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# EXTREME HEAT IN KOUDOUGOU, BURKINA FASO: ANALYSING TRENDS, COMMUNITY PERCEPTIONS AND MIGRATION MEASURES

**Abstract:** Climate change is having a profound impact on urban population in the Sahel region, particularly in Burkina Faso, affecting various aspects of daily life. Koudougou, the third largest city in the country, is not exempted. The aim of this article is to examine the main coping strategies of the inhabitants of Koudougou in the face of increasing heat waves. To this end, temperature data for the hottest months (March, April and May) from 1981 to 2024 were analysed to identify climate trends. These data were first subjected to a normality test, then analysed using linear regression and standardised temperature anomaly (STA) methods. At the same time, a survey was conducted among the population to assess the impact of this phenomenon on their daily lives. The results showed that temperatures in Koudougou have increased significantly in recent years and are perceived as high (38.04%) or very high (40.97%) by most of the respondents. This situation is a serious threat for the population wellbeing as it is causing health problems and reducing the productivity of the population. Residents are developing adaptations strategies by redesigning their houses and

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adopting individual behaviours, such as drinking more water or wearing light clothing, although they often consider these measures to be ineffective. As the effects of climate change on vulnerable regions is projected to increase, awareness raising should be developed through social media, television and radio channels to promote adaptation best practices.

**Keywords:** extreme temperatures, climate trends, adaptation strategies, mitigation strategies, Koudougou

## Introduction

Climate change is intensifying natural disasters and increasing societal vulnerability (Dia et al., 2012). The Intergovernmental Panel on Climate Change (IPCC) (2007) reports that global temperatures have already risen by 1.1°C above pre-industrial levels, with projections indicating an increase of 1.5°C by 2052. In response, the Paris Agreement aims to limit global warming to below 2°C. Despite these efforts, extreme weather events, particularly heat waves, are becoming more frequent and intense (Norrant-Romand, 2010). These events have significant impacts on the environment and human health (Bégin-Galarneau, 2021). Across many regions, extreme heat is becoming frequent. In Tunisia for instance, summer temperatures often reach 45°C (Chebli et al., 2023), while a United Nations report predicts that Europe could experience a 2°C increase by 2027. Historical data indicates that both the intensity and frequency of heat waves have increased over the past 1,300 years (Mann et al., 2008). The Sahel region is particularly affected: over the past 30 years, heat waves there have increased by 50% (Ndiaye, 2017), with their frequency rising from five events per decade in the 1980s to significantly more in the 2010s (Ndiaye, 2019). In this region, maximum temperatures often reach between 45°C and 47°C (Rome et al., 2016).

The IPCC (2016) report underscores the Sahel region vulnerability, citing rising temperatures and increased rainfall variability. In Burkina Faso, projections show that heat waves could regularly bring temperatures up to 46–48°C by the end of the century. Rome et al. (2016) also report that extreme temperatures have already contributed to a 20% increase in heat-related mortality between 2000 and 2020, particularly affecting vulnerable groups such as children, diseased persons and the elderly. Cities in in Burkina Faso are facing major challenges due to extreme temperatures. Urban centres like Koudougou, the country's third-largest city, are struggling with the compounded effects of heat waves on public health, the economy, infrastructure, and essential services like water and electricity. Health systems in these cities remain fragile and under strain.

Against this backdrop, a crucial question arises: how does the population cope with heat waves during periods of intense heat? This article aims to examine temperature trends in Koudougou from 1981 to 2024 and explore the main coping strategies adopted by the residents in response to increasing temperature extremes.

## Methodology

### *Study area*

The city of Koudougou, which serves as the study area, is situated in the commune bearing the same name on the Mossi Plateau, approximately 100 km west of Ouagadougou. As the third largest city in Burkina Faso, following Ouagadougou and Bobo-Dioulasso, it is located in Boulkiemde Province, within the Centre-Ouest region, where it functions as the regional capital. Population data from the 1985, 1996, 2006, and 2019 censuses indicate a notable growth, with the number of inhabitants rising from 51,529 in 1985 to 160,239 in 2019. Figure 1 presents a map of Koudougou.

