

*Full Length Research Paper*

# Cumulative distribution of rainfall data for tropical countries

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**This paper presents the monthly average cumulative rainfall data for 24 regions over a 9-year period for giving reliable rain data for tropical countries that are famous for heavy rains. By acquiring the monthly rainfall average from the selected regions, system designers for tropical countries such as Malaysia, Nigeria, Kenya, Indonesia, and Papua New Guinea (PNG) can be used to devise suitable designs for the rainy seasons of these countries. Signal quality and service for the selected regions can thus be improved.**

**Key words:** Rainfall, tropical climate, cumulative distribution.

## INTRODUCTION

The propagation effects over the earth-space path at higher bands, especially above 10 GHz, are in the form of attenuation, depolarization, and scintillation; these are mainly caused by rain. At such high frequencies, the sizes of falling raindrops are close to a resonant sub-multiple of the signal wavelength. The droplets, therefore, are able to absorb, scatter, and depolarize the radio waves passing through the earth's atmosphere (Kumar and Ramachandran, 2004). Many theoretical and experimental studies of rain attenuation have been carried out in developed countries located at temperate regions of the world (Mandeep, 2009). In the tropical regions, however, which are famous for heavy rains, the situation is not very encouraging. This is because the data coverage for these regions remains inadequate due to the complex and varying climatic behaviors compared to the temperate regions (Kaustav and Animesh, 2010; Allnut and Haidara, 2000). Thus, the performance of communication systems in tropical countries is affected negatively during the heavy rain season (Matricciani, 1996; McCarthy et al., 1992). Attenuation of microwave signals by rain is a major problem for designers and service providers in tropical countries. The lack of reliable

rain studies in tropical countries cause system designers to fail to devise suitable designs for these regions.

Hence, the cumulative distributions of rainfall data for 24 states from 5 tropical countries (that is, Malaysia, Nigeria, Kenya, Indonesia, and Papua New Guinea (PNG)) were collected (Table 1). With the help of this rain data, designers for tropical countries can be familiar with the rainy season in tropical countries and be able to devise suitable designs for these regions. Thus, the performance of communication systems in tropical countries could be improved during the rainy season (Omotosho and Oluwafemi, 2009; Pan and Allnut, 2004).

## TROPICS REGION

The tropical zone, being near the equator (Figure 1), is not associated with the temperate seasons of spring, summer, and winter. The tropic regions, areas on the Earth where the sun reaches a point directly overhead once during the solar year, are located between Northern [23°26' (23.4°) N] and Southern [23°26' (23.4°) S] Hemispheres. The tropical rain belt dominates the weather in tropics. It oscillates to the southern tropics from the north in the Eastern Hemisphere over the course of the year. The northern tropics experience a dry season from October to March, throughout which the days are typically hot and sunny, with very little precipitation.

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**Table 1.** Description of Regions, Climate, location and annual rainfall (mm) for the 24 locations.

Country	Regions	State	Climate	Latitude (°)	Longitude (°)	Average Annual rainfall (mm)
Malaysia	North Peninsular	Alor star	Tropical	6.2	100.4	1990.5
		Baling	Tropical	5.7	100.9	2183.2
		langkawi	Tropical	6.23	99.74	2427.9
		Penang	Tropical	5	100	2485.7
		Ipoh	Tropical	4.57	101.1	2427.9
Nigeria	South West	Lagos	Tropical wet	6.58	3.3	1538
		Benin	Tropical wet	6.22	5.39	1948
		Ile-ife	Tropical wet	7.42	4.31	1245
		Warri	Tropical wet	5.52	5.7	2776.4
		Ibadan	Tropical wet	7.21	4.01	1245
Kenya	West Province	Eldoret	Sub Tropical	0.53	35.2	1062
		Kisumu	Tropical wet	0.10S	34.7	1388
		Nairobi	Sub Tropical	1.32S	36.79	1043.2
		Kitale	Tropical wet	1.02	35	1185.6
		Kericho	Tropical wet	0.37S	35.29	1751.9
Indonesia	Peninsular Sumatera	Medan	Tropical	3.57	98.6	2263
		Padang	Tropical	0.88S	100.3	4305.3
		Bandar Acheh	Tropical	5.52	95.4	3620.3
		Riau	Tropical	1.05S	103.4	2344
		Palembang	Tropical	2.90S	104.7	2474.6
PNG	North Region	Lae	Tropical wet	6.73S	147	4579.4
		Madang	Tropical wet	5.22S	145.8	3498.9
		Kavieng	Tropical wet	2.69	150.29	2984.7
		Vanimo	Tropical wet	2.27S	141.7	2792.9

