Jagannath University Journal of Life and Earth Sciences, **5**(2):169-183, 2019 ISSN 2414-1402

SPATIO-TEMPORAL DISTRIBUTION OF LIGHTNING INDUCED FATALITIES AND INJURIES IN BANGLADESH

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Abstract

This study was aimed to analyse the spatio-temporal variation of lightning induced fatalities and injuries during the year of 2012 to 2016 in Bangladesh. Moreover, lightning related relevant information like occurring places, seasonal and diurnal frequency, gender and occupation of the affected people are also being investigated under this study. Data and information were collected from three widely circulated national dailies of Bangladesh, other government sources and research institutes. Collected data and information have compiled and cross-checked avoiding overlapping and inconsistency. Data analysis and mapping has been done using SPSS, MS Excel programs and ArcGIS software. This study revealed that total 1002 fatalities and 613 injuries occurred during the observed period in Bangladesh. The yearly average rate of lightning induced fatalities and injuries was about 200 and 123 respectively. Lightning associated fatalities and injureis have found in all districts of the country except Barguna. The highest number of fatalities was identified in the Sunamganj District. This study also mentioned that most of the lightning induced fatalities and injuries happened during the morning and noon, and most of them were male. Furthermore, it was also identified that farmers, day labours and fishermen account more than 60 percent of the total fatalities and injuries.

Key words: *Lightning Hazard, Fatality, Injury, Spatial Distribution, Temporal Distribution*

Introduction

Lightning is one of the most naturally occurring global phenomena in the world that capable of causing damage to the property and death or injury to people and animals (Ab-Kadir, 2016; Shrigiriwar *et al*., 2014 and Van Alstine & Widmer, 2003). It usually occurs when an area of atmosphere gains an adequately bulky electric charge which is able to making electrical collapse (Ab-Kadir, 2016). It has been reported that lightning flash happens approximately 100 times per second, more than 8 million times per day around

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the world (Ab-Kadir, 2016; Mistovich *et al*., 2008 and Orville & Spencer, 1979 and Shrigiriwar *et al.*, 2014). It has further been estimated that 50 thousand thunderstorms occur per day that causing fires and injuries (Okafor, 2005). This calamity causes to about 0.2 to 1.7 fatalities per million people per year in the world, including 0.2 in the United Kingdom, 0.25 in India, 0.6 in the United States, 1.5 in South Africa and 1.7 in Singapore (Aslar *et al*., 2001; Singh & Singh, 2015 and Tan & Goh, 2017). Most of the lightning fatalities occur between the month of March and August (Holle, 2013 and Singh & Singh, 2015). Moreover, about two-thirds of lightning happens during the afternoon from 1200 to 1800 local mean time (Dewan *et al*., 2017 & Holle, 2013).

Bangladesh has been affected by lightning and many other natural hazards like flood, storm surge, cyclone, tornado, riverbank erosion, drought, earthquake, etc. (Karim, 1995; Moniruzzaman, 2012 and Siddik *et al*., 2018). Globally lightning induced casualties become a public health concern (Apanga *et al*., 2017). Bangladesh has had a high occurrence of preventable deaths from lightning for quite a long time (Biswas *et al*., 2016). It is evident from the literature that Bangladesh observed total 5,468 numbers of casualties, including 3,086 fatalities and 2,382 injuries from 1990 to mid-2016 (Dewan *et al*., 2017). The government of Bangladesh has declared lightning as a natural disaster in 2016 *(Biswas et al*., 2016 & Jahan, 2016). After that, the government has made an initiative towards planting one million palm trees across the country to control deaths occurring from lightning strikes each year (Arman & Chaity, 2017).

Several studies (Ab-Kadir, 2016; Aslar *et al*., 2001; Curran *et al*., 2000; Holle, 2013; Mistovich *et al*., 2008; Okafor, 2005; Orville & Spencer, 1979; Shrigiriwar *et al*., 2014; Singh *et al*., 2017; Singh & Singh, 2015; Tan & Goh, 2017 and Williams *et al*., 2002) have been carried out focusing lightning hazards and associated impacts considering country wise or world wide database but relatively few researches (Biswas *et al.*, 2016; Dewan *et al.*, 2018b, 2018a, 2017; Farukh *et al*., 2018; Gomes *et al.*, 2012 and Holle, 2016) were conducted addressing Bangladesh. Therefore, the present study tried to find the spatio-temporal distribution of lightning induced fatalities and injuries during the year of 2012 to 2016 in Bangladesh. Lightning related other information like occurring places, seasonal distribution, diurnal frequency, gender, occupation of the affected people have also been investigated under this study.

