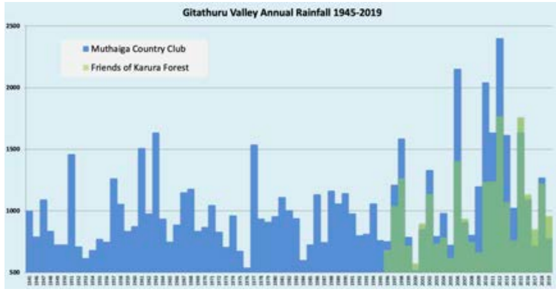
The Rain-Year in Karura Forest: Wetter & Wetter

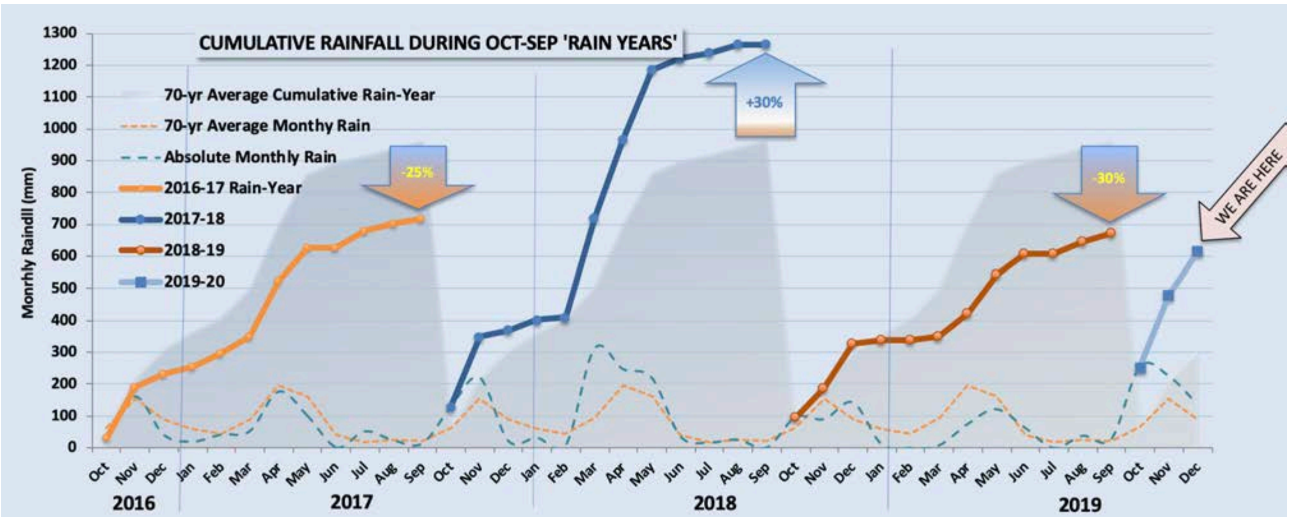
Harvey Croze, December 2019

Karura Forest, like much of Kenya, received more than its usual share of this year's 'short-rains'. October was the wettest one in 74 years. Is Karura Forest area getting wetter? The answer is yes.

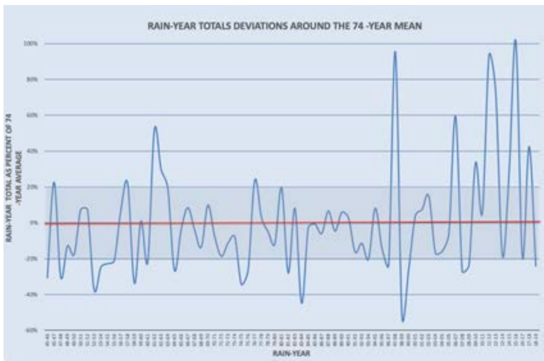
The Friends of Karura Community Forest Association has recorded rainfall in the Gitathuru River valley on the Karura Forest Reserve boundary since 1994 (green bars in the graph, right, aggregated to annual totals). The monthly rainfall amount over the period is highly correlated with rainfall recorded by the Muthaiga Country Club (MCC) since 1945 (blue bars, also aggregated here to annual totals, $p < 0.001$), with a slight but insignificant tendency for the Gitathuru data to be ca. 20 mm less per month on average than the MCC data. The two datasets were adjusted and merged for the following analyses.



VARIABILITY Karura rainfall is undeniably variable, as you can see on the graph below of the last three 'rain-years' (see box at bottom of next page for definition of rain-year).



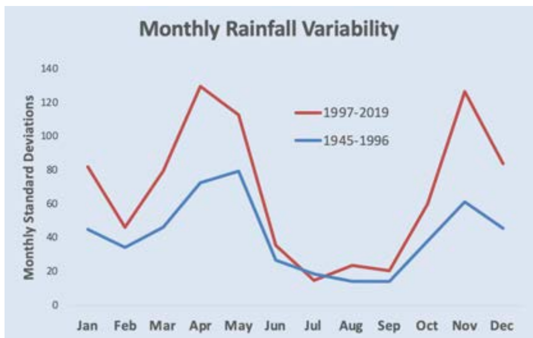
The last three rain-years have gone from bad to good and back to bad. The rain-years (coloured lines) have see-sawed from a 25% deficit of cumulative rain, to a 30% surplus, back down to a 30% deficit compared to the the 74-year average (grey blobs).



