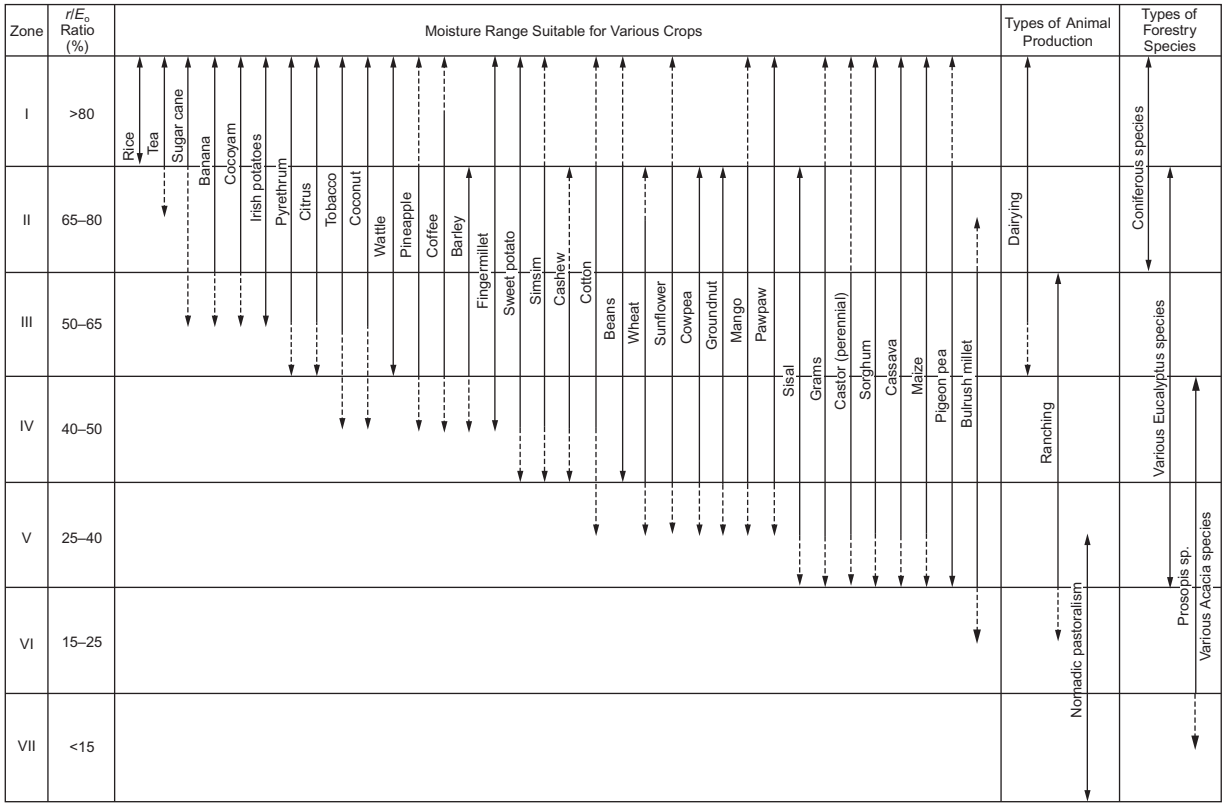
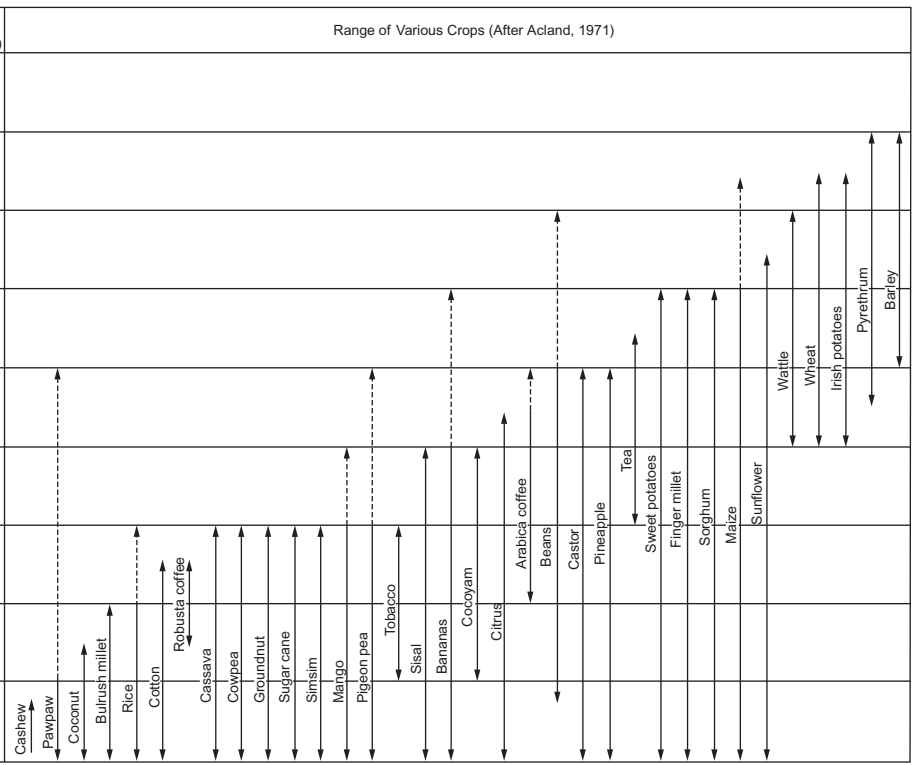


