



Lightning related human casualties in Mongolia

Myagmar Doljinsuren

Institute of Meteorology, Hydrology and Environment
Juilchny Gudamj-5,
Ulaanbaatar 210646, Mongolia
dosharty@yahoo.com

Chandima Gomes

Center for Electromagnetic and Lightning Protection
(CELP), Universiti Putra Malaysia, Serdang,
Selangor, 43400, Malaysia
chandima@upm.edu.my

Abstract—Lightning related casualties collected by the Institute of Meteorology in Mongolia from 2003 to 2015 have been analyzed. Being a country with one of the lowest population density, Mongolia records a relatively high human death rate per unit population per year, 15.4 dptm yr⁻¹, which is much higher than that of many countries with similar isokeraunic level. During this period 57 deaths and 58 injuries have been reported, thus death to injury ratio is nearly 1:1. Around 88% of both deaths and injuries has been reported to be occurred while the victim is in wild area, typically the low-grown slopes in steppe climate. Other 12% of the death and injury cases have been located either in open spaces within the village or inside the fabric enclosed houses known as ger. Nearly 80% of the gender-known deaths are of males. Almost 100% of the deaths of which the time of incident is known has happened between noon and midnight. Almost all case of injuries have also been reported during the same period. About 80% of the age-reported deaths were of people below 30 years. Slightly more than 50% of the deaths and 54% of the injuries have been reported from Central province.

Keywords—Mongolia; lightning injuries; steppe; death rate; slope

I. INTRODUCTION

During the recent past, many investigations have been reported on the lightning related casualties in many developing countries. The reason for such impulse of research may be the unprecedented number of lightning casualties reported from these countries during the past decade, perhaps due to the development and rapid spread of mass communication. These research have focused on many aspects such as the effects of lightning on human beings and animals and the dependence of these effects on various parameters that intern are based on meteorological, geographical and sociological factors [1-8]. The outcomes of these research as well as the sociological studies that has been done on human perspectives and level of awareness on lightning threats among native populations, revealed that lightning related scientific work has not been extended to the regions with high casualty areas which needs much higher attention with regard to both safety and protection against lightning. These studies also emphasize that irrespective of the marked declination in lightning related deaths and injuries in developed countries during the last century [9-17], the situation in the developing world in Asian, African and Southern American continents, is either turning towards worse scenarios or is comparable with that of developed countries, many decades or a century back.

In such backdrop, this study has been conducted to analyze the pattern of lightning related deaths and injuries in Mongolia, a country which records a much higher human death rate per unit population per year than many other countries with similar lightning ground flash density. Lightning related human casualties in Mongolia

II. MONGOLIA IN BRIEF

Being a landlocked country Mongolia borders Russia in North and China in other directions. The geographical coordinates are latitudes 41° N and 52° N and longitudes 87° E and 120° E, with average altitude of 1560 m amsl. The country has a land area of 1,564,116 km², population of 2.8 million (in 2012). By the meteorological, geographic and topographical features the country can broadly be categorized into four parts (figure-1); Western part where high mountains starts from the north-western boundaries, Central part with another high mountain range with slopes of steppe climate, Mostly flat and arid Southern and Eastern parts that end up in Gobi desert. Mongolia is characterized by extreme temperature conditions; short but very hot summers and ultra-cold winters. The four seasons spread as; winter from November to end of March, spring from March to May, summer from June to August and autumn from September to October. The average rainfall of the country is 200-400 mm with highest to lowest values gradually vary from North to South.

As the high mountains ranges in the northern and north western territories prevent moist air masses generated in the water bodies and rich forests blowing into the eastern and southern slopes of the western and central parts. The low annual rainfall results in low grown shrubs, grasslands and even some no-grown spots, typical to steppe climate in many parts of the country. This topographic feature is of significance in explaining the observation of lightning casualties in the country. As per the study of Doljinsuren and Gomes [1], the rate of human deaths in Mongolia is 15.4 deaths per ten million per year (dptm yr⁻¹). This value is approximately an order higher than the same in many European and North American countries with similar ground flash density. This very high number is attributed to the above low grown features. A lightning stepped leader that reaches towards ground have a very high chance of being attached to an isolated house or a person standing outside, due to the lack of tall vegetation canopy in the surrounding.