Cumulative rain gives a good picture of how much water is available for plant growth and aquifer recharge over time. At the end of the period, it is obviously equivalent to the period's total rain.

Karura's rainfall is undeniably variable as can be seen in the chart (right, top) of annual rain-year departures from the seven-decade mean of 880 mm. Nearly half of the years varied by 20% or more above or below the mean rainfall (red line), especially over the last two decades.

The chart on the right shows a comparison of the standard deviations of actual monthly rainfall for the first five decades of the data set (1945-1996) with the S.D.s of the last two decades (1997-2019) shows a significant increase in variability ($p < 0.001$ Wilcoxon[1]).



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AMOUNT & CHANGE

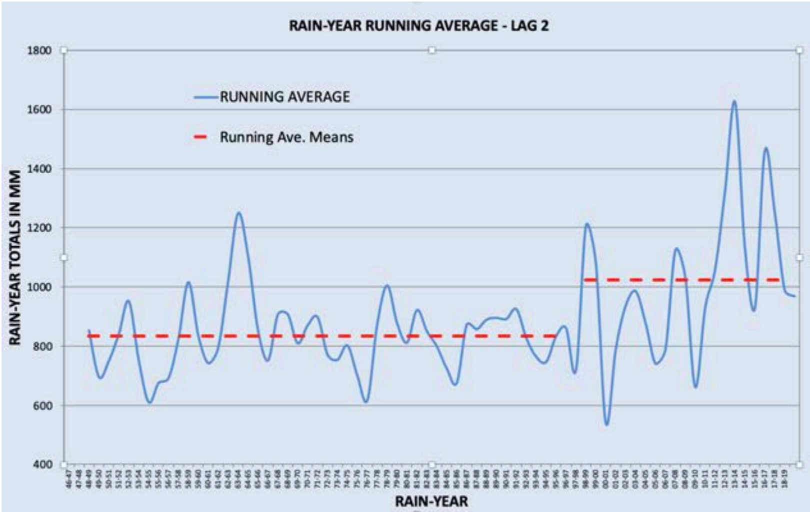
The 2019-20 rain-year has begun with a splash, as it were, with October and November together kicking off one of five wettest short rains since 1945 — by the beginning of December, we've had an accumulation of over 600 mm, over half the amount of the total average rain-year (previous page, righthand side of top graph).

There has been an anecdotal increase in rainfall amount over the past couple of decades, one that is also suggested in the annual fluctuation around the long-term mean (previous page) especially on the wetter (upper) side of the average, beginning with the El-Niño event in 1997-98.

A good way of looking at effective rainfall is to use *running averages*, that is, cumulative totals averaged over a number of periods. It's logical, if you think about it. The trees and shrubs growing in Karura Forest are not slaves to the Gregorian calendar: they use soil moisture accumulated in rain this month and, depending on topography and drainage, quite likely last month as well.

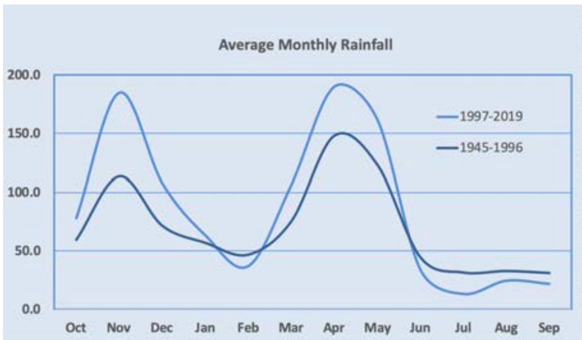
The chart below shows the two-month running average (blue line) for rain years from 1945-46 to 2018-19. The apparent upward trend is statistically significant ($p < 0.002$) Mann-Kendal). The annual MCC data (first chart on previous page) show a similar, but less pronounced trend ($p < 0.02$).

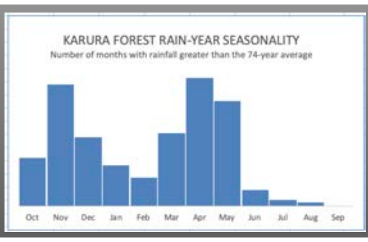
Moreover, looking at the two-month averages themselves averaged over two time periods — the five decades from 1945 to 1996, and the two decades from 1997 to 2019 (dashed red lines) — we find that the average rain-year rainfall has increased nearly 200 mm, from around 800 to 1,000 mm ($p=0.0002$, Mann-Whitney U-Test). Not surprisingly, a similar increase can be found in the MCC annual rainfall data set from an average of 900 mm to 1150mm ($P= 0.008$).



