

Climate Change and Human Sufferings: An Exploratory Research on Lightning to Build Mitigation Measures for the State of Odisha



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Abstract

The objective of the paper is to analyse the trend of death toll and prepare a suggestive measures to minimize the human sufferings. Natural disasters can strike a locality in any form like cyclone, flood, tsunami, earthquake, heat wave/cold wave etc. and cause lots of destruction and devastation in the area. It leads to number of deaths of human beings and animals. It also causes physical injuries which in some cases remain permanently disabled along with emotional scar. In contrast to the above calamities lightning strike in recent years is emerging to be the major killer around the world but draws less attention. In state like Odisha in any particular year the causalities due to lightning is more than the sum total deaths of all other calamities taken together leaving aside the snake bites and drowning. It is the third largest killer natural calamity in Odisha. Odisha is an agricultural economy where majority of population are engaged in agriculture and allied activities. Mostly people are poor and do the agricultural work with primitive tools in a traditional manner. People working in small patch of paddy field with moist land surface are the major victims of lightning. Their uprising posture gives the path to negatively charged electron particle suspended from the cloud to rush to the positively charged proton from the earth's surface. The result is devastating. Around 100 million volts of electricity rushes through the person and instantly he/she gets burnt down. Not only the individuals but also the trees, animals grazing in the field or children playing in the ground are also the victims. Most of the secondary research highlights the fact that the poor and marginalized are the worst victims in any kind of disasters. Similarly, large numbers of people who have died or affected by lightening are from developing or underdeveloped countries and further from low socio-economic background.

Keywords: Cloud, Death, Electron, Lightning, Natural Calamity.

Introduction

Natural disaster can strike a locality in any form like cyclone, flood, tsunami, earthquake, heat wave/cold wave etc. and cause lots of destruction and devastation in the area. It leads to number of deaths of human beings and animals. It also causes physical injuries which in some cases remain permanent disability along with emotional scar. In contrast to the above calamities lightning strike in recent years is emerging to be the major killer around the world but draws less attention. While severe weather like hurricanes and tornadoes typically only hit particular areas of the globe, lightning can strike anywhere. And it does, a lot. A bolt of lightning flashes through the sky and hits the ground somewhere around the world about hundred times every second. That's 8 million lightning strikes in a single day. People working in small patch of paddy field with moist land surface are the major victims of lightning. Their uprising posture gives the path to negatively charged electron particle suspended from the cloud to rush the positively charged proton from the earth's surface. The result is devastating. Around 100 million volts of electricity rush through the person and instantly he gets burnt down. Not only the individuals but also the trees, animals grazing in the field or children playing in the field are used as a passage way to reach the ground.

Lightning Scenario around the World

In Indian states like Odisha, West Bengal, Assam, Bihar and Meghalaya lightning is a major natural destructor. Majority of lightning strike the states receives due to the sudden eruption of local "Nor'westers"- whirl wind that devastate the local economy but receives less national attention. "Nor'westers" and lightning strikes go hand in hand, spreading to neighboring country like Bangladesh creating havoc in social and economic life. Md Abdul Mannan, a senior meteorologist at Dhaka Met Office, told "The Independent" that lightning strikes mostly happen during Nor'westers, the seeds of which are sown over West Bengal in India and its adjoining areas. Their final stages mostly batter Bangladesh, causing a huge loss of lives, trees and property every year. He also said that Bangladesh is the most vulnerable country in South Asia to severe thunderstorms and lightning. According to non-government statistics, around 400 people in Bangladesh were killed by lightning strikes in 2016 alone while the figure was 186 in 2015, 210 in 2014 and 285 in 2013. At least 81 people were killed by lightning strikes in 26 districts on May 12 and 13 alone in 2016. This incident forced the Bangladesh Disaster Preparedness Forum to compile a database on lightning in Bangladesh. They found a total of 5,468 casualties, composed of 3,086 fatalities and 2,382 injuries between 1990 and mid-2016. The annual deaths in Bangladesh have been 114 and close to 89 people get injured. This comes up with the average of 0.92 fatality per million population per year and injury rate of 0.71 per million per year. The trend also shows higher fatality rate during early morning and early evening. This rise in death due to lightning has prompted Bangladesh to add lightning as one of the disasters in the national list and has made necessary provision of support to the people.

