Study of Extra Ordinary Heat Wave Condition over Bangladesh in 2024

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Abstract

A heat wave is one of the most extreme weather events affecting Bangladesh. Bangladesh is a tropical country located in South Asia, where the summer season typically extends from March to May. During this period, air temperature gradually increases and heat wave conditions occasionally occur. However, when such conditions persist into the monsoon season (June to September), they can be considered an extraordinary climatic event. This study examines the extraordinary heat wave conditions over Bangladesh in 2024. The analysis shows that the highest maximum temperature recorded was 43.8°C at Jashore on 30 April 2024**.** In addition, several heat wave spells were observed during the monsoon months, particularly in June, and continued intermittently until September, although this period is normally dominated by monsoon rainfall. Consecutive heat wave spells were also detected, with heat wave conditions persisting for more than 27 days**.** The calculated temperature deviations were positive in both the summer and monsoon seasons, indicating significantly higher temperatures compared to the climatological average. Such a pattern has not been observed in the past thirty years. Spatial distribution analysis and interpolation results further reveal that the heat wave conditions extended into the monsoon season across different regions of Bangladesh. Therefore, the findings suggest that 2024 experienced an extraordinary heat wave condition over Bangladesh**,** characterized by unusually high temperatures and prolonged heat wave occurrences extending beyond the typical summer season.

Keywords: Maximum Temperature, Normal Temperature, GIS, Python.

1. INTRODUCTION

Severe heat waves have emerged as one of the most critical climate-related hazards, causing substantial disruption to livelihoods and significantly affecting human well-being across the globe. The increasing frequency, intensity, and duration of extreme heat events are strongly linked to ongoing climate change, with rising global temperatures amplifying heat-related risks [1,2]. According to the Intergovernmental Panel on Climate Change, extreme heat events are projected to occur more frequently and persist for longer durations, particularly in tropical and subtropical regions. These changes have profound implications for human health, labor productivity, food security, and economic stability. The World Health Organization further identifies heat waves as a major environmental health threat, contributing to increased mortality, heat stress, and reduced work capacity, especially among vulnerable populations such as outdoor workers and low-income communities [3,6].

In Bangladesh, heat waves are a common climatic phenomenon, particularly during the pre-monsoon (summer season), known as March–April–May (MAM). During this period, high temperatures combined with elevated humidity levels create intense thermal stress, significantly affecting daily activities and economic productivity. While heat waves are typically confined to the summer season, their persistence into the monsoon period (June to September) is considered an extraordinary climatic event, indicating a shift in seasonal patterns and an extension of heat stress beyond its normal temporal boundary [7,8]. Such prolonged exposure to extreme heat can severely impact agriculture, reduce crop yields, disrupt water availability, and increase the risk of heat-related illnesses. The situation became particularly alarming in 2024, when Bangladesh experienced an extended period of extreme heat conditions. From March to September, most parts of the country recorded a rapid and sustained increase in temperature, leading to widespread heat stress. Data from the Bangladesh Meteorological Department indicate that the highest maximum temperature reached 45.1°C, significantly exceeding the long-term climatological average (BMD,

2024). This record-breaking temperature highlights the growing severity of heat wave events and reflects broader regional warming trends observed across South Asia [9,10]. Such extreme conditions have disrupted livelihoods, particularly for those engaged in outdoor and climate-sensitive occupations, including agriculture, construction, and informal labor sectors. The Bangladesh Meteorological Department defines a heat wave when the daily highest maximum temperature exceeds 36°C. Based on intensity, heat waves are categorized into four levels: mild (36–38°C), moderate (38–40°C), severe (40–42°C), and very severe (above 42°C) (BMD, 2024). These classifications are essential for assessing the severity of heat events and their potential impacts on human health and socio-economic systems.

2. DATA USED, EXPERIMENTAL SET UP AND METHODOLOGY

To investigate the extraordinary heat wave conditions over Bangladesh in 2024, a comprehensive dataset of daily highest maximum temperature records was collected from the Bangladesh Meteorological Department (BMD) observatories covering the pre-monsoon (March–May) and monsoon (June–September) seasons. Quality control procedures were applied to remove missing, erroneous, and inconsistent data. Heat wave events were identified based on standard threshold criteria (e.g., highest maximum temperature ≥ 36°C, 38°C, or 40°C as per national classification). The frequency, duration, and intensity of heat wave occurrences were computed for each station.

This study is based on three-hourly and daily

highest maximum temperature data collected from all surface meteorological stations of the Bangladesh Meteorological Department (BMD) for the year 2024. The dataset was subjected to quality control procedures, including the removal of missing, inconsistent, and erroneous values, and conversion into a uniform format suitable for analysis. Geospatial analysis was performed using GIS techniques to visualize the spatial distribution of temperature and heat wave intensity across the country. Interpolation methods were applied to generate continuous temperature surfaces and isothermal maps, which helped identify the most vulnerable regions. All data processing, analysis, and visualization tasks were conducted using Python, enabling efficient handling of large datasets and reproducible results. The combined use of statistical and spatial analysis techniques provided a comprehensive understanding of the heat wave characteristics over Bangladesh in 2024.

3. RESULTS AND DISCUSSION

3.1 Highest Maximum Temperature in March, 2024

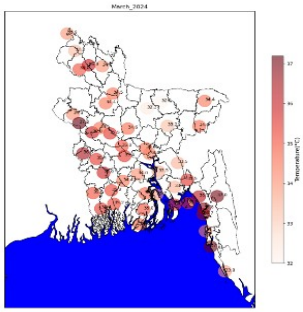

Fig. 1: Highest maximum temperatures observed at stations in March 2024.

