

From Fulminology to Human Safety: A Case of N8 Road South Africa

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ABSTRACT: *All thunderstorms are detrimental and can be associated with a number of hazards. Heavy rains resulting from these storms lead to flash flooding that causes a number of fatalities in our communities and lightning is another by-product of thunderstorm that is produced from every thunderstorm and causes at least 80 fatalities and 300 injuries per year (NOAA, 2015). This study used conceptual research design in pursuit of understanding the root causes of thunderstorm and lightning and their mitigation measures for public safety more especially those who work in the open places. A specific reference was made to N8 road in South Africa where six fatalities were reported in March 2015. The study used extensive literature review (secondary data) for data collection in order to conceptualise thunderstorms and lightning and their subsequent consequences. The study ended with reduction measures to be taken by the public during thunderstorms to ensure safety. Authorities are also urged to educate the public about the risks of thunderstorms taking into cognisance the myths borne by the same public about lightning.*

Key words: *Fulminology, Thunderstorms, Lightning, Disaster, Hazard*

INTRODUCTION AND THEORETICAL BACKGROUND

Scientists are confident that global temperatures are yet to increase in the next decades to come mainly because of greenhouse gases produced by human activities (Jenkins, Jackson & Shaftel, 2015). Several scientists in the world agree that the cause of the current global warming is as a result of the atmosphere trapping heat radiation towards the earth's space. Global warming causes climate patterns to change in which case the later has a direct link with lightning (United States Environmental Agency, 2014). Similarly, Price, (2008:1) asserts that lightning distribution around the globe is directly linked with the earth's climate driven by solar insolation. According to Torlach, (1999) lightning is a phenomenon that cannot be prevented only effects can be safeguarded against through employment of protective systems and exercising due diligence as well long-standing established precautions. Many people are killed or injured each and every year by severe thunderstorms despite the present technologies for early warning systems (American Red Cross, 2015). Therefore given the present rapid climate change conditions, more deaths are yet to be recorded. Six construction workers were declared dead and five injured from a lightning bolt that occurred approximately 20 kilometres from Botshabelotowards Bloemfontein in March 2015 (Free State theweekly, 2015). These workers are said to have sought shelter from a wooden structure near a spot locally called "Eseng" meaning an "S" during a thunderstorm. The Free State Weekly, (2015) states that factors that possibly lead to this incidence are telephone lines and electrical cables and metal objects such as fences and windmills. Owing to the above background, the current conceptual study therefore seeks to assess the vulnerability of Botshabelo Township (adjacent to N8 highway road) to thunderstorms and lightning and how it progresses to a disaster in order for both the government and public to take necessary precautionary measures against adverse impacts lightning hazards.

Definition of Key-Concepts

Fulminology is the study or science of lightning (Fakhrudin,

2010). Thunderstorm is said to be a rain shower during which a thunder is heard. This sound comes from lightning, therefore all thunderstorms have lightning (The National Severe Storms Laboratory (NSSL), 2015). These are said to be severe when they consist of one or more of the following; one inch or greater of hail, winds gusting in excess of 50 knots or a tornado. According to World Meteorological Organisation, (2015) thunderstorms are a major trigger for many other hazards such as wildfires started by lightning, tornados and flash floods. We therefore in this study regard lightning as a hazard though this phenomenon is said to be localised in nature.

Lightning is defined as a discharge of electricity between clouds and the earth seen as bright flash followed by sound of thunder heard after a short while (Dictionary of Engineering, 2004). Similarly, Finnish Meteorological Institute, (2015) define lightning as an electrical discharge that is caused by thundercloud. This can occur within clouds referred to as intra-cloud lightning, between clouds called inter-cloud lightning, and between clouds and the earth known as cloud-to-ground lightning.

Hazard is referred to as a potential occurrence of a natural or human-induced physical event which may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012). Though lightning on its own can hardly be considered as a hazard due to its localised nature, this is a direct by-product of thunderstorms which is an indirect trigger of hazards such as wildfires, in this study therefore lightning is considered as a hazard.

The disaster risk equation= Hazard x Vulnerability Equation-1

Vulnerability refers to diminished capacity of group, system, or individual to cope with, resist and recover from impacts of natural or man-made hazards (IFRC, 2012).

Disaster is defined as a calamitous, sudden event that disrupts the proper functioning of a community or society and causes human, material, economic and environmental losses that exceed the community's ability to cope using its own resources (International Federation of Red Cross and Red Crescent Societies, 2013).