Lightning related death in India is 2,500 on an average per year. According to National Crime Record Bureau (NCRB) lightning killed more Indians than any other natural calamity in any particular year. Bureau report said that in 2014 death due to lightning was 2,582, whereas sunstroke killed 1,248 people in India. It is the major natural calamity killer in the country. In the neighboring country Nepal, more than 100 people are killed by lightning every year. The Ministry of Home Affairs of Nepal which has been recording deaths caused by lightning since 2000 said lightning have killed 547 people in the last five years, which is higher than any other natural calamity barring April's earthquake in 2015. However, in South Africa, about 260 people have been killed on average per year.

While the number of deaths is increasing in most of the country, it is, however, lowering in USA compared to the developing countries. But in 2016, the numbers exceed the previous year's tolls and reached up to 40. In 2015, the number was 27. The highest tolls were 45 and 48, which were reported in 2007 and 2006, respectively. A paper presented in the 24th International Lightning Detection Conference & 6th International Lightning Meteorology Conference, San Diego, U.S.A, 2016 by Ronald L. Holle indicated

a stark difference in the striking of lightning and the resultant fatalities. The paper "The Number of Documented Global Lightning Fatalities" found that fatality rate is inversely proportional to the stage of development of the country. Higher in the economic development ladder the country is in, the impact of lightning gets reduced and conversely lower economic growth accumulates lightning pressure on the country. About 24,000 people die around the world due to lightning and majority of them belongs to the developing countries. The report emphasis on the fact that the wrath of lightning is more on people engaged in agricultural activities in rural areas in comparison to the urban areas engaged in formal set up. According to the report in the continent of Africa country Malawi's average fatalities per year is 1008 seconded by South Africa with 264 average death rates. In European continent Turkey receives highest burnt of lightning strike with 28 average death per year while United Kingdom and Austria facing 2 and 1 average death respectively per year. Mexico's average lightning death rate is 230 while that of Canada in North American continent is 9. In South America Brazil suffer the most with the celestial affair with 132 average death rate seconded by Colombia with 76 deaths. All these facts and figures indicate one thing that the poor suffer the hardest burnt of lightning strike.

Vulnerabilities of Poor People

The countries vulnerable to lightning strikes have both a hot, humid climate and an agriculture-based economy, which increase the risk of lightning-related tragedies. A more substantial problem is the lack of lightning awareness across both the scientific community and the general public. However there are number of reasons adding to the vulnerabilities of poor people residing in rural areas and practicing agricultural work in these countries in a traditional manner.

1. Nature of job- Farmers doing work in open agricultural field with holding metal equipments are very vulnerable. Small patch of moist land bordered with raised boundaries are the idle ground for lightning strike. Along with this when the person holds metal equipment and stands inside the land area the chances of receiving the strike increases many fold times. In countries like Indonesia the agricultural sector accounts for a whopping 41 percent of the workforce. Most of the work involves backbreaking manual labor alone in the field. The country simply doesn't have the kind of large-scale industrial farms now common in the US. That industrialization brings with it heavy machines to replace physical labor—things like fully enclosed tractors, which are far better at protecting farmers from lightning strikes than a water buffalo and a plow.
2. Low literacy rate and awareness about lightning strikes- lightning is a growing problem and mostly people are not aware about it. In the developing Asian and African countries people are mostly guided by the superstition about lightning than the scientific facts and figures. So the lightning incidents of death and injuries is picking up in

countries like Indonesia, Thailand, Cambodia, Vietnam, Malawi, South Africa just to name the few countries.

3. Low economic conditions restrict the access to safe housing facilities. High death rates in developing countries according to experts can be attributed to inadequate infrastructure. The number of lightning deaths in the United States dropped dramatically as better home construction, a shift in labor practices, and the spread of lightning rods took hold.
4. Agricultural workers in the developing economy mostly use the traditional practices instead of modern equipments. The modern mechanisms like tractors are safer in comparison to hand holding tools. In countries like U.S.A tractors used in big agricultural operations are fully enclosed, making them as safe as a car during a storm. Tractors also reduced the number of people needed to raise and pick crops and thus contributed significantly in reducing the death rates in the agricultural field.
5. Animal herds and the herdsman are vulnerable during the grazing practices. The animals in the wild life sanctuaries are also very vulnerable to strike. Many dead rhino due to celestial strike are found in Kajiranga National park, Assam. In stray incidents of lightning strike there is report of animal death but this has not been properly enumerated to ascertain the loss of animal life.
6. Cutting down of tall tree like palm and coconut tree add to the vulnerabilities. Growth of population leading to deforestation and cutting down of tall trees like palm and coconut invites the lightning flashes at ground level. The tall trees used to act as a shield in the rural areas now with its disappearance poor people's vulnerability in the rural areas has increased.

