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Original Article

Overtime Modelled Climate Variability Effect in Roysambu Sub-County in Nairobi Kenya: A Retrospective Analysis

Roselyn Gathoni Ngigi[1], Dr. James Kibii Koske, PhD[1] & Dr. Cecilia Gichuki, PhD[1]*

[1] Kenyatta University. P. O. Box 00100 – 43844, Nairobi Kenya.
[*] Author for Correspondence ORCID ID: https://orcid.org/0009-0003-9179-7931; Email: ngigiroselyn@gmail.com

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Climate Variability, Rainfall, Temperature, Retrospective analysis, Simple Regression.

ABSTRACT

The effect of climate variability is unprecedented, affecting an array of ecosystems globally. Intensified effects of rainfall and temperature variations are affecting urbanised ecosystems where urban sprawl has ramified. This study looks at modelled retrospective climate variability changes in the Roysambu area, an urbanised suburb in Nairobi County, Kenya. The study aimed to ascertain the changes in rainfall and temperature in the past 30 years. From the simple regression analysis, the total annual average rainfall has slightly increased in the area ($y = 0.5235x + 72.037$, $R2 = 0.0618$). There were changes in temperature where the maximum average temperature had increased by 0.5 °C with a simple regression model ($y = 0.012x + 0.6281$, $R2 = 0.0814$). From the findings, climate variability has been experienced in the area through simple regression model retrospective analysis over time.

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INTRODUCTION

Globally, the effects of climate variability and its unprecedented extremes are unparalleled, posing challenges to physical infrastructure and agroecological ecosystems (Keane *et al.,* 2021). These exacerbating effects could worsen in the next five decades if the world does not commit to lowering carbon emissions. The Intergovernmental Panel on Climate Change's sixth assessment report (AR6) projects that the global ambition target of cutting emissions by 50% could not be met to lower global temperature by 1.5 °C below the pre-industrial period if the National Determined Contribution (NDC) index is not emphasised and actioned along with the Paris Accord (Zhou, 2021; Zhongming *et al.,* 2021).

Urban areas are fast experiencing the effect of climatic changes with the accumulation of greenhouse gases (GHGs) owing to the daily economic activities and industrial processes that proliferate the increase of GHGs (Georgescu *et al.,* 2021). In Sub-Saharan Africa, urban areas are experiencing extreme climate indices from intense flooding to urban heat islands (UHI), affecting the human population (Govender *et al.,* 2022). The term "urban heat island" (UHI) refers to the phenomenon in which cities have warmer air and surfaces than their surrounding rural areas. It is an environmental effect of urbanisation and industrialisation's transformation of the land surface of cities from natural landscapes to impervious surfaces (Kimuku & Ngigi, 2017). In most cases, urbanisation alters the amount of water near the surface and the types of plants that can grow there because of the reduction in natural landscapes. Changing the surface's thermal, radioactive, moisture, and aerodynamic properties are a consequence of paving over green spaces in urban centres (Khan, 2022).

It is projected that 65% of the world's population will live in urban areas by the year 2050, a significant increase from the current 45% (UNEP, 2017). Each city is said to require an ecological footprint three times larger than its actual land area in order to support its population and economy (NRC, 2014). Therefore, cities are widely acknowledged to have some of the most severe environmental impacts. This study sought to ascertain the notable retrospective climate variability changes in the urbanised Roysambu area in Nairobi, Kenya. The area has witnessed mushrooming urban sprawl, heightening climatic change resulting from land use changes and degradation of green spaces that are major carbon sinks.

METHODOLOGY

Study Area

Roysambu Sub-County is located in the North-eastern part of Nairobi's central business within latitude 36^0 50' 0" E and $36^0$56'0" E and longitude 1^0 40' 0" S and 1^0 10' 0" S. The area covers an area of 48.8. km^2 as shown in Figure 2. The area experiences an annual rainfall of between 1000 to 1500 mm annually, a temperature range of 15–20 °C and a relative humidity range of 40–70% (Gathungu, 2019). The dry season ranges from 6–8 months between January and March, followed by long rains and then the dry spell continues to August, followed by short rains. November-December is characterised by SE-NW dry, cold, and dusty harmattan trade wind. Roysambu Area has wetland lowland areas which are dominated by light forest wet areas that cover 10% of the area, which initially had a cover of 43%, most of which had been impacted by human activities as a result of the housing demand (IEBC, 2013).