Causes of Lightning

It all starts with thunderstorm which is created by strong rising

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air currents called updrafts forming cumulonimbus clouds. The warm updrafts and the cool downdrafts create turbulence resulting in tiny water particles and microscopic ice crystals (Harfield LTD, 2015). A continuous collision of these particles create an electric charge in the thunderclouds until the whole cloud is filled with charges where the lighter positive charge form at the top of the cloud and heavier negatively charged particles sink to the bottom of the cloud (Planet Science, 2015). As these negative charges are at the bottom, they force negative charges from the ground away leaving it positively charged as shown in the Figure 1 (Wagon, 1999). As the cloud moves, the positive charges will follow the cloud wherever it goes, the largest build-up of these positive charges will be in any protruding objects such as house, trees, poles and as an electrical potential builds up lightning occurs (Smith, 2010).

Lightning Cases around the World

Lightning fatalities rates in selected countries and Cases of lightning death in South Africa from 2009 to 2010 are given in Tables 1 and 2.

Consequences of Lightning

According to the National Institute of Health, (2001) the direct effects of lightning are extremely low compared to its subsequent long term impacts. These include but not limited to; muscular and sensory disturbances, keraunographic skin markings, and audiovisual dysfunction and as well as amnesia. Similarly a study conducted in 2012 in Switzerland revealed 6 out of 9 patients struck by lightning had nervous system injuries, followed by 5 out of 9 who had cardiovascular system injuries. The third group of these patients had injuries in their skin (3 out of 9) (Carmen et al., 2012). The Table 3 below summaries some of the negative effects of lightning on humans.

Conceptual Framework Used (Figure 2)

Root Causes of Vulnerability to Thunderstorm and Lightning in South Africa

Singh, (2014) root causes are the most distant processes that are

embedded in economic, social, demographic and political scenarios and portray distribution of power in an area. Botshabelo and its vicinity are inhabited by black people who have been marginalised by the apartheid governance in terms of development activities, therefore given the vast climate variability today, this condition propagates to unsafe conditions driven by dynamic pressures processes.

Dynamic pressures

These work on underlying root causes to create unsafe conditions (Singh, 2014). In this study lack of training of workers that work in the open places such as agriculture and construction workers are possibilities since the six workers who were struck by lightning on N8 ran to a small wooden structure for shelter. South Africa being a developing country where more constructions (rapid urbanisation) are taking place exposes construction workers to risks of being struck by lightning.

Unsafe Conditions

Though rapid urbanisation may be viewed by many authors as a dynamic pressure process, this can also be regarded as an appropriate indicator of unsafe condition (Birkmann, 2006). Botshabelo and other regions in the outskirts of the Free State Capital Bloemfontein are yet to undergo infrastructural development in which more workers are to be exposed to risks of lightning due rapid changing climate that induces thunderstorms.

Vulnerabilities to Lightning

Developing countries have got a long list of problems ranging from, poverty, illiteracy, diseases and hunger. There is one more problem that has gotten less attention, until recently: lightning strikes, which cause a disproportionately high number of deaths in developing countries (Quinn, 2013). Countries that have a high death toll due to lightning such as South Africa, India and Nepal all have hot, humid climate and agriculture-based economy in common in which case the latter exposes people to lightning risks (Tsong, 2014). Moreover, lack of public awareness seems to be the most substantial problem in the developing countries that increases vulnerability to