Understanding Lightning

Lightning is defined as sudden transfer of electric discharge during a storm or in a cloudy situation. This flow of current allows the region in the environment temporarily create a neutralized situation when it strikes the object on the ground. This celestial phenomenon releases about 100million volts of electricity within a thousandths of seconds. The strike discharge around 1-10 billion joules of energy and produce a current of 30,000-50,000amph. The striking of lightning depends on the temperature of earth's surface. When the ground is hot, it heats the air above it. This warm air rises along with water vapor and when it cools in the atmosphere it forms a cloud. When air continues to rise, the cloud gets bigger and bigger. In the tops of the clouds, temperature is below freezing and the water vapors turns into ice. A build up of positive charge builds up on the ground beneath the cloud, attracted to the negative charge. The cloud

generates static electricity of high intensity where the positive charge is created in the upper part of the cloud and the negative charged particles gather around the lower part of the cloud. This positive and negatives charges grow large enough building an environment for a giant spark – lightning within the cloud. Most lightning happens inside a cloud, but sometimes it happens between the cloud and the ground. in the bottom of the cloud. The ground's positive charge concentrates around anything that sticks up - trees, lightning conductors, even people! The positive charge from the ground connects with the negative charge from the clouds and a spark of lightning strikes.

There are three types of lightning;

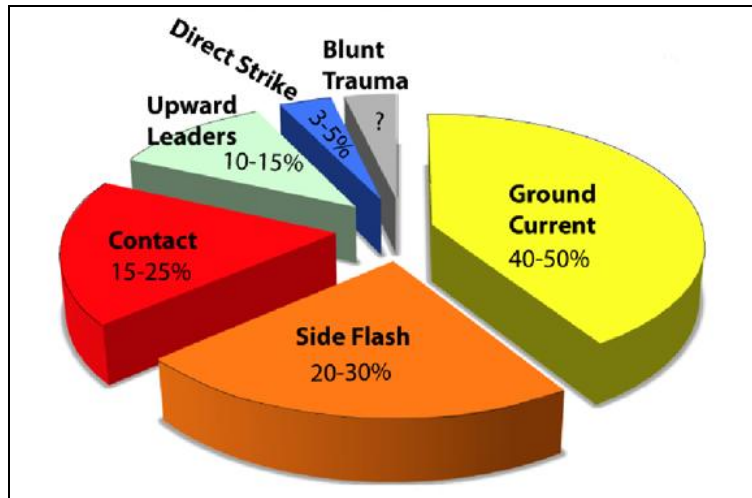
1. Intra-cloud lighting (IC), which takes place between electrically charged regions of a cloud
2. Cloud-to-cloud (CC) lighting, where it occurs between two functional thunderclouds
3. Cloud-to-ground (CG) lightning, which primarily originates in the thundercloud and terminates on an earth surface (but may also occur in the reverse direction). CG lightning is the best known because, unlike other forms of lightning, it terminates on a physical object (most often the earth), and, therefore, lends itself to being measured by instruments. In addition, it poses the greatest threat to life and property.

Various types of Lightning Strikes

Cloud to ground lightning travel through various medium and hence in the process injured many human, trees, animals. Following are the ways by which victims get affected-

1. Ground current-Lightning enters the earth, travels through it and voltages are set up in the ground.
2. Side flash-Lightning can travel down an object before jumping to a nearby victim
3. Contact (with an object struck by lightning)- Lightning can make contact through an object a person is touching or holding onto, such as a tree, wire fencing or telephones poles.
4. Upward leaders- In a storm, the cloud gets electrified and also creates the right opportunity for the flow of electricity from the elevated objects on the ground.
5. Direct strike-Lightning connects directly to the victim. Only 3% to 5% of lightning fatalities result from a direct strike.
6. Blunt trauma-Blunt trauma occurs when a shock wave on the ground throws a person up to three meters away, causing injuries. Blunt trauma can also occur from injuries related to fire, explosions, or falling objects that are caused by the lightning strike. When a tree is hit by lightning, branches can explode off and hit a person standing underneath.