During this time, the tropical rain belt lies in the Southern Hemisphere of the Indian Ocean and Western Pacific Ocean. When the rain belt lies in the Northern Hemisphere, roughly from April to September, a wet season occurs in the northern tropics, and a dry season takes place in southern tropics. Figure 1 shows the world rain rate in the climate region. From the figure, the location of the selected tropical countries can be clearly observed. Figure 1 shows location of tropical countries in the world map with rain rate climate regions.

#### METHODOLOGY

Rainfall for all the locations were measured by using automatic recording raingauge. The equipments uptime in average for Malaysia, Nigeria and Kenya are 97.6%, 99.85% and 99.76%. For Indonesia and PNG are 98%. The intensity of rainfall is 5 min for all the locations. Description of the regions, climate and location are shown in Table1.

#### RESULTS AND DISCUSSION

Figure 2 shows that the maximum rainfall occurs in

Penang in October, with 374.5 mm of rainfall. The rainfall is influenced by the seasonal monsoons, particularly the northeast monsoon from October to March and the Southwest monsoon from April to September. In most places, there is a definite double rainy season, with the heaviest rains falling in the two periods, from March to May and September to November. Among all others state in the northern region of Peninsular Malaysia, Penang is famous for high rainfall, with 374.5 mm, and Alor Setar for a low rainfall rate, with 19.1 mm, during the northeast monsoon season. October is the wettest month in the northern region of Peninsular Malaysia, and all the four states reach the highest rainfall on the same month.

Figure 3 shows that the maximum rainfall occurs in July and September. The period of July to September is known as the wet season in Nigeria, where intertropical convergence moves north at approximately 20°N from July to August. Drier and sunnier weather with higher temperatures prevails in December and January. September is the wettest month in Warri, Benin, and Ibadan with 450, 317, and 176.7 mm of rainfall, respectively. December is the driest month in Ibadan, with 9.5 mm of rainfall, and January is the driest month in

