This review article summarizes published studies to provide a comprehensive overview of the lightning scenario in Bangladesh, including its occurrence, impacts, and mitigation strategies, while identifying key measures to reduce lightning-related hazards and enhance resilience.

Lightning in Bangladesh: Causes, Impacts, and Recommendations for Mitigation (বাংলাদেশে বজ্রপাত: কারণ, প্রভাব এবং ঝুঁকি হ্রাসের সুপারিশ)

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Introduction

Lightning is one of the most dangerous atmospheric hazards associated with severe thunderstorms. It is a sudden, intense discharge of electricity that takes place in a cloud, from one cloud to another, or from a cloud to the ground. Lightning is primarily formed by strong convective activity within thunderstorms through the separation of electrical charges within the thundercloud generated by the collision of graupel, ice crystals, and supercooled water particles in the mixed phase regions. As the electric field grows strong enough, electrical discharge is produced in the form of lightning.

Cloud-to-ground lightning poses the greatest risk to life and property because of its direct interaction with the ground. Every year, lightning causes large numbers of deaths and injuries, structural damage, power disruptions, forest fires, and agricultural losses around the world. Earlier research suggested that approximately 24,000 people die annually worldwide due to lightning-related incidents. In many tropical and subtropical countries, lightning risk is particularly high because large populations remain outdoors during thunderstorms.

Bangladesh is identified as one of the lightning-prone areas in South Asia. Fig. 1 shows the average monthly variation of lightning activity from 2015 to 2024. It is found that the highest number of lightning occurred in May, followed by April and June. The analysis revealed that lightning activity follows a bimodal pattern, with a primary peak in April-May (pre-monsoon season) and a secondary peak in August-September (monsoon season), while the least activity occurs in November-January. Severe thunderstorms known as Nor'westers, frequently occur during the pre-monsoon season, locally referred to as "Kalbaishakhi". These storms frequently bring intense lightning, strong winds, and heavy rain, as well as hailstorms. The country's geographic location, high atmospheric moisture, strong convective instability, and extensive agricultural activities make lightning a significant natural hazard in Bangladesh.

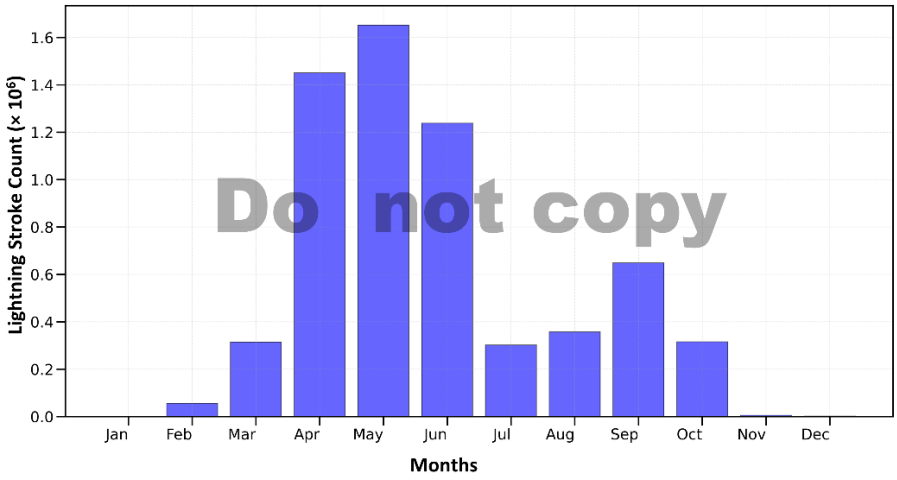

Fig. 1. Monthly variation of lightning stroke count over Bangladesh during 2015–2024.

The number of deaths due to lightning has significantly grown in recent decades in Bangladesh. It was brought to national attention following the catastrophic lightning events of 12-13 May 2016 that resulted in 81 fatalities in 48 hours. After this, the Government of the People's Republic of Bangladesh officially declared lightning a natural disaster. Past studies also showed that the majority of lightning deaths in Bangladesh occur during the pre-monsoon and monsoon seasons, and these deaths are strongly associated with agricultural work in open fields, especially during the Boro rice harvesting period.