Material and Methods

Lightning related hazards are not familiar in the relevant government agencies. So Bangladesh Metrological Department (BMD) and government domain didn't collect or record the systematic and organized database of lightning casualty information. In that aspect, lightning induced fatalities and injuries data and information were collected from three most circulated *National Bangla Dailies* in Bangladesh. These are the Daily *Prothom Alo*, the Daily *Jugantor* and the Daily *Ittefaq* from March-November of each year during the year 2012-2016. Collected data and information were compiled and

cross-checked in order to avoid overlapping and inconsistency. For avoiding overlapping, data were first matched with all of the demographic variables and location of each entry. Then, cross-checking was done against the corresponding day and year of that entry using MS Excel. Cases were excluded if any duplication and overlapping was encountered. This study incorporated all relevant available attributes (found in the national dailies) of each fatality or injury for making the database detail. Analysis has been done using SPSS and MS Excel software. The fatality maps have been created using ArcGIS 10.0 software along with 'WinSurfer (Version 10)' software.

Results and Discussion

Fatalities and Injuries

This study revealed that fatalities occurred in all districts in Bangladesh except Barguna during the period of 2012 to 2016. The total number of fatalities and injuries were 1002 and 613 during the observed period. Figure 1 shows year wise number of fatalities and injuries in the Bangladesh during the observed period. Total 232, 253,122, 128 and 267 numbers of fatalities occurred in the year of 2012, 2013, 2014, 2015 and 2016 respectively. On an average 200 numbers of fatalities occurred every year during 2012 to 2016. On the other hand, total 172, 172, 92, 75 and 103 numbers of injuries occurred in the year of 2012, 2013, 2014, 2015 and 2016 respectively. On an average 123 numbers of injuries occurred every year during 2012 to 2016. Figure 1also shows that during 2012 and 2013, the number of fatalities and injuries were more than 200 and 100 respectively. Both the fatalities and injuries were decreased in the year of 2014 and 2015. But, in the year of 2016 fatalities and injuries were increased again and the increasing trend of fatalities was more rapid than injuries.

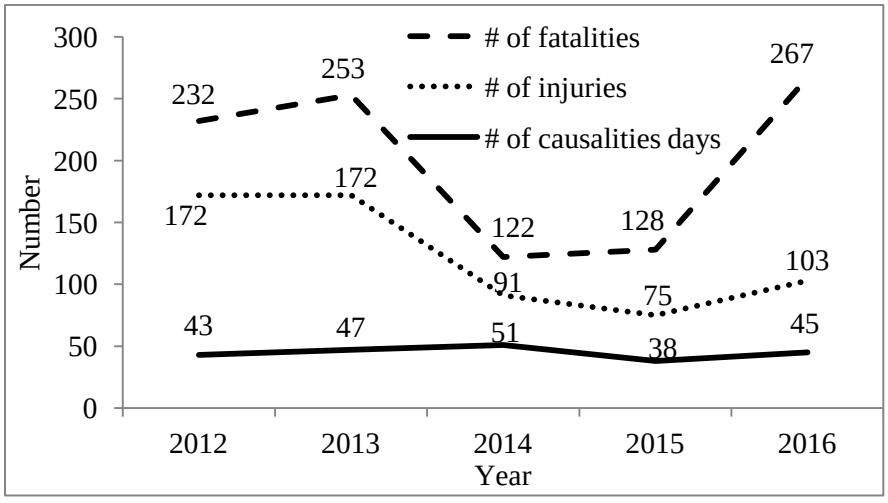

Figure 1. Year wise number of fatalities and injuries during the observed period (2012-2016) in Bangladesh

Demographic Profile of Lightning Victims

Gender Information

Gender information of all fatalities and injuries were not available in the newspaper. Among the fatalities (N=1002) about 2 percent (N=21) information was missing. In case of injuries, most of the information (52.7 percent) regarding gender was missing in the newspaper. The study found that males are more vulnerable than female after considering available information. Amongst the fatalities (N=981) during the observed period, about 77 percent were male. The result was almost similar for injuries. Among the injuries (N=290) in the study period, about 70.3 percent were male (
Table 1).This was because males are supposed to go outside than female owing to economic and socio-cultural activities.

Table 1. Number of fatalities, injuries and their gender statistics

Variables	Fatalities	Injuries
(a) Presence of gender information in newspapers		
Number	1002 (%)	613 (%)
Yes	981 (97.9)	290 (47.3)
No	21 (2.1)	323 (52.7)
(b) Gender		
Number	981(%)	290(%)
Male	757 (77.2)	204 (70.3)
Female	224 (22.8)	86 (29.7)

Occupation of Lightning Victims

This study revealed that the people who work outside or engage in outdoor activities were more affected by lightning than the people work in inside. Occupation related information of the causalities was not fully reported by the newspapers. Only about 49.8 percent occupation information on fatalities and about 21.7 percent information on injuries were reported. Farmers are the most affected in terms of fatalities and followed by students, day labours, housewives, fishermen and business persons. On the other hand, in terms of injuries day labour was most affected occupation and followed by farmer, student, fisherman and housewife.
Table 2 shows detail about occupation wise fatalities and injuries.