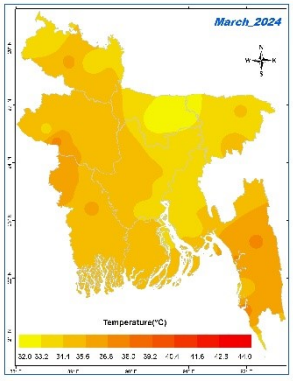

Fig. 2: Spatial distribution of highest maximum temperature (°C) in March 2024.

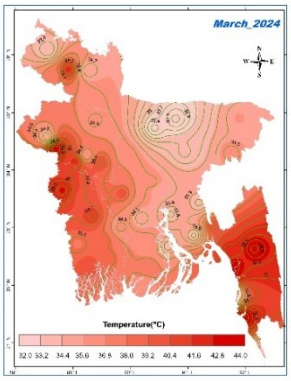

Fig. 3: Isothermal map of highest maximum temperature (°C) for March 2024.

The spatial distribution of highest maximum temperature in March 2024 (fig. 2) across Bangladesh reveals a clear and uneven pattern, indicating the early influence of pre-monsoon heat conditions. The observed temperatures range approximately from 32°C to 37°C, with higher predominantly concentrated in the western and southwestern regions, including areas such as Khulna, Jessore, and Rajshahi (fig. 1). In

contrast, the central region, including Dhaka and its surrounding areas, records moderately high temperatures ranging between 34°C and 36°C, which may also be influenced by urban heat island effects. The northern parts of the country exhibit slightly lower, generally between 33°C and 35°C. Furthermore, the eastern and northeastern regions, particularly Sylhet, show relatively lower maximum temperatures ranging from 32°C to 34°C. The spatial distribution of highest maximum temperature in March 2024 exhibits a distinct regional gradient across Bangladesh, characterized by comparatively higher temperatures in the western and southeastern parts of the country. The western region, particularly areas adjacent to the Jashore and Chuadanga belt, shows elevated temperature zones, generally exceeding 36–38°C, indicating early seasonal heat intensification. Similarly, the southeastern region including parts of Chattogram, also records relatively highest maximum temperatures. In contrast, the central-northeastern region, especially around Mymensingh, Netrokona, Sunamganj, displays relatively lower temperature values (approximately 32–34°C), forming a cooler pocket within the national temperature field. The overall pattern reflects a west-to-east and northwest-to-central cooling tendency, likely influenced by regional climatic factors such as topography, proximity to water bodies, and atmospheric circulation. The thermal distribution of highest maximum temperatures across Bangladesh in March 2024 reveals a distinct pattern of regional variation, characterized by significant thermal gradients between the western and eastern sectors (fig. 3). Data analysis indicates that the highest temperatures, exceeding 39.2°C and reaching localized peaks above 41.6°C were concentrated in the western and southwestern border regions within the Rajshahi and Khulna divisions and the southeastern Chittagong Hill Tracts. These areas exhibited intense heat clusters, likely driven by low moisture levels and continental air masses. In contrast, the northeastern and central-northern regions, including the Sylhet and Mymensingh divisions, maintained relatively lower maximum temperatures, generally ranging between 32.0°C and 34.4°C. The dense concentration of isotherms in the west and southeast highlights sharp spatial heterogeneity, suggesting that while the country experienced a seasonal transition, the geographical positioning and varying topography significantly influenced the severity of the heat distribution.

3.2 Highest Maximum Temperature in April, 2024

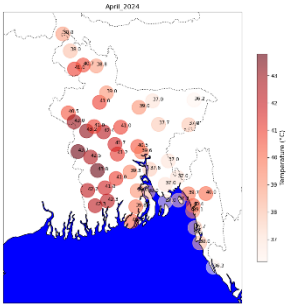

Fig. 4: Highest maximum temperatures observed at stations in April 2024.

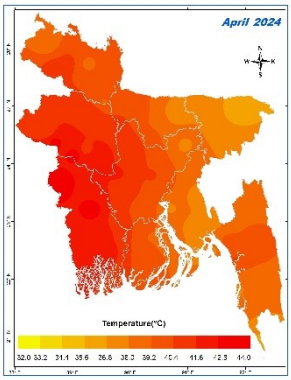

Fig.5: Spatial distribution of highest maximum temperature (°C) in April 2024.

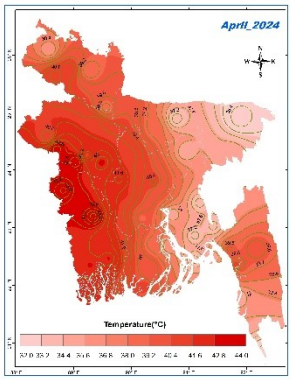

Fig.6: Isothermal map of highest maximum temperature (°C) for April 2024.

The map illustrates the spatial distribution of highest maximum temperatures recorded at meteorological stations across Bangladesh during April 2024 (fig. 4). A clear variation in temperature is observed across different regions of the country. The highest temperatures, exceeding 43°C, are concentrated over the western and southwestern regions, particularly in areas such as Jessore, Chuadanga, and Rajshahi. These regions experienced extreme heat conditions, indicating the early onset of heat wave activity. Central parts of the country, including Dhaka and surrounding areas, recorded temperatures generally ranging between 40°C and 42°C, reflecting significantly hot conditions but slightly lower than the western extremes. In contrast, the eastern and northeastern regions, including Sylhet and parts of Chattogram division, show comparatively lower maximum temperatures, mostly between 36°C and 39°C. The moderating influence of

topography and proximity to moisture sources may have contributed to these relatively lower values. The coastal belt also exhibits slightly reduced temperatures (around 37°C to 40°C) compared to inland western regions, likely due to the influence of the Bay of Bengal. Overall, the map indicates a pronounced west-to-east temperature gradient, with the most intense heat centered in the western part of Bangladesh.

This spatial pattern highlights the severity and uneven distribution of heat conditions during April 2024, which is consistent with typical pre-monsoon heat wave characteristics in the region. The spatial distribution of highest maximum temperatures across Bangladesh in April 2024 reveals a severe heat wave concentrated primarily in the western and southwestern districts (fig. 5). Data from the map indicates a pronounced west-to-east thermal gradient, with the most extreme temperatures exceeding 42.8°C and reaching up to 44.0°C clustered in the Rajshahi and Khulna divisions. These deep red zones signify a critical heat core likely influenced by dry continental air masses from the west. As the distribution moves toward the central and eastern regions, the intensity gradually diminishes. Central Bangladesh, including the Dhaka region, recorded temperatures ranging between 40.4°C and 41.6°C. In contrast, the northeastern (Sylhet) and southeastern (Chittagong hill tracts and coastal belts) sectors remained significantly cooler, with highest maximum temperatures dropping into the 34.4°C to 36.8°C range. Data from the isothermal map indicates that the Rajshahi and Khulna divisions experienced the highest thermal stress, with peak temperatures ranging from 41.6°C to 44.0°C (fig. 6). This concentration of extreme heat is likely driven by the influx of dry, continental air masses from the neighboring landmass. Conversely, the northeastern (Sylhet) and eastern regions recorded significantly lower maximums, with temperatures dropping to between 32.0°C and 35.6°C. This spatial heterogeneity underscores the cooling influence of maritime air and orographic features in the east, contrasting sharply with the intense, localized heat waves observed along the western border. Central regions, including Dhaka, served as a transitional zone with temperatures fluctuating between 39.2°C and 41.6°C.

3.3 Highest Maximum Temperature in May, 2024

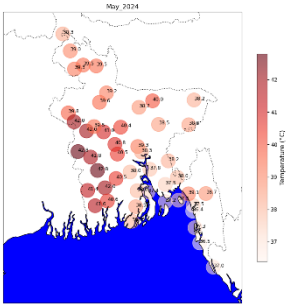

Fig. 7: Highest Maximum temperatures observed at stations in May 2024.

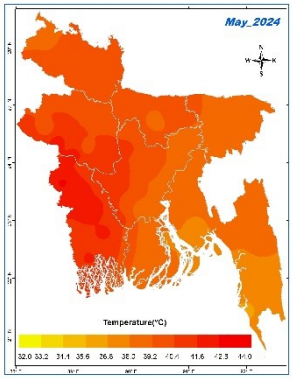

Fig. 8: Spatial distribution of highest maximum temperature (°C) in May 2024.

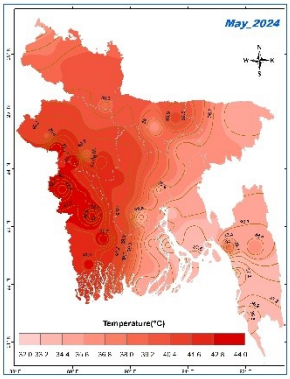

Fig. 9: Isothermal map of highest maximum temperature (°C) for May 2024.

In May 2024, stations located observed of highest maximum temperatures (fig. 7) across Bangladesh exhibited a pronounced west-to-east thermal gradient, with a severe heat core concentrated in the western and southwestern regions. Data analysis from the map indicates that the Khulna and Rajshahi divisions experienced the highest thermal intensity, with recorded maxima frequently exceeding 41.0°C and reaching localized peaks of 42.6°C. This concentration suggests significant continental heating influences along the western border. Conversely, the northeastern (Sylhet) and southeastern (Chittagong) regions maintained relatively lower maximum temperatures, typically ranging between 37.0°C and 38.7°C. The central regions, including the Dhaka division, served as a transitional zone with temperatures hovering around the 39.0°C to 40.5°C mark. This spatial pattern reveals a significant longitudinal disparity, where the western half of the country bore the brunt of extreme thermal stress while the eastern and coastal belts remained comparatively moderated.

The spatial distribution of highest maximum temperatures across Bangladesh in May 2024 reveals a pronounced thermal gradient, with intense heat concentrated in the western and southwestern regions (fig. 8). Analysis of the map data indicates a "heat core" where temperatures reached peak values between 41.6°C and 44.0°C, primarily encompassing the Khulna and Rajshahi divisions. This high-intensity zone signifies severe thermal stress likely driven by dry continental air masses. As the distribution shifts eastward, a gradual cooling trend is observed; the central regions, including Dhaka, exhibited transitional temperatures ranging from 39.2°C to 41.6°C. In contrast, the northeastern (Sylhet) and southeastern coastal belts experienced significantly lower maximums, with temperatures dropping to between 35.6°C and 38.0°C.

This spatial heterogeneity highlights a significant longitudinal disparity, where the western border regions bore the brunt of the heat wave while maritime and orographic factors provided relative moderation in the east. In the isothermal map reveals a heat core spanning the Rajshahi and Khulna divisions**,** where highest maximum temperatures peaked between 41.6**°C** and 42.8**°C,** signifying extreme thermal stress (fig. 9). In contrast, the northeastern (Sylhet) and southeastern (Chittagong and coastal) regions remained significantly more moderated, with maximums ranging from 35.6°C to 38.0°C. The central region, including Dhaka, served as a transitional zone with recorded temperatures between 39.2°C and 40.4°C. This spatial heterogeneity underscores a significant regional disparity, likely driven by the influx of dry continental air in the west versus the relative cooling influence of maritime and orographic factors in the east.

3.4 Highest Maximum Temperature in June, 2024

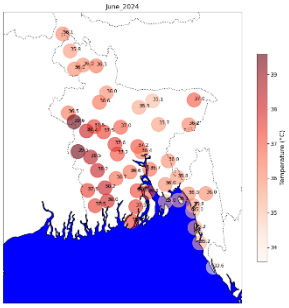

Fig. 10: Highest maximum temperatures observed at stations in June 2024.

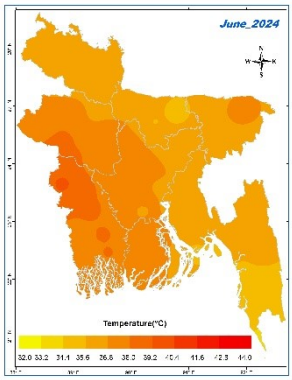

Fig. 11: Spatial distribution of highest maximum temperature (°C) in June 2024.

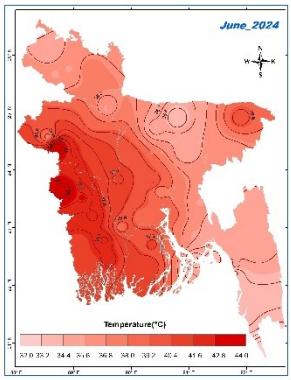

Fig. 12: Isothermal map of highest maximum temperature (°C) for June 2024.

Highest maximum temperatures observed at stations in June 2024 that across Bangladesh reveals a clear thermal gradient increasing from the northeast toward the southwest. Data from the map indicates that the highest temperatures were concentrated in the western and southwestern regions (Khulna and Rajshahi divisions), with peaks ranging between 33.5°C and 34.2°C (fig. 10). These areas represent the most significant heat clusters for the month. In contrast, the northeastern region (Sylhet division) remained the coolest sector, with highest maximum temperatures significantly lower, ranging from 27.0°C to 29.0°C. The central and coastal belts served as transitional zones, maintaining moderate temperatures between 31.0°C and 32.5°C.

The spatial distribution of highest maximum temperatures across Bangladesh in June 2024 reveals a pronounced west-to-east thermal gradient, with the most intense heat concentrated in the western and southwestern regions. According to the isothermal map, the highest temperatures reaching peaks between 39.2°C and 40.4°C were recorded in the Rajshahi and Khulna divisions, indicating a persistent heat core along the western border (fig. 11). In contrast, the northeastern (Sylhet) and southeastern coastal regions experienced significantly lower maximums, with temperatures ranging from 33.2°C to 35.6°C. The central region, including Dhaka, functioned as a transitional zone, with recorded temperatures fluctuating between 36.8°C and 38.0°C.

This spatial heterogeneity underscores the influence of dry continental air in the west, while the eastern and coastal belts were likely moderated by the onset of monsoon precipitation and maritime air masses.

Analysis of the isothermal map reveals a heat core spanning the Rajshahi and Khulna divisions, where temperatures reached peak values between 41.6°C and 44.0°C (fig. 12). These high-intensity clusters indicate severe thermal stress in the western landscape, likely driven by dry continental air masses. In contrast, the northeastern (Sylhet) and southeastern (Chittagong and coastal) regions remained significantly more moderated, with highest maximum temperatures ranging from 32.0°C to 35.6°C. The central region, including the Dhaka division, served as a transitional zone with recorded temperatures fluctuating between 38.0°C and 40.4°C. This spatial heterogeneity underscores a significant regional disparity, where maritime influences and orographic features in the east provided a cooling effect compared to the scorched western and southwestern districts.

3.5 Highest Maximum Temperature in July, 2024

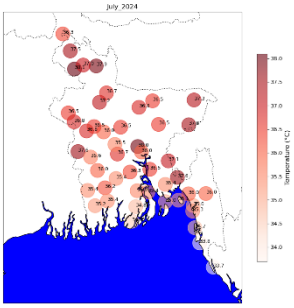

Fig. 13: Highest maximum temperatures observed at stations in July 2024.

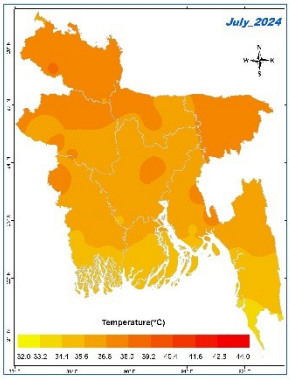

Fig. 14: Spatial distribution of highest maximum temperature (°C) in July 2024.

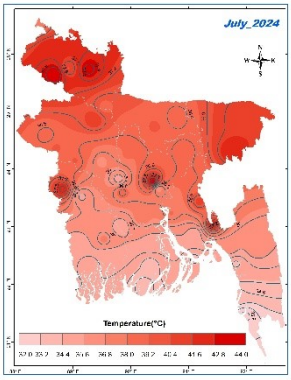

Fig. 15: Isothermal map of highest maximum temperature (°C) for July 2024.

Highest maximum temperatures across Bangladesh in July 2024 observed that demonstrates a significant north-to-south thermal gradient, with the highest intensity concentrated in the northern and northwestern districts. Data analysis from the map indicates that the Rangpur and Rajshahi divisions functioned as the primary heat core, with highest maximum temperatures reaching peak values between 37.5°C and 38.0°C (fig. 13). These areas represent the most severe thermal hotspots for the month. As the distribution shifts southward and eastward, a cooling trend is observed. The central region, including Dhaka, maintained moderate maximums ranging from 35.5°C to 36.5°C. In contrast, the northeastern (Sylhet) and southeastern coastal belts recorded the lowest maximum temperatures, falling within the 33.5°C to 35.0°C range. This spatial heterogeneity suggests that while the northern landmass experienced strong continental heating, the southern and eastern regions benefited from the moderating influences of maritime air and monsoon-related cloud cover. The spatial distribution of highest maximum temperatures across Bangladesh in June 2024 exhibits a pronounced west-to-east thermal gradient, with extreme heat concentrated along the western and southwestern border regions. Data from the isothermal map reveals a heat core spanning the Rajshahi and Khulna divisions, where highest maximum temperatures peaked between 39.2°C and 40.4°C (fig. 14). These high-intensity clusters indicate severe thermal stress in the western landscape, likely driven by dry continental air masses. In contrast, the northeastern (Sylhet) and southeastern (Chittagong and coastal) regions remained significantly more moderated, with highest maximum temperatures ranging from 33.2°C to 35.6°C. The central region, including the Dhaka division, served as a transitional zone with recorded temperatures fluctuating between 36.8°C and 38.0°C. This spatial heterogeneity underscores a significant regional disparity, where maritime influences and early monsoon-related precipitation in the east provided a cooling effect compared to the more intense heat observed in the west. The isothermal map indicates that the highest thermal intensity was concentrated in the northern and northwestern regions, particularly within the Rangpur and Rajshahi divisions, where temperatures peaked between 40.4°C and 41.6°C (fig. 15). These localized heat cores suggest intense continental heating in the northern landmass during this period. In contrast, the southeastern and coastal

regions remained significantly more moderated, with highest maximum temperatures ranging from 33.2°C to 34.4°C. The central part of the country, including the Dhaka division, functioned as a transitional zone, maintaining values between 36.8°C and 38.0°C. This spatial pattern underscores a clear climatic disparity where the northern interior experienced extreme heat, while the southern maritime influence and orographic features in the east provided a substantial cooling effect, resulting in a temperature difference of approximately **7**°C to 8°C across the national landscape.

3.6 Highest Maximum Temperature in August, 2024

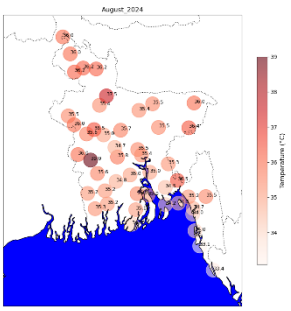

Fig. 16: Highest maximum temperatures observed at stations in August 2024.

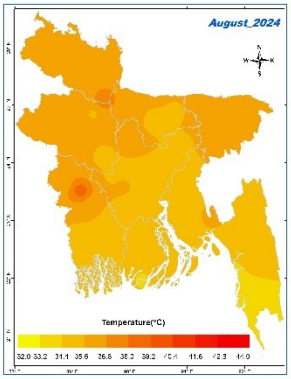

Fig. 17: Spatial distribution of highest maximum temperature (°C) in August 2024.

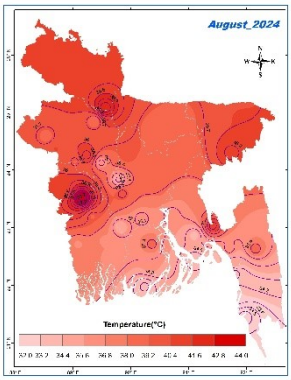

Fig. 18: Isothermal map of highest maximum temperature (°C) for August 2024.

In August 2024, the highest maximum temperatures across Bangladesh exhibits a pronounced west-to-east thermal gradient, with the highest intensity concentrated along the western border. Data analysis reveals a significant heat in the southwestern and western regions (notably within the Khulna and Rajshahi divisions), where temperatures reached peak values between 37.5°C and 38.8°C (fig. 16). These high-intensity clusters indicate localized thermal stress, likely driven by continental air influences. In contrast, the coastal belt and southeastern regions remained significantly more moderated, with highest maximum temperatures ranging from 32.0°C to 34.5°C. The central region, including the Dhaka division, functioned as a transitional zone with temperatures fluctuating between 35.5°C and 36.8°C. The spatial distribution of highest maximum temperatures across Bangladesh in August 2024 reveals a pronounced west-to-east thermal gradient, with a distinct heat core in the western districts. Data from the isothermal map indicates that the highest temperatures were concentrated in the west-central region of Khulna and Rajshahi divisions, where localized peaks reached between 39.2°C and 40.4°C (fig. 17). The southern coastal belt and the southeastern regions including the Chittagong and Cox's Bazar areas maintained the lowest highest maximum temperatures, ranging from 32.0°C to 34.4°C. This spatial heterogeneity highlights the strong moderating influence of maritime air and monsoon precipitation in the south and east. The central and northern regions, including Dhaka and Rangpur, functioned as a transitional zone, with highest maximum temperatures predominantly fluctuating between 36.8°C and 38.0°C. Collectively, the data illustrates a significant regional disparity, with the western interior bearing the brunt of the heat while coastal influences provided a cooling effect of nearly 8°C across the national landscape.

According to the isothermal map, a severe heat wave is concentrated in the west-central region, notably within the Rajshahi and Khulna divisions, where temperatures reached peak values between 41.6°C and 44.0°C (fig. 18). Another localized hotspot is visible in the northern interior, with temperatures peaking around 39.5°C. These high-intensity clusters indicate extreme thermal stress along the western border, likely influenced by dry continental air masses. Conversely, the southern coastal belt and the southeastern regions experienced the lowest highest maximum temperatures, ranging from 32.0°C to 34.4°C. This spatial pattern highlights the strong moderating influence of maritime air and monsoon-related precipitation in the south. The central and northeastern regions, including Dhaka and Sylhet, served as transitional zones with highest maximum temperatures predominantly fluctuating between 36.8°C and 38.0°C. Overall, the data

illustrates a sharp climatic disparity, where the western interior bore the brunt of the heat while coastal and eastern factors provided significant cooling.