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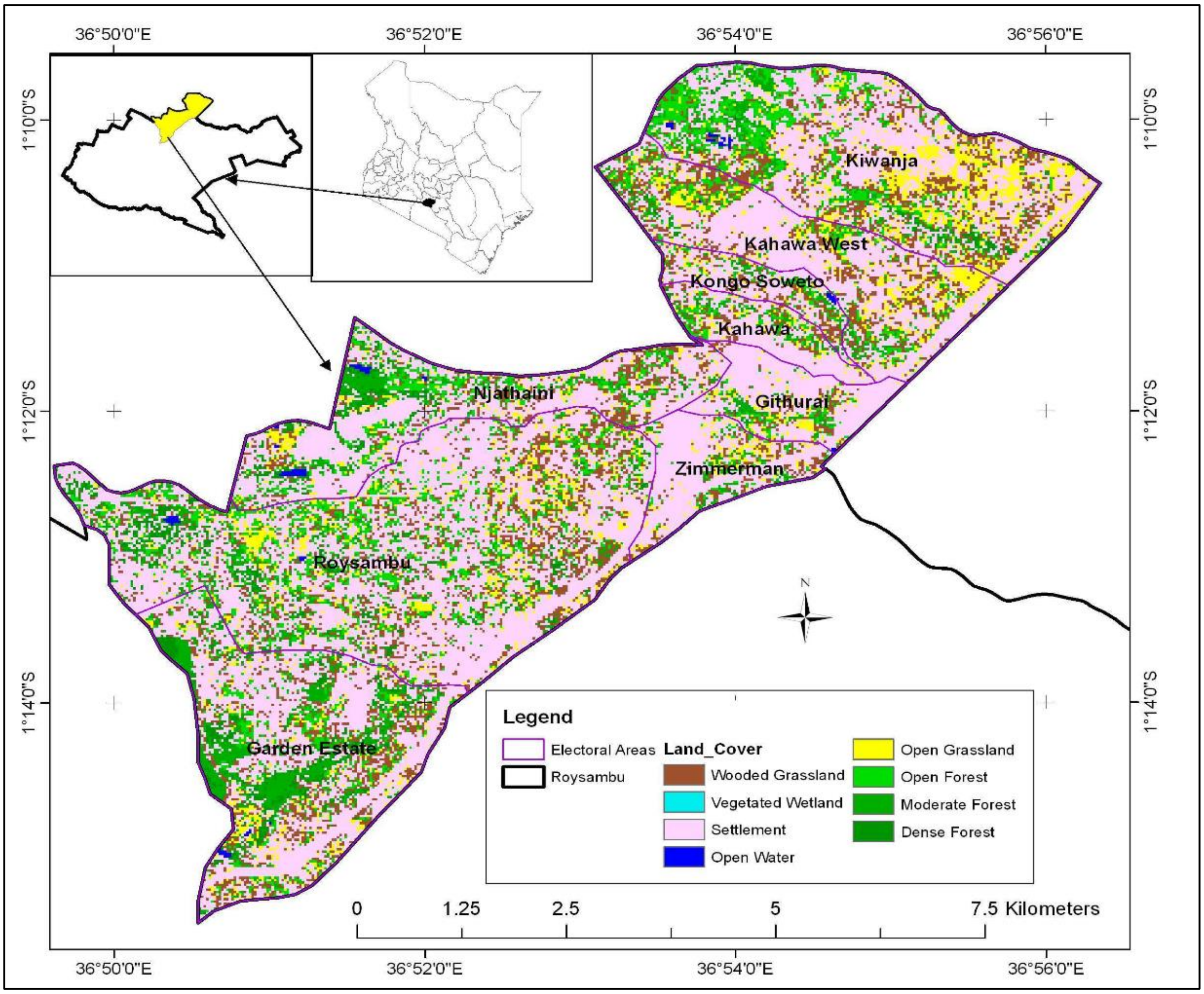
Figure 1: Map of Roysambu Sub-County land cover



(**Source** IEBC, 2013)

Data Analysis

This study used a descriptive research design with the use of secondary raw data. The climate variability data (rainfall and temperature) between the years 1984 – 2015 was obtained from the Kenya Meteorological Department (KMD), which has collated data for the past 30 years. The monthly rainfall and temperature data were organised and processed in Excel spreadsheets. Through simple regression analysis, climate variability data was modelled to show anomalies and retrospective observed intercessional oscillations on data through annual, total, minimum, and maximum indices on temperature and rainfall (Ngare et al., 2020).