Fig. 2 presents the annual lightning-related fatalities in Bangladesh from 2015 to 2024, while Fig. 3 shows the district-wise spatial distribution of fatalities. The figures indicate that the annual casualties are approximately 350. The northeastern, northern, and some northwestern districts are more vulnerable to lightning-related casualties than southern and coastal regions.

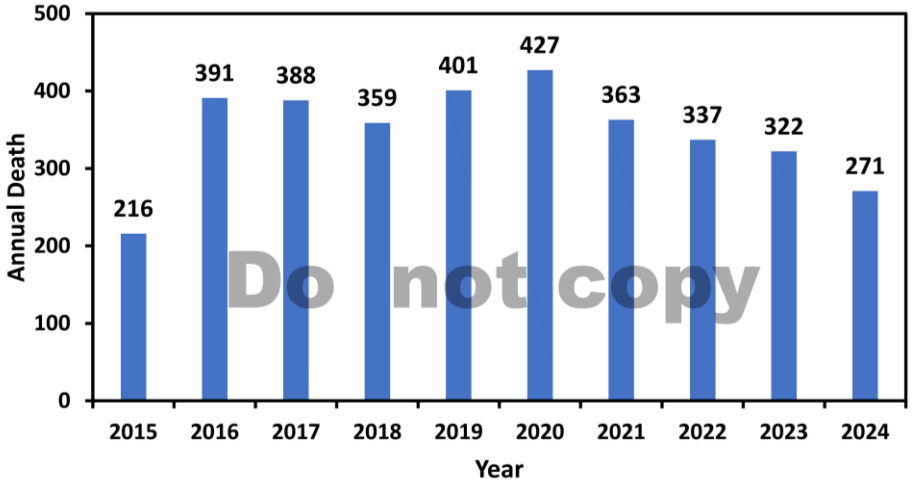

Fig. 2. Annual lightning-related fatalities in Bangladesh during 2015-2024.

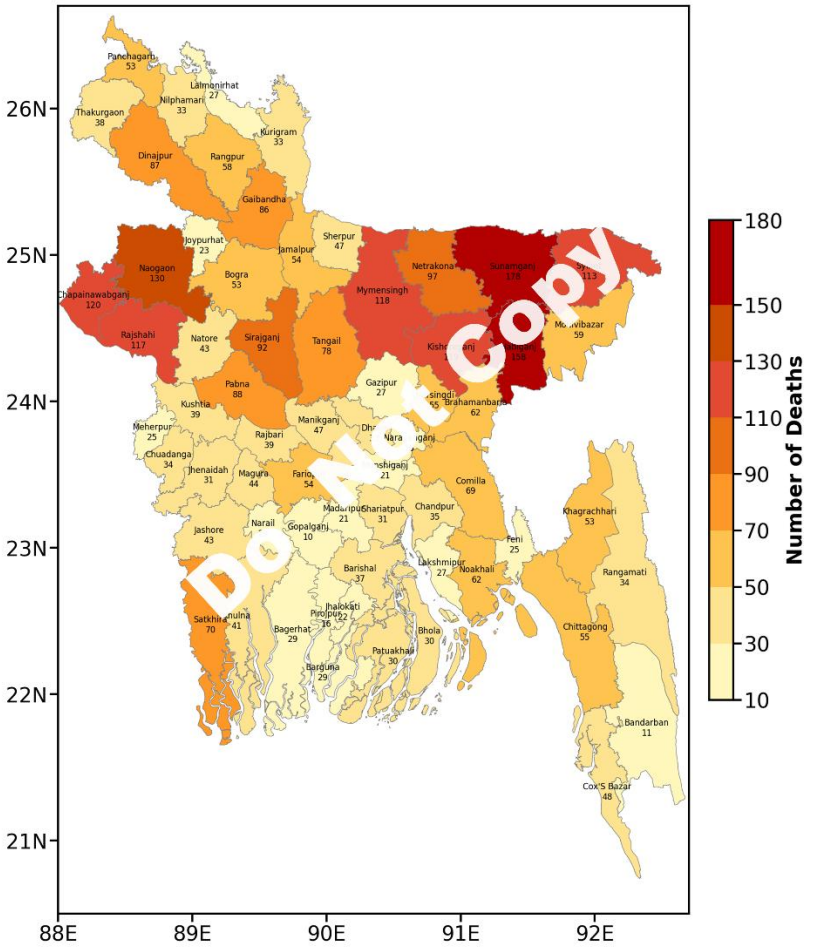

Fig. 3. District-wise lightning-related fatalities in Bangladesh during 2015-2024.