PATTERN & EXTREMES

The weather pattern in Karura is changing. The chart on the right compares the mean monthly rainfalls of the last two decades to those of the previous five decades. Clearly, the wet seasons are getting wetter, and the dry seasons, somewhat drier. Indeed, we may need to re-visit the popular term 'short rains' for the October to December wet periods.





RAIN-YEAR defines the ecosystem growing season and captures more accurately than the calendar year the annual cycle of soil moisture accumulation, and the growth and maturation of vegetation. In this part of East Africa the rain-year begins with the short rains, usually late October, enjoys a 'long rains' in April-May, and finishes with long dry season, June through September.

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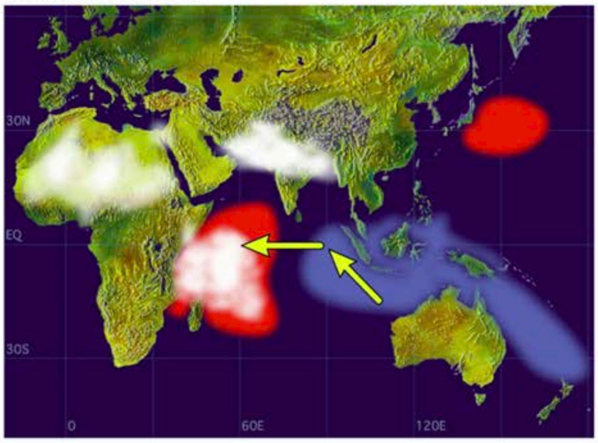
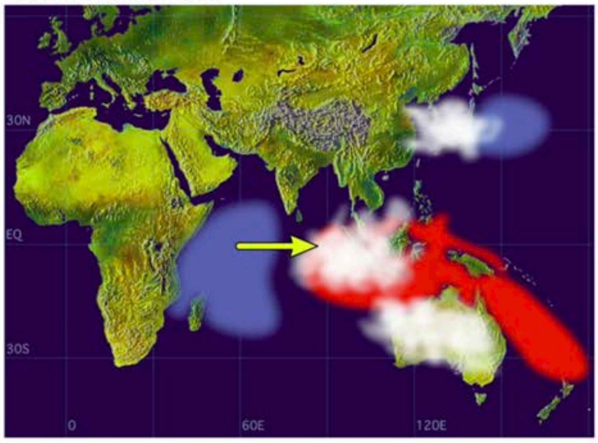
CAUSES? At the root of the variability, intensity, and extremes of East African weather patterns is one of the complex tropical air-sea coupled climate phenomena known as the Indian Ocean Dipole (IOC). According to the Research Institute for Global Change JAMSTEC) the IOD "… is normally characterised by anomalous cooling of SST [sea surface temperature] in the south eastern equatorial Indian Ocean and anomalous warming of SST in the western equatorial Indian Ocean. Associated with these changes the normal convection situated over the eastern Indian Ocean warm pool shifts to the west and brings heavy rainfall over the east Africa and severe droughts/forest fires over the Indonesian region." (http://www.jamstec.go.jp/aplinfo/sintexf/e/iod/about_iod.html)

The IOD looks like this:

Positive Dipole Mode



Negative Dipole Mode



Source: JAMSTEC

Sea surface temperature anomalies are shaded in red for warm and blue for cold. White patches indicate increased convective activities, and arrows indicate anomalous wind directions during IOD events. Although it is tempting to assume that the IOD is linked to the famous El Niño-Southern Oscillation (ENSO) events, in fact, the IOD functions quite on its own[2], and the dipole is observed in both El Niño and non-El Niño periods[3]. In addition, Owiti et al. found that the IOD influence is stronger on the October-December short rains, but has little influence on the March-May long rains.

Now, what causes IOD anomalies themselves is another question beyond the scope of this note, but the answer will certainly lie in the realm of the global atmospheric, land cover and ocean water linkages that are part of global climate change.

CONCLUSION So, yes, it is getting wetter in Karura Forest. Whether or not the same increases and variability are true of the rest of Nairobi and other parts of the country will require further study by Kenya's meteorologists.

Global weather these days is bedevilled by variability and extremes, and Kenya is getting a strong dose of both. But, as visitors to the forest will attest, Karura Forest is always cool and leafy green. And as long as we keep the forest secure and continue the programme of indigenous forest recovery, visitors to Karura, even in the severest of dry seasons, will enjoy green vegetation and cool fresh air, all part of the ecosystems services provided by Karura Forest.

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[1] The data analyses for this note were generated using the Real Statistics Resource Pack software (Release 6.2). Copyright (2013 – 2019) Charles Zaiontz. www.real-statistics.com.

[2] Saji, N.H, B. N. Goswami, P. N. Vinyachandran & T. Yamagata (1999) A dipole mode in the tropical Indian Ocean. Nature 401: 380-363. https://www.nature.come/artriclews/43854

[3] Owiti, Z., L.A. Ogallo & J. Mutemi. (2008) Linkages between the Indian Ocean Dipole and East African Seasonal Rainfall Anomalies. J. Kenya Meteorological Society 2(1): 3-17. https://www.kms.or.ke/images/phocadownload/v2p1.pdf