RESULTS AND DISCUSSION

Overtime Climate Variability in Roysambu Sub-County

Climatic variability changes in the Roysambu sub-county were assessed through a modelled simple regression analysis. *Figure 2* shows the average maximum temperature changes in the study area in the past 35 years (1980–2015). There were noted variations in temperature across the years that showed increasing and declining anomalies.

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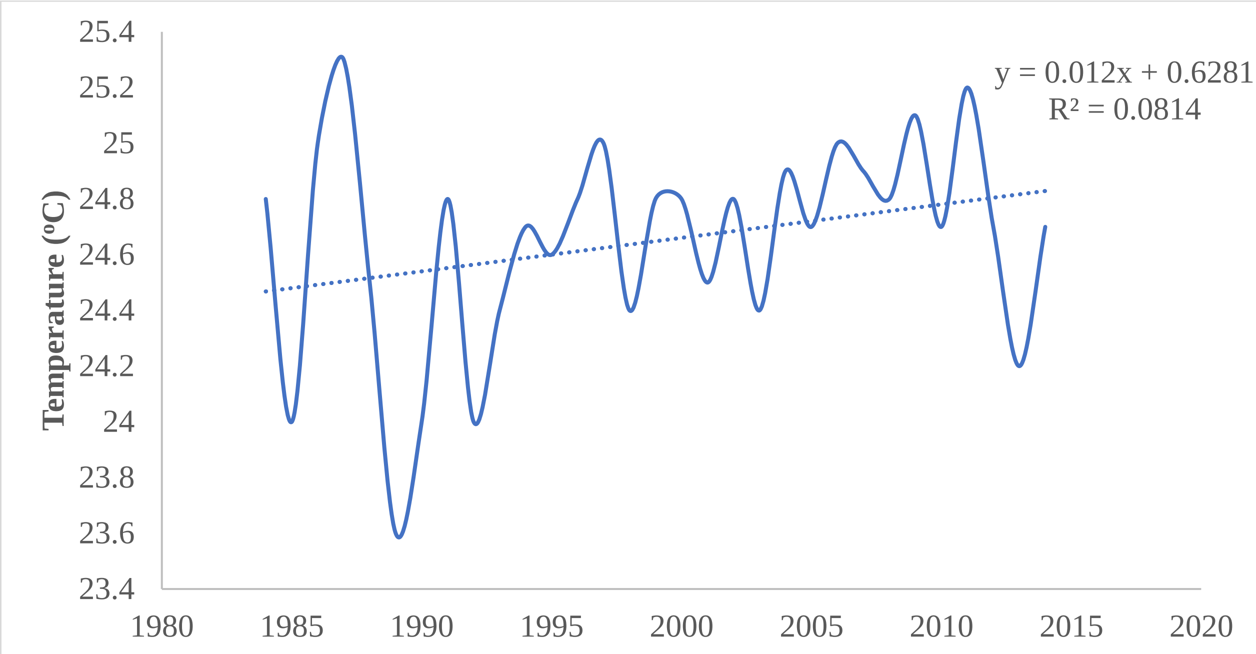
Figure 2: Average maximum temperature



The temperature rose (1985-1987), with recorded temperature changes ranging from 24 ⁰C to 25 ⁰C using a simple regression model (y = 0.012x + 0.6281, R^2 = 0.0814). From the observed change, it was evident that in a span of two years, the accumulative temperature had increased by 1 ºC.

Another noted increase in temperature was between the years 1989-1991, when the years recorded 23.6 ºC and 24.8 ºC, respectively. Temperatures rose above 1 degree Celsius cumulatively before falling steadily in the preceding year, 1992, which recorded 24 degrees Celsius. Temperature increases were felt in the years 2013-2015, where the years recorded 24.2 ºC and 24.7 ºC, respectively. From the observed changes through analytical computation, the residents of Roysambu felt the effect of increasing temperature changes in the past 35 years. The findings are similar to those of Bathiany et al. (2018) who found that global surface temperatures have increased exponentially, exacerbated by the accumulation of GHGs, affecting the climate and its entirety.