Table 2. Occupation wise fatalities and injuries

Variables	**Fatalities**	**Injuries**
Number	1002 (%)	613 (%)
(a) Occupation information in newspapers		
Reported	499(49.8)	133(21.7)
Not reported	503(50.2)	480(78.3)
(b) Occupation of the reported causalities		

Variables	Fatalities	Injuries
Farmer	199(39.9)	46(34.6)
Student	111(22.2)	24(18.0)
Day labour	84(16.8)	51(38.3)
House wife	60(12.0)	3(2.3)
Fishermen	15(3.0)	8(6.0)
Teacher	6(1.2)	1(0.8)
Business	12(2.4)	0(0.0)
Others	12(2.4)	0(0.0)

Occurring Places of Fatality and Injury

In developing countries, lightning casualties often occurred inside unsafe structures and outside during labour-intensive agriculture. It was revealed that about 53.5 percent fatalities and about 41.1 percent injuries took place in an open place during the observed period. Amongst them, highest number of fatalities and injuries happened in crop fields, homestead area and open water body. Out of the total fatalities and injured people about

Table 3. Occurring places of fatalities and injuries

Occurring places	Fatalities	Injuries
Number	1,002 (%)	613 (%)
a) In open place	536 (53.5)	251 (41.1)
Homestead area	170 (31.7)	44 (17.5)
Madrasha yard	3 (0.6)	0 (0)
School yard	2 (0.4)	22 (8.7)
Crop field	172 (32.1)	65 (25.8)
Play ground	17 (3.2)	10 (4)
Brick field	3 (0.6)	12 (4.8)
Grazing place	4 (0.7)	0 (0)
Water body	92 (17.2)	42 (16.7)
Road side	35 (6.5)	45 (17.9)
Open space	38 (7.1)	12 (4.8)
b) In under roof	103 (10.3)	100 (16.3)
Inside the house	45 (43.7)	41 (41)
Under the tree	23 (22.3)	4 (4)
Inside the machine house	12 (11.7)	9 (9)
Inside the market	3 (2.9)	24 (24)
Inside the rail station	2 (1.9)	2 (2)
Inside the mosque	18 (17.5)	20 (20)
c) Not reported in newspapers	363 (36.2)	261 (42.6)

10.3 fatalities and 16.3 injured people took shelter during lightning. Amongst them, highest number of fatalities and injuries happened inside the house, under the tree, inside the mosque, and inside the machine room.

Table 3 shows the detail information about occurring places of fatal and injured people in Bangladesh during 2012 to 2016.

Temporal Distribution of Lightning Induced Fatalities and Injuries

Monthly Distribution

The study found that most of lightning events occured in between the month of April and October in Bangladesh. Figure 2 shows monthly distribution lightning induced total number of fatlities and injuries in the period of 2012 to 2016.

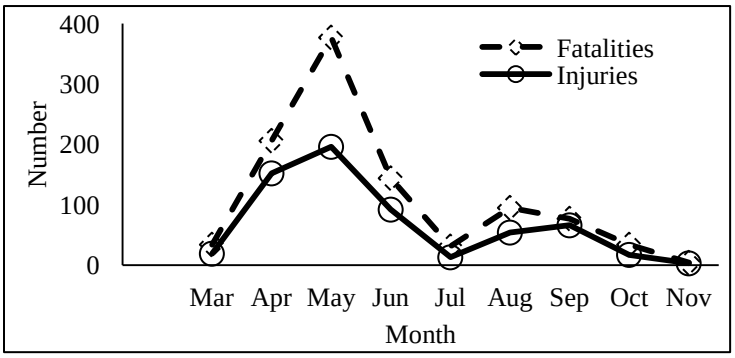

Figure 2. Monthly distribution of lightning induced fatalities and injuries (2012-2016)

It is revealed that May is the most hazardous month in terms of lightning related fatalities and injuries. A total of 377 fatalities and 196 injuries took place in this month during the observed period. The second most hazardous month is April and followed by June,

Table 4. Year and month wise numbers of reporting days, fatalities and injuries

	Number of reporting days						Fatalities						Injuries					
Months	2012	2013	2014	2015	2016	Total	2012	2013	2014	2015	2016	Total	2012	2013	2014	2015	2016	Total
Mar	1	0	2	5	4	12	2	0	3	14	15	34	1	0	0	11	7	19
Apr	12	8	7	9	3	39	125	28	12	34	7	206	105	15	9	13	10	152
May	13	13	14	6	11	57	53	120	52	28	124	377	21	70	52	17	36	196
Jun	7	8	9	7	10	41	12	40	20	24	48	144	2	41	8	26	15	92
Jul	0	1	3	6	1	11	0	2	4	20	5	31	0	1	3	8	1	13
Aug	4	4	8	3	7	26	22	28	20	5	20	95	25	11	12	0	6	54
Sep	4	8	4	0	6	22	8	24	5	0	40	77	7	28	4	0	27	66
Oct	2	5	1	2	3	13	10	11	2	3	8	34	11	5	0	0	1	17
Nov	0	0	3	0	0	3	0	0	4	0	0	4	0	0	3	0	0	3

August, September, March, October, July and November. The study didn't find any lightning induced fatalities and injuriesin the month of January, February and December during the observed period.

Table 4 presents year and month wise distribution of lightning induced fatalities and injuries.