TABLE 8 Ranges of Crops Suitable Under Various Altitude and Temperature Ranges

Temperature Zone	Altitude (ft)	Average Annual Temperature (°C)	Range of Various Crops (After Acland, 1971)
9	> 10,000	< 10	
8	9000 – 10,000	10 – 12	
7	8000 – 9000	12 – 14	
6	7000 – 8000	14 – 16	
5	6000 – 7000	16 – 18	
4	5000 – 6000	18 – 20	
3	4000 – 5000	20 – 22	
2	3000 – 4000	22 – 24	
1	<3000	24 – 30	



management through its forecasts, advisories and warnings of severe weather and the monitoring of climate especially rainfall.

6.2 Floods

Flood hazards are caused by natural events, which transform into disasters through complex interactions between social, economic, political and environmental processes. A Strategy for Flood Management for the country therefore not only directly deals with the flood hazard but also has strong links with national social, economic and other development policies. Disaster prevention and mitigation due to floods is therefore a multidisciplinary endeavour wherein development activities in different sectors of the economy help in the prevention of the disasters and reduce the vulnerability of the society.

6.3 Drought

Drought is an extended period of months or years when a region notes a deficiency in its water supply whether surface or underground water. Generally, this occurs when a region receives consistently below average precipitation. It can have a substantial impact on the ecosystem and agriculture of the affected region. Although droughts can persist for several years, even a short, intense drought can cause significant damage and harm the local economy. As a drought persists, the conditions surrounding it gradually worsen and its impact on the local population gradually increases. Occurrence of drought is partly related to climate change as observed by Ongwenyi et al., 2000, who noted in a study that increased drought is anticipated in arid and semi arid parts of Kenya which will experience drier conditions due to reduced rainfall and increased evapotranspiration rates. This global warming related impact will therefore significantly affect water resources. Regions that already a favourable amount of rainfall will be expected to receive even higher amounts of rainfall.

7 A NOTE ON METEOROLOGIC NETWORKS AND OBSERVATIONS IN KENYA

In Kenya, systematic collection of all weather data is carried out by the Kenya Meteorological Department (KMD). Most of the weather-related disasters discussed in Section 6 can be avoided by issuing alerts and warnings. These are only possible if the station network is good. KMD has invested a lot on station network, but there is still a long way to go before optimum monitoring network is achieved. The network of synoptic meteorological stations (operational over 24 hour period) is illustrated in Figure 2. The purpose of weather station network is to provide accurate and representative weather information to an area. Automated, electronic weather stations are the least costly means to accomplish this objective over a large area. When properly sited and maintained and sensors are kept calibrated, weather stations will provide accurate data for computation and forecasting weather.

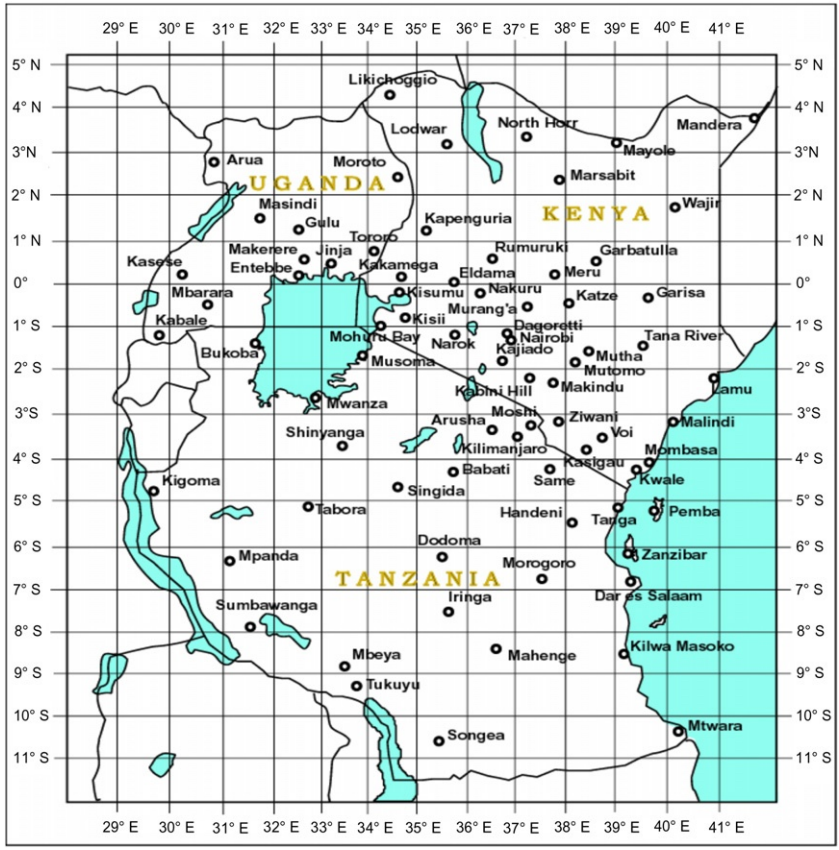


FIGURE 2 Surface synoptic and rainfall station network in East Africa (map not drawn to scale).

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