According to the Kenya Meteorological Data, over the past 30 years, temperature declines have been observed. The data shows that temperatures fell between the years 1987 and 1989. The recorded average maximum temperatures were 25.3 ºC to 23.6 ºC, respectively. There was a temperature decrease from 1991, with 24.8 ⁰C, to 1992, with a maximum average temperature of 24 ⁰C. The temperature decrease between the two years was an average of 0.8 ⁰C. Another observed average temperature descent was in 2011; it was recorded at 25.2 ºC to 24.2 ºC in 2013 as an annual maximum average temperature.

Climate variability has been present in the past three years in the Roysambu sub-county. According to Ji et al. (2014), the evolution of land surface air temperature trends indicates that global climate change has experienced significant warming. There is discernible evidence of global temperature trend changes from 1901 to 2009 at an unprecedented pace. This study supports the witnessed ascending and descending maximum average temperatures in Roysambu Sub-County. The results from *Figure 3* agree with those of Camberlin (2018), who found that in the period 1984–2013, the average temperature in East Africa increased by 0.7 ⁰C and by 1 ⁰C for areas that have wetlands nearby. Another

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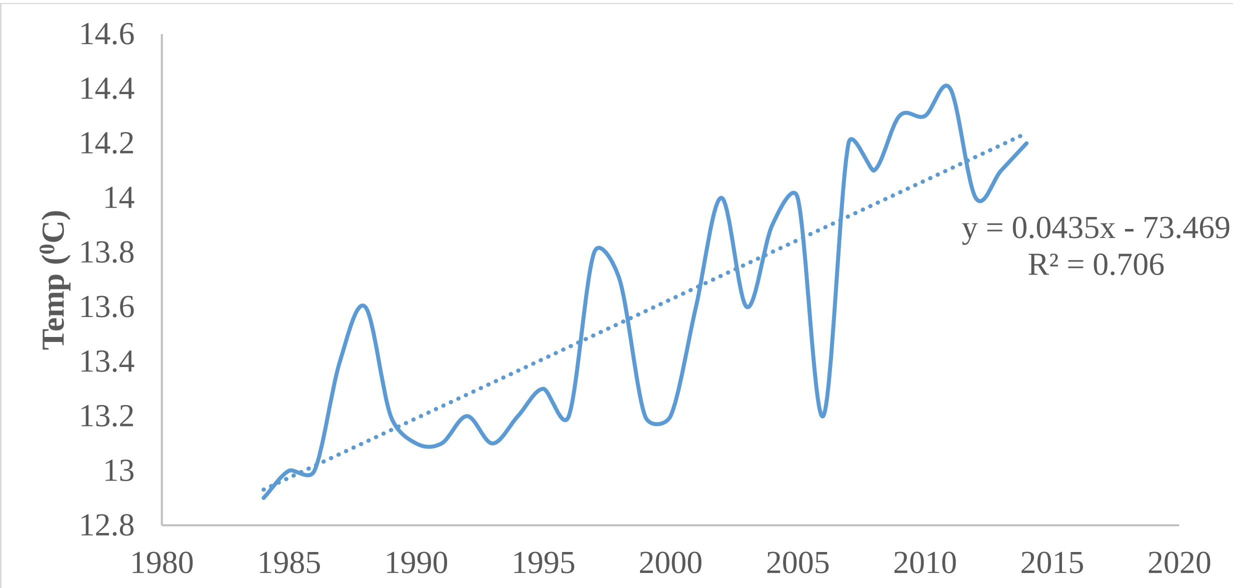
study by Nicholson (2019) agrees with this study and found that for the same period, Nairobi's average temperature increased by at least 0.8 to 1 ^{0}C.

Minimum Average Temperature of Roysambu in the Past 35 Years

Minimum average temperatures in the study area in the past 30 years had variations impacted by climate variability (y=0.043x-73.469, R^2=0.706). The significant annual increase and the significant decrease in minimum average temperature were the most notable variations. *Figure 3* shows that the year 1984 had the lowest average minimum temperature, cumulatively recording 12.9 ºC in the study area. The highest annual average minimum temperature was observed in 2011, with a record of 14.4 ºC.

Figure 3: Average minimum temperature



The years 1989, 1992, and 1996 had an identical average minimum temperature, averaging 13.2 ºC. It was also observed that between these years, minimum average temperatures had the least ascending and descending averages compared to other years in the past 30 years in the Roysambu area. There was a sharp temperature increase in 2000-2002 with a sharp decline in 2005-2006 as the average temperature significantly increased from 2006-2007 compared to other years.

From *Figure 3*, it can be deduced that there were years with the same minimum temperature, 1991 and 1993, with a temperature of 13.1^0 C, and 1999, 2000, and 2006, with a temperature of 13.2 ^{0}C. Hence, for the past 30 years, only two years, 1984 and 1986, had the coldest average minimum temperature below 13 ^{0}C. This aligns with a study by Hawkins and Sutton (2016) about connecting climate model projections of global temperature change with the real world. They argue that different projections of global climate models show different data and anomalies propagated by climate variability on annual average temperatures. Studies by Ndolo et al. (2018) for climate variability in Nairobi County for a period of 1961 to 2007 indicated that the county had had climate change since the analysis of temperatures over the period indicated a 0.43 ºC to 1 ºC increase. That was mainly attributed to the relatively high rate of urbanisation and degradation of the natural environment that used to exist in the 1960s, 1970s and 1980s.

Average Annual Precipitation

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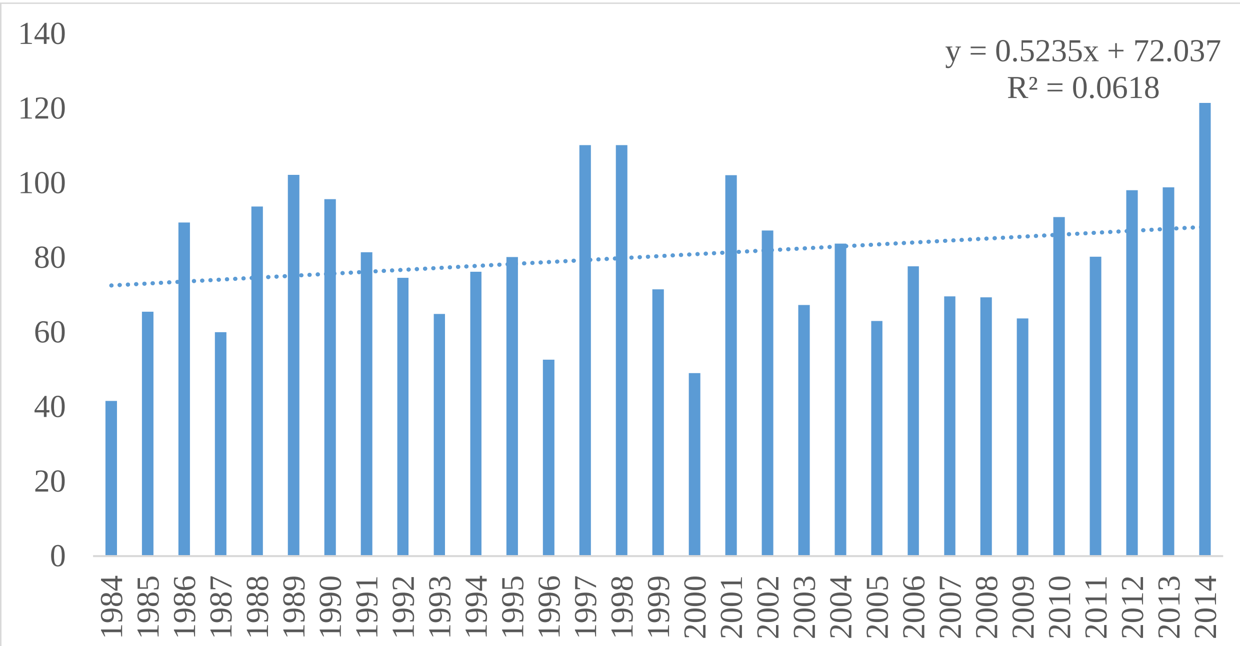
The average annual precipitation for Roysambu Sub-County is represented by *Figure 4* in the past 30 years (between 1984 and 2014). There were noted precipitation changes over time in the study area (y = 0.5235x + 72.037, R^2 = 0.0618). Annual precipitation increased in some years while decreasing in others. From the analysis, three years recorded the highest annual precipitation in the past 30 years. The years were (1998, 1999, and 2014) with 110.2 mm, 110.2 mm, and 121.5 mm, respectively. This was the opposite of the years (1984, 1996, and 2000) that recorded the lowest average annual precipitation of 41.6 mm, 52.7 mm, and 49.1 mm, respectively, across the observed trend.

Figure 4: Average annual precipitation



Over the years of average annual precipitation, there have been consistently ascending and descending precipitation trends in some years. Annual precipitation average changes were noted in 1984, 1985, and 1986. These years recorded 41.6 mm, 65.5 mm, and 89.5 mm, respectively, with a noted average precipitation increase trend of 24 mm in three years. The other annual average precipitation rises were between the years 1996 and 1997, with 52.7 mm and 110.2 mm. Precipitation also rose steadily in 2010-2014, with a record 98.9 mm to 121.2 mm.

This study agrees with Williams et al. (2015) on climate variability and seasonal change effects on precipitation. They argue that with projected climate change uncertainties, different places globally will experience annual precipitation variations like spring and autumn that will keep changing in preceding years in the same seasons. Another scholar, Douglas (2017), noted that the flash floods experienced in cities like Nairobi and Kampala are not related to the amount of rainfall increased over the period, but wetlands have been drained for development purposes. Wetlands assist in storing excess runoff, and by building on them, the city's rainwater does not find a natural site for storage. This study agrees with Nyika (2017), who argues that the precipitation of the areas whose wetlands have been affected is projected to have inconsistency of increasing and decreasing across the year. This is due to the region depending on water bodies from other regions to complete the

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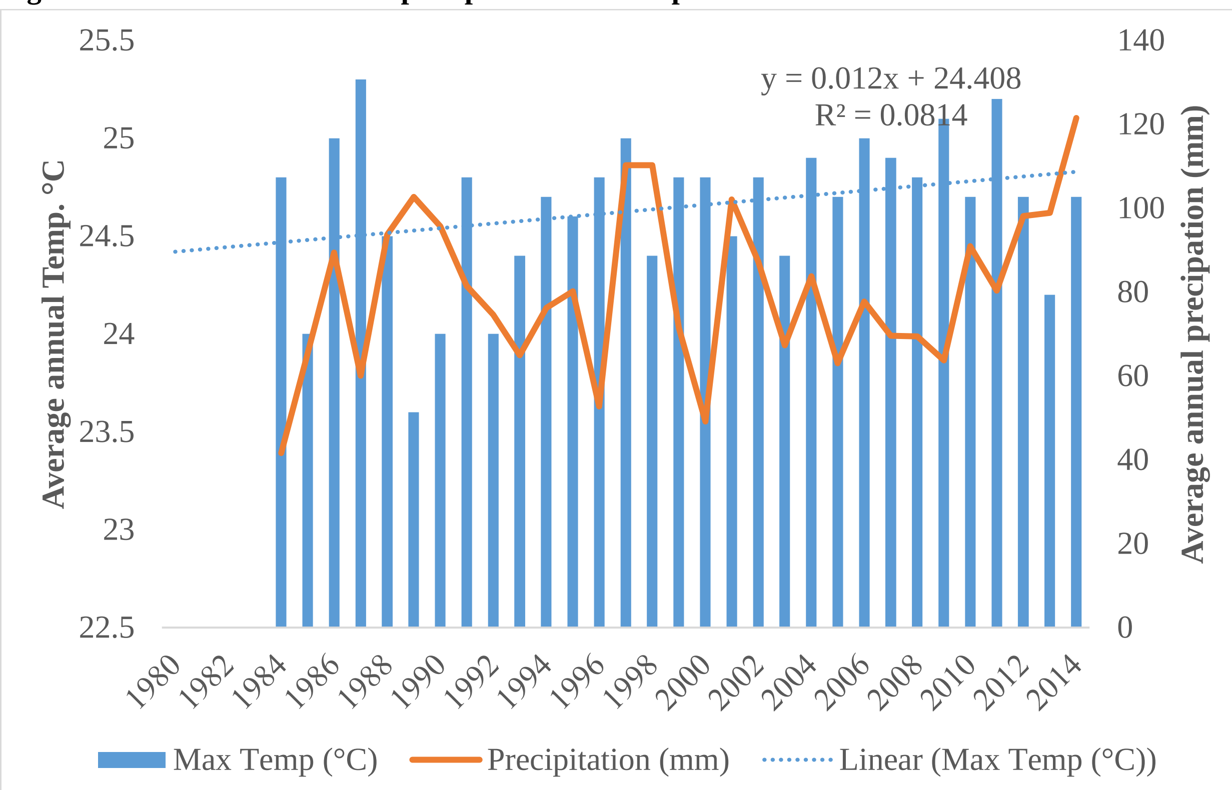
rainfall cycle, as these areas have no wetlands to store excess rainwater and thus no evaporation experience.

Analysis between Precipitation and Temperature (1984-2014)

Figure 5 shows the analysis of annual precipitation and temperature for the years 1984–2014 for the Roysambu Sub-County. From the figure, temperature and precipitation undergo different changes across the years. The only years when there was a high temperature with low rainfall were 1989, 1990, 1998, and 2013. These years show the natural projection of climatic conditions where it is expected that when the temperature is high, the rainfall amount should be low (Ayugi *et al.*, 2019). From the start of 1984, the annual temperature has been relatively low compared to the amount of precipitation that year. This trend continued for the years 1986, 1987, 1994, and 1995. A close analysis of the years 1996 and 2000 shows a different trend where the amount of precipitation for those years is high, but the temperatures have a relatively steep reduction compared to the trends of the previous years. Another interesting observation from this analysis is that in 1997 and 1998 the amount of precipitation was equal in 1997, and although precipitation dropped in 1998, the temperatures stagnated before sharply dropping for the years 1999 and 2000.

Figure 5: Annual correlation of precipitation and temperature



Another observation is that, for most years, the temperatures maintained a trend that was relatable through the years. This implies that the annual average temperature had a mean of around 23.5 ºC, and the precipitation averaged 98 mm for the period. This analysis agrees with Ndolo et al. (2018), who argued that in Nairobi, there is variation in temperature trends and precipitation, with most parts of the year having microclimate conditions. They also analysed the variations and concluded that they are the best way of showing if there has been climate variability over the years, with some

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years showing colder seasons than others and some areas showing abnormal temperatures due to the destruction of the natural environment by residential and commercial housing developers.

CONCLUSION

The study found that the area has had significant increases in temperature and precipitation in the last 30 years. From the analysis of the trend, the average maximum temperature was recorded in 1987 at 25.3 ^{0}C with 23.6 ^{0}C being the least average maximum temperature recorded in 1989. Analysis of the average minimum temperature found that the year 1984 had recorded the lowest average minimum temperature of 12.9 ^{0}C, and the highest average minimum temperature was recorded in 2011 at 14.4 ^{0}C. Over the 30-year trend analysis period, a temperature increase of 1 ^{0}C was noted in the Roysambu area. On the other hand, the average annual temperature had 2014 with the highest recorded precipitation of 121.5 mm, and 1984, 1996, and 2000 all recorded average minimum precipitation of 41.6 mm. The 30-year trend saw a 24 mm precipitation increase**.**

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Competing Interest

The authors declare no competing interests

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REFERENCES

Ayugi, B., Tan, G., Ullah, W., Boiyo, R., & Ongoma, V. (2019). Inter-comparison of remotely sensed precipitation datasets over Kenya during 1998–2016. *Atmospheric Research, 225,* 96-109.

Bathiany, S., Dakos, V., Scheffer, M., & Lenton, T. M. (2018). Climate models predict increasing temperature variability in poor countries. *Science Advances*, *4*(5), eaar5809. https://doi.org/10.1126/sciadv.aar5809

Camberlin, P. (2018). *Climate of Eastern Africa. In Oxford Research Encyclopedia of Climate Science.* Oxford University Press.

Douglas, I. (2017). Flooding in African cities, scales of causes, teleconnections, risks, vulnerability and impacts. *International Journal of Disaster Risk Reduction*, *26*, 34-42.

Gathungu, J. G. (2019*). Environmental Impact Assessment Study Report for the Proposed two Blocks Residential Units Development on Plot Lr No: 10119/4-Next to Garden City Mall, Off Thika Super Highway, Kasarani Sub County, Nairobi County*.

Georgescu, M., Broadbent, A. M., Wang, M., Krayenhoff, E. S., & Moustaoui, M. (2021). Precipitation response to climate change and urban development over the continental United States. *Environmental Research Letters*, *16*(4), 044001.

Govender, T., Dube, T., & Shoko, C. (2022). Remote sensing of land use-land cover change and climate variability on hydrological processes in Sub-Saharan Africa: Key scientific strides and challenges. *Geocarto International*, 1-25. https://doi.org/10.1080/10106049.2022.2044175

Hawkins, E., & Sutton, R. (2016). Connecting climate model projections of global temperature change with the real world. *Bulletin of the American Meteorological Society*, *97*(6), 963-980. https://doi.org/10.1175/BAMS-D-14-00254.1

Article DOI: https://doi.org/10.37284/ajccrs.2.1.1169

IEBC. (2013). *Electoral Boundaries*. Nairobi, Kenya: Kenya Gazette.

Ji, F., Wu, Z., Huang, J., & Chassignet, E. P. (2014). Evolution of land surface air temperature trend. *Nature Climate Change*, *4*(6), 462-466. https://doi.org/10.1038/nclimate2223

Keane, J., Mendez-Parra, M., Pettinotti, L., & Sommer, L. (2021). *The climate and trade nexus in Africa: Climate change and the transformation of African trade*. ODI Report. https://www.odi.org/publications/17403-climate-and-trade-nexus-africa-climate-change-and-transformation-african-trade

Khan, M. A. (2022). Vision of a Sustainable, Smart, and Resilient City. In *Cities and Mega Risks* (pp. 295-338). Springer, Cham.

Kimuku, C. W., & Ngigi, M. M. (2017). Study of urban heat island trends to aid in urban planning in Nakuru County-Kenya. *International Journal of Urban Sciences*, *21*(1), 94-110. https://doi.org/10.1080/12265934.2017.1352817

Ndolo, I. J., Nzioka, J. M., Oludhe, C., Ng'ang'a, J. K., & Odingo, R. S. (2018). Influence of urbanisation on minimum and maximum temperature characteristics over Nairobi City. *International Journal of Climatology*, *38*(14), 5147-5160. https://doi.org/10.1002/joc.5716

Ngare, I. O., Koske, J. K., Muriuki, J. N., Chitechi, E. W., & Gathuku, G. N. (2020). Urban climate variability trend in the coastal region of Mombasa Kenya. *African Journal of Environmental Science and Technology*, 14(8), 214-221. https://doi.org/10.5897/AJEST2019.2773

Nicholson, S. E. (2019). A review of climate dynamics and climate variability in Eastern Africa. In M. J. Leng & R. C. Kay (Eds.), *The limnology, climatology and paleoclimatology of the East African lakes* (pp. 25-56). Springer.

National Research Council. (2014). *Wetlands: Characteristics and Boundaries*. National Academies Press.

Nyika, J. (2017). Situational analysis of Nairobi River Basin (NRB). *Water Practice and Technology, 12*(3), 589-603.

UNEP. (2017). *Integrated Monitoring Guide for Sustainable Development Goal 6 on Water and Sanitation: Good practices for country monitoring systems (Version 6)*. United Nations Environment Programme.

Williams, A. P., Seager, R., Abatzoglou, J. T., Cook, B. I., Smerdon, J. E., & Cook, E. R. (2015). Contribution of anthropogenic warming to California drought during 2012–2014. *Geophysical Research Letters*, *42*(16), 6819-6828.

Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z., & Wei, L. (2021). *AR6 climate change 2021: The physical science basis*. Intergovernmental Panel on Climate Change.

Zhou, T. (2021). New physical science behind climate change: What does IPCC AR6 tell us? The *Innovation, 2*(4), 100171.