Seasonal Variation

The present study also revealed pre-monsoon as the most lightning induced fatalities recorded season. Total recorded fatalities during pre-monsoon season were 617 and which was about 61.6 percent of total fatalities of the observed period. Table 5 shows detail information about season wise fatality distribution.

Table 5. Seasonal variation of fatalities during 2012-2016

Season	2012	2013	2014	2015	2016	Total
Pre-monsoon	180	148	67	76	146	617
Monsoon	42	94	49	49	113	347
Post-monsoon	10	11	6	3	8	38

Diurnal Variation

Based on the reported information in national dailies, the present study found that the highest number of fatalities and injuries occurred in the morning and noon period during the observed years (

Figure 3). About 60 percent fatalities and injuries occurred during the morning and noon time and this scenario almost same all the years. Table 6 shows the diurnal distribution of lightning induced fatalities and injuries during the observed years (2012-2016).

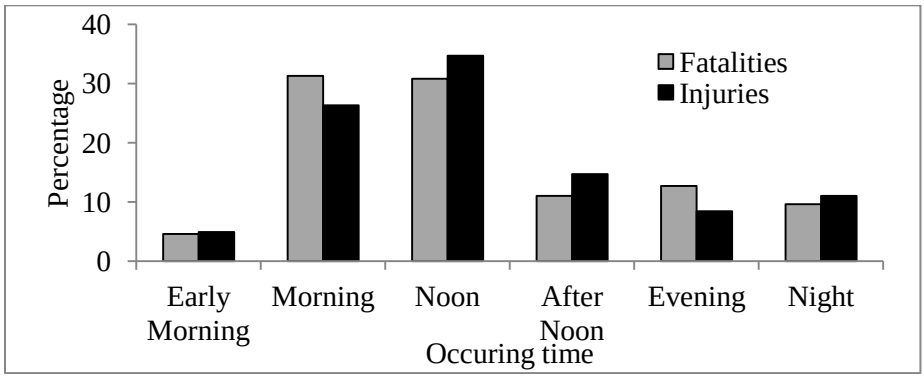

Figure 3. Diurnal distribution of lightning induced total fatalities and total injuries in Bangladesh.

Table 6. Diurnal distribution (%) of lightning induced fatalities and injuries (2012-2016)

Variables	Fatalities (%)						Injuries (%)					
	2012	2013	2014	2015	2016	Total	2012	2013	2014	2015	2016	Total
Number	232	253	122	128	267	1002	172	172	91	75	103	613
(a) Reported in newspapers												
Yes	65.9	75.1	74.6	67.2	50.6	65.4	48.8	77.9	36.3	46.7	58.3	56.4
No	34.1	24.9	25.4	32.8	49.4	34.6	51.2	22.1	63.7	53.3	41.7	43.6
(b) Diurnal distribution												
Early Morning	5.9	2.1	7.7	4.6	4.5	4.6	4.7	0	18.2	5.7	8.4	4.9
Morning	42.5	28.4	19.8	26.7	33.3	31.3	32.1	22.4	15.2	22.9	35	26.3
Noon	20.9	40.5	34	32.6	25.2	30.8	19.1	49.2	24.2	45.7	23.3	34.7
After Noon	5.9	10	16.5	12.8	13.3	11	6	18.7	21.2	8.6	18.3	14.7
Evening	11.1	8	16.5	19.8	14.1	12.7	9.5	3	18.2	14.3	10	8.4
Night	13.7	11..0	5.5	3.5	9.6	9.6	28.6	6.7	3	2.8	5	11

Spatial Distribution of Lightning induced Fatalities and Injuries

Year Wise Spatial Distribution of Lightning Fatalities

The present study have identified year wise fatality distribution of the affected districts (Figure 4 to 8). Figure 4 shows the highest number of fatalities were found in the Sunamganj District (20) and followed by Nilphamari (11), Dinajpur (10), Jamalpur (10) and Satkhira District (10) in the year of 2012. In this year, no fatalities were reported in Barguna, Feni, Jhenaidaha, Joypurhat, Khagrachari, Meherpur, Narail, Natore and Rajbari District. Range of the number of fatalities in other districts was 1 to 9 respectively.

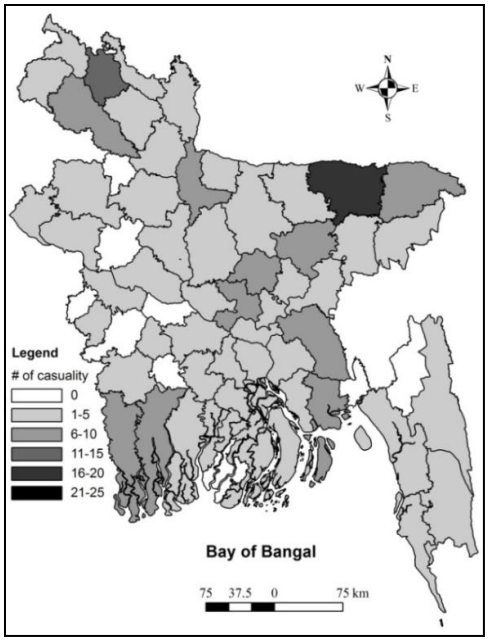

Figure 4. Spatial distribution of total lightning fatalities in 2012.

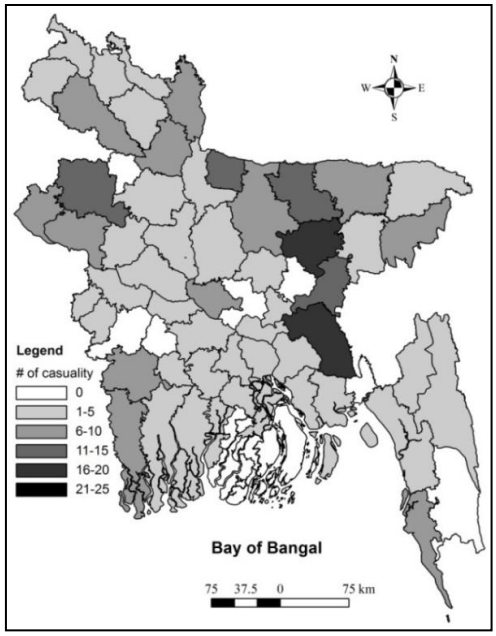

Figure 5. Spatial distribution of total lightning fatalities in 2013.

Figure 5 shows district wise fatality distribution of 2013 and indicated that the highest number of fatalities was found in the Comilla District (17) and followed by Kishoreganj (16), Brahmanbaria (14), Netrakona (13), Sherpur (13), Naogaon (11), Sunamganj (10) and Mymensingh (10). In this year, no fatalities were reported in Barguna, Bandarban, Bhola, Dhaka, Jhalokathi, Jhinaidaha, Joypurhat, Magura, Narshingdi and Patuakhali District. Rest of the district ranges were between 1-9 fatalities.

In the year of 2014, the highest number of fatalities was found in the Chapainawabganj District (8) and followed by Nilphamari (6), Brahmanbaria (5), Habiganj (5), Kishoreganj (5), Meherpur (5), Mymensingh (5). In this year, no fatalities were reported in Barguna, Barisal, Bhola, Comilla, Feni, Gaibandha, Gopalganj, Jessore, Joypurhat, Khagrachari, Khulna, Kurigram, Lakshmipur, Narshingdi, Natore, Patuakhali, Rajbari,Sylhet and Thakurgaon District. Other districts are categorized as 1-4 fatalities (Figure 6).

District wise fatality distribution of 2015 indicated that the highest number of fatalities was found in the Sunamganj District (10) and followed by Comilla (8), Netrokona (8), Habiganj (8), Rajbari (7). In this year, no fatalities were reported in Barguna, Bagerhat, Bandarban, Bhola, Cox's Bazar, Dhaka, Feni, Jamalpur, Jhalokathi, Joupurhat, Khagrachari, Kurigram, Kushtia, Lalmonirhat, Madaripur, Meherpur, Naogaon, Nilphamari, Noakhali, Panchager, Patuakhali, Satkhiraa, Shariatpur and Sylhet District. Ranges of other districts were 1-6 fatalities (Figure 7).