Types of Lightning



The diagram above shows the pattern of various lightning striking the ground. The most frequent has been the ground current followed by the side flash. The Contact and the Upward Leaders follow the list in affecting the human lives and properties. The frequency of lightning has increased in the recent years and many of the research finding suggests that the global warming and presence of humidity in the atmosphere is creating a comfortable environment for formation of thunderstorm at a lower heights and therefore resulting in striking the ground.

Impact of Lightning Health

Available data shows direct strike victims of lightning is very few in number in comparisons to the indirect victims like contact, side flash or ground current. The victims who survived the strikes show various signs of trauma both physical and mental. In case of physical sign like a gunshot, lightning strike causes both an exit and entrance wound, marking where the current both entered and left the victim. One of the most intense effects of lightning strike occurs within the brain. Affected brain cells appear more subtly over time.

Table-1 Lightning Strike Victims Sequelae, frequency 25% or greater

Memory Deficits & Loss	52% **	Depression	32% *
Attention Deficits	41% **	Inability to Sit Long	32%
Sleep Disturbance	44% *	External Burns	32%
Numbness	36% **	Severe Headaches	32% **
Dizziness	38% *	Fear of Crowds	29% *
Easily Fatigued	37% *	Storm Phobia	29% *
Stiffness in Joints	35%	Inability to Cope	29% *
Irritability/Temper Loss	34% *	General Weakness	29% **
Photophobia	34%	Unable to Work	29% **
Loss of Strength/Weakness	34% **	Reduced Libido	26% *
Muscle Spasms	34%	Confusion	25% **
Chronic Fatigue	32% *	Coordination Problems	28% **
Hearing Loss	25%		

* Denotes Psychological ** Denotes Psychological or Organic No Asterisk Denotes Organic
 Source: Lightning's Social and Economic Costs - Richard Kithil, President & CEO, NLSI- National Lightning Safety Institute.

Many people who have survived the disasters have shown the indicators of memory loss and also fails to focus and concentrate in the later part of life. Sometimes they also suffer from brain functioning and also moderate to severe nerve damage in the ear drum. Overall the effects of a lightning strike may range from inconvenience to a debilitating life long struggle.
 Economic loss

The impact of lightning is felt in many parts of the world. Other than killing people, it also brings in huge loss of infrastructure losses. It affects both the daily commercial activities and recreational activities. In the United States alone damages due to lightning

strikes amount to tens of millions of dollars annually. In recent years, with increasing interest in renewal energy, wind turbines have become extremely vulnerable to lightning damage. Furthermore most commercial airliners are struck about once a year by lightning; however, due to the protective metal skin, generally little damage is incurred. This has also been a major cause of forest fire in many temperate and high altitudes; especially in the countries like Canada and Siberia. In many of the cases of forest fire, the cause of fire has never been identified and it is assumed that lightning must have been the cause. National Lightning Safety Institute a premier institute in USA with regard to lightning safety policies and

procedure states that thirty percent of USA business suffers lightning losses. In aggregate the country losses \$6-7 billion dollar/year due to the unprecedented celestial affairs. The sources of lightning consequences includes fire, insurance industry report, storage and processing activities, electrical infrastructure, petro chemical industry and mining industry.

In developing countries of South East Asian regions the victims of Lightning are mostly engaged in the livelihood activities when they are struck by the celestial strike. People are either doing some odd jobs holding metal tools in paddy field or fishing in ponds/river, or searching for pasture for their herds in grassy bushy lands. These set up in the developing countries are the informal sector without any formal assessment structure. So the loss of property or the economic cost of lightening can't be evaluated properly. But one thing is clear that the survivor's partial disability reduce the earning of the family and force the family to abject poverty condition which is grossly ignored in calculating lightning economic cost.

In case of India lightning does not come under the guidelines of calamity relief rules and most of the lightning-affected states in India provide an ex-gratia amount of Rs one lakh to the kith and kin of the deceased person from the Chief Minister's Relief Fund (CMRF). Partial attack which leads to permanent disabilities, crop loss, or any other semi property loss affecting severely the economic backbone of poor agricultural family is ignored under the relief scheme. In addition to the loss of life, sufferings and economic loss, there is indirect cost of lightning in terms of monuments and national heritage sites. These cases are under reported and hence economic loss is not properly represented. In countries like South Africa the cost incurred by governments on lightning accident insurance is more than R500 million per year (Gijben 2012).

