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Analysis of Lightning Hazard Scenario: A Study on Pabna District, Bangladesh

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ABSTRACT

Bangladesh is a nation plagued by natural disasters, the majority of which are caused by hydro-meteorological hazards. Climate change has a direct impact on the severity and frequency of these events. Lightning strikes have become more common in recent years, taking more lives than in the past. With a maximum flash intensity density of 72 flashes per km^2, Bangladesh is one of the most lightning-prone countries on the Indian subcontinentyear-1, accounting for more than a quarter of all deaths in Bangladesh. The study's aim is to look into the death and causes of lightning strikes, as well as public awareness, memory, and sensitive actions in the event of a lightning strike. This research used mixed approach, and the primary data was collected from respondents through face-to-face interviews and a questionnaire the random sampling method. In Bangladesh's Pabna district, public awareness, comprehension, and response to the lightning threat are insufficient to reduce the impact of lightning and must be strengthened. Low literacy rates, a lack of proper knowledge, theological orthodoxy, and the acceptance of lightning as a natural occurrence are the key causes of this lack of knowledge. In Bangladesh, incorrect lightning precautions, a lack of awareness about first-aid care, hazardous building systems, and a lack of training and workshop all contribute to the high rate of deaths and injuries. This research can be used to raise public consciousness about the dangers of lightning and how to deal with it safely.

Keywords:-*Lightning, Hazard, Lightning Strike, Pabna*

INTRODUCTION

In Bangladesh, a complicated coastal structure and shallow water depth make it prone to natural calamities [24]. Natural calamities like as floods, cyclones, and droughts, as well as a rise in thunderstorms and lightning, affect the region almost annually [16]. The Ganges, Brahmaputra, and Meghna basins span Bangladesh, Bhutan, China, India, and Nepal, with a combined total catchment area of about 1.76 x 106 km^2[3]. Bangladesh only makes up 7% of this massive catchment area. The country's annual rainfall is expected to range between 1500 and 5000 mm, with an average of 2300 mm [3].

In recent years, the Ministry of Relief and Disaster Management has classified lightning a disaster due to its disastrous impact [9]. Bangladesh is one of the most vulnerable nations, as a great number of disruptive lightning incidents have resulted in a high rate of fatality and morbidity in recent years. Numerous tropical and

subtropical low and middle-income countries are impacted by lightning [11].

Extremely deadly lightning can strike something high above the ground. Lightning strikes can also cause trees to collapse and catch fire [5]. Despite the fact that the chances of having struck by lightning are exceedingly low, hundreds of people are killed annually by lightning [22]. Even when thunder and lightning strike simultaneously, the lightning strike enters the eyes first because light travels quicker than sound. Once upon a time, it was believed that lightning was a supernatural force sent by God to punish offenders. In contrast, Benjamin Franklin (1706-1790) sought to demonstrate that lightning was a kind of electricity [19]. The average distance traveled by lightning is a few kilometers. It has a very high peak power and total energy, with peak power discharges exceeding 100 million watts per meter of channel and peak channel temperatures exceeding 30,000 degrees Celsius. In lightning discharges, peak currents can surpass hundreds of kilo amperes (kA), with an average value of 40 kA. Lightning's exact timing and location is notoriously difficult to predict. Several nations, however, have established a season or time of lightning occurrence [19].

Pabna is one the major districts in Bangladesh with a large variation in climate change specially temperature and rainfall [6]. Most of the economies are Agriculture based and most of the people's income source in agriculture [3]. Due to climate change and increase in average rainfall and temperature Pabna District is going through a dangerous condition of Lightning Strike. This study aims to identify the scenario of Lightning Strike in Pabna District (Deaths, Injuries, Seasonal Distribution, Gender Variation, and Fatality Rate) and to analyze the annual average (Temperature and Rainfall).

There has been a huge decline in lightning deaths in developing countries over the last century as a result of a movement in population from rural to urban settings. In emerging countries, the availability of lightning-resistant structures and equipment has grown as a result of greater economic development. Lightning-related deaths have decreased as a result of the availability of houses, fully covered metal-topped trucks, and other considerations [23]. Lightning, on the other hand, is an unappreciated natural menace in affluent countries, despite the fact that it poses a major risk to life and property [21].

The majority of the population continues to operate in lightning-prone regions, reside in lightning-prone households, and engage in subsistence agriculture for the long term. Work in lightning-resistant structures and reside in lightning-resistant dwellings [8]. The increase in potentially deadly lightning strikes in Bangladesh can be attributed to population growth and the loss of numerous tall trees. In addition, using metal farm equipment in open fields, using mobile phones during thunderstorms, standing near metal cell phone towers or electrical power towers, and seeking shelter beneath trees during electrical storms are all factors that are likely to increase the number of lightning-related fatalities [10].

The result of the research will be useful further in two ways. Firstly, it will contain some lightning risk management recommendations that policy makers will find useful, make people aware of the risks and provide advice about how to stop them. Secondly, it will raise awareness among the uneducated and illiterate, as well as at all levels of society, about how to protect themselves against these deadly threats.