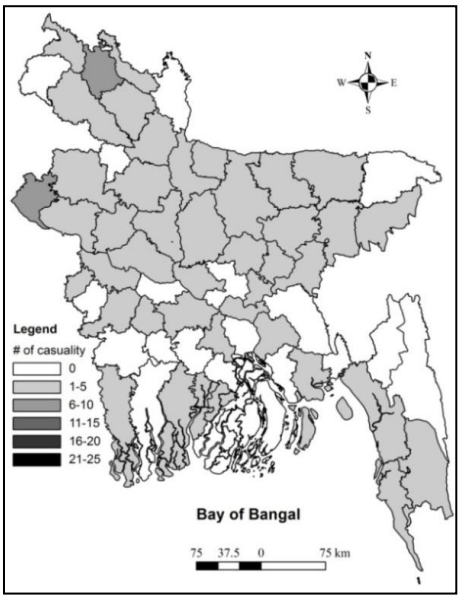

Figure 6. Spatial distribution of total lightning fatalities in 2014

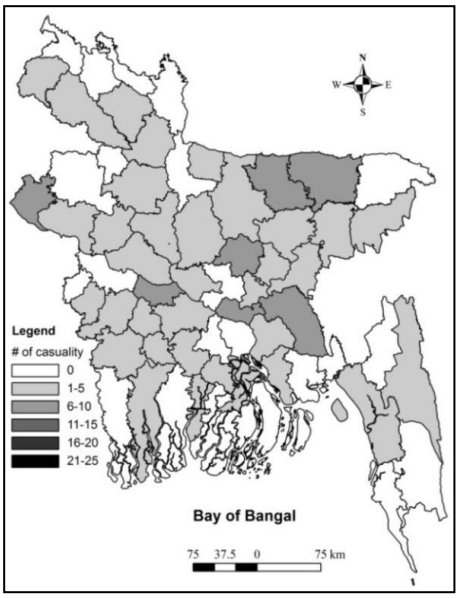

Figure 7. Spatial distribution of total lightning fatalities in 2015

Figure 8 presents district wise fatality distribution of 2016. In this year the highest number of fatalities was found in the Sunamganj District (25) and followed by Kishoreganj (17), Tangail (14), Pabna (13), Sirajganj (11), Dinajpur (10) and Dhaka District (10). In this year, Bandarban, Barguna, Bhola, Bogra, Chandpur, Chuadanga, Kushtia, Lalmonirhat, Magura, Meherpur, Rangamati and Shariatpur Districts were found with 'nil' fatality but rest of districts were categorized as 1-9 fatalities group.

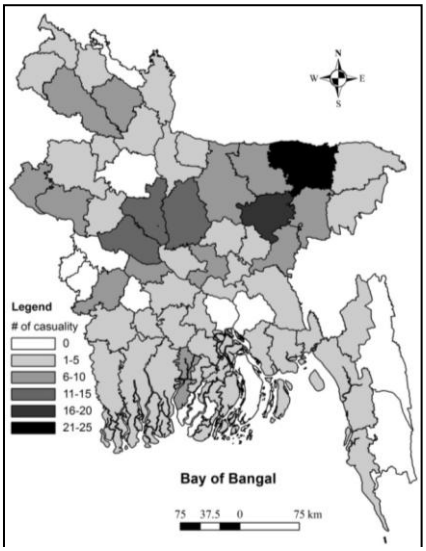

Figure 8. Spatial distribution of total lightning fatalities in 2016

District Wise Ranking and Cumulative Spatial Distribution

It is mentioned earlier that lightning induced fatalities were found in all districts of Bangladesh except Barguna.The present study has made a district ranking list according to the death statistics.

Table 7 and Figure 9 present district wise ranking of lightning induced fatalities. The highest number of fatalities during the study period have found in Sunamganj (69) followed by Kishoreganj (48), Comilla (35), Netrokona (35), Chapainawabganj (32) and Dinajpur (31). On the other hand, highest death case of a single event observed in Dharmapsaha upazila of the Sunamganj District on 10th August in 2012.

Table 7. Rank of districts based on the number of lightning induced fatalities during 2012-2016.

District	Number of death	District	Number of death	District	Number of death
Sunamganj	69	Gaibandha	17	Bogra	9
Kishoreganj	48	Rajbari	17	Chandpur	9
Comilla	35	Rajshahi	17	Chittagong	9
Netrokona	35	Jessore	16	Gopalganj	9
Chapainawabganj	32	Manikganj	16	Lakshmipur	9
Dinajpur	31	Noakhali	16	Madaripur	9
Mymensingh	29	Moulvibazar	15	Meherpur	8
Brahmanbaria	29	Faridpur	14	Natore	7
Tangail	27	Munshiganj	14	Jhalokathi	6
Gazipur	25	Panchagarh	14	Chuadanga	5
Nilphamari	24	Thakurgaon	14	Kushtia	5
Sirajganj	24	Khulna	14	Magura	5
Sherpur	24	Narayanganj	13	Bandarban	4
Habiganj	22	Bagerhat	12	Patuakhali	4
Pabna	22	Sylhet	11	Rangamati	4
Dhaka	20	Barisal	10	Bhola	3
Rangpur	20	Jhenaidah	10	Joypurhat	3
Pirojpur	20	Kurigram	10	Shariatpur	3
Naogaon	19	Lalmonirhat	10	Khagrachari	2
Satkhira	19	Narail	10	Feni	1
Cox's Bazar	17	Narsingdi	10	Barguna	0
Jamalpur	17				