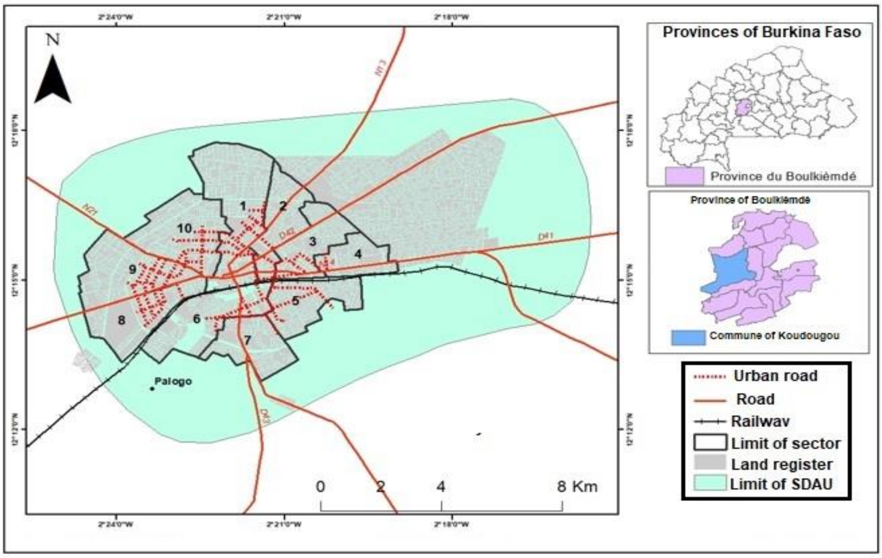


*Fig. 1. Location of the town of Koudougou*

### *Data acquisition*

The data collection process was carried out in two stages. Initially, secondary data related to minimum and maximum were collected. These data were obtained from Burkina Faso's National Meteorological Agency (ANAMB), specifically from the synoptic station of Ouagadougou. The data covered the hottest months (March, April, May) in the study area, spanning the period from 1981 to 2024.

In addition, primary data on population perceptions were collected on the field. To select the proportion of the population to be surveyed, a sample size was calculated using the method proposed by Serhier et al. (2020), based on the following formula.

$$N = Z\alpha 2.\ P\ Q\ /\ d2 \quad (1)$$

Where, N= sample size by sector; Zα = deviation set at 1.96, which is equivalent to a level of confidence of 95%; P = number of households in the sector; Q = 1 – P; d = margin of error which is equal to 5%.

Applying this formula to the number of households in the city, 40.688, according to INSD, (2019) results in a total of 205 households to survey. Survey forms were then prepared, and the survey was conducted during the hot season.

### *Method of data analysis*

The analysis is based on maximum and minimum temperature data collected during the hottest months (March, April, and May). To assess their suitability for statistical modelling, the temperature data were tested for normality using the Shapiro-Wilk, Anderson-Darling, and Lilliefors tests. In each case, the null hypothesis ($H_0$) assumes that the data follow a normal distribution, while the alternative hypothesis ($H_a$) assumes they do not. As shown in Table 1, the results confirmed the normality of the data, justifying the use of linear regression for the study.

*Table 1. Normality tests for temperature data*

| Month | | | |
|---|---|---|---|
| | Maximum Temperature | | |
| March | Test de Shapiro-Wilk | W | 0.991 |
| | | p-value | 0.988 |
| | | α | 0.05 |
| | Test de Anderson-Darling | A² | 0.132 |
| | | p-value | 0.980 |
| | | α | 0.05 |
| | Minimum temperature | | |
| | Test de Shapiro-Wilk | W | 0.979 |
| | | p-value | 0.635 |
| | | α | 0.05 |
| | Test de Anderson-Darling | A² | 0.397 |
| | | p-value | 0.353 |
| | | α | 0.05 |
| | Maximum Temperature | | |
| April | Test de Shapiro-Wilk | W | 0.971 |
| | | p-value | 0.367 |
| | | α | 0.05 |
| | Test de Anderson-Darling | A² | 0.384 |
| | | p-value | 0.380 |
| | | α | 0.05 |
| | Minimum temperature | | |
| | Test de Shapiro-Wilk | W | 0.981 |
| | | p-value | 0.721 |
| | | α | 0.05 |
| | Test de Anderson-Darling | A² | 0.365 |
| | | p-value | 0.420 |
| | | α | 0.05 |
| | Maximum Temperature | | |
| May | Test de Anderson-Darling | A² | 0.338 |
| | | p-value | 0.487 |
| | | α | 0.05 |
| | Test de Shapiro-Wilk | W | 0.970 |
| | | p-value | 0.349 |
| | | α | 0.05 |
| | Minimum temperature | | |
| | Test de Shapiro-Wilk | W | 0.970 |
| | | p-value | 0.349 |
| | | A | 0.05 |
| | Test de Anderson-Darling | A² | 0.342 |
| | | p-value | 0.476 |
| | | α | 0.05 |