Lightning has not been considered as a major natural threat in Mongolia until recent times. In their study, Doljinsuren and Gomes [1] analyzed human and livestock casualty data pertinent to several extreme weather events including lightning. Their results show that lightning casualties are significant with respect to human deaths, although the financial losses are almost negligible compared with losses due to other extreme weather events. However, they predict that with the rapid industrialization taking place in the country, the financial losses may also increase significantly with time, if no safety and protection measures are contemplated to curb the possible mishaps from early stages. This study is to further enhance the knowledge of [1] on lightning related human casualties which will support scientists and engineers in planning safety modules and protection techniques for the future.

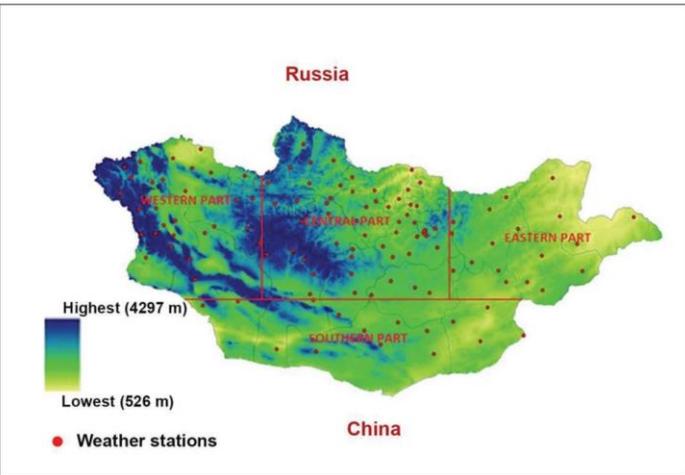


Figure 1. Map of Mongolia with regional divisions considered in the analysis. Red dots indicate the locations of weather stations where the data has been collected (Adopted from [1]).

III. METHODOLOGY

The human death and injury information has been collected by Institute of Meteorology, Hydrology and Environment (IMHE) of Mongolia through various information sources during the period 2003-2015. The data have been cross checked through several sources before taking into account for the analysis. The country has a well distributed and regularly function meteorological observation centers at 118 locations which are operated by the NAMEM. Due to the lack of pre-information on data collection methodologies, some information has not been recorded uniformly.

IV. RESULTS AND DISCUSSION

During the period from 2003-2015, IMHE has collected 70 lightning related accidents that have resulted 57 deaths and 58 injuries with some detailed information on the incidents. The data has been analyzed on gender, age, location of incident, time of the day and region of the country. Note that the cumulative figures in each case may not tally as some incident records do not provide some parameters due to reporting or recording irregularities. Only the region of accident and the place of incident have been recorded in all cases.

A summary of the outcomes have been given in Table 1. Note that the age limits have been defined as Children: less than 15; Youth: 15-30; Middle aged: 30-50; Elderly more than 50. The marginal cases were included in the lower limits. The time of the day has been defined as Morning: 06.00-12.00 Afternoon: 12.00-18.00; Evening: 18.00-24.00; Night: 0.00-06.00.

TABLE 1. SUMMARY OF CASUALTY PATTERN

| Feature | Detail | Deaths | Injuries |
|-----------------|--------------------------|--------|----------|
| Gender | Male | 39 | 15 |
| | Female | 11 | 11 |
| Age | Children | 12 | 7 |
| | Youth | 29 | 12 |
| | Middle Aged | 9 | 5 |
| | Elderly | 2 | 1 |
| Location | Indoor (inside ger) | 3 | 10 |
| | Outdoor (within village) | 4 | 3 |
| | Outdoor (in wild area) | 50 | 45 |
| Time of the day | Morning | 1 | 1 |
| | Afternoon | 18 | 18 |
| | Evening | 8 | 21 |
| | Night | 0 | 0 |
| Region | Western part | 15 | 12 |
| | Central part | 29 | 31 |
| | Eastern part | 10 | 10 |
| | Southern part | 3 | 4 |