As a result of global climate change, lightning strikes and fatalities have risen

significantly. Climate change, such as a 1°C increase in temperature, will increase lightning disasters in the atmosphere by 20–40% [3]. Bangladesh has seen an increase in the number of fatalities from lightning, a natural hazard, in recent days as a result of increasing temperatures [20]. The geographical area's air circulation, Thunderbolts and lightning are caused by the formation of thunderclouds over Bangladesh as a result of extreme heat, especially in areas with large bodies of water, such as the hoar areas. The general public's lack of understanding is leading to a spike in casualties. The most common cause of lightning is clouds colliding, but air pollution may also because it also plays a part. In the month of Boishakh, lightning is more common when the air is thicker with dust and carbon, and casualties are concentrated in areas where people work in open fields, especially in the Hoar region [1]. The majority of deaths in Bangladesh occurred between the hours of early morning and early evening. It was discovered that rural areas accounted for 93% of the deaths [6]. More people died in the pre-monsoon season (March-May) than in the monsoon season (June–September). Since men spend more time outside for agricultural purposes than women, they account for the majority of lightning-related deaths farming [4]. Although there is controversy over whether increased lightning is due to global warming, we can all accept that rising temperatures are a factor. The bulk of the lightning deaths occurred in Bangladesh during the last few days of April, when the average temperature was over 30 degrees Celsius [7].

Weinstein [25] demonstrated that people's perceptions change over time are People are affected by prior experience, and they take precautions when they feel it is necessary for the specific danger based on their previous experience. It's possible that men and women hold opposing views. According to Kung and Chen [15] danger in Taiwan, earthquakes made women more scared, worried, concerned, and threatened. Lightning strikes can cause cardiac or pulmonary arrest, neurological problems, and loss of responsiveness, paralysis, seizures, temporary blindness, and feathery or fern-like burns perhaps at the points of entry and exit trauma caused by being hit or thrown (fractures, internal bleeding, etc.) [12]. Newspaper estimates put the number of annual lightning deaths at over 150, but the true death toll may be 500-1,000, according to the study. According to data gathered by the Foundation for Disaster Forum, lightning is the leading cause of death in the United States strikes is at an all-time high and that was 179 in 2011, 301 in 2012, 285 in 2013, 210 in 2014, 186 in 2015, 245 in 2016, and 205 in 2017 [1].According to the Ministry of Disaster Management and Relief, at least 70 people have died as a result of lightning strikes in March and April of this year. In March, 12 of them were killed. In April, 58 people were killed, with 29 of those killed in the last two days of the month [1].

Lightning-related studies are rare in Bangladesh because lightning is not regarded as a disaster most of the cases. In Bangladesh, this type of research is inadequate, but it is an alarming rate in the majority of the country's districts. There may be some lightning myths and misconceptions, inadequate safety measures, or a lack of proper lightning training and information that needs to be discussed Bangladesh has seen a large number of deaths and property losses. The goal is to look at how people think about lightning and what steps they take to stay safe during a lightning strike.

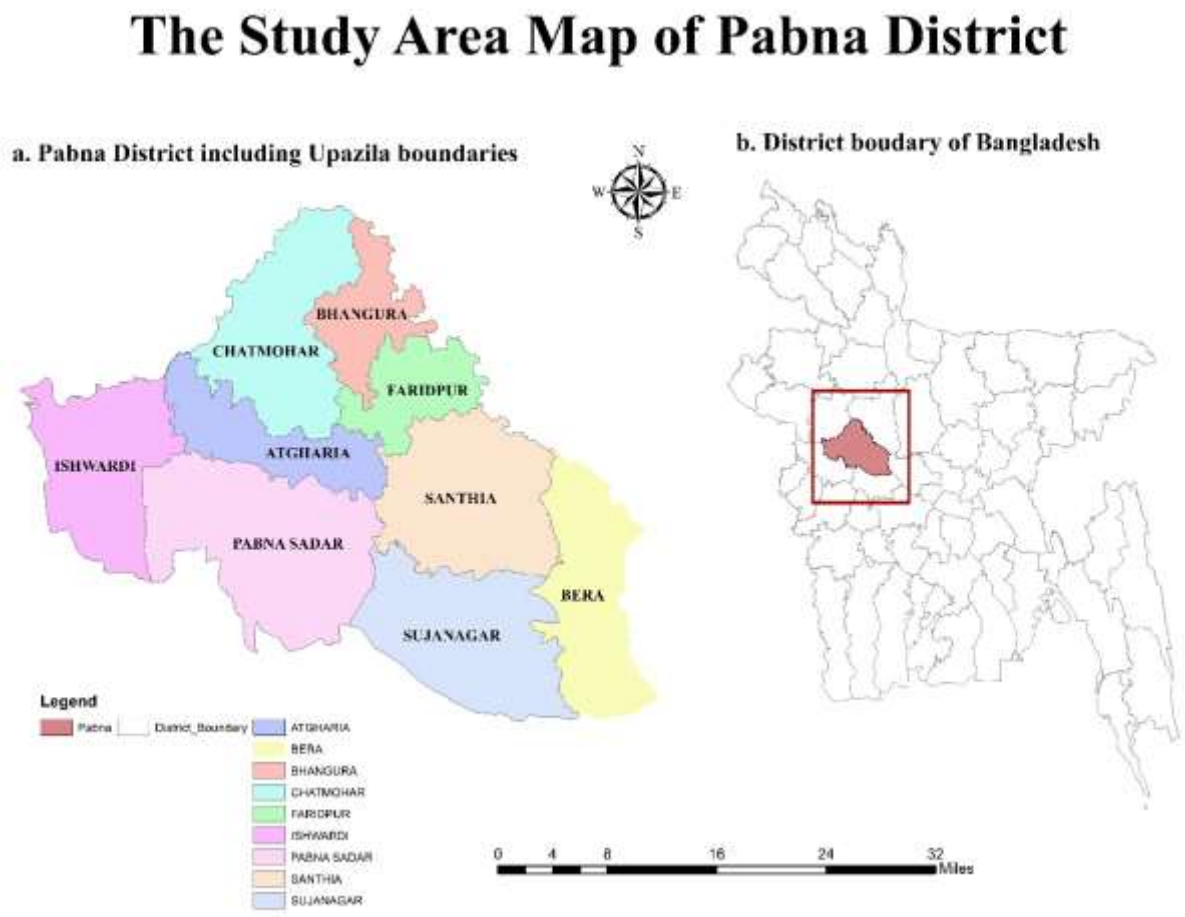
RESEARCH METHODS

The study is carried out in a mixed method using both primary and secondary data that have been collected to complete the

research. The data regarding death and causalities from lightning strike, injuries, gender variation, seasonal distribution, fatality rate, annual average rainfall and temperature are gathered from secondary sources i.e. Bangladesh Bureau of Statistics [3], Bangladesh Metrological Department [6], Department of Disaster Management (DDM), NDRCC and the Network for Information Response and Preparedness Activities on Disasters (NIRAPAD . People's perception on lightning hazard is collected from a questionnaire survey including a sample size of 384 households. The study is analyzed using statistical calculations for analyzing both the secondary data and primary data.

Study Area Profile [Figure 1]

Pabna district is situated in the country's northwestern corner. The area is 2371.50 square kilometers, with latitudes ranging from 23°48' to 24°21' north and longitudes ranging from 89°00' to 89°44' east. Pabna district was established in 1832. There are 9 upazilas, 8 municipalities, 81 wards, 191 mahallas, 72 union parishads, 1321 mouzas, and 1540 villages in this district [3]. Pabna district has a total population of 19, 51,822 people (males 9, 71,599 and females 9, 80,223), with a population density of 1062 people per square kilometer [3]. The temperature, humidity, and coldness in the district are all moderate. In 2011, the district's annual rainfall totaled 1736 millimeters. In April, the humidity level was around 76.8%, and in July, it was around 85 percent and annual average temperature was 31°C [6].



Source: Author, 2021
Fig.1:- *Study Area*

Sample Size Determination

The Pabna district has a total of 590749 households. It is divided into nine Upazilas. The sample size n is determined using the formula below:

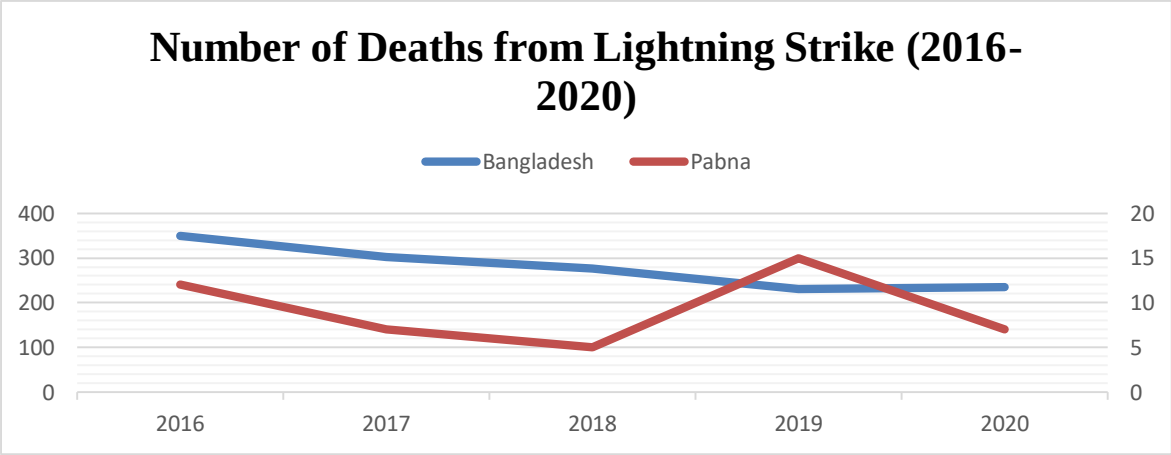
n = N*X / (X + N – 1), n = N*X / (X + N – 1), n = N*X

MOE= 5%, X = Z/2 2 *p*(1-p) And Z/2 is the Normal distribution's critical value at /2 (e.g., for a 95% confidence level, is 0.05 and the critical value is 1.96), MOE stands for margin of error, p stands for sample proportion, p = 0.5 stands for maximum possible proportion value when p is uncertain, and N stands for population size. The sample size formula has been updated to provide a Finite Population Correction. (WW, 1999) The sample size at the start, 384.16 = (1.96)2*0.5*(1-0.5)/0.052

The following equation is used to change the sample size.

384.16+590749-1) = 383.91=384 n = 590749*384.16 / (384.16+590749-1) = 383.91=384 n = 590749*384.16 / (384.16+5907)

As a result, 384 households in the Pabna district are surveyed. There are 9 upazilas in Pabna district. 43 households are surveyed from each upazila.



Source: BMD, 2021

Fig.2*:-Number of death from lightning strike in Bangladesh and Pabna*

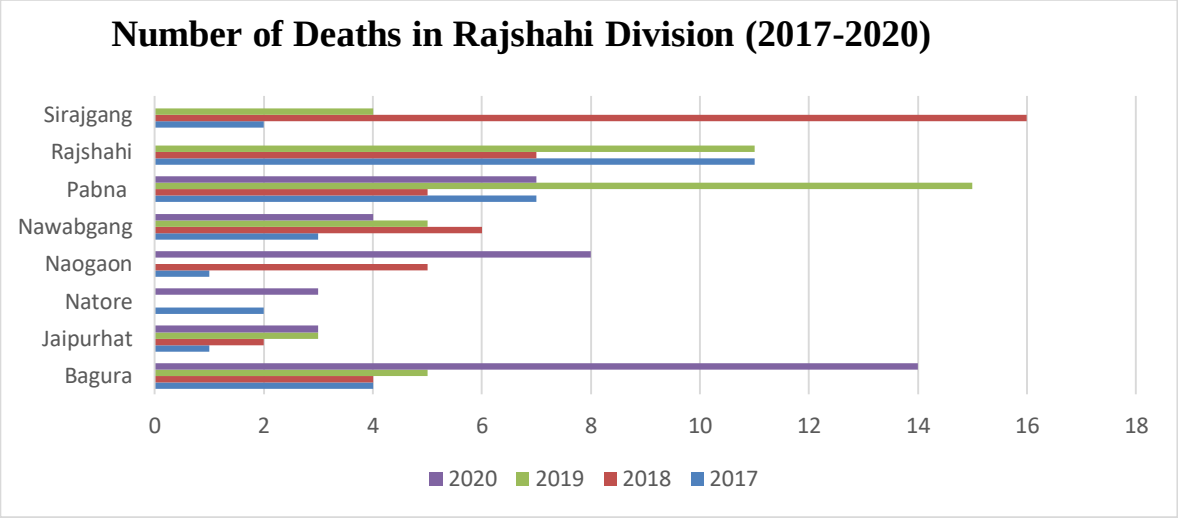
RESULTS AND DISCUSSION

Death and Casualties from Lightning strike (Comparison between Bangladesh and Pabna district): The number of death from lightning hazards in the year 2016 to 2020 is shown in the Figure 2. The total number of death from a lightning strike in Bangladesh is decreased gradually but at the same time, the total number of death in the Pabna district is increased.

The year-wise number of death in Bangladesh is 350, 302, 277, 230, and 235 in the year 2016, 2017, 2018, 2019 and 2020. The year-wise number of deaths in the Pabna district is 12, 7, 5, 15 & 7 in the year 2016, 2017, 2018, 2019 and 2020 respectively.

The situation of Pabna District in Rajshahi Division: Rajshahi division consists of eight districts and they are Rajshahi, Nawabganj, Naogaon, Jaipurhat, Bogura, Natore, Shirajganj and Pabna district. Among these eight districts, the number of death in the Pabna district is

more than in other districts. Death occurs every year in the Pabna district & the number is 7, 5, 15, 7 in the year 2017, 2018, 2019, and 2020. Almost every year death is arrived in Pabna district rather than other districts in Rajshahi division and that's why Pabna district become more vulnerable for lightning hazard in Rajshahi division as shown in Figure 3.



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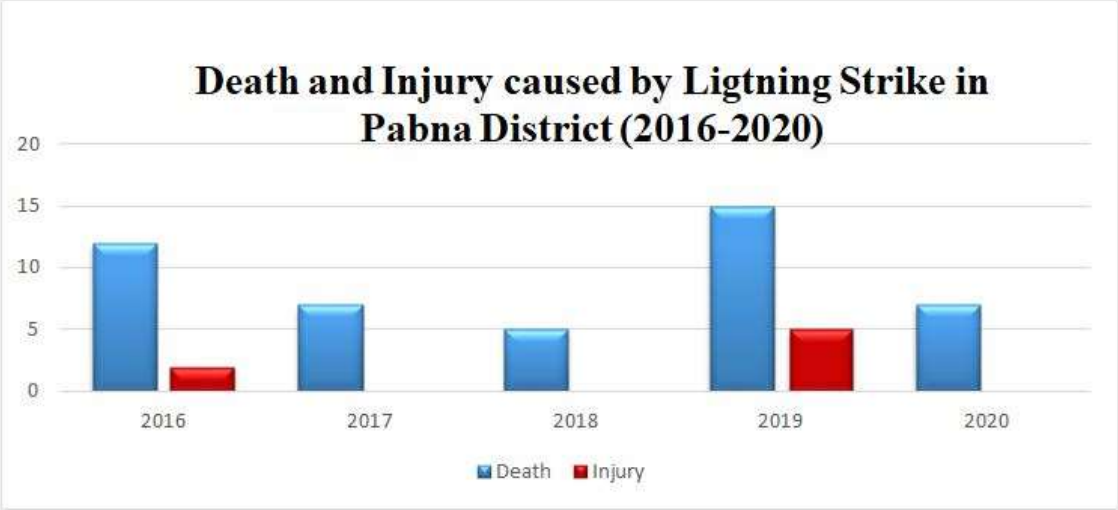
Source: BMD, 2021

Fig.3:-*Number of Deaths in Rajshahi Division*

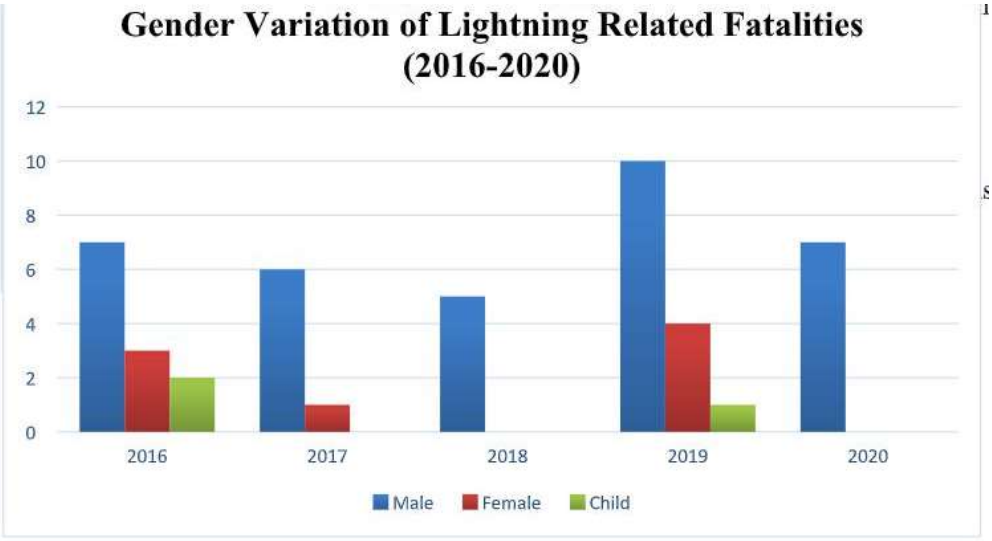
Death and Injury data in Pabna district: In a lightning strike, this graph shows the year-by-year death and injury data for Pabna district from 2016 to 2020. In the year 2019, the highest number of deaths and injuries occurred, with 15 deaths and 5 injuries. The lowest number of deaths occurred in 2018, with only 5 deaths between 2016 and 2019. In 2017 and 2018, there were no injuries. As shown in the graph, in the year 2019 the death frequency is higher as shown in Figure 4.



Source: BMD, 2021

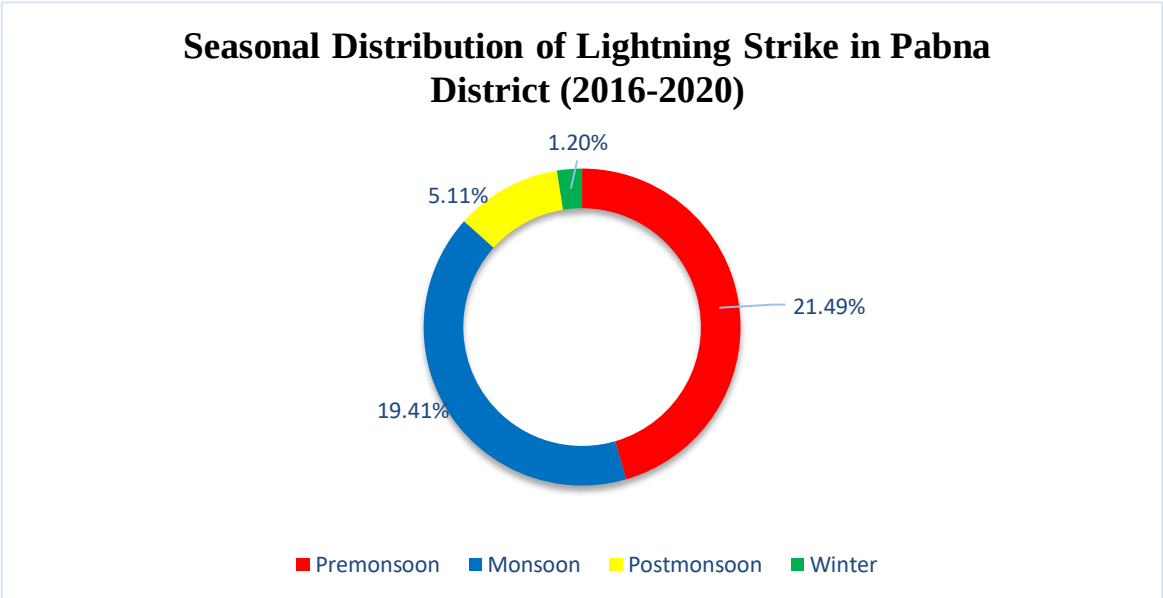
Fig.4:-*Death and Injury caused by Lightning Strike in Pabna District*

Gender variation of lightning-related fatalities in Pabna district: In this chart Figure 5, it is shown the gender variation of lightning-related fatalities from the year of 2016 to 2020. Males are mostly affected by lightning due to work outside. Female is also death by lightning but the number is less than the male. The child is scarcely affected by lightning strike. The high ratio of male to female and child indicates that men are more likely to engage in traditional tasks, be exposed to outdoor activities, and engage in labor-intensive practices such as agriculture (plow, cattle herding), construction, and recreation. Surprisingly, Bangladesh has a very high male-to-female ratio, possibly due to the country's agricultural economy and, as a result, more men Outdoor activities, which are dominated by men, are also dominated by men.



Source: BMD, 2021

Fig.5:-Gender Variation of Lightning Related Fatalities



Source: BMD, 2021

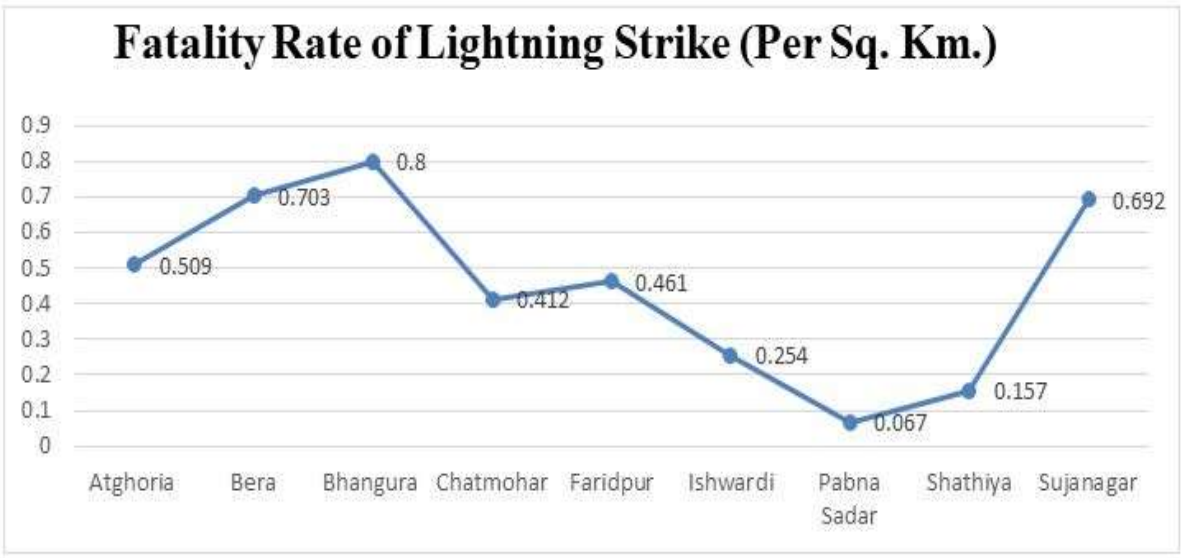
Fig.6:- Seasonal Distribution of Lightning Strike in Pabna District

Seasonal Distribution of lightning causalities in Pabna district: According to the seasonal variation in lightning fatalities and injuries, the pre-monsoon season has more casualties than the other seasons. The season-by-season lightning fatality rate is depicted in the pie chart [Figure 6]. The highest lightning fatality rate of 21.49 percent occurred during the pre-monsoon season. The months of March, April, and May are considered pre- monsoon.

Thunderstorms are common during the pre-monsoon because of the strong, incoming solar radiation. The monsoon season had slightly more CG lightning than the pre- monsoon season during this time period. Additional spatial and temporal lightning climatologists were inferred from the lightning. Then 19.41% occurred during the monsoon season, with a few numbers affected in the post-monsoon season (5.11 percent). The number of fatalities was lowest in the winter.

The fatality rate of the lightning strike in Pabna district (Upazila- wise): There are nine Upazilas in the Pabna district. The fatality rate in Pabna Sadar is 0.067, in Ishwardi it is 0.254, in Bera it is 0.703, in Shathiya it is 0.157, in Sujanagar it is 0.692, in Chatmohar it is 0.412, in Bhangura it is 0.8, in Faridpur it is 0.461, and in Atghoria it is 0.509.

The upazila of Bhangura has the highest rate of fatalities among them is equivalent to 0.8. Bhangura Upazila has a total area of 138.36 square kilometers and a population of 125000 people. From 2016 to 2019, seven people died in this Upazila as a result of lightning strikes. Pabna Sadar Upazila has a minimum fatality rate of 0.067, with a total area of439.30 sq km and a population of 591000 as shown in Figure 7.

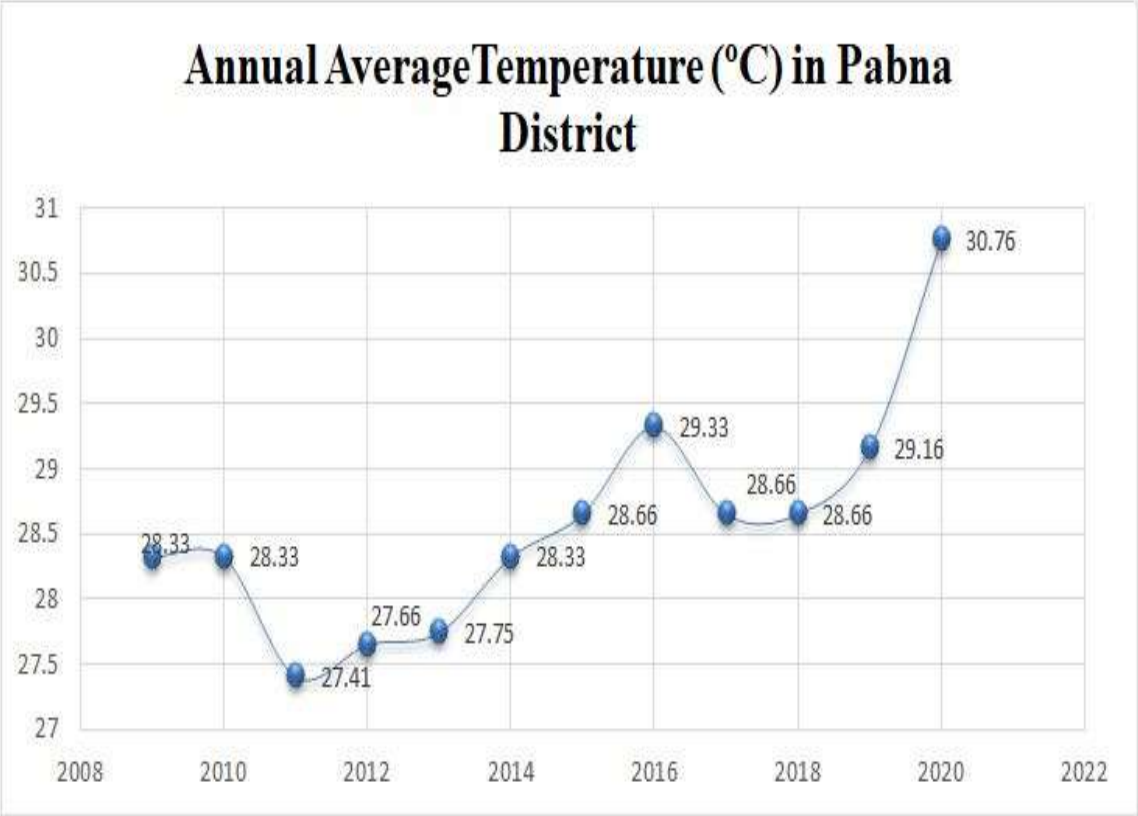


Source: BMD, 2021

Fig.7:-*Fatality Rate of Lightning Strike (Per Sq. Km.)*

Average Annual Temperature in Pabna district: The most common cause of lightning strikes is a change in temperature. The temperature of the Pabna district from 2009 to 2019 is depicted in this graph. The year with the highest temperature (29.18°C) was 2019. The average annual temperature is rising year after year, as shown in this graph Figure 8. Climate change is influenced by the temperatures, which raises thunderstorms and lightning. According to experts, every

1-degree Celsius rise in global temperature increases the frequency of lightning strikes by 21%. Lightning is the main cause of nitrogen oxides in the middle and upper troposphere. Controlling this gas indirectly impacts other greenhouse gases such as ozone and methane.



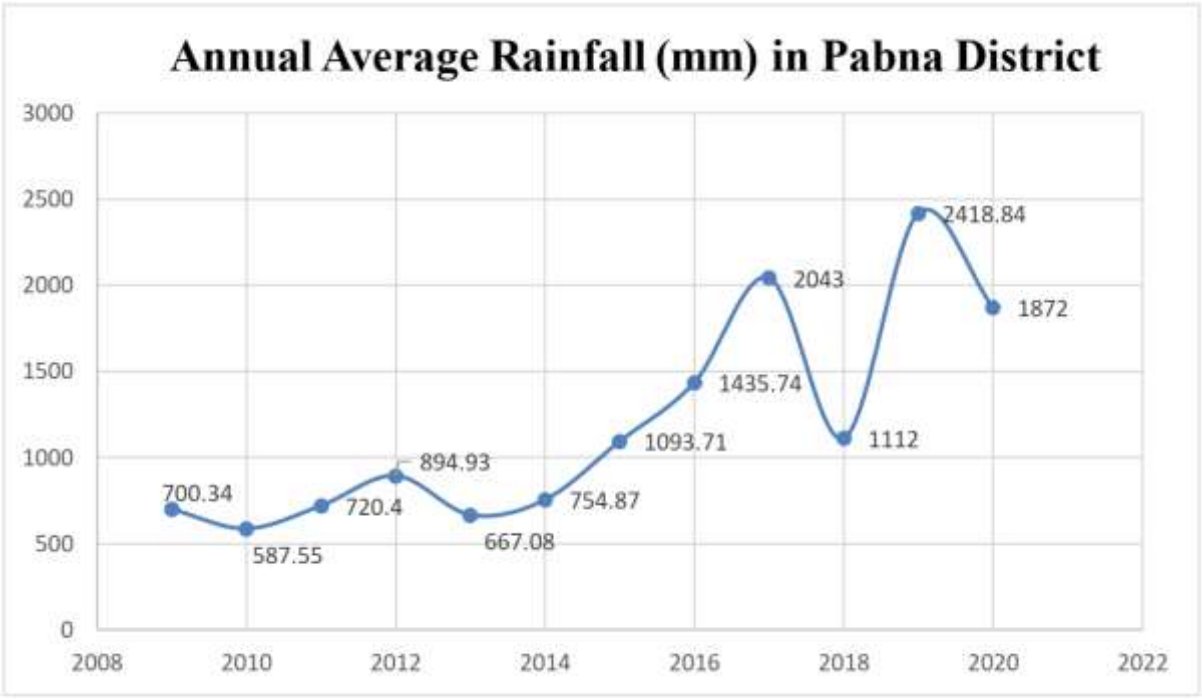
Source: BMD, 2021

Fig.8:*-Annual Average Temperature (°C) in Pabna District*

Average Annual Rainfall in Pabna district: There is a close connection between rainfall accumulation and lightning activity.

The northeastern part of Bangladesh experiences heavy to very heavy rainfall, which is also accompanied by extreme thunderstorms. A 2°C rise in temperature associated with a 10%increase. A worrying prediction of potential lightning hazards in the Ganges-Brahmaputra-Meghna (GBM) river basin is the increase in population in precipitation.

The graph [Figure 9] depicts the Pabna district's average rainfall steadily increasing from 2009 to 2019. The total annual rainfall in 2016 was 1435 millimeters, 2043 millimeters in 2017, and 1112 millimeters in2018 Pabna district.



Source: BMD, 2021

Fig.9*:-Annual Average Rainfall (mm) in Pabna District*

Percentile Checklist on the people's perception on Lightning hazard (Part 1)[Table 1]: The research questions below were sought to determine what the general knowledge of the respondents was towards the lightning hazard. By conducting a questionnaire survey it is found that 82% of respondents heard about the lightning hazards and 18% are not acquainted with lightning as a disaster. Maximum people disparage lightning strikes in stormy weather, 55% of respondents do not think they are in danger while struck. 34% of the respondent has lost their property.6 no question is about what organizations were doing in attempting to reduce the severity of lightning strikes to either human or properties.

Table 1:*-Perception on Lightning hazard (Part 1)*

Question	**YES**	**NO**
1. Do you know hear/read about lightning disasters?	82%	18%
2. Do you think you'll be hit by lightning when you're outside?	45%	55%
3. Have you suffered any losses as a result of lightning strikes?	34%	66%
4. Has someone you know been wounded as a result of a lightning strike?	31%	69%
5. Does your neighborhood have a lightning- related siren, sign, or announcement?	0	100%
6. Did your local government provide you with any lightning safety precautions or training?	0	100%
7. Do you believe lightning is a threat?	89%	11%

8. Is there some kind of sign, siren, and announcement at your place of business when you're not at home?	0	100%
9. Do you take any care if you hear thunder unexpectedly?	54%	46%
10. Do you believe that strike victims are electrically neutral and can be safely touched?	75%	25%
11. Are you already in danger if you hear thunder outside?	78%	22%
12. Has there been a shift in the incidence of lightning in recent years?	56%	44%

Source: Field Survey, 2021

Before lightning, there is no siren, announcement, or alarm device. The local government does not have any lightning training. Just 46% of respondents are willing to seek cover if thunder is heard unexpectedly. 75 percent of respondents accept that strike victims are not electrically charged and can be safely touched, although 25% disagree. Sixty-six percent of respondents believe that the frequency of in recent years, lightning has improved.

Percentile Checklist on the people's perception of Lightning hazard (Part 2)[Table 2]: These research questions below looked at folk understanding and belief. Surprisingly, 65 percent of respondents correctly identified the season when lightning strikes are most common, while 26 percent did not know and 9 percent did not respond. 57 percent of people were aware of the importance of locating a secure location in the event of a lightning strike. 35 percent of respondents gave incorrect answers, indicating that they have a misunderstanding about safe places. 8% of those polled did not respond.

The survey showed 70% of respondents have the idea about metal objects can attract lightning. 74% of respondents had right conception respectively on highest points and isolated trees regarded as more prone to lightning hit. 15% of people did not know and 11% did not answer.

Table 2:-*Perception on Lightning hazard (Part 2)*

Question	**Answered correct**	**Answeredwrong**	**Unknown**
1. During which season does lightning strike in your area??	65%	26%	9%
2. Has the death rate from lightning changed in recent years?	77%	15%	8%
3. Where do you stay healthy during a thunderstorm?	57%	35%	8%
4. How did you learn about the lightning deaths?	42%	41%	17%
5. Metals have the potential to draw lightning?	70%	19%	11%
6. What are the causes of lightning strikes?	41%	51%	8%
7. Lightning always hits the high point.	74%	15%	11%
8. Lie flat on the ground in a thunderstorm.	56%	31%	13%

9. Lightning cannot occur without thunder and rain.	38%	56%	6%
10. Hide under an isolated tree to keep safe during a thunderstorm.	60%	29%	11%
11. Lightning is a warning, premonition, or punishment.	55%	35%	10%
12. In a group, you are safe from lightning	54%	35%	11%

Source: Field Survey, 2021

Lightning cannot occur without thunder and rain, according to 38% of respondents. It was misunderstood by 56 percent of respondents. During a thunderstorm, 60% of people seek shelter under a single tree. Lightning is thought to be a warning, foreshadowing, or retribution by 55% of respondents, which is disappointing and shows that social and religious orthodoxy often lack understanding.

Only 35% of respondent did not think lightning is a warning, premonition, or punishment from god.54% of respondents answered they were safe in a group from lightning.35% respondent answered accurately and 11% had no clue about it. According to the results of this questionnaire study, 100% of the respondents in the Pabna district are aware of lightning strikes, but only a few of them consider lightning to be a tragedy. They were unaware of stormy weather or snowy conditions while employed outdoors or in the agricultural fields. Working in the field with metallic equipment during a heavy downpour is extremely dangerous. Even if there isn't a hurricane, going outside is dangerous. People in rural areas dismiss troublesome conditions like heavy rainfall or strong winds as normal occurrences and prefer to ignore them think in primitive ways. As a result, the majority of lightning-related deaths occurred in open fields, while working in bodies of water, driving, or seeking shelter under a tree.

RECOMMENDATION & CONCLUSION

Recommendation

Lightning is a dangerous natural force. Since they did not act quickly to get to a safe spot, several lightning victims are trapped outside during a storm [13]. When working outdoors, proper preparation and good practices can easily improve lightning protection. Early warning and weather forecasting systems must be improved by disaster management agencies and meteorological departments [17]. Although the Ministry of Disaster

Management and Relief in Bangladesh recently installed US-made sensors for pinpointing lightning-prone areas and early warnings on lightning strikes, proper implementation and management are still needed. Remove myths about lightning by educating people and raising awareness through community seminars and public campaigns [5]. Multi-stakeholder enrolment could help raise community members' awareness and perceptions in this regard. A flowing building code and fire-resistant materials should be used to improve structural development. Each school should be inspected to ensure that lightning protection and safety measures are in place [9]. Dos and Don'ts, as well as Personal Safety during Lightning, should be taught to each boy, and a mock fire drill should be held on a regular basis [18]. Lightning Safety Rule (LSR) should be followed for personal, indoor and outdoor

safety as this rule is the simplest form to ensure safety during lightning strike.

Conclusion

Bangladesh and other developing countries are suffering greatly as a result of climate change. Extreme climatic phenomena, such as lightning strikes, are becoming more frequent as a result. One of the leading causes of weather-related death in Bangladesh has been reported as lightning. In reaction to the 2017 lightning strikes, which resulted in the deaths of 21 people in a single day, and in 2016, when lightning took the lives of 55 people. In recent years, the severity of the problem has increased. The majority of the patients were men from rural areas, and the majority of the injuries occurred in the afternoon.

The majority of people were hit by lightning while working outdoors, such as in the field, hoar, or along the roadside. During this time, farming is the most common practice Deaths caused by lightning When people were indoors, such as in a house, mosque, or shop, one-seventh of all lightning deaths occurred. Lightning-related deaths and injuries can be avoided in a safe, timely, and cost-effective manner, and lightning protection can primarily be achieved by raising public awareness and providing professional education on the issue. Lightning safety, as well as lightning and surge prevention education. Where appropriate, stringent steps must be taken to ensure that building standards and codes are enforced, as well as to encourage lightning protection research and development. Lightning must be treated as a natural threat and prioritized in national emergency response plans.

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