3.7 Highest Maximum Temperature in September, 2024

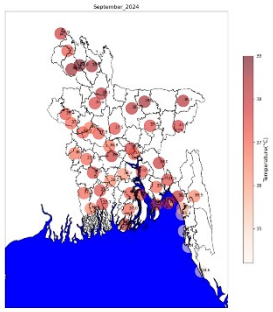

Fig. 19: Highest maximum temperatures observed at stations in September 2024.

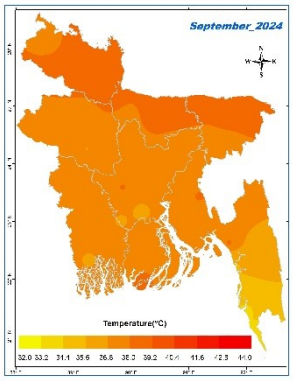

Fig. 20: Spatial distribution of highest maximum temperature (°C) in September 2024.

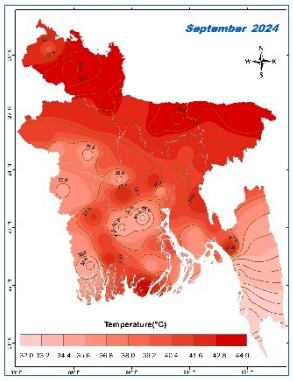

Fig. 21: Isothermal map of highest maximum temperature (°C) for September 2024.

Data from the map (fig. 19) indicates that the most intense heat was concentrated in the northern and northwestern regions, particularly within the Rangpur and Rajshahi divisions, where temperatures peaked between 38.8°C and 39.5°C. These "heat cores," represented by the deepest red clusters, suggest a strong continental heating influence in the northern landmass during this period. In contrast, the southern and southeastern coastal regions remained significantly more moderated, with highest maximum temperatures falling into the 34.5°C to 36.5°C range. The central part of the country, including the Dhaka region, functioned as a transitional zone with recorded temperatures fluctuating between 37.0°C and 38.0°C. This spatial pattern highlights a clear climatic disparity where the northern interior bore the highest thermal stress, while maritime influences and potentially higher cloud cover in the south provided a substantial cooling effect of approximately 3°C to 5°C across the national landscape.

According to (fig. 20), the spatial distribution of highest maximum temperatures across Bangladesh in September 2024 exhibits a clear north-to-south thermal gradient, characterized by higher intensities in the northern interior and relative moderation along the coast. Analysis of the isothermal map reveals that the highest temperatures were concentrated in the northwestern (Rangpur) and northeastern (Sylhet) regions, where maximum values reached between 38.0°C and 39.2°C. These localized hotspots, represented by deeper orange hues, indicate significant continental heating and potential late-monsoon heat stress. Conversely, the southeastern coastal belt and Chittagong Hill Tracts recorded the lowest maximum temperatures, ranging from 33.2°C to 35.6°C. The central region, including Dhaka, functioned as a transitional zone with temperatures predominantly fluctuating between 36.8°C and 38.0°C. This spatial heterogeneity underscores a distinct climatic disparity of approximately 4°C to 6°C across the country, where the northern landmass bore the brunt of the thermal intensity while maritime influences provided a cooling effect in the south.

In September 2024, analysis of the isothermal map (fig. 21) indicates that the primary heat core was concentrated in the northern and northwestern regions (Rangpur and Rajshahi divisions), where temperatures peaked between 38.2°C and 38.9°C. These high-intensity zones, represented by the deep red shading, signify significant continental heating late in the monsoon season. Conversely, the southern coastal belt and southeastern regions exhibited a marked cooling influence, with highest maximum temperatures dropping into the 32.0°C to 34.4°C range. The central region served as a transitional zone with complex micro-thermal pockets ranging from 35.6°C to 37.2°C, while a localized hotspot of 37.5°C is visible in the southeastern hilly tracts. This spatial heterogeneity underscores a significant regional disparity of approximately 7°C, where the northern landmass bore the brunt of the thermal stress while maritime air masses provided a substantial cooling effect in the south.

3.8 Deviation of the Highest Maximum Temperature During the Pre-Monsoon Season, 2024

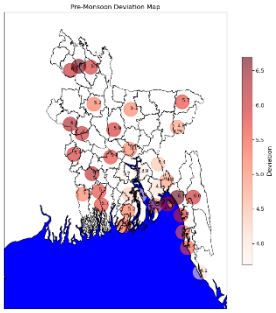

Fig. 22: Deviation of highest maximum temperature observed at stations in pre-monsoon season 2024.

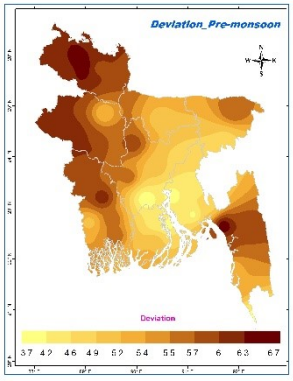

Fig. 23: Spatial distribution of deviation for highest maximum temperature in pre-monsoon season 2024.

The spatial distribution of highest maximum temperature deviations during the 2024 pre-monsoon season in Bangladesh reveals a significant nationwide warming trend, with anomalies ranging from 3.7°C to 6.7°C above long-term averages (fig. 22). The data indicates a pronounced northwest-to-southeast thermal gradient, where the highest deviations exceeding 6.0°C are concentrated in the extreme northwestern districts and localized pockets of the southeastern hill tracts. These anomaly cores represent the areas of most intense thermal stress relative to historical norms. While the entire country experienced positive deviations, the central and southwestern regions showed moderate anomalies between 4.9°C and 5.5°C (fig. 23). In contrast, the lowest relative deviations though still substantially high were recorded in the southeastern coastal belt, with values dipping toward the 3.7°C mark. This widespread positive departure from the mean highlights an exceptionally severe pre-monsoon heat wave, with the northern landmass serving as the primary epicenter for climatic irregularity.

3.9 Deviation of the Highest Maximum Temperature During the Monsoon Season, 2024

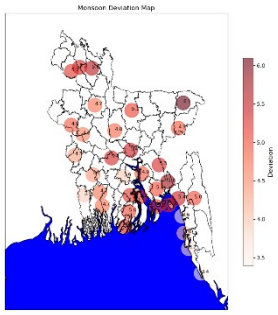

Fig. 24: Deviation of highest maximum temperature observed at stations in monsoon season 2024.

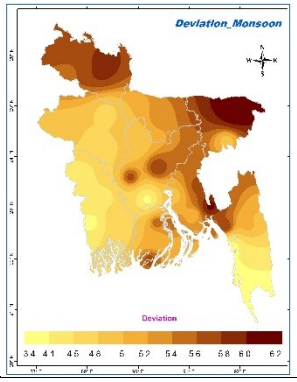

Fig. 25: Spatial distribution of deviation for highest maximum temperature in monsoon season 2024.

The spatial distribution of highest maximum temperature deviations across Bangladesh during the monsoon season of 2024 reveals a significant nationwide warming anomaly, with values ranging from 3.4°C to 6.2°C above historical means (fig. 24). Data analysis indicates a pronounced north-to-south thermal gradient, where the most extreme deviations are concentrated in the northernmost districts (Rangpur division) and parts of the northeast, peaking between 5.8°C and 6.2°C. These anomaly hotspots suggest a severe departure from expected seasonal cooling. While the central and western regions maintained substantial

anomalies between 4.8°C and 5.4°C, the southeastern coastal belt exhibited the lowest relative deviations, dipping to a minimum of 3.4°C (fig. 25).

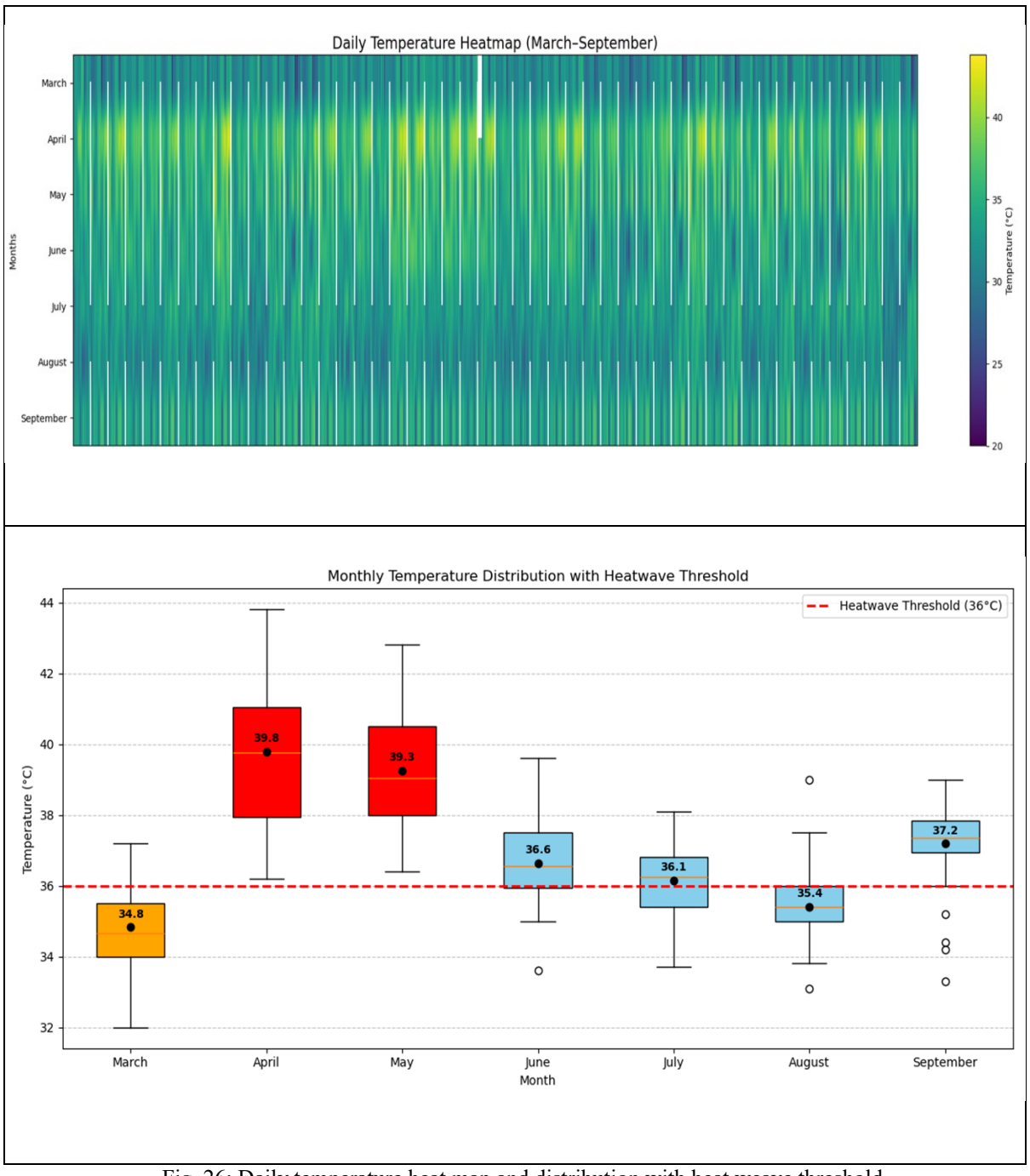

Fig. 26: Daily temperature heat map and distribution with heat weave threshold

The temporal analysis of temperature distribution from March to September 2024 reveals a distinct bimodal heat wave pattern, with peak intensities occurring in the pre-monsoon and late-monsoon phases. According to the data, April and May were the most extreme months, recording the highest mean temperatures of 39.8°C and 39.3°C, respectively. During this period, the entire interquartile range remained well above the 36°C heat wave threshold, indicating persistent and widespread thermal stress (fig. 26). A relative moderation is evident during the mid-monsoon months of June, July, and August, as mean temperatures dipped toward the threshold, with August recording the seasonal low mean of 35.4°C. However, the Daily

temperature heat map (fig. 26) and box plot highlight a significant late-season thermal resurgence in September, where the mean rose back to 37.2°C. This secondary peak, characterized by numerous outliers and a mean exceeding the threshold, confirms the re-emergence of heat wave conditions after the primary monsoon peak.