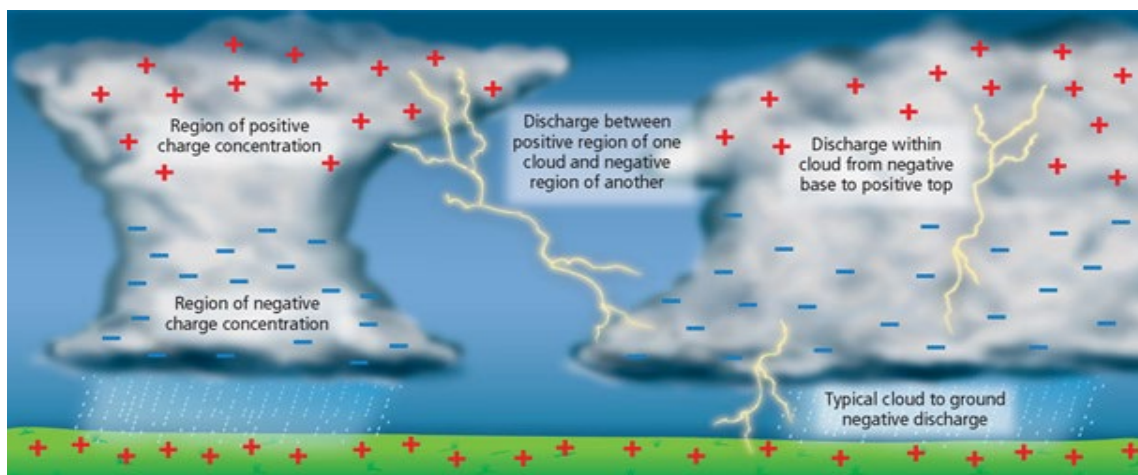


Figure 1. Bottom negatively charged cloud and positively charged ground and showing different types of lightning Source: http://fden2.phys.uaf.edu/211_fall2010.web.dir/Levi_Cowan/lightning.html

Table 1. Lightning fatalities rates in selected countries

Country/region	Number of reported fatalities	Time
United States	261	2006-2013
Zimbabwe	150 fatalities annually	1990-recent
China	420 fatalities annually	1997-2005
Nepal	130 fatalities	2012
South Africa	>500 fatalities annually	1999-recent

Source: National Weather Service, NOAA; Holle, R.L., 2008

Table 2.
Cases of lightning death in South Africa from 2009 to 2010

Source	Publication date	Number of deaths	Place of Occurance
IOL News	05-01-2009	5	Kwamashu (KZN)
IOL News	11-01-2009	1	Bhamshela (KZN)
SABC News	02-02-2009	3	Majabe Village (EC)
news24	26-11-2009	2	Elliotdale (EC)
news24	26-11-2009	2	Mquandile (EC)
news24	26-11-2009	1	Enqcopb (EC)
Daily Dispatch	26-11-2009	14	Transkie (EC)
Daily Dispatch	28-11-2009	2	Mqandule (EC)
Daily Dispatch	28-11-2009	1	Nqobo (EC)
Daily Dispatch	28-11-2009	2	Elliotdale (EC)
Daily Dispatch	28-11-2009	1	Dumsi (EC)
IOL News	02-12-2009	1	Vereeniging (Gauteng)
BEELD	03-12-2009	1	Vaaldriehoek (MPL)
IOL News	10-01-2009	1	Nkwenkwana Village (EC)
IOL News	10-01-2009	1	Mthatha (EC)
Daily Dispatch	12-01-2010	4	Rhoda Village
IOL News	11-01-2010	3	Enqcoobo (EC)
IOL News	11-01-2010	1	Qumbu (EC)
IOL News	19-01-2010	2	Qumbu (EC)
news24	25-01-2010	1	Okhukho (KZN)
STAR	18-02-2010	3	Mid-Illovo (KZN)
IOL News	26-02-2010	6	Jece Village (EC)
Sowetan Live	07-05-2010	1	Tlhalane (NW)
IOL News	08-10-2010	1	Mpikwana (EC)
IOL News	08-10-2010	1	Mthatha (EC)
news24	08-10-2010	1	Midrand (Gauteng)
IOL News	18-02-2010	3	Mid-Illovo (KZN)
news24	25-10-2010	1	Tzaneen (Limpopo)
news24	25-10-2010	3	Nkumbi (KZN)
news24	25-1-2010	1	Eesterust (Gauteng)
IOL News	30-10-2010	1	Soweto (Gauteng)
IOL News	09-11-2010	1	Soweto (Gauteng)
Sowetan Live	12-11-2010	1	Thohoyandou (Limpopo)
IOL News	23-11-2010	4	Port St. John (EC)
news24	27-11-2010	7	Pongola (KZN)
TOTAL		84	

Table 3.
Lightning effects on humans

Effect	Explanation
Vascular effects	Electrical injuries to blood vessels causing disruption of the endothelium as well as disintegration of the media producing considerable hemorrhage or thrombosis.
Pulmonary effects	Lightning evidence may be found in cellular damage to the respiratory and cardiac centers in the fourth ventricle as well as with damage to the anterior surface of the brainstem.
Renal effects	Electrical injury to kidneys which is due to massive tissue destruction as a result of related rhabdomyolysis and myoglobinuria.
Abdominal and GI Effects	Problems such as hemorrhagic necrosis of the intestines and gallbladder, liver failure, gastrointestinal hemorrhage from stomach and duodenal ulcers, curling ulcers, acute appendicitis, pancreatitis, small bowel perforation, splenic injuries, and mesenteric abdominal trauma
Eye effects	55% of lightning victims suffer ocular effects due to thermal or electrical damage, intense heat, contusion from the thunder shock wave or combinations of these factors.
Ear effects	High pressure shock waves from thunder, measuring up to ten atmospheres may create blast effects leading to ruptured tympanic membranes.