Source: Burkina Faso's National Meteorological Agency, 1981-2024

*Linear regression*

Linear regression is a parametric method employed to identify trends within a time series (Yanogo & Yameogo, 2023; Yameogo & Sawadogo, 2024). It operates under the assumption of a linear relationship between the dependent and independent variables. Linear regression formula is expressed in equation 2.

$$Y = Ax + B \tag{2}$$

Where Y is the dependent variable, x is the independent variable, and A is the estimated slope and B is the estimated intercept. The direction of the trend depends on A. If A is positive, the trend is positive, while if A is negative, the trend is negative.

*Standardised Temperature Anomalies (STA)*

Standardised temperature anomalies were calculated by dividing the anomalies by the climatological standard deviation. The standardised value removes the effects of variability, allowing for a clear interpretation of the anomalies 'magnitude. Equation 3 show the formula for the standardised anomaly computation.

$$Z = \frac{X_i - \mu}{\sigma} \tag{3}$$

Z is STA; $X_i$ is the annual temperature for a particular year; $\mu$ is the long-term average annual temperature over an observation period (1981-2024), et $\sigma$ is the standard deviation of annual temperature.

## Research Results

### ***Trend in maximum and minimum temperatures for the warm months in Koudougou***

Figure 2 shows an upward trend in both maximum and minimum temperatures, as indicated by the positive leading coefficients. However, the level of statistical significance differs across the months. March shows a very high level of significance, clearly supporting the observed increase. In contrast, April presents a moderate level of significance. On the other hand, May and April are the most statistically significant months for minimum temperatures, reinforcing the strength of the rising trend.

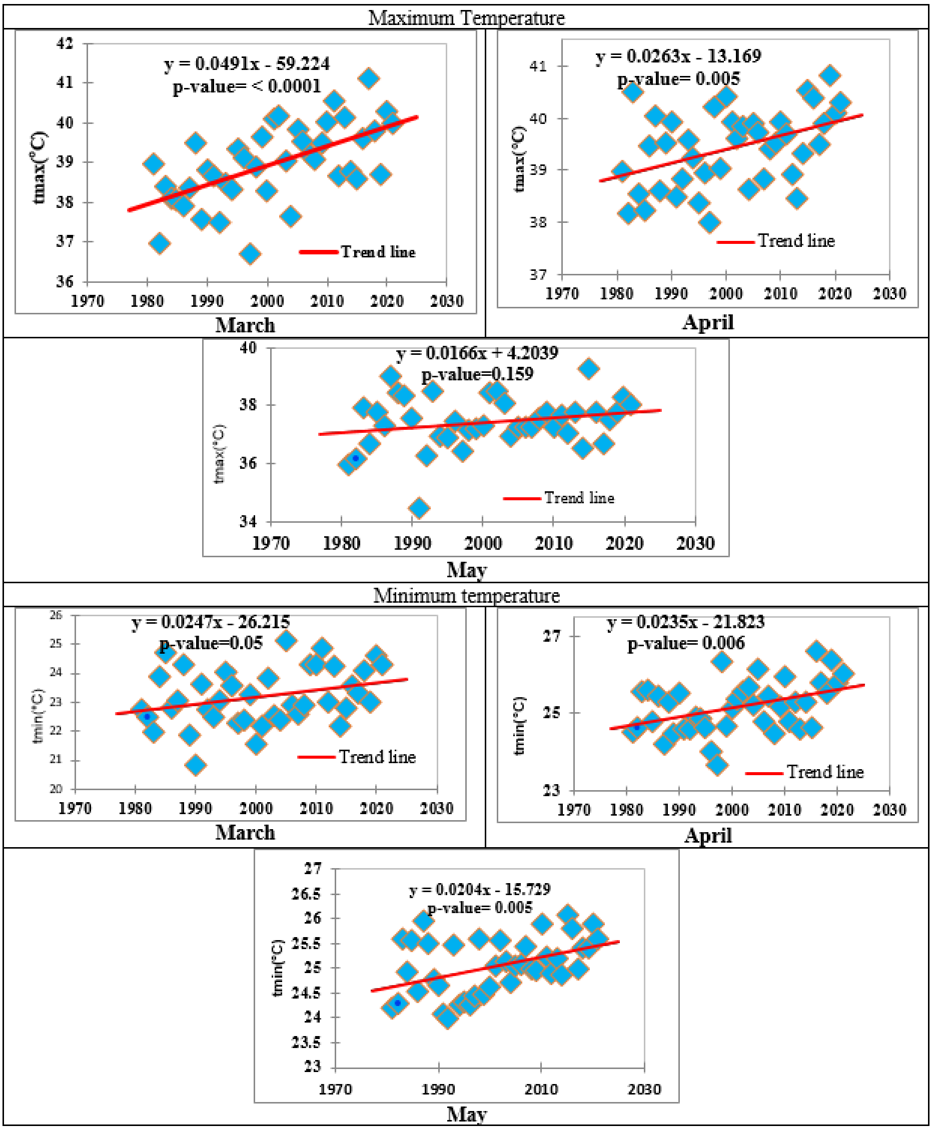


*Fig. 2. March-April-May temperature trends in Koudougou from 1981 to 2024*

### *Annual temperature anomaly trends for warmest and coolest months*

Figure 3 reveals an upward trajectory in maximum temperature anomalies for the months under investigation. March 2024 (STA = 2.56) and April 2024 (STA = 2.66) stand out with markedly above-average values, whereas May's anomaly hovers close to the long-term mean, punctuated by notable peaks in 1987, 2015 and 2024.

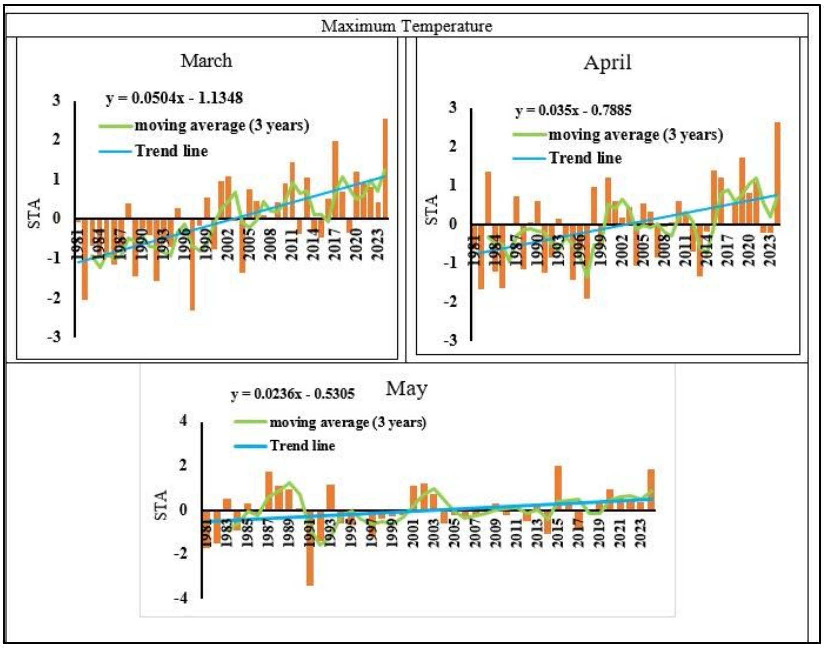


*Fig. 3. Annual maximum temperature anomalies for the hottest months in Koudougou from 1981 to 2024*

Regarding the minimum temperatures, figure 4 illustrates a rising trend in anomalies during the warmest months. In 2024, March (STA = 3.24), April (STA = 4.72) and May (STA = 4.49) all recorded temperatures well above the long-term average.

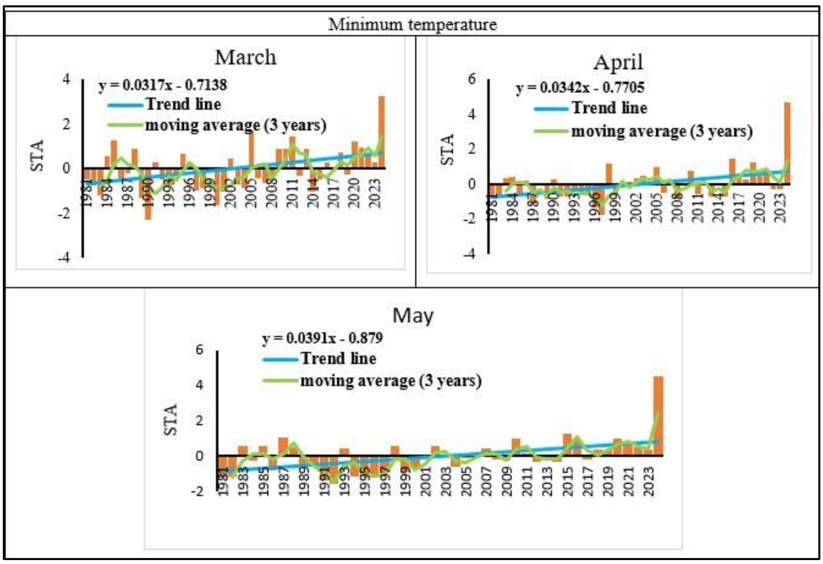


*Fig. 4. Annual minimum temperature anomalies for the hottest months in Koudougou from 1981 to 2024*

***Trends in decadal temperature anomalies for the warmest and coolest months over the period 1981-2024***

Over the decade from 2015 to 2024 (Figure 5), peak temperatures have risen steadily. In 2024, March and May registered maximum values close to the long-term average, whereas April continued the upward drift, culminating in significantly higher temperatures that year.

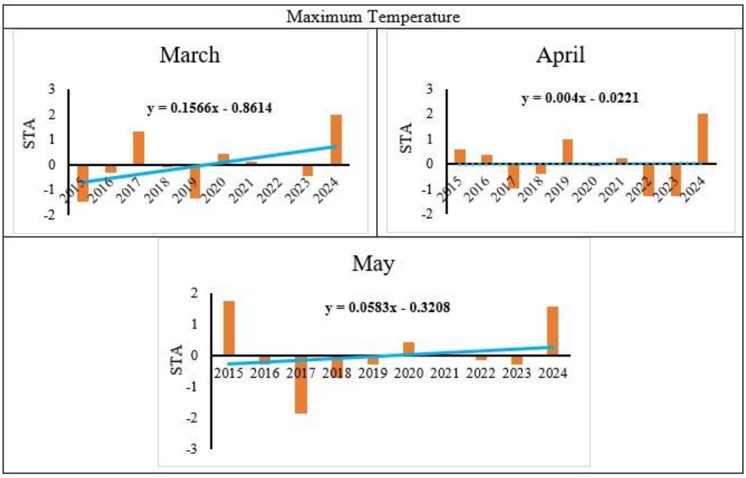


*Fig. 5. Ten-year average maximum temperature anomaly for the hottest months in Koudougou from 2015 to 2024*

For minimum temperatures, figure 6 shows an upward trend in temperature anomalies. Significant increases above-average minimum temperatures were observed in 2024.

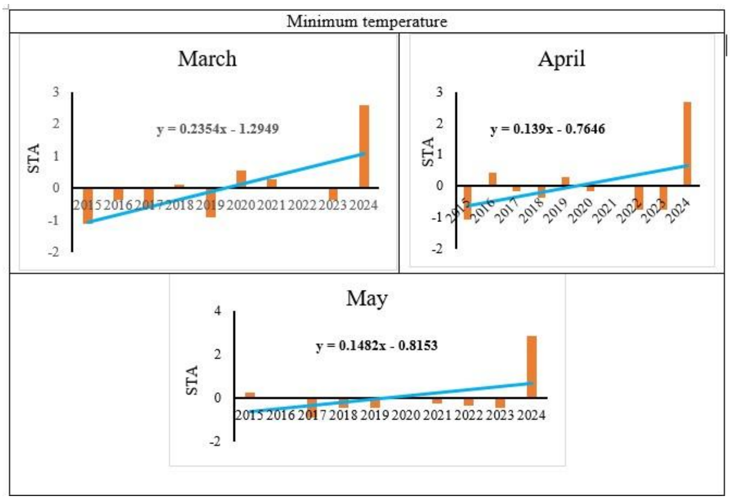


*Fig. 6. Ten-year average minimum temperature anomaly for the hottest months in Koudougou from 1981 to 2024*

***Population's perceptions on temperature patterns quote in the town of Koudougou***

Figure 7 illustrates that respondents clearly recognize a rise in extreme temperatures: 42 % describe them as "very high," 39 % as "high," 17 % as "average," and just 2 % as "low." This pattern indicates that most of the residents perceive temperatures increase in their environment.

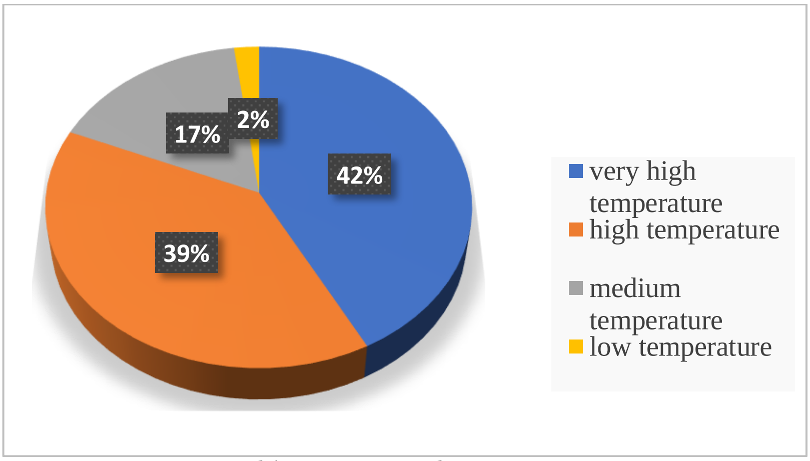


*Fig. 7. People's perception on the temperature patterns*
*Source: Survey, April-May 2024*

These results suggest that the population is mainly experiencing high to very high temperatures. An overwhelming majority (81%) believe that 2024 was the hottest year on record. This situation is not without consequences for the city dwellers and their activities.

***The impact of the increase in extreme temperatures in the city of Koudougou***

*The impact of rising temperatures on bars and restaurants*

An examination of the survey data reveals that heatwaves significantly influenced how people in Koudougou carried out their daily tasks, with the degree of impact varying by profession. Two-thirds of participants (66%) reported that extreme heat disrupted their usual routines, leading to measurable declines in performance at work. Indeed, 36 % of respondents linked these temperature spikes directly to reduced productivity. Conversely, a small minority (4%) found that intense heat had no detrimental effect on their activities; rather, they experienced a boom in business. In particular, vendors of cold refreshments—juice and ice-cream sellers, refrigeration and air-conditioning technicians, and bartenders—saw heightened demand when temperatures soared.

During heatwave episodes, juice and ice-cream operators recorded sales increases ranging from 10 % to 400% compared with the periods immediately before and after these events. Refrigeration and air-conditioning services similarly enjoyed a 10 % to 50 % rise in daily revenue, to the point where customers were sometimes willing to wait several days for services delivery. Meanwhile, maquis and bar owners emerged as the biggest winners, posting daily sales uplifts of 50% to 500% relative to non-heatwave periods.

On the household side, 88% of those surveyed indicated that their expenses climbed during heatwaves. Additional costs stemmed primarily from greater reliance on fans, air conditioners, and refrigerators, as well as increased purchases of fresh water and chilled beverages to stay hydrated. Health concerns were also prominent: 75% of respondents believed that heatwaves lead to heatstroke and dehydration, 15% associated them with respiratory issues, and 5% cited other ailments (see figure 8).