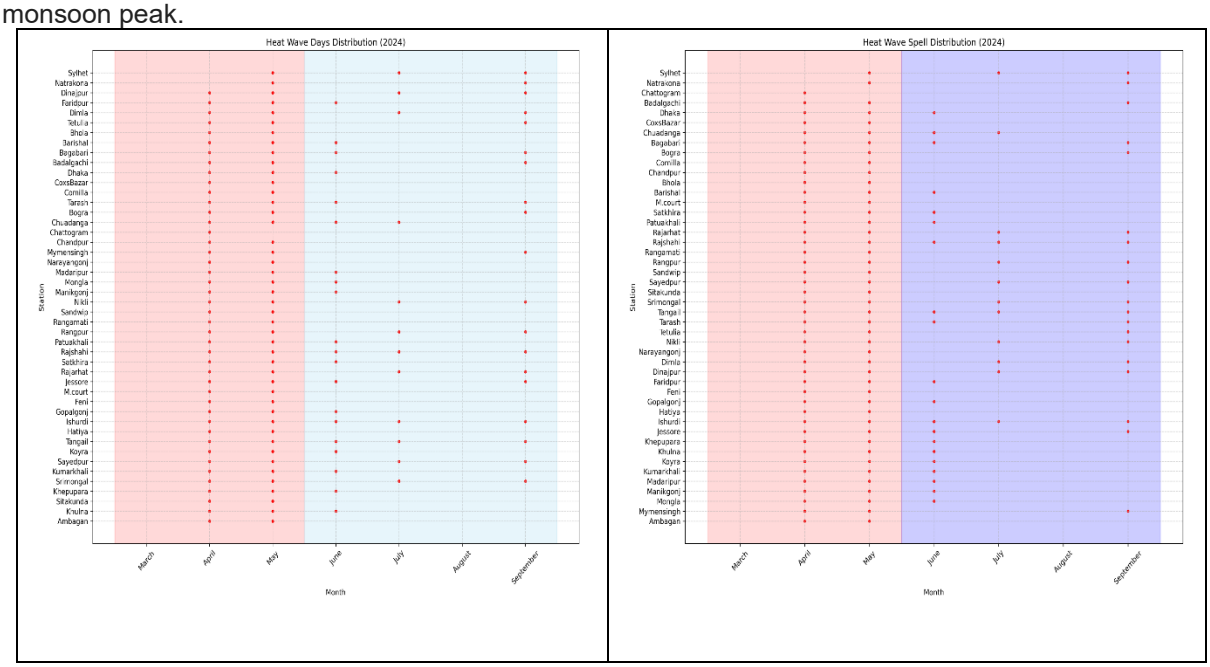

Fig. 27: Monthly distribution of heat wave days and spell

The temporal analysis of heat wave days and spells across Bangladesh in 2024 reveals a distinct bimodal distribution, with the most severe activity concentrated in the pre-monsoon and late-monsoon periods. Data from the distribution plots indicates that April and May served as the primary peak, during which nearly every monitored station ranging from the northern highlands to the southern coast recorded a dense frequency of heat wave days and prolonged spells. This period represents the maximum thermal stress of the year. A significant monsoon-induced moderation is observed in the middle of the season, particularly in August, which serves as a thermal trough with virtually no heat wave occurrences recorded across the stations. However, the data highlights a notable secondary resurgence in September, where both the frequency of heat wave days and the duration of spells increased significantly across northern, central, and southwestern districts. This pattern underscores a climatic transition where the cooling effect of the peak monsoon is bookended by intense heat events, with the pre-monsoon peak remaining the most geographically widespread and persistent.

4. CONCLUSION

The analysis shows that the highest maximum temperature recorded was 43.8°C at Jashore on 30 April 2024. Several heat wave spells were observed during the monsoon months, particularly in June, and continued intermittently until September. Consecutive heat wave spells were also detected, with heat wave conditions persisting for more than 27 days. Temperature deviations were positive in both the summer and monsoon seasons, indicating significantly higher temperatures compared to the climatological average.

April and May, entire distributions are well above 36°C. Indicate persistent and widespread heat wave conditions. June and July, the means are around or slightly above 36°C. Suggest moderate heat wave occurrence. March and August, this means are below 36°C, but upper ranges cross the threshold. Indicates occasional heat wave days. September, the mean is above 36°C, with many values exceeding the threshold. Suggests late-season heat wave re-emergence.

Spatial distribution analysis and interpolation results further reveal that the heat wave conditions extended into the monsoon season across different regions of Bangladesh. The findings suggest that 2024 experienced an extraordinary heat wave condition over Bangladesh, which has not been observed in the past thirty years.

Therefore, this study aims to examine the extent to which severe heat waves disrupt livelihoods and affect people, with a focus on recent extreme events. By addressing this gap, the research seeks to contribute to the development of targeted adaptation strategies and evidence-based policy interventions to mitigate the adverse impacts of heat waves.

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