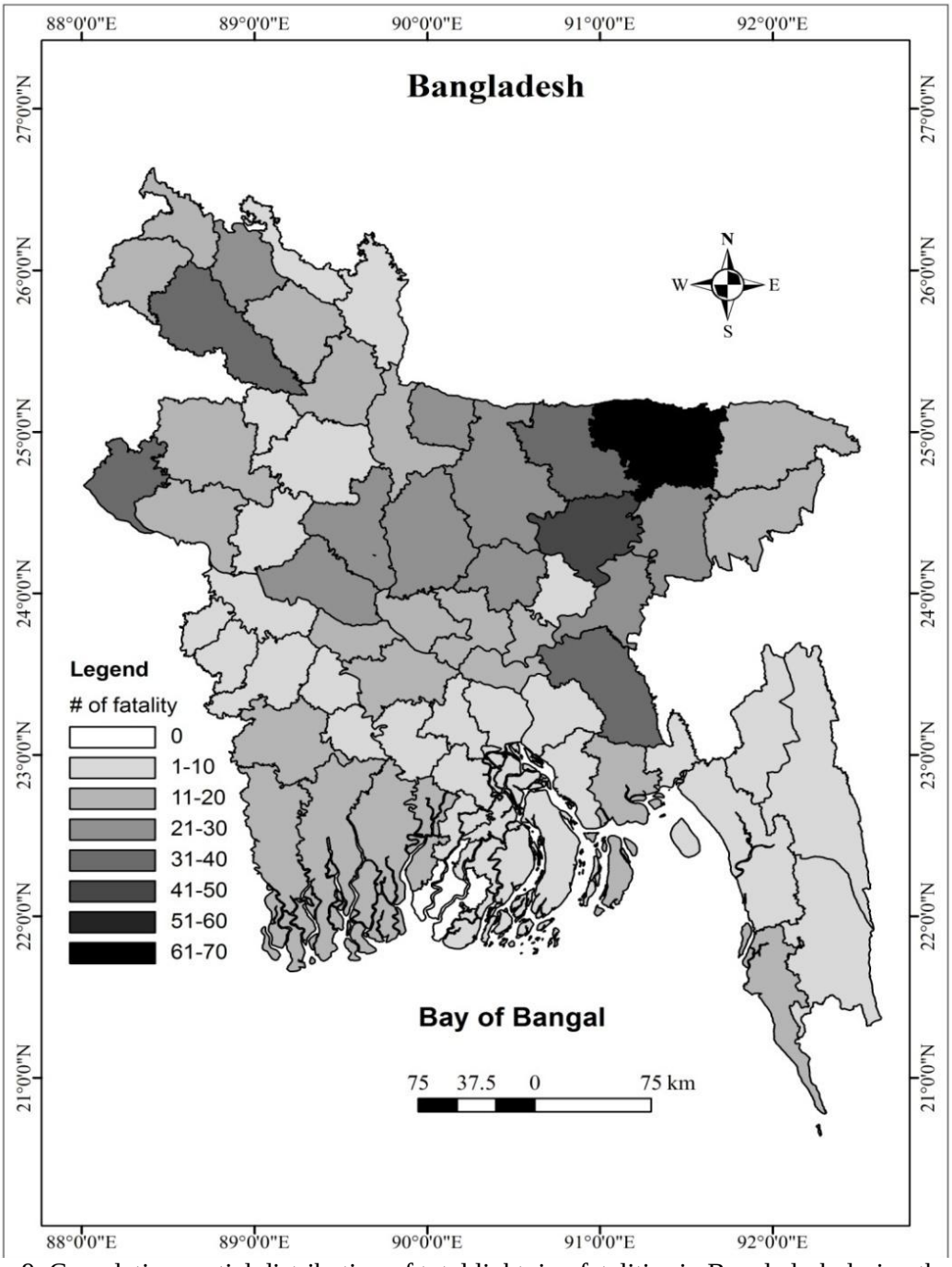

Figure 9. Cumulative spatial distribution of total lightning fatalities in Bangladesh during the year 2012-2016

Conclusion

Lightning is one of the leading causes of weather-related fatalities and injuries in the world. The present study found that the yearly average rate of lightning induced fatalities was about 200 and injuries about 123 during the year 2012-2016 in Bangladesh. Except Barguna, all other districts in Bangladesh were experiened lightning fatality. Spatial distribution reveals that fatalities due to lightning is the higher over Sylhet- Mymensingh region and lower over Noakhali- Chittagong region with the highest in Sunamganj district and then in Kishoreganj and in Comilla and Netrokona respectivly.. It is also revealed that the majority of lightning related fatalities and injuries were found at noon and then morning time. Number of causalities was high in pre-monsoon than monsoon and post-monsoon. The highest fatalities and injuries were found among farmers then the dwellers because they usually go outside frequently for their works. For this reason it was also found that cause for more fatalities and injuries among male than female in the country. The study findings are decidedly useful to the policymakers, and planners to develop lightning mitigation plans, improve public awareness and lightning education and safety campaign to reduce the impacts of lightning hazards in Bangladesh. Research of the further study would encourage finding out the causes of lightning in the recent time.

Acknowledgement

The authors very much thankful to the Ministry of Science of Technology, Government of the People's Republic of Bangladesh for financial support to carry out the research project entitled "Spatial and Temporal Analysis of Lighting Hazards in Bangladesh'' [grant numbers SL-309, 2016-17].We would like to thank the authorities of the daily *Prothom Alo*, the daily *Jugantor*, and the daily *Ittefaq* for their support during data collection. We would also like to express our gratitude to the anonymous peer reviewers for their valuable comments on the manuscript.

References

Ab-Kadir M.Z.A. (2016). Lightning severity in Malaysia and some parameters of interest for engineering applications. *Therm. Sci.*, https://doi.org/10.2298/TSCI151026028A.

Apanga, P.A., Azumah, J.A. and Yiranbon, J.B. (2017). A rare manifestation of burns after lightning strike in rural Ghana: A case report. *J. Med. Case Rep*. https://doi.org/10.1186/s13256-017-1378-0.