Countries like Cambodia, Vietnam and Thailand, Indonesia, Sri Lanka, Nepal even though suffers a lot to heavenly wrath don't even have proper experts and so the issue is left unaddressed. In case of Bangladesh after including lightning strikes to the list of natural disasters in 2016, the authorities have started giving financial assistance to the victim's family as it does in case of storms, floods, and river erosions. The compensation amount varies between BDT7, 500 -25,000. The Disaster Management Ministry within one year period has already distributed BDT1.8 million among families of lightning victims. However the scanty literature restricts the proper assessment of economic loss.

Climate Change and Lightning

Increased frequency of lightning in the summer season and during pre monsoon period forced the scientist to search for the link between the climate change and lightning strikes. New research determining the impact of climate change on the world's lightning and thunderstorm patterns has found that for every one degree Celsius of long-term warming there will be a near 10 percent increase in lightning activity. The study was led by Professor

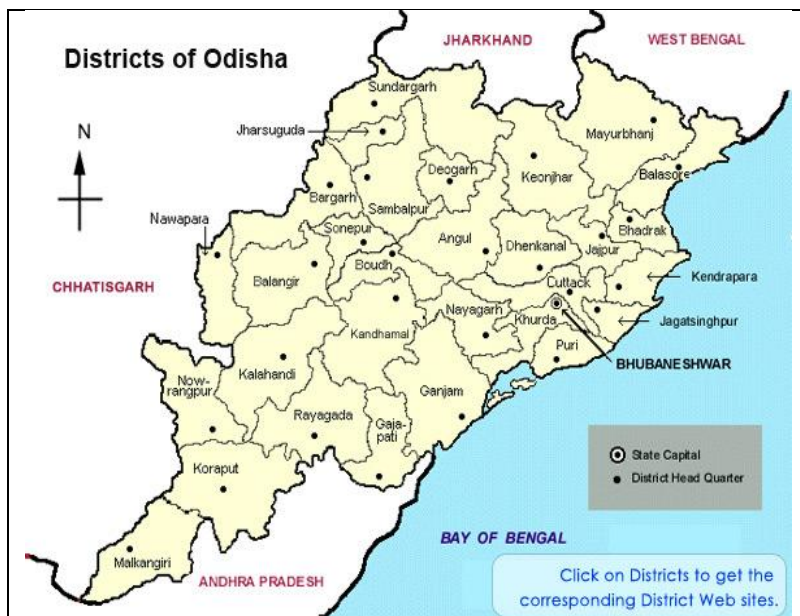
Colin Price, who is the head of the Department of Geophysics, Atmospheric and Planetary Sciences at Tel Aviv University in Israel. Scientists say warmer conditions associated with climate change are causing more water evaporation from the land and ocean, increasing process of cloud formation and rainfall and the potential for lightning storms. Professor Price also noted that the increase in lightning would also lead to a higher number of wildfires. A research paper "Projected increase in lightning strikes in United States due to global warming" was published in the magazine Science, which was carried out with the help of data from a US network of lightning detectors. The research tried to co-relate the rise in temperature of earth with that of lightning strikes frequency. According to the paper, for every two lightning strikes in 2000, there will be three lightning strikes in 2100. These increased incidents of lightning will trigger more wild fires which would alter the chemistry of the atmosphere. The paper made a calculation that every 1C rise in global temperature would lead to an increase in the frequency of lightning strikes by 12%.

A new NASA-funded study finds that lightning storms were the main driver of recent massive fire years in Alaska and northern Canada, and that these storms are likely to move farther north with climate warming, potentially altering northern landscapes. The study undertaken by University of California and University of Amsterdam comes up with the finding that there has been a rise in the forest fire and in most of the cases it has been due to the strike of the lightning. To make it more specific, the team studies the Canadian Northwest Regions in 2014 and also Alaska in 2015 and found similar results. The team found increases of between two and five percent a year in the number of lightning-ignited fires since 1975. Lead author Sander Veraverbeke of Vrije Universiