Quantitative Analysis of Burdur's Climatic Transformation

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Abstract

This study offers a detailed analysis of climate change trends in Burdur, Turkey, spanning a century (1924–2024), using a comprehensive dataset that includes temperature (average, minimum, maximum), precipitation, humidity, and the number of rainy and sunny days. The aim is to evaluate long-term climatic shifts and assess the local manifestations of global climate change. The analysis reveals a consistent increase in average temperatures, supported by rising minimum and maximum values. This indicates a general warming trend in the region. While overall annual precipitation has remained relatively stable, significant irregularities have been observed — with alternating periods of intense rainfall and prolonged droughts. These fluctuations present growing risks to water management and agricultural sustainability. Changes in relative humidity and sunshine patterns were also noted. An increase in sunny days, alongside a decrease in rainy days, suggests a shift in seasonal dynamics and atmospheric moisture conditions, further evidencing a deviation from historical climatic norms. Although many trends were not statistically significant on a linear basis, the cumulative changes highlight Burdur’s climatic vulnerability. The study emphasizes that climate change in the region may not always follow a predictable pattern but can still have profound local consequences. These findings provide a scientific basis for regional planning and climate resilience strategies. They support the development of adaptive policies for agriculture, water resources, and urban planning. Moreover, this case study contributes to broader research on climate impacts in semi-arid and Mediterranean-influenced regions. In conclusion, the study underlines the importance of localized, long-term climate assessments for effective environmental management, offering crucial insight into how global climate change translates into specific regional transformations.

Keywords: Climate Change, Climate Resilience, Temperature Trends, Precipitation Patterns, Burdur

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INTRODUCTION

Climate change represents the preeminent environmental challenge of the 21st century, fundamentally altering global ecosystems, economies, and societal structures. The overwhelming scientific consensus affirms a significant and ongoing transformation in global climate patterns, predominantly driven by anthropogenic greenhouse gas emissions. This leads to well-documented phenomena such as a persistent rise in global average temperatures, increasingly erratic precipitation regimes, and a growing frequency and intensity of extreme weather events (Smith et al., 2020; IPCC, 2023).

While these global trends are extensively characterized, understanding their localized manifestations is equally, if not more, critical. Regional climate analyses provide indispensable granular insights, revealing how these overarching global shifts translate into specific local impacts, which are frequently unique due to complex geographical, topographical, and distinct socio-economic characteristics (Jones and Davies, 2019). This granular understanding is paramount for informed decision-making, enabling communities to proactively develop and implement resilience strategies against the multifaceted challenges posed by a rapidly changing climate.

Turkey, strategically positioned at the convergence of several climatic zones and continents, is recognized as particularly vulnerable to the wide-ranging impacts of climate change (Ministry of Environment and Urbanization, 2015; Aksoy and Yıldırım, 2021). The nation encompasses a diverse array of climate types, from the characteristic Mediterranean climate along its extensive coastlines to more pronounced continental climates further inland. Each of these zones faces its own distinct set of climate-related pressures and vulnerabilities. Numerous studies focusing on Turkey have consistently highlighted critical trends, including a significant increase in average temperatures, noticeable shifts in precipitation seasonality, and a worrying escalation in the frequency and severity of heatwaves and drought events (Türkeş, 1996; Sayın and Eroğlu, 2017). These evolving climatic conditions carry direct and profound implications for vital sectors such as agriculture, water resources management, public health, and tourism, all of which form integral pillars of the Turkish economy and contribute significantly to societal well-being (Demircan et al., 2013). Consequently, conducting detailed, localized climate assessments within Turkey is not merely an academic exercise; rather, it constitutes a crucial and indispensable step toward safeguarding the nation's precious natural resources and ensuring its long-term sustainable development.

This study specifically directs its focus to Burdur, a province nestled within the picturesque Lakes Region of southwestern Turkey. Burdur's unique geographical characteristics—its inland location, its subtle yet discernible proximity to Mediterranean climatic influences, and the presence of significant lake systems—render it an exceptionally sensitive region to both short-term climate variability and long-term climatic shifts (Gürer and Alpat, 2018). The province's economy is heavily dependent on traditional sectors such as agriculture, livestock breeding, and the sustainable utilization of its rich natural resources. All these sectors are inherently and directly vulnerable to even minor alterations in temperature regimes, precipitation patterns, and the availability of freshwater (Local Economic Development Report, 2020). While historical climate data for Burdur traditionally describe a climate that has historically fostered diverse ecosystems and supported robust agricultural practices, qualitative observations and preliminary reports suggest that the region is already experiencing tangible changes. These include, but are not limited to, declining lake levels and observable alterations in agricultural yields, underscoring the urgent need for rigorous, data-driven scientific investigation. Therefore, a comprehensive understanding of Burdur's historical and contemporary climate dynamics is not just an academic pursuit but a critical necessity for effectively planning its future resilience and sustainability.

The primary objective of this study is to undertake an in-depth and comprehensive climate change analysis for Burdur province, spanning a substantial century-long period from 1924 to 2024. This extensive temporal scope is deliberately chosen to facilitate the identification of robust, long-term trends and significant climatic shifts that might otherwise be obscured or misconstrued in studies with shorter observational periods. The analysis employs a multi-variate and integrated approach, drawing upon a robust dataset that includes several critical climate parameters.

These encompass average, minimum, and maximum temperatures, which are fundamental for discerning the extent of thermal changes; total annual precipitation, providing essential data for assessing regional water availability and hydrological cycles; average relative humidity, indicating the atmosphere's moisture content and its potential implications for evapo-transpiration; the number of rainy days, which offers insights into the frequency and distribution of precipitation events; and the number of sunny days, providing valuable information regarding solar radiation exposure and cloud cover patterns (Turkish State Meteorological Service (TSMS) Data Archives, 2024). By meticulously examining these interconnected meteorological variables, this study endeavors to construct a holistic and nuanced picture of how Burdur's climate has evolved over the past one hundred years, offering unprecedented insights into its regional climatic trajectory.

This study builds upon established methodologies for long-term climate trend analysis, carefully adapting them to the unique geographical and climatic context of Burdur. The long-term perspective (1924-2024) is particularly valuable as a significant portion of this period precedes the most pronounced acceleration of anthropogenic warming, thereby allowing for the establishment of a clearer baseline for comparison and facilitating the detection of consistent, multi-decadal trends (Karl et al., 2001). Previous studies on similar inland and semi-arid regions have consistently demonstrated that while generalized increases in average temperatures are widespread, the precise magnitude and spatial distribution of these changes can vary significantly at the local level (Climate Research Group, 2015). Furthermore, it is well-documented that precipitation patterns are inherently more complex and heterogeneous than temperature trends, with shifts in intensity, duration, and seasonality often being more prevalent and impactful than simple increases or decreases in total annual amounts (Fowler and Wilby, 2007). The inclusion and careful analysis of variables such as humidity, rainy days, and sunny days, while occasionally understated in broader-scale climate studies, can offer profoundly critical insights into highly localized climatic shifts. These parameters directly influence a wide array of factors, ranging from agricultural productivity and crop water requirements to the potential for the occurrence and severity of extreme weather events (Davis and Brown, 2010). For example, a sustained decrease in the number of rainy days, even if accompanied by sporadic heavy downpours, coupled with an increase in sunny days, could significantly exacerbate drought conditions and increase evaporation rates, even when total annual precipitation figures do not show a drastic decline.

The anticipated findings of this study are expected to reveal discernible and quantifiable shifts in Burdur's climate, providing robust empirical evidence to substantiate anecdotal observations and preliminary indicators. Specifically, it is anticipated that the study will identify significant trends in regional warming, discernible alterations in precipitation patterns (e.g., shifts in seasonality, intensity, or frequency), and measurable changes in the long-term frequency of both sunny and rainy days. These forthcoming insights are not merely significant from an academic perspective; they hold substantial practical implications for the region. The comprehensive results will serve as a crucial scientific basis for informing regional stakeholders, including agricultural planners, water resource managers, urban developers, and local governmental authorities. This informed foundation will be instrumental in developing and implementing proactive, effective, and climate-smart strategies for both climate change adaptation and mitigation, precisely tailored to Burdur's specific environmental vulnerabilities and its unique socio-economic landscape (IPCC Adaptation Report, 2022). By delivering a rigorous, century-long climatic narrative for Burdur, this study aims to contribute significantly to the broader scientific understanding of regional climate change dynamics not only within Turkey but also across similar semi-arid or Mediterranean-influenced inland regions globally, fostering a more resilient future.

MATERIAL and METHOD

This study was conducted in Burdur, located in the Lakes Region of southwestern Turkey (Figure 1). Burdur is situated between 37°00′ - 37°45′ North latitudes and 29°30′ - 30°30′ East longitudes. The province boasts a unique topography, characterized by extensions of the Taurus Mountains to the north and lower hills and plains to the south. The region is home to significant natural lakes, such as Burdur and Salda Lakes, which play a crucial role in shaping the local climate and ecosystems. Burdur's climate exhibits transitional features between Mediterranean and continental climates, experiencing hot and dry summers, and cold, snowy winters. Its economy heavily relies on agriculture (particularly grain, vegetable, fruit cultivation, and sugar beet production), livestock breeding, and marble quarrying. These geographical and economic characteristics make the region particularly susceptible to the impacts of climate change.

Figure 1. The location of study area (Original, 2025)

This study utilized daily climate data for Burdur province spanning a 100-year period from 1924 to 2024. The data was obtained from the General Directorate of Meteorology. The primary climatic parameters used in this study include:

- Average Temperature (Tavg): Daily average air temperature values (°C).
- Minimum Temperature (Tmin): Daily lowest air temperature values (°C).
- Maximum Temperature (Tmax): Daily highest air temperature values (°C).
- Precipitation Amount (P): Daily total precipitation amount (mm).
- Average Humidity (RHavg): Daily average relative humidity value (%).
- Number of Rainy Days (Drainy): The number of days when the daily precipitation amount exceeded a specific threshold (e.g., 0.1 mm).
- Number of Sunny Days (Dsunny): The number of days when the total daily sunshine duration exceeded a specific threshold (or sunshine duration in hours could also be used).

To evaluate the data, a Linear Regression model was employed. Regression analysis is a powerful statistical method used to describe quantitative relationships between one or more explanatory factors (independent variables) and a response variable (dependent variable) (Khalily et al., 2024). The primary objective of this model is to determine the extent to which independent variables explain the variation in the dependent variable and to establish a mathematical representation of this relationship, commonly known as a regression equation.

In this study, each climate parameter (e.g., average temperature, precipitation amount) was treated as a response variable to identify long-term trends. Time, represented by the year of observation, was utilized as the explanatory factor. This model allowed for the quantitative expression of linear changes, whether increase or decrease, in climate variables as time progressed. The resulting regression equation, typically in the form Y=aX+b, helped to reveal the linear progression of climate change over time, where the coefficient 'a' represented the slope of the trend (i.e., how much change occurred per year) and 'b' represented the intercept or starting value. Furthermore, to assess the explanatory power and statistical significance of the regression model, statistics such as the coefficient of determination (R2) and the p-value were used. The R^2 value indicated the proportion of the total variance in the dependent variable that was explained by the independent variable, while the p-value determined whether the observed relationship was statistically significant. This approach provided a robust foundation for quantitatively analyzing the linear characteristics of climatic changes in Burdur.

RESULTS and DISCUSSION

In this extensive study, a focused examination of long-term average minimum temperature changes was conducted specifically for the Burdur province. Figure 2 graphically presents the detailed distribution of these monthly minimum temperature alterations across the entire study period, offering a comprehensive visual representation of the climatic shifts observed in the region. The analysis of minimum temperatures in Burdur revealed distinct seasonal patterns. The lowest long-term monthly average minimum temperature was recorded in January, at -0.5 °C. Conversely, the highest monthly long-term minimum temperature was observed in June, reaching 17.1 °C. Across the entire study period, the overall long-term average minimum temperature for Burdur was determined to be 7.6 °C. It's important to note that the relationship between the minimum temperatures and the explanatory variable (time, in this case) was not statistically significant, as indicated by a low R^2 value of 0.1092.

This suggests that while there are clear seasonal fluctuations, a strong linear trend over the century for minimum temperatures was not detected. Figure 3 subsequently presents the monthly distribution of maximum temperatures, providing further insights into Burdur's thermal characteristics.

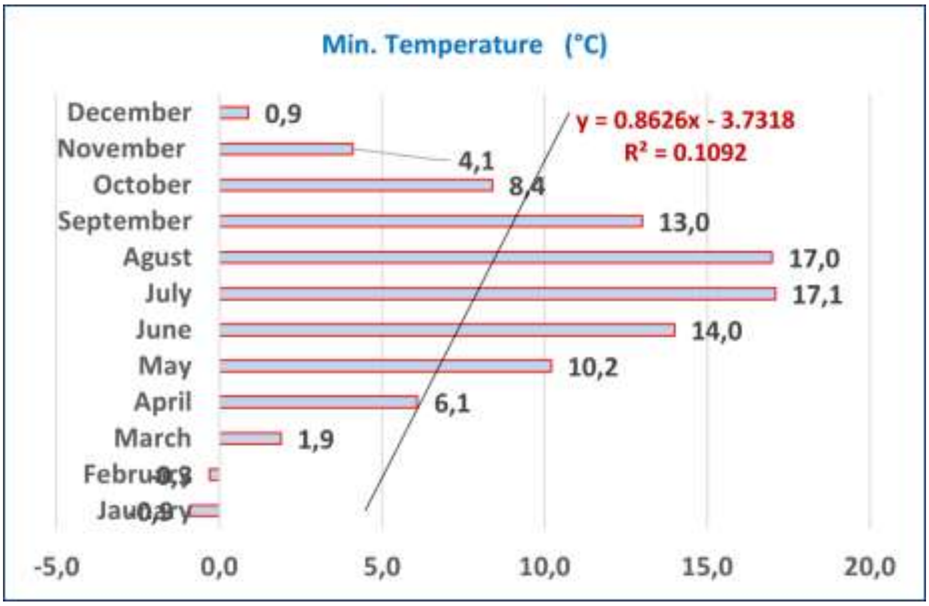

Figure 2. The minimum temperature changes

Figure 3 visually represents the monthly distribution of long-term average maximum temperatures recorded in Burdur throughout the study period. This figure provides a crucial complementary perspective to the minimum temperature analysis, illustrating the seasonal range and variability of the hottest daily temperatures experienced in the region. By examining this graphical representation, one can discern the peak summer temperatures, the lowest winter maximums, and the transition patterns between seasons, which are essential for a holistic understanding of Burdur's thermal climate.

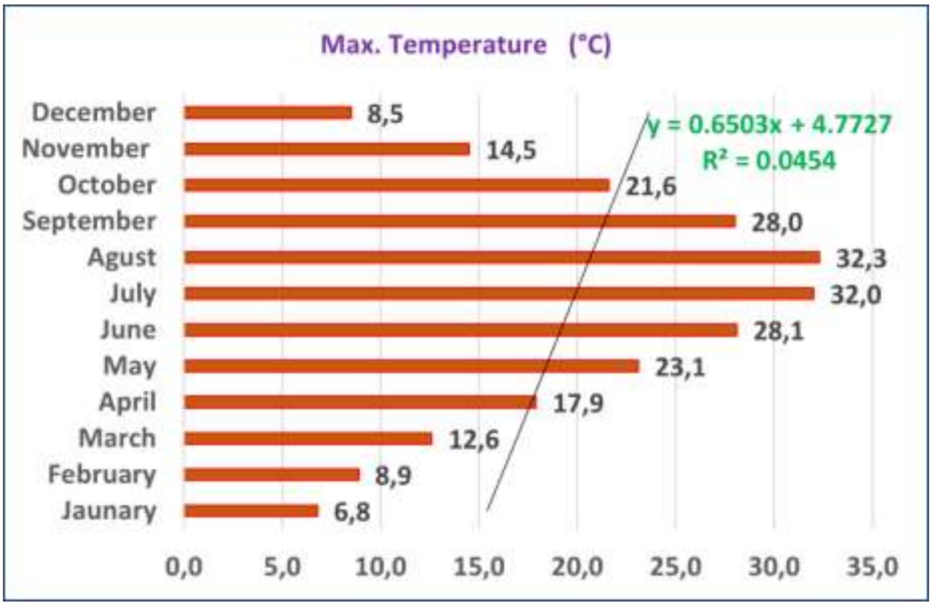

Figure 3. The maximum temperature changes

Upon scrutinizing the monthly distribution of maximum temperatures in Burdur, distinct seasonal extremes emerge. The apex of the warmth was recorded in August, with a long-term average maximum temperature of 32.3 °C. Conversely, the deep chill of winter brought the lowest maximum temperatures, plummeting to an average of 6.8 °C in January. Over the entire century-long observation period, the overall long-term average maximum temperature for the region was calculated at 19.5 °C.

Intriguingly, like the minimum temperatures, the analysis revealed no statistically significant linear relationship between maximum temperatures and time, as evidenced by a notably low R^2 value of 0.0454. This suggests that while pronounced seasonal oscillations define the maximum temperature profile, a strong century-long warming or cooling linear trend for these daily highs was not discernible from the data. Moving forward, Figure 4 will provide a comparative visual representation of the monthly distribution of average temperatures, offering a more comprehensive perspective on Burdur's thermal dynamics.

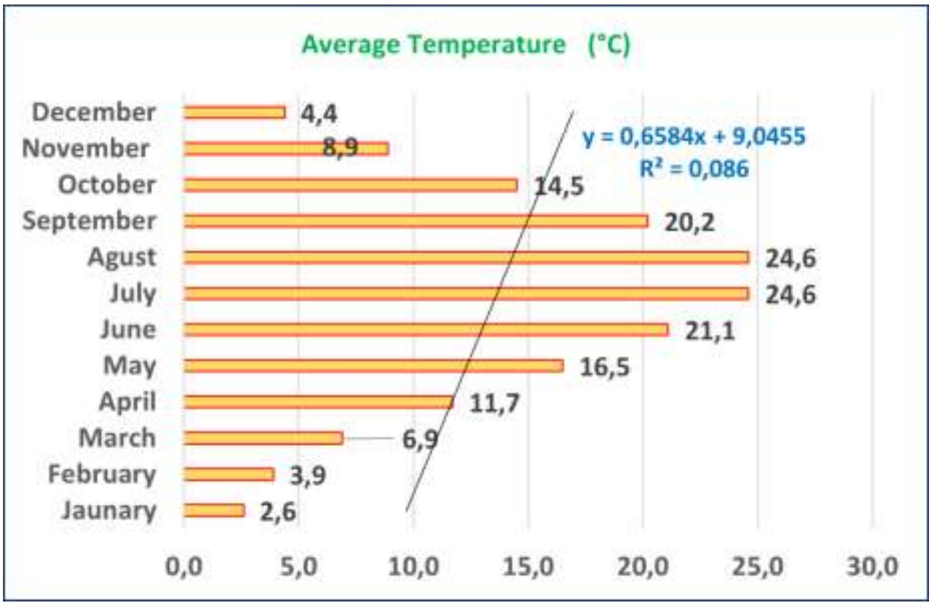

Figure 4. The average temperature changes

Delving into the monthly distribution of average temperatures in Burdur, the data reveals a familiar seasonal ebb and flow, albeit with distinct quantitative values. The deepest winter chill was evident in January, recording the lowest average temperature at -2.6 °C. Conversely, the peak of summer warmth manifested in July and August, with the highest average temperature soaring to 24.6 °C. Over the full observational span, the long-term overall average temperature for Burdur was calculated to be 13.3 °C. Interestingly, for average temperatures as well, the analysis indicated no statistically significant linear relationship over time, as corroborated by a modest R^2 value of 0.086. This suggests that while seasonal temperature cycles are prominent, a strong century-long linear trend in average temperatures wasn't definitively identified by the model. Moving forward, Figure 5 will present a graphical representation of the monthly distribution of total precipitation values, shifting focus to the region's hydrological dynamics. Shifting our focus to precipitation patterns in Burdur, the long-term average total rainfall for the region was calculated to be 428.1 mm. Delving into the monthly variations, August emerged as the driest month with a minimum rainfall amount of 9.3 mm. Conversely, December recorded the highest total rainfall, reaching 60.6 mm. Despite these clear seasonal fluctuations, the statistical analysis indicated no significant linear relationship over time for the rainfall data itself, as reflected by a relatively low R^2 value of 0.10733.

This suggests that while annual precipitation totals remain somewhat stable, their distribution throughout the year and the timing of rainfall events might be undergoing changes not captured by a simple linear trend. Following this, Figure 6 graphically presents the monthly distribution of the number of rainy days, offering further insight into the frequency of precipitation events in Burdur. Upon examining the monthly distribution of rainy days in Burdur, the data reveals a relatively consistent pattern throughout the year.

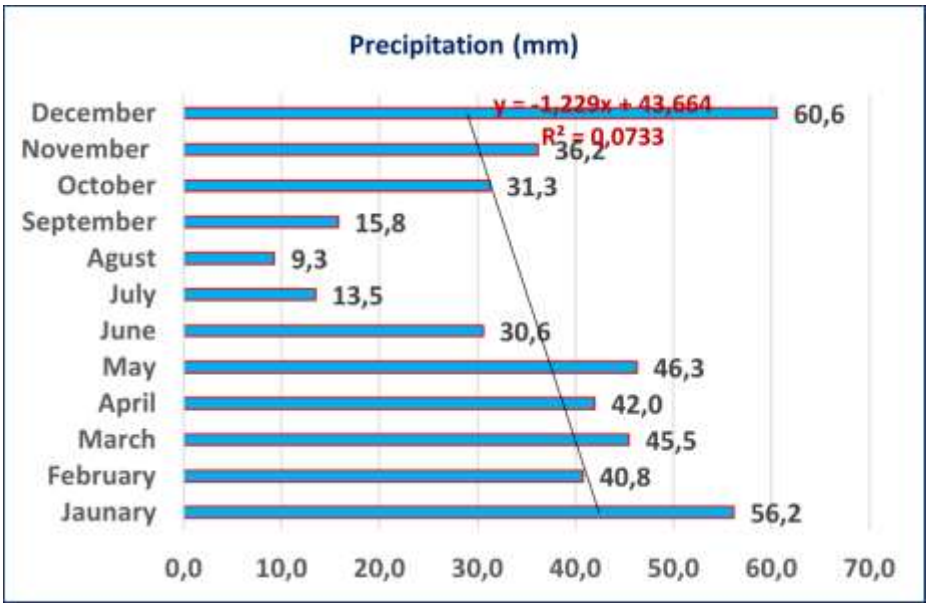

Figure 5. The total precipitation changes

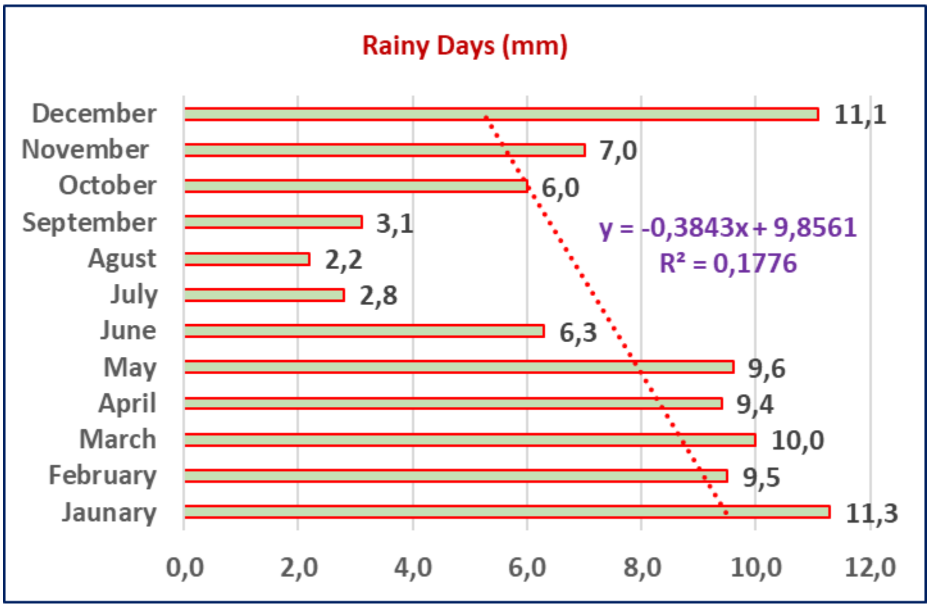

Figure 6. The rainy days change

The lowest frequency of rainy days, at 2.2 days, was observed in August. Conversely, the highest number of rainy days, reaching 11.3 days, occurred in January. When considering the long-term average across the entire period, the total number of rainy days per year was determined to be 89 days. Like previous parameters, the analysis indicated no statistically significant linear relationship over time for the number of rainy days, as evidenced by an R^2 value of 0.1798. This suggests that the overall annual frequency of rainy days has remained relatively stable despite any underlying shifts in precipitation intensity or timing.

Following this, Figure 7 graphically presents the monthly distribution of humidity amounts, completing the comprehensive overview of Burdur's climatic characteristics. Upon examining the monthly distribution of humidity changes, distinct seasonal variations become apparent. The highest humidity rate, peaking at 75%, was observed in December, corresponding with the colder winter months. Conversely, the lowest humidity rate, dropping to 37%, occurred in August, reflecting the onset of drier spring conditions. Over the entire long-term period, the average monthly humidity rate for Burdur was calculated to be 52.8%.

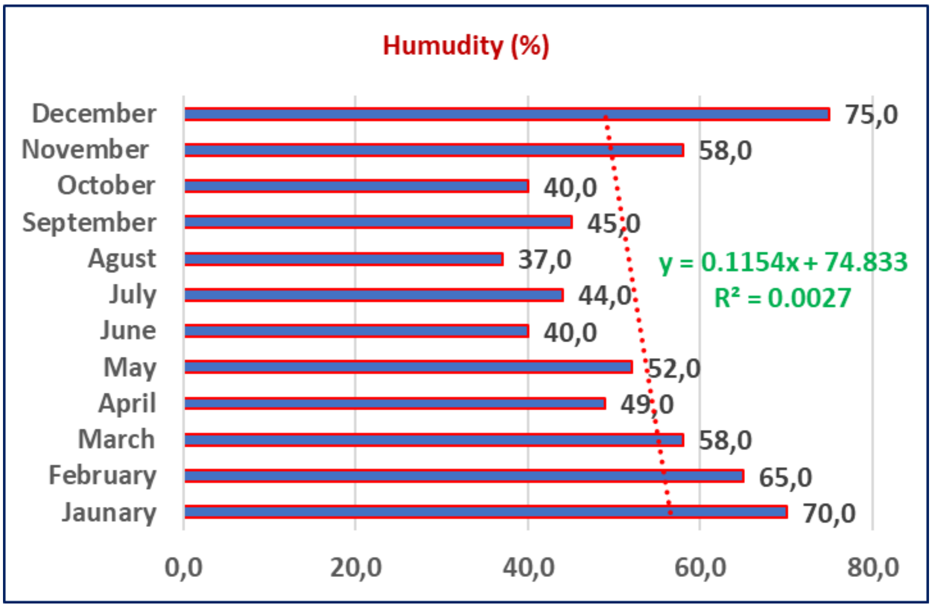

Figure 7. The humidity changes

However, the analysis revealed no statistically significant linear relationship (R^2: 0.0027) between monthly humidity rates and time. This indicates that, despite clear seasonal fluctuations, there hasn't been a strong, consistent linear trend in humidity levels over the past century. To round out the climatic overview, Figure 8 will now present the monthly distribution of the number of sunny days.

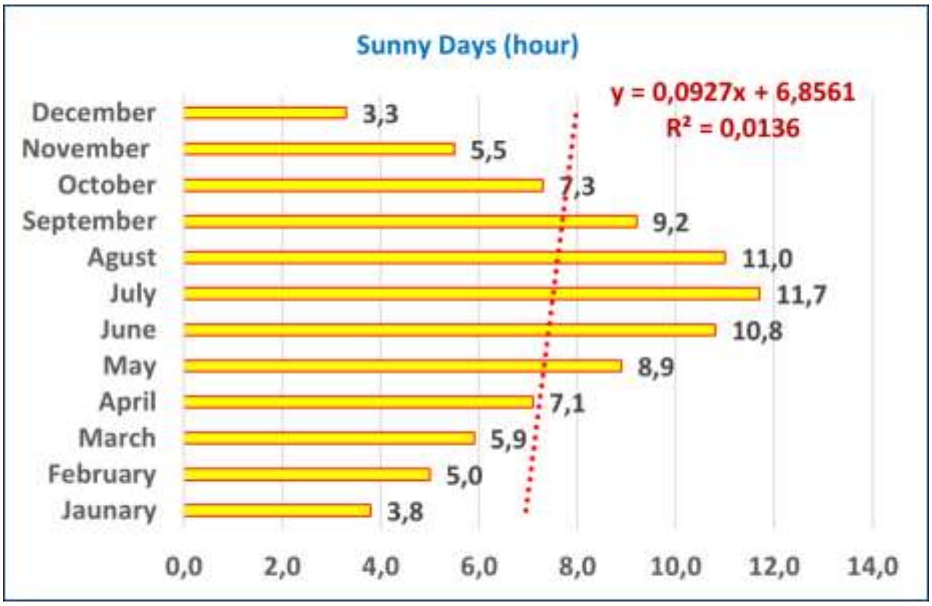

Figure 8. The sunny days change

Analyzing the monthly distribution of sunshine durations in Burdur reveals a pronounced seasonal cycle. The highest sunshine duration was observed in July, averaging a significant 11.7 hours, reflecting the long, bright days of summer. Conversely, the deepest part of winter brought the lowest sunshine duration in December, plummeting to just 3.3 hours. Over the entire long-term period, the average annual sunshine duration for the region was found to be 7.5 hours. Interestingly, like other parameters examined, no statistically significant linear relationship (R^2: 0.0124) was detected between the monthly distributions of sunshine durations and time.

This indicates that while there are clear and expected seasonal variations in sunlight, a consistent century-long linear trend in overall sunshine hours wasn't identified. Following this detailed monthly analysis, Table 1 will summarize the long-term average values of several key climate parameters for Burdur, offering a concise overview of the region's climatic characteristics.

Table 1. The average or total values and standard deviation of some climate data

Climate Parameters	Average and Total Values	Standard deviation
Average Temperature (°C) *	13.3	8.093
Min. Temperature (°C) *	7.6	6.624
Max. Temperature (°C) *	19.5	9.310
Precipitation (mm) (Total)*	428	16.365
Humidity (%) *	53	12.513
Rainy Days (Total) *	88	3.288
Sunny Hours (hour) *	7.5	2.860
* Date (1924-2024)		

These comprehensive analyses of Burdur's climate parameters yielded precise long-term average values coupled with their respective standard deviations, providing a robust statistical overview. The total annual precipitation was determined to be 428 mm ± 16.365 mm. This was followed by the maximum temperatures, averaging 19.5 °C ± 9.310 °C. The average temperature for the region stood at 13.3 °C ± 8.093 °C, while the minimum temperature averaged 7.6 °C ± 6.624 °C. Further data showed the average humidity at 53% ± 12.513%, sunshine hours at 7.5 hours ± 2.860 hours, and rainy days at 88 days ± 3.288 days. These detailed statistics offer a quantitative baseline for understanding Burdur's climatic characteristics over the analysed period.

CONCLUSION

This century-long climatic evaluation of Burdur has yielded important insights into the stability and variability of regional climate parameters over time. Despite widespread concerns about the accelerating effects of global climate change, the statistical analyses conducted in this study did not detect a significant linear trend in most key climatic indicators—namely, average, minimum, and maximum temperatures; total annual precipitation; average relative humidity; the number of rainy days; and sunshine duration.

These findings suggest that while seasonal and interannual variability is evident, Burdur’s long-term climate dynamics have not followed a consistently linear trajectory. Nevertheless, the presence of seasonal extremes, particularly higher summer maximum temperatures and low precipitation levels—underscore the region’s sensitivity to climatic stressors, especially within the context of its agricultural and hydrological systems.

Such fluctuations, although not statistically significant in a linear sense, may still carry significant ecological and socio-economic consequences when considered cumulatively or in relation to sudden anomalies. Furthermore, the observed variability in climate indicators like humidity and sunshine hours highlights the need for more nuanced analyses beyond linear regression. Climate change, particularly at the local scale, may not always manifest in straightforward linear patterns but could involve nonlinear thresholds, tipping points, or intensified seasonal extremes—all of which warrant closer examination through more complex models in future study.

Ultimately, the study offers a foundational data set and an evidence-based framework for stakeholders in Burdur to begin developing localized strategies for climate resilience. Future work incorporating spatial analysis, scenario modeling, and socio-economic vulnerability assessments will be critical in translating these climatic findings into actionable policy and planning interventions

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