Arman, T.U. and Chaity, A.J.(2017). One million Palmyra palm trees to be planted to prevent lightning strike deaths. *Dhaka Tribune. March, 10, 2017*

Aslar, A.K., Soran, A., Yildiz, Y., and Isik, Y. (2001). Epidemiology, morbidity, mortality and treatment of lightning injuries in a Turkish burns units. *Int.J.Clin.Pract. 55(8):* 502-504.

Biswas, A., Dalal, K., Hossain, J., Baset, K.U, Rahman, F. and Mashreky, S.R. (2016). Lightning Injury is a disaster in Bangladesh? - Exploring its magnitude and public health needs. *F1000Research.* https://doi.org/10.12688/f1000research.9537.1

Curran, E.B., Holle, R.L. and Lopez, R.E. (2000). Lightning casualties and damages in the United States from 1959 to 1994. *J. Clim.* https://doi.org/10.1175/1520.

Dewan, A., Hossain, M.F., Rahman, M.M., Yamane, Y. and Holle, R.L., (2017). Recent Lightning-Related Fatalities and Injuries in Bangladesh. *Weather. Clim. Soc.* https://doi.org/10.1175/wcas-d-16-0128.1

Dewan, A., Ongee, E.T., Rafiuddin, M., Rahman, M.M. and Mahmood, R.(2018a). Lightning activity associated with precipitation and CAPE over Bangladesh. *Int. J. Climatol.* https://doi.org/10.1002/joc.5286

Dewan, A., Ongee, E.T., Rahman, M.M., Mahmood, R. and Yamane, Y. (2018b). Spatial and temporal analysis of a 17-year lightning climatology over Bangladesh with LIS data. *Theor. Appl. Climatol.* https://doi.org/10.1007/s00704-017-2278-3

Farukh, M., Ahmed, S., Islam, M. and Baten, M., (2018). Spatial Vulnerability Assessment of Extreme Lightning Events in Bangladesh Using GIS. *J. Environ. Sci. Nat. Resour.* https://doi.org/10.3329/jesnr.v10i2.39008

Gomes, C., Ahmed, M. and Žele, D., (2012). Lightning related fish mortality: Case study from Bangladesh, in:*31st International Conference on Lightning Protection, ICLP* 2012. https://doi.org/10.1109/ICLP.2012.6344259

Holle, R.L. (2016). Lightning-caused Deaths and Related to Agriculture. *Proc. 33rd Int. Conf. Light.* Prot.www.aconf.org.

Holle, R.L. (2013). Diurnal Variations of NLDN-Reported Cloud-to-Ground Lightning in the United States. *Mon. Weather Rev*. https://doi.org/10.1175/mwr-d-13-00121.1

Jahan, N., (2016). *Lightning: The New Natural Disaster.* 30, September 2016, The Daily Star.

Karim, N. (1995). Disasters in Bangladesh. *Nat. Hazards.* https://doi.org/10.1007/BF00613409

Moniruzzaman, M. (2012). Geospatial Analysis of Damage, Loss, Recovery and Reconstruction: A Case on Cyclone Sidr. Ph.D. Thesis. Department of Geography and Environment, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh.

Mistovich, J.J., Krost, W.S. and Limmer, D.D.(2008). Beyond the basics: lightning-strike injuries. *EMS Mag* 37(3): 82-87.

Okafor, U.V. (2005). Lightning injuries and acute renal failure: a review. Ren. Fail. https://doi.org/10.1081/JDI-200048216

Orville, R.E. and Spencer, D.W. (1979). Global Lightning Flash Frequency. *Am. Meteorol. Soc.* 107: 934-943.

Shrigiriwar, M.B., Gadhari, R.K., Jadhao, V.T., Tingne, C.V. and Kumar, N.B.(2014). Study of fatalities due to lightning in Nagpur region of Maharashtra. *J. Indian Acad. Forensic Med.36(3)*: 259-262.

Siddik, M.A., Akhtar, M.P. and Moniruzzaman, M., (2018). Cyclone Induced Land Transformation in the Bagerhat Coast of Bangladesh. *Int. J. Innov. Res.* 3: 68-72.

Singh, O., Bhardwaj, P. and Singh, J. (2017). Distribution of Lightning Casualties over Maharashtra, India. *J. Indian Geophys Union*. 21(5): 415-424.

Singh, O., Singh, J.(2015). Lightning fatalities over India: 1979-2011. *Meteorol. Appl.* https://doi.org/10.1002/met.1520, 22: 770-778.

Tan, H., Goh, S. (2017). Lightning Injury: Changi Hospital Experience. *Hong Kong J. Emerg. Med*. https://doi.org/10.1177/102490790301000404

Van Alstine, W.G. and Widmer, W.R. (2003). Lightning injury in an outdoor swine herd. *J. Vet. Diagnostic Investig.* https://doi.org/10.1177/104063870301500313

Williams, E., Rothkin, K., Stevenson, D. and Boccippio, D. (2002). Global Lightning Variations Caused by Changes in Thunderstorm Flash Rate and by Changes in the Number of Thunderstorms. *J. Appl. Meteorol.* https://doi.org/10.1175/1520-0450(2001)040<2223:glvcbc>2.0.co;2