The total number of deaths and that of injuries show that the ratio between them is nearly 1:1. Similar observations have been done in some parts of Uganda as well [5, 6]. Such observation is in strong disagreement with the empirical relation proposed in [14] as 1:10. However, the total number of surviving people after being injured may be an underestimation as some cases may not be reported, especially if they do not seek medical treatment at recognized hospitals or medical clinics. On the other hand, it is a legal requirement to formally inform the authorities on deaths, thus most often each case will be reported with details. It should also be noted that unlike ‘death’, the term ‘injury’ is not well-defined. This may be an issue for the reporting/recording personal as well. Personal communication with officers as meteorological centers reveals that most often, an injury is counted when a person register at an authorized medical clinic for treatment at least as an outdoor patient.

The 51% of the number of deaths in Central part (figure-2) is well understandable as the region is characteristic by many mountain slopes with low grown vegetation or grassland. This observation is linked to the location of incident as well. As per the data in Table-1, 88% of the deaths have been reported while the victims are in wild areas. These wild areas are referred to the above described landscapes of steppe climate. This outcome re-emphasizes that there are many factors, apart from isokeraunic level, which influence the rate of lightning accidents in a country. The highly uneven distribution of the percentage of deaths in four regions with similar area and

population distribution, also reflects that considering an entire country defined by political boundaries, in determining lightning accident statistics may provide grossly unrealistic results.

It is worth mentioning that Mongolia is characterized by a unique type of domestic structures termed ‘ger’. These are most often made of cotton, fabrics and wood (figure-3). Due to the low sparsely populated landscapes most gers are isolated and pose as the only protrusion in a given landscape. In the present days, many gers are installed with television antenna and communication monopoles positioned on tall wooden or unearthed aluminium poles. Under such circumstances, the probability of lightning attaching to such structures is high and in the event of such strike, triggering fire is imminent due to the inflammable materials of the structure. Although the number of lightning accidents related to gers are low at present, the number may increase with time as the population expands and more gers are fitted with unearthed antenna poles.

The male deaths are nearly 4 times the female deaths. This is quite expected as the chances of the males being caught outside village areas (in forests) under thunderstorm conditions is much higher than that in the case of female. In the Mongolian cultural traditions, male members of the family typically go for hunting and feeding of livestock in the grasslands. Similar observations have been made in Malaysia [18], a country with different socio-economic structure, where the male to female ratio of the number of lightning victims is more than 12:1. In that case, the reason has been attributed to the large number of migrant male workers employed in the outdoor construction industry. Thus, this higher male victim rate may be somewhat common observation in the world and safety module developers should pay their attention to this factor in planning their safety promotion programs.

Nearly 80% of the total lightning victims are under 30 years of age. The number of deaths below 30 years of age is also nearly 80%. Several socio-economic factors may contribute to this outcome, however, unawareness and stubbornness to adopt safety advices may be a dominant factor. It should also be noted that a majority of indoor victims belongs to children category. Among the child victims, those are categorized as ‘kids’ by the record takers without mentioning the gender (usually below 6 years of age) have been affected while they are indoors. This is another point that can be emphasized by the safety promoters to encourage the people to adopt at least some low cost protection schemes for their houses. Small children may not be able to understand safety tips, thus they should be provided with adequate protection.

The time dependency (time of the day) of lightning accidents in Mongolia seems much stronger than that in many other countries. Several studies have revealed that lightning accidents, especially in tropics, are higher in the afternoon and evening hours [3, 8, 18, and 19], in none of the cases the death and injury percentages were nearly 100% as it is observed in Mongolia. Such trend may be due to both the thunderstorm occurrence pattern and the behavioral aspects of the society. This is another issue to be taken into consideration in developing safety modules for the country.