Causes of Lightning in Bangladesh

Several meteorological, geographical, and environmental factors contribute to the frequent occurrence of lightning in Bangladesh.

Geographical and Meteorological Factors

The geographic location of Bangladesh is highly favorable for the development of severe convective storms, as the country is bordered by the Bay of Bengal and the foothills of the Himalayas (Fig. 4). Abundant low-level moisture is supplied by warm, moist southwesterly winds from the Bay of Bengal, particularly during the pre-monsoon season. The presence of moist air near the surface, combined with the relatively dry air aloft, creates instability conducive to the development of deep convective clouds. The northeastern part of Bangladesh is mostly influenced by the Meghalaya Plateau and the surrounding topography. Strong moisture convergence coupled

with orographic lifting further enhances thunderstorm activity over this area. Past studies show that the northeastern part of Bangladesh is one of the country's lightning hotspots.

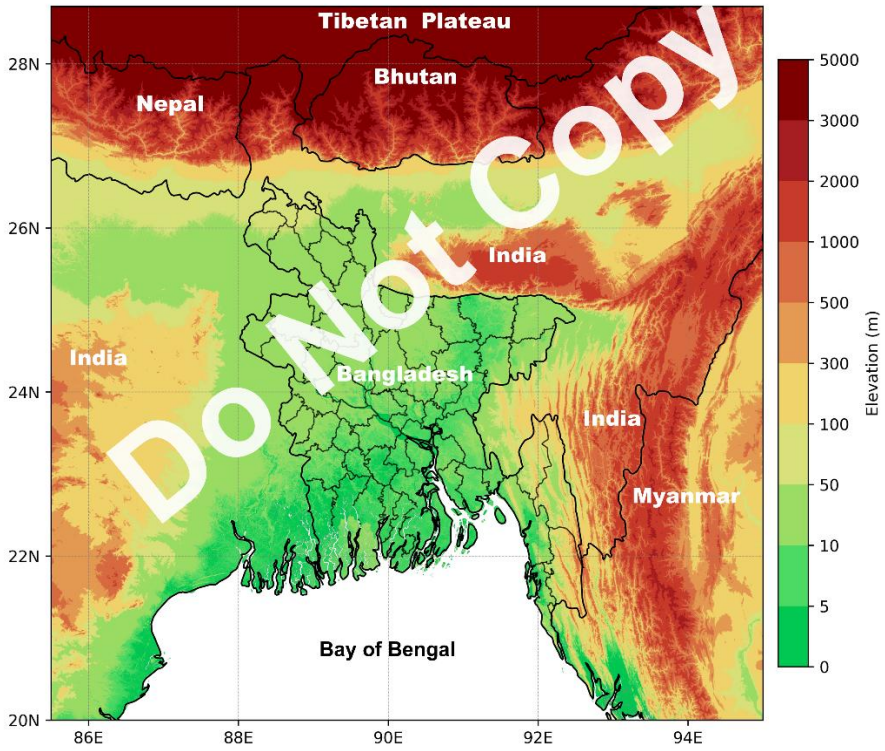

Fig. 4. Topography of Bangladesh and its surroundings.

Bangladesh experiences strong surface heating, high to moderate convective available potential energy (CAPE), strong vertical wind shear between 0 and 6 km, and intense upward motion during the pre-monsoon and monsoon seasons. The conditions are ripe for the formation of strong thunderstorms producing frequent lightning. Further research indicated that warm, moist flow from the Bay of Bengal is an important factor in enhancing thunderstorm activity over Bangladesh. The moist environment also increases the frequency of hazardous cloud-to-ground lightning strikes, which pose a serious threat to life, infrastructure, and livestock across the country. Unfortunately, the proportion of cloud-to-ground lightning in Bangladesh is about 51% of total lightning activity, which is higher than that observed in many other parts of the world.

Cloud Microphysical Processes

Cloud microphysical processes in thunderclouds are closely related to lightning initiation. Research on Bangladesh found that intense lightning activity is associated with the coexistence of graupel, ice particles, snow particles, and cloud water within the mixed-phase region of convective clouds. Collisions between graupel and ice particles in the presence of supercooled liquid water produce charge separation, which ultimately leads to lightning discharge.

Seasonal and Spatial Variability

The lightning activity in Bangladesh exhibits strong seasonal variability. Total lightning is concentrated in the pre-monsoon and monsoon seasons, accounting for about 91% of all lightning observed. The pre-monsoon season has greater convective instability, more intense thunderstorms, and higher lightning activity. Fig. 5 illustrates the spatial distribution of lightning stroke density over Bangladesh based on GLD360 lightning data during 2015-2024. This figure clearly shows that lightning density is higher in the northeastern part of Bangladesh and lower in the western, southwestern, and coastal areas.

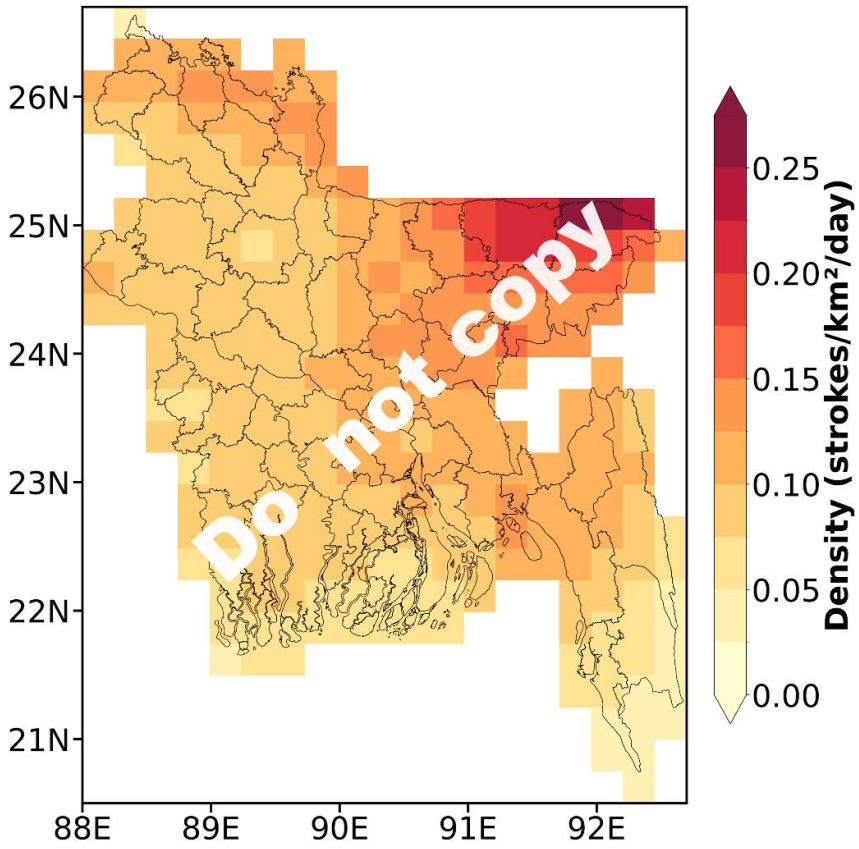

Fig. 5. Lightning stroke density over Bangladesh during 2015-2024.

Environmental and Anthropogenic Influences

Recent studies, however, show that air pollutants and aerosols can also influence the lightning activity in Bangladesh. Positive relationships between dust aerosols, sulfate concentrations, and lightning were identified, particularly during the main lightning season. Further studies are needed to fully elucidate these connections, but it is possible that atmospheric pollution can alter thundercloud microphysics and electrification.

Apart from meteorological reasons, socioeconomic vulnerability is also a major factor in the large number of lightning fatalities in Bangladesh. Many lives are lost because people remain outdoors for farming, fishing, transportation, and other outdoor activities during thunderstorms. Rarely available safe shelters and insufficient public awareness further increase vulnerability.

Recommendations for Mitigation

To minimize lightning-related deaths in Bangladesh, a coordinated scientific, technological, and public awareness campaign is required.

Short-Term Initiatives

- The government should strengthen reliable lightning forecasting and early warning systems by improving real-time weather monitoring and ensuring rapid dissemination of alerts through SMS, television, radio, mobile applications, and social media platforms.
- Nationwide public awareness campaigns should be launched, with special focus on high-risk groups such as farmers, fishermen, students, and rural communities (including 30/30 lightning safety guidelines).
- Clear safety guidelines should be enforced to discourage people from staying in open fields, near water bodies, under isolated trees, or near metal structures during thunderstorms.
- Local administration should ensure immediate advice for suspension of outdoor agricultural and labor activities when severe thunderstorm warnings are issued.

Medium-Term Initiatives

- The government should establish lightning safe shelters in highly vulnerable haor regions and agricultural zones.
- Lightning protection systems and lightning arresters should be made mandatory in all educational institutions, hospitals, government buildings, and high-risk infrastructures.
- Structured and scientifically guided tree plantation (including local trees that grow rapidly and tall) programs should be implemented in rural and high-risk areas for both environmental protection and partial lightning risk reduction.
- Community-based disaster preparedness programs should be expanded nationwide, focusing specifically on lightning risk awareness and response.
- Lightning safety education should be formally integrated into national school curricula and disaster management training programs.

Long-Term Initiatives

- The government should develop a modern national lightning detection and monitoring network using advanced satellite, radar, and ground-based sensor systems.
- Long-term scientific research on lightning climatology, thunderstorm dynamics, and climate-induced changes in lightning activity should be significantly expanded and funded.

- Strong institutional collaboration should be established among universities, research organizations, the Bangladesh Meteorological Department (BMD), and disaster management agencies.
- A centralized national database of lightning-related deaths and injuries should be developed for effective monitoring, research, and evidence-based policymaking.

Conclusions

Lightning is now a major natural hazard in Bangladesh. Geographical location, high convective instability, abundant moisture from the Bay of Bengal, and favorable topographic conditions all play a significant role in lightning occurrence in the country. The occurrence of lightning and the number of lightning-related deaths are particularly high in the northeastern parts of Bangladesh.

Although meteorological conditions play a dominant role in lightning generation, socioeconomic vulnerability, exposure of people in open fields for agricultural activities, and low public awareness contribute significantly to the number of human casualties. Scientific forecasting from the lightning researchers' group, public awareness campaigns, lightning-safe infrastructure, and improved disaster preparedness can significantly reduce lightning-related deaths and injuries in Bangladesh.

Lists of lightning-related publications of the Atmospheric Physics Research Group, Department of Physics, BUET:

1. **Rafiuddin, M., Akter, N.,** Dewan, A., Adnan, M. S. G., & Holle, R. L. (2025). Pre-monsoon lightning in Bangladesh: Separating most from least active days with thermodynamic and synoptic composites. *Atmospheric Research*, 325, 108261.

2. **Azam, A. T. M. S., Akter, N.,** Dewan, A., Molla, M. A. M., & **Rafiuddin, M.** (2025). Role of pollutants on the bimodal lightning distribution in Bangladesh. *Earth Systems and Environment*, 10, 663-678.

3. Dewan, A., Islam, K. M. A., Enan, M. E., Fariha, T. R., **Rafiuddin, M.,** & Adnan, M. S. G. (2024). Cloud-to-ground lightning in cities: Seasonal variability and influential factors. *Earth Systems and Environment*, 8, 545-560.

4. Holle, R. L., Dewan, A., Said, R., Brooks, W. A., Hossain, M. F., & **Rafiuddin, M.** (2019). Fatalities related to lightning occurrence and agriculture in Bangladesh. *International Journal of Disaster Risk Reduction*, 41, 101264.

5. Ashraf Dewan, Emmanuel Ongee, **M. Rafiuddin**, Md. Masudur Rahman, & Rezaul Mahmood, (2018). Lightning activity associated with precipitation and CAPE over Bangladesh, *International Journal of Climatology*, 38: 1649-1660, 2018.

6. **Azam, A. T. M. S., Rafiuddin, M., Akter, N.**, & Dewan, A. (2026). Relationship between observed lightning and simulated hydrometeors over Bangladesh, *Journal of Meteorology and Atmospheric Physics*, 138, 54 (2026). https://doi.org/10.1007/s00703-026-01157-4

7. **Azam, A. T. M. S., Rafiuddin, M., Akter, N.**, & Dewan, A. (2026). Spatiotemporal variability of intracloud and cloud-to-ground lightning and their environmental controls in Bangladesh. (*Manuscript under review*).