Source: National Lightning Safety Institute, 2015

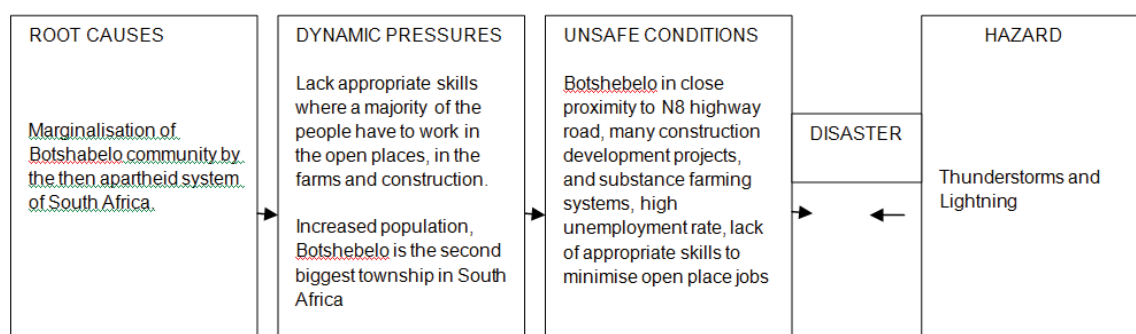


Figure 2. PAR Model for Progression of vulnerability Source: Wisner et al. 2003

Table 4.
Lightning safety measures

Outdoor measures	Indoor measures
Avoid being the most exposed object	Do not handle any electrical appliances, such as telephones, disconnect all electrical equipment
Avoid being in contact with water	Stay away from sinks, showers, tubs, and toilets. Plumbing can conduct electricity from lightning strikes from outside.
Stay away from electrical conductors	
Seek shelter from vehicles	
In a forest seek shelter in a low lying area(land depressions), however beware of the flash floods. Avoid small shelters, such as caves	
When possible options are exhausted, crouch down with your hands on your ears to become the smaller target, do not lie down.	

Source: Weather and Meteorology, 2015: Monsoon Safety, 2015

Table 5.
Myths and facts about lightning

Myth	Fact
If caught outside by a thunderstorm, crouch down to reduce the risks of being struck by lightning	Crouching does not make anybody safer, go to substantial building or hard-topped vehicle
Lightning never strikes the same place twice	Lightning often strikes the same place repeatedly
Rubber shoes and tires on the car protect people from being struck by lightning	Vehicles are safe, it is the metal roof and metal sides that give protection, however do not touch any metal during your stay in the vehicle
If outside during thunderstorm, seek shelter under a tree	Tree are often struck by lightning due to their protrusion above the ground
If you are in the house you are 100% safe from lightning	House is a safe place to be during storms as long one avoids being in contact with anything that conducts electricity

National Oceanic and Atmospheric Administration, 2015

lightning strikes. In South Africa the highest lightning ground flash densities are in the interior parts of the country of which Free State province is. Given the high unemployment rate most community members are compelled to do security guards jobs, agriculture and construction which are in the open giving a high exposure to lightning risks (Gill, 2008).

METHODS AND MATERIALS

This study followed a conceptual study research design which gathered its data from literature on the meaning of these two concepts, their consequences and mitigation measures. A PAR model for vulnerability was used guided by the reviewed literature in order to understand why South Africa could be of the countries prone to thunderstorms and lightning thereby possibly causing disasters.

Lightning Mitigation/Safety Measures (Table 4)

Myths and Facts about Lightning (Table 5)

RESULTS AND DISCUSSION

The study revealed lightning does not only cause fatalities but also long term bio-physical impairment to people which retard their productivity. Lack of skills also plays a contributing factor in the myths borne by communities which turn to be agent to vulnerability to lightning hazards. A comprehensive list of measures to be taken in case one is caught in thunderstorms is presented especially people working in the open places such as construction and others. An in-depth knowledge about the evolution of lightning has been deliberated by this study for public safety.

CONCLUSION

Given the current high climate change variability, thunderstorms and lightning are more frequent and intense leaving property and human lives damaged and lost respectively. It is encouraged that awareness on the dangers of lightning is raised for communities' resilience against lightning impacts. The government on the other hand has to see to it that skills development programmes are

intensified to reduce high number of people employed in the open-place industries such as agriculture and construction.

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