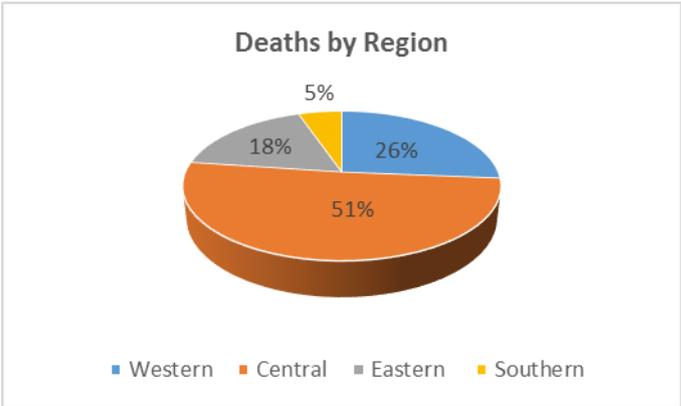


Figure-2. Percentage of deaths by region in Mongolia

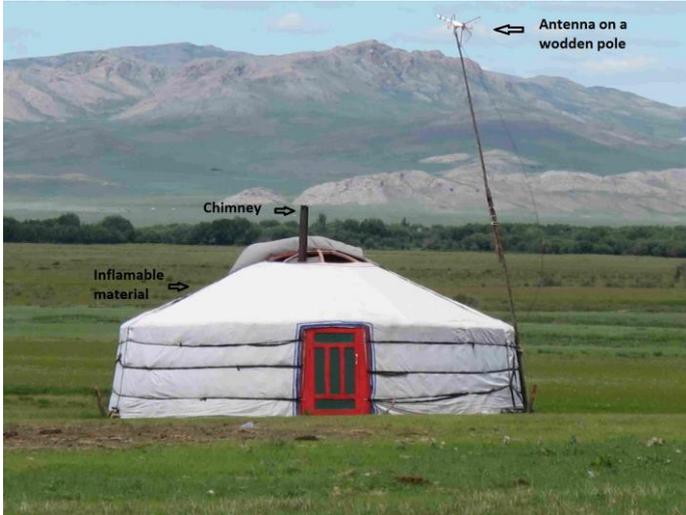


Figure-3. A typical Mongolian house termed ger

The outcomes of this study emphasizes the need for both lightning safety awareness and physical protection measures in parallel. Although ger carries a significantly high potential of lightning risk, one cannot easily change such traditional structures that practiced for millennia, within a short period. Thus, low cost systems that provide at least reasonable protection is in demand. It is also not possible to restrict the life-style of rural Mongolian population that requires daily travelling to remote low-grown forestry sites for various functions related to their professions. Thus, portable safety structures should be provided at least community-wise or simple lightning protection cages should be implemented at regular intervals at locations of potential risk. Such structures have been either proposed or discussed in some literature [20, 21], however, scientifically proven products or techniques with further improvised performance is a need of the hour.

It should also be noted that no significant study has been carried out in the country on mapping the lightning density and soil resistivity profile, reviewing lightning protection systems and protection schemes adopted by existing large buildings or at least the situation of existing earthing systems of the buildings. Such investigations will play key role in developing proposals to curb the lightning related accidents in the country.

V. CONCLUSIONS

This study further enhances the information base pertinent to lightning related casualties in Mongolia, where such studies have been initiated quite recently. The country has significantly high rate of lightning related deaths per year per unit population compared with other countries of similar isokeraunic level. The analysis of deaths and injuries during 2003-2015 period reveals that there are many country dependent factors which should be taken into account in developing promotional modules to enhance the awareness of safety and protection against lightning in a given region.

In Mongolia, the death to injury ration is almost 1:1 which is in disagreement with some empirical speculations found in the literature that predicts 1:10 ratio. Nearly 80% of the deaths are of males. In the case of both deaths and injuries the age group below 30 years contributes to nearly 80%. Out of the total deaths 88% has happened while the victims are in wild area and almost 100% of the accidents has happened during the afternoon and evening hours. The Central part of the country dominates with over 50% of the total deaths and injuries.

ACKNOWLEDGMENT

The authors would like to acknowledge the facilities and support rendered by the NAMEM, IMHE of Mongolia and the Centre for Electromagnetic and Lightning Protection, University Putra Malaysia in making this project a success.

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