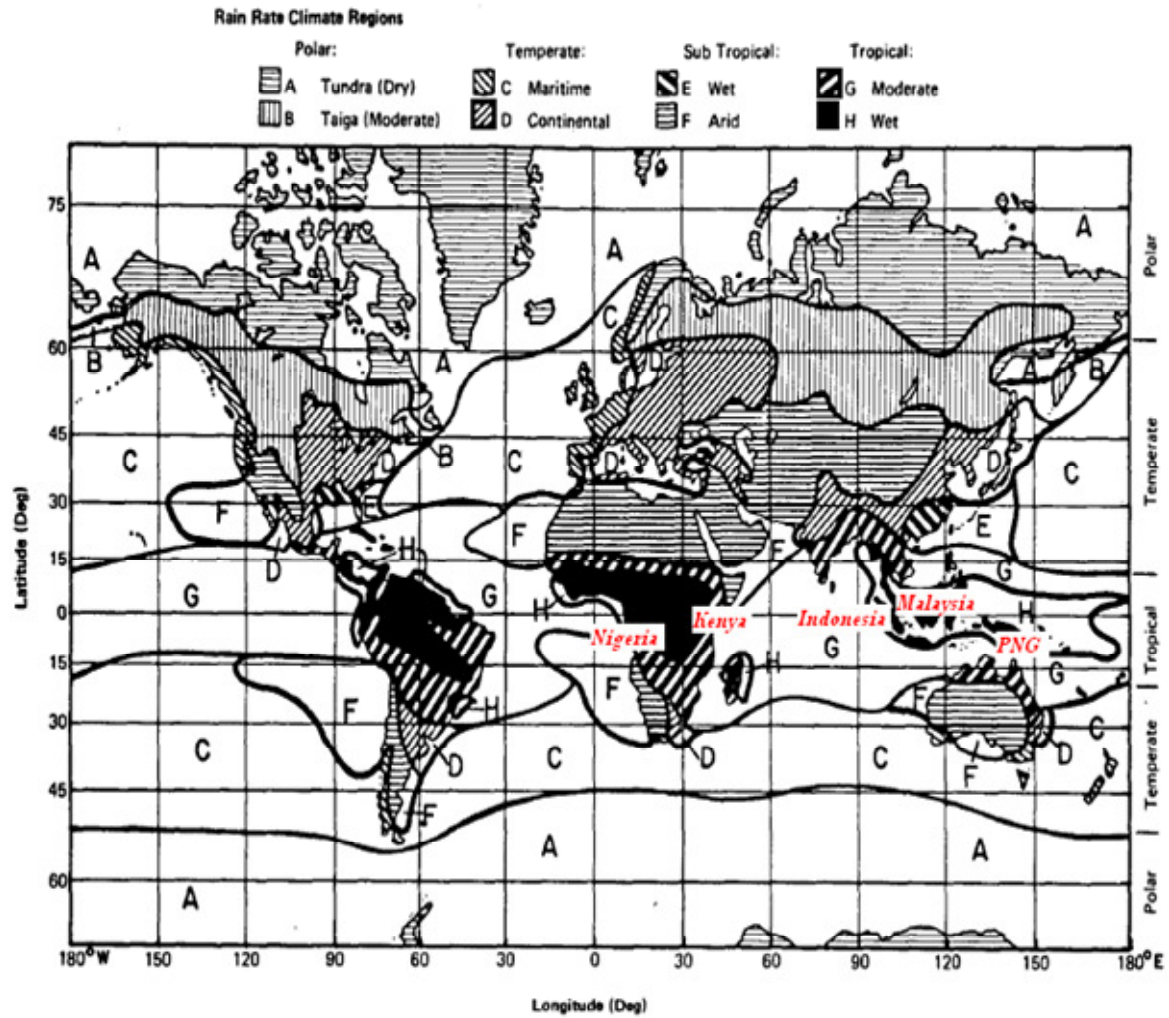


Figure 1. World rain rate climate region (Crane, 1980).

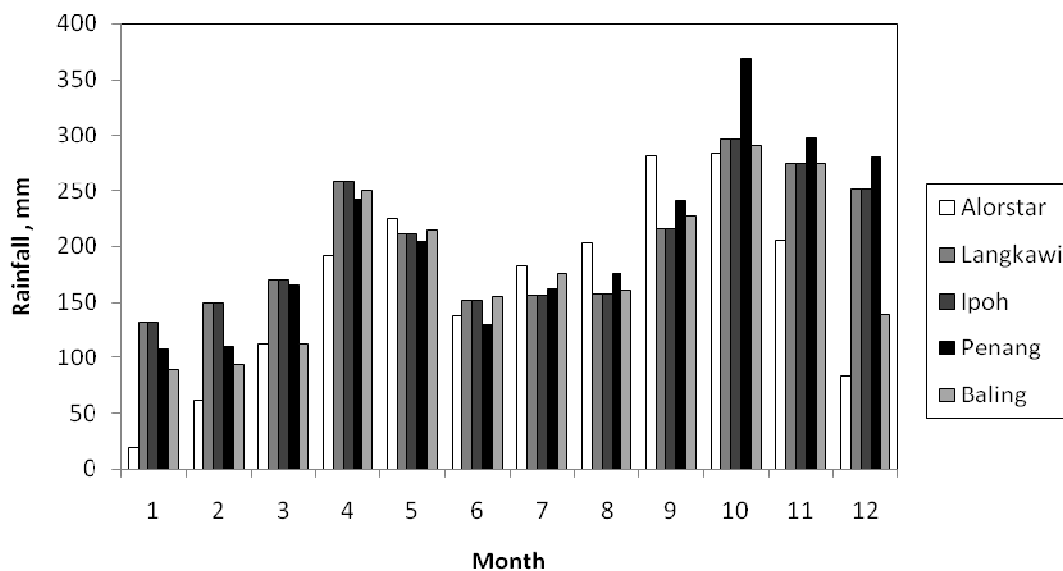


Figure 2. Variation of monthly average rainfall for the northern region of Peninsular Malaysia.

