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Short communication

Trends in rainfall and temperature extremes during 1954-2019 in Addis Ababa, Ethiopia

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The rising frequency of extreme weather events, such as heat waves, droughts, and flooding, is a clear indicator of climate change, as multiple studies have shown (Huang *et al.,* 2013) and the resulting forcing continues to increase. Aerosols partially offset the forcing of the WMGHGs and dominate the uncertainty associated with the total anthropogenic driving of climate change. As in previous IPCC assessments, AR5 uses the radiative forcing (RF. These events have a substantial impact on both natural and human systems (Oakes, 2009; Zhai *et al.,* 2020) a five-model ensemble mean from CMIP6 was chosen to project drought characteristics in South Asia under the latest SSPs-RCPs emission scenarios (SSP1–2.6, SSP2–4.5, and SSP5–8.5. Climate change is a major long-term factor contributing to social, economic, and environmental changes. There are significant geographical variations in the worldwide impact of its alteration. Unquestionably, rising air temperatures and altered precipitation patterns may have positive or negative effects on a range of facets of human existence, including energy use, agricultural goods, and human settlements (Herrador *et al.,* 2021). As extreme events occur more frequently and with greater severity, future climate change may make the climate over East Africa more complicated (Dibaba *et al.,* 2020) aquifer recharge, and river flows. The evaluation helps to identify the level of water resources exposure to the changes that could help to plan for potential adaptive capacity. In this research, Cellular Automata (CA. Climate change consequently affects society, economy, and population. climate change may complicate the climate of East Africa as extreme events become more frequent and severe (Case, 2006).

Extreme weather events brought on by climate change result in variations in temperature and precipitation in Africa. Lunagaria *et al.,* (2015) have reported trends of temperature and rainfall extremes for Gujarat India using RClimDex tool. This work employs the RClimDex tool to analyze temporal variations in extreme climatic events in Addis Ababa with a focus on temperature and rainfall data. The long-term historical (1954 to 2019) data on daily rainfall and maximum and minimum temperatures of Addis Ababa (Latitude 9 ° 1′48″N, Longitude 38 ° 44′24″E and Altitude 2,355 m above mean sea level) were obtained from the Ethiopian Meteorology Institute, Addis Ababa, Ethiopia.

In Addis Ababa, the main rainy season, known as Kiremt, usually lasts from June to September. December received 7.1 mm of rain on average, while August received 319.7 mm. Over the lengthy run, the average maximum and lowest temperatures varied from 14.6 to 20.8°C and 4.8 to 7.6°C, respectively. May was the month with the highest average maximum and minimum temperatures. During the rainy seasons, there was a noticeable drop in temperature. Fig. 1 shows Addis Ababa's monthly rainfall, maximum temperature, and minimum temperature.

To analyze the historical meteorological raw data, RClimDex was utilized. This tool offers a user-friendly software package for computing climatic extreme indexes in order to track and identify climate change (Zhang and Yang, 2004). The Climate Research Division of the Meteorological Service of Canada developed this R-based software RClimDex to ensure the accuracy of temperature and rainfall data. The software looks for numbers that are out of range, outliers, duplicate dates, and consecutive days with equal values. Moreover, coherence between temperatures is detected. Trends are calculated using Kendall's tau-based slope estimator, which has a 95% confidence level P Value less than 0.05. Trends judged statistically significant at the 0.05% level are the only ones included in the analysis.

Different rainfall and temperature extremes analyzed in the present study are presented and explained in Table 1. The trend analyses of extreme climatic indices along with p values are also presented (Table 1).

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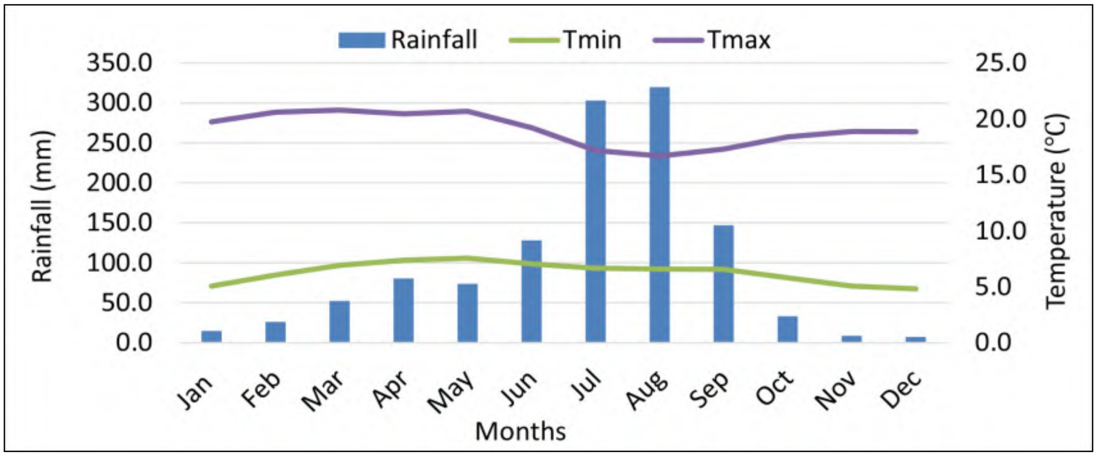

Fig. 1: Long-term average monthly rainfall, minimum temperature (Tmin) and maximum temperature (Tmax) of Addis Ababa

Table 1: Extreme climate indices and their trend (slope and p-values) for Addis Ababa

No.	Index	Description	Definition	Units	Slope	P-Value
1	PRCPTOT	Wet day precipitation	Annual total precipitation from wet days(>1mm)	mm	1.081	0.284
2	R20	Very heavy precipitation	Annual count of days when PR ≥20mm	days	0.032	0.255
3	SU25	Hot days	Annual count when TX>25°C	days	1.12	0
4	TN10p	Cool nights	Percentage of days when TN < 10th percentile	days	-0.732	0
5	TX10p	Cool days	Percentage of days when TX < 10th percentile	days	-0.237	0
6	TN90p	Warm nights	Percentage of days when TN > 90th percentile	days	0.342	0
7	TX90p	Warm days	Percentage of days when TX > 90th percentile	days	0.412	0
8	WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX > 90th percentile	days	0.648	0
9	DTR	Diurnal temperature range	Monthly mean difference between TX and TN	˚C	-0.008	0.24
10	SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days (defined as PR ≥ 1.0 mm) in the year	mm per day	0.01	0.142
11	CDD	Consecutive dry days	Maximum number of consecutive days with RR < 1 mm	days	0.155	0.396
12	CWD	Consecutive wet days	Maximum number of consecutive days with RR ≥ 1 mm	days	0.054	0.221

Trends in rainfall extremes

The annual total precipitation (PRCPTOT) trend exhibits a positive slope at the 5% significant level (Table 1). The presence of CWD is a reliable indicator of sufficient water for agricultural systems. A reliable indicator of the possibility of insufficient water for agricultural systems is the occurrence of CDD. At the 5% significant level, CDD trends revealed an increase in CDD. Days with heavy precipitation of 20 mm of rain per day are counted as heavy precipitation days. At 5% significant level, trends exhibited an increment. The study of Tashebo (2022), the trends of precipitation indices also indicated a decreasing trend on the study area.

The ratio of the total annual rainfall to the number of days when precipitation fell during the year is known as the "Simple Day Intensity Index for rain" (SDII). When there are more rainy days in a given year, the overall amount of precipitation falls, but the rain intensity index decreases. In addition, the number of rainfall days may have increased/decreased more than the annual rainfall, leading to a decline. Similarly, a decrease in rainfall days without affecting the overall annual rainfall amount or a larger rise (smaller decrease) in the annual rainfall relative to the increase (decrease) in the number of rainy days could lead to an increase in this indicator. As a result, if the index falls, there will be, on average, less rain each day, and more rain each day, if the index rises. The SDII trends indicated a rise at the 5% significant level (Table 1).

Trends in temperature extremes

Based on the result of temperature trends analysis, the number of warm days has continued to rise over city. At a 5% significant level, the examples presented for the station clearly show an increasing trend in the number of days when the temperature exceeds 25˚C (SU25). A declining trend is observed in the frequency of days with Tmin <10th percentile of daily lowest temperature "cold nights" (TN10P) at the 5% level of significance (Table 1). The study region showed a declining trend at the 5% significant level for the trend in days with T_{max} <10th percentile of daily maximum temperature, or "cold day times" (TXI0P). The study area also indicated an increasing trend in warm nights (TN90P) at a significance level of 5%. Others scholars aslo presented similar findings regarding the pattern of hot and cold extreme increase over the study area (Alemu and Dioha, 2020; Tashebo, 2022). One reliable measure of the durability of the warm weather in the area is the WSDI's growing trend. On the other hand, the mean DTR showed declining trends, as shown in the example given for the Addis Ababa, which have slopes of 0.008 at the 5% significant level.

The number of consecutive rainy days and the annual rainfall trend on the Addis Ababa showed an increment based on indices. For both the maximum and minimum temperature indices, consistent warming trends are apparent. Days with high temperatures are becoming more frequent on the station. Conversely, there are trends toward decline in the diurnal temperature ranges, cool day, and cool night.

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