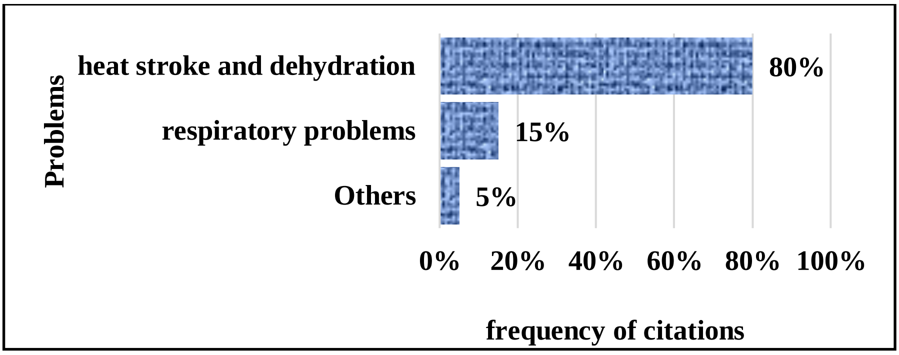


*Fig. 8. Health-related issues caused by rising extreme temperatures*
*Source: Survey, April-May 2024*

*The impact of rising temperatures on the city's electricity and water supply*

Heatwaves bring frequent power outages and interruptions in water service. In fact, 94 % of those surveyed reported experiencing blackouts during hot spells. Of these, 35 % estimated outages lasting around six (06) hours, 44 % around twelve (12) hours, and the remaining 15 % up to twenty-four (24) hours. Such interruptions disrupt daily routines and underscore the vulnerability of the national electricity supply company (SONABEL) network under heavy load. The only households spared are those equipped with solar panels. Moreover, many respondents in Koudougou face similarly timed water cut-offs during these periods, revealing both the surge in demand for water when temperatures increase and the fragility of the Office national water supply company (ONEA). Both, power and water shortages hamper productivity for individuals and businesses, and drive-up costs, as families must purchase water or rent generators.

***Mitigation strategies developed by the population during heat waves***

To cope with heat waves and hot spells, the people of Koudougou have adopted both individual and collective measures to enhance their thermal comfort, mainly by redesigning their homes. Surveys reveal that 57 % of residents have altered their dwellings: wealthier households have installed air-conditioning, while 90 % have added fans and thermal insulation.

In addition to these structural upgrades, 20 % of respondents turn to traditional practices—most notably ventilating living spaces by opening windows and doors—and employ personal tactics like moistening sheets and courtyard floors to cool their surroundings.

Beyond home improvements and ancestral techniques, many inhabitants embrace behavioural adaptations: 30 % report drinking more water while wearing lighter clothing, and another 25 % cite increased hydration alone as their primary strategy (figure 9).

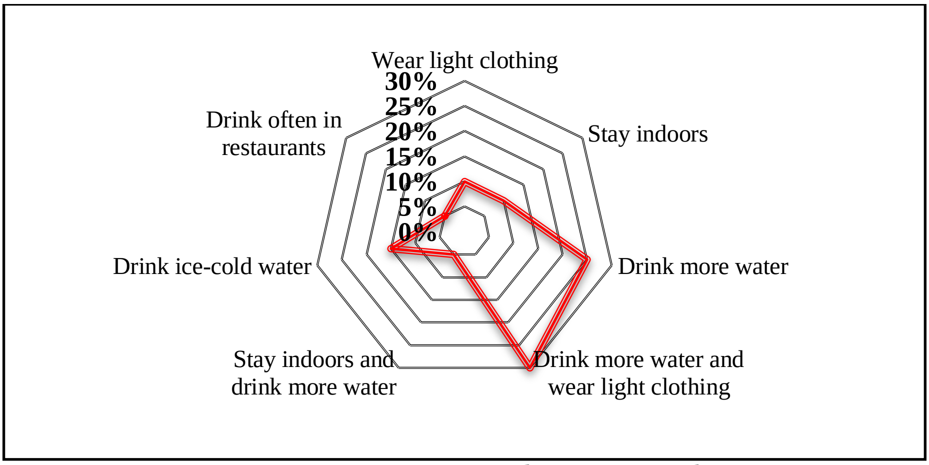


*Fig. 9. Key mitigation strategies under promotion in the city*
*Source: Survey, April-May 2024*

High temperatures also drive the city's residents to adopt collective coping strategies. In fact, 65% choose to spend time in outdoor areas, typically savannahs, green parks, and other cooling spots, where they expect to find fresher air. All respondents in this group favour green spaces, believing that the trees there create a pleasant microclimate, as illustrated in Plate 1. During heatwaves, over 65% of people prefer to spend the night outdoors, while 35% prefer to stay indoors.

*Fig. 10. City dwellers in a shaded area in April.*
*Source: Survey, April 2024*

## Discussion

### *Temperature trends in Burkina Faso and West Africa*

Analysis of temperature records for Koudougou, Burkina Faso, over the period 1981 - 2024 revealed a clear warming trend. The year 2024 stood out for its extreme heat, with daily highs nearing 45 °C and several pronounced heatwave events. These findings align with sociological survey results indicating that March, April, May and June are the hottest months locally. An upward trajectory in both extreme maximum and minimum temperatures has already been documented for Burkina Faso's Sudano-Sahelian zone by Yaméogo (2024) and Yaméogo and Yanogo (2023). For the entire country, the studies of Yaméogo and Rouamba (2023) as well as Rouamba et al. (2023) have revealed the increasing trend of temperature extremes for the period 1960 - 2023. Likewise, Ngoungué-Langué (2023) reported an increasing frequency and severity of West African heatwaves, a pattern attributed to climate change, with rapidly growing urban centres particularly at risk. Since 2014, the most intense heatwaves have impacted this region, notably the Sudanese belt encompassing Koudougou (Rome et al., 2016). Bambara et al. (2018) observed that cold spells occur less often than hot spells in Ouagadougou and Ouahigouya, coupled with rising minimum temperatures in Ouagadougou and rising maximums in Ouahigouya between 1956 and 2015. Kaboré et al. (2019) further noted that 97 % of residents perceive a general increase in heat. The evolving patterns in heatwave frequency, intensity, and spatio-temporal extent underscore the urgent need to rethink public health awareness around heat-related risks.

### *Heatwaves-related issues and mitigation strategies*

Heatwaves lead to dehydration and respiratory issues for a portion of the population. According to Ngoungué Langué (2023), heatwaves significantly affect both human health and the environment in West African cities. He noted that these urban areas, being densely populated, are strongly vulnerable to the impacts of extreme heat. Rome et al. (2016) also highlighted the health risks associated with heatwaves. Similarly, Pascal et al. (2019) reported that heatwaves contributed to nearly 36,000 deaths in France between 1974 and 2018. This is further supported by De Bono et al. (2004). Eady et al. (2020) emphasized that urban areas, due to the heat island effect, experience increased rates of mortality and morbidity during such events.

However, these studies largely overlooked the effects of heatwaves on household productivity. Indeed, high temperatures disrupt daily activities, reduce productivity, and increase household expenses. At the same time, certain sectors, such as refrigeration services, air conditioning, and maquis/bar businesses record increased profits during these periods.

In response to recurring heatwaves and high temperatures, residents of Koudougou have developed various coping strategies. Some households have installed fans and air conditioning, while individuals have adopted adaptive behaviours such as drinking more water, wearing lighter clothing, and staying indoors. Eady et al. (2020) stressed the importance of raising awareness about the dangers of extreme heat to ensure that the population is well-informed.

## Conclusion

The temperature has significantly increased between 1981 and 2024 and has affected the population's daily life. These changes have disrupted routine activities, lowered productivity, and increased household expenses. Power outages and water shortages have worsened the situation, underlining the fragility of existing infrastructure in the face of extreme heat. To address heat-challenges and enhance resilience to climate change, it is crucial to develop a comprehensive and integrated strategy. This should include investments in upgrading electricity and water supply systems to minimize load shedding and service interruptions, particularly during periods of intense heat. Effective communication of mitigation strategies through diverse platforms, including social media, is essential. Moreover, promoting both traditional and modern heat management practices can play a vital role.

Public awareness campaigns should emphasize personal protection measures such as staying hydrated and wearing lightweight clothing. In addition, financial assistance should be made available to support the installation of cooling technologies and improve home insulation. These interventions will help reduce the adverse effects of heatwaves and boost the population's capacity to adapt to climate-related challenges. In the era of increasing climate change effects of population and their environment, there is a need for evaluating the adaptation strategies and their socio-economic effects in vulnerable urban settings.

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