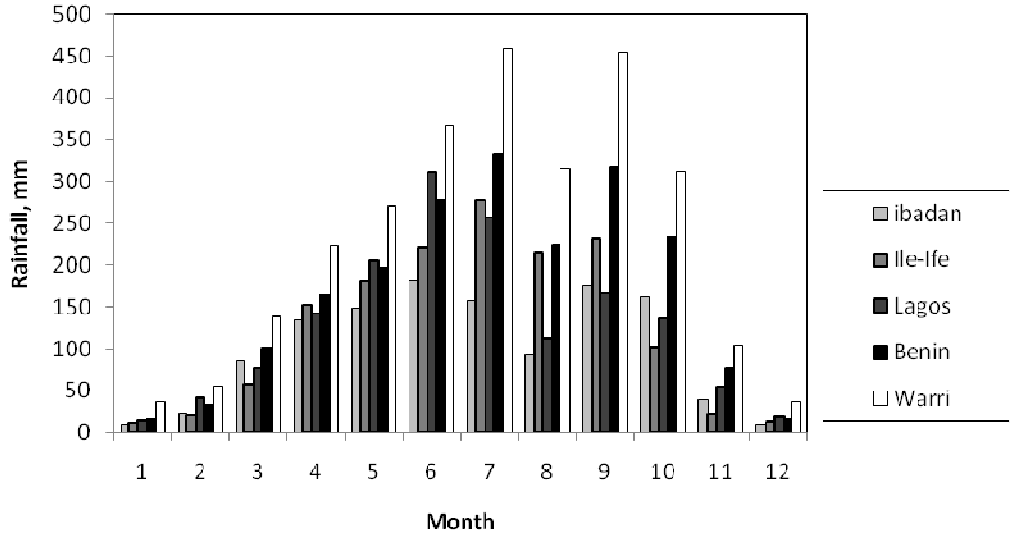


Figure 3. Variation of monthly average rainfall for the southern region of Nigeria.

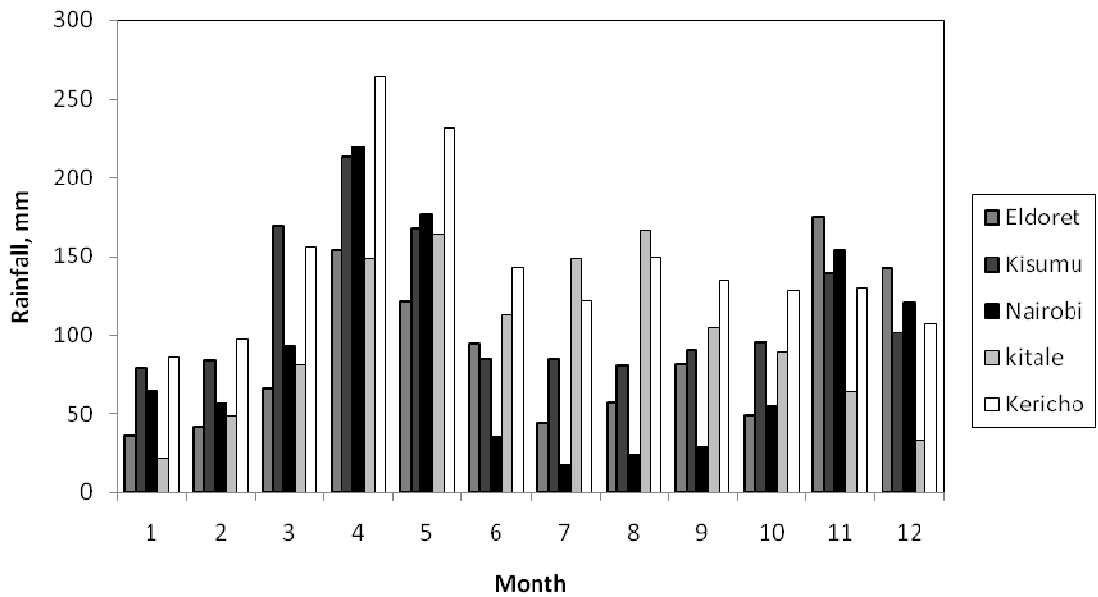


Figure 4. Variation of monthly average rainfall for the coastal region of Kenya.

Ile-Ife, Lagos, Benin, and Warri, with 1.5, 14.3, 15.8, and 36.7 mm of rainfall, respectively. Figure 4 shows that the maximum rainfall occurs between March and May and between November and December. This period is known as the wettest season in the coastal region of Kenya because the intertropical belt of clouds and rain moves north and passes over Kenya in April and again in November. April is the wettest month in Kericho, Nairobi, and Kisumu, with 263.8, 219.4, and 213 mm of rainfall, respectively; in November, Eldoret experiences 175 mm of rainfall and, in August, Kitale experiences 166.1 mm of rainfall. The wettest months in all states are between March and May, which occur in the wet season in Kenya.

January is the driest month in Eldoret, Kisumu, Kitale, and Kericho with 36, 79, 21.6, and 86 mm of rainfall, respectively. July is the driest month in Nairobi, with 17.5 mm of rainfall.

Figure 5 shows that the maximum rainfall for all the locations occurs from October to January. October to April is the time of rain in the northern part of the equator due to the western monsoon. The least rainfall occurs from May to September, as the dry season takes place in Sumatera during this period due to the eastern monsoon. November is the wettest month in Aceh and Padang, with 610.25 and 509.5 mm of rainfall, respectively. In October, Medan experiences 256 mm of rainfall; in

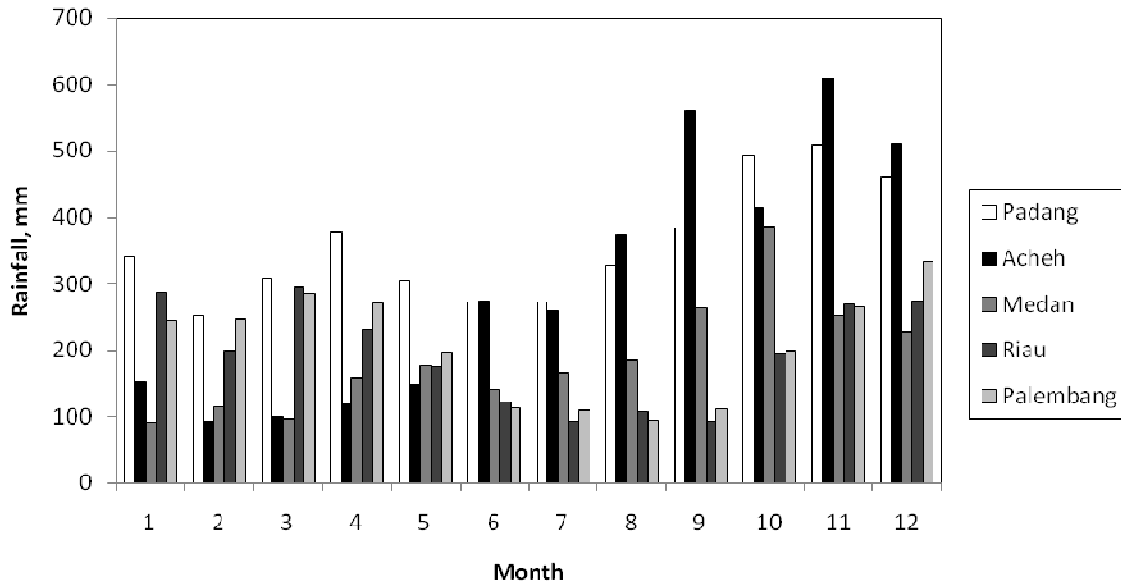


Figure 5. Variation of monthly average rainfall for the northwestern corner region of Indonesia.

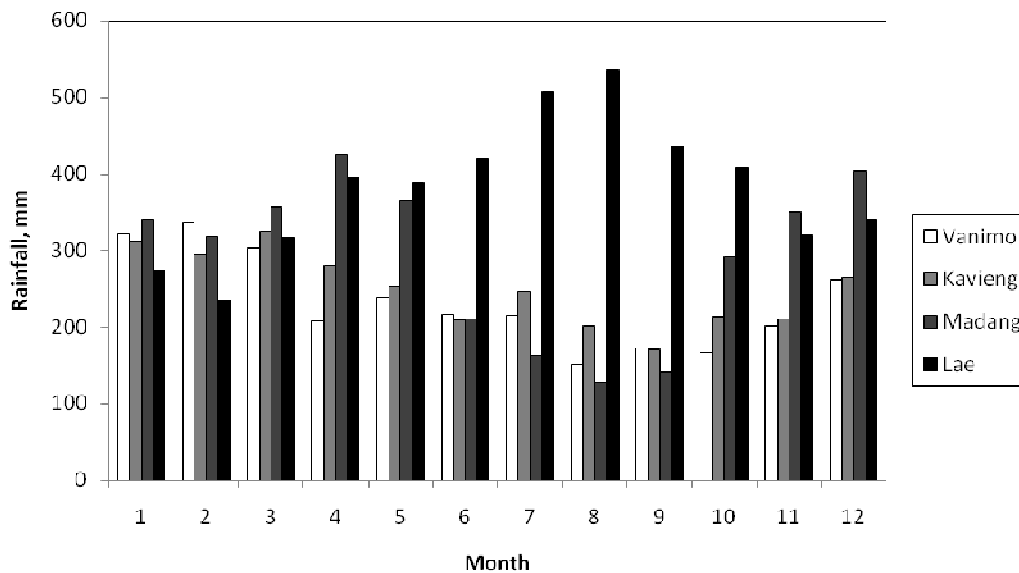
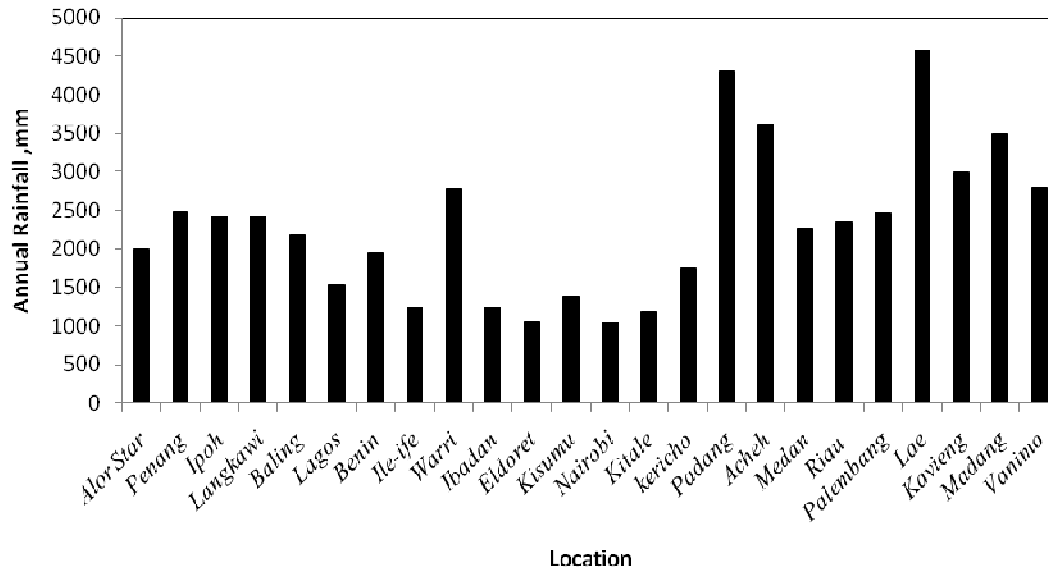


Figure 6. Variation of monthly average rainfall for the northern region of PNG.

December, Palembang and Riau experience 334.2 and 243 mm of rainfall, respectively. February is the driest month in Padang, Medan, and Aceh, August is driest in Palembang, with 252.2, 94, and 93 mm of rainfall and September is driest in Riau with 93 mm of rainfall. Figure 6 shows that Lae experiences rain throughout the year. April to September is a mixture of stratiform and convective rain seasons in Lae, whereas in October to March the rain is entirely convective and often accompanied by violent thunderstorms. July to September are dryer months in Madang, Kavieng, and Vanimo, whereas November to May comprise the rainy season, with

thunderstorms. August is the wettest month in Lae, with 535.4 mm of rainfall. February to April is the wettest months in Vanimo, Kavieng, and Madang with 337, 325.8, and 426.2 mm of rainfall, respectively. February is the driest month in Lae, with 236 mm of rainfall. In August, Madang and Vanimo experience 128.6 and 152 mm of rainfall, respectively. September is the driest month in Kavieng, with 171.6 mm of rainfall.

Figure 7 shows variation of average annual rainfall for all the 24 locations. Highest rainfall occurred in Lae, with 4579.4 mm of rainfall. It is because Lae is under tropical wet climate and it experiences rain throughout the year.



**Figure 7.** Variation of average annual rainfall for 24 regions over a nine years period.

Nairobi is the driest place, with 1043.2 mm of rainfall. As the state under sub-tropical climate and it experiences wet and dry season by depends on movement of intertropical belt.

### Conclusion

With the help of the provided monthly cumulative rainfall data, system designers for the tropical region can determine the rainy and sunny season for the above countries and can come up with a suitable design that would be able to give better communication services. In doing so, the performance of communication systems in tropical countries would not be affected badly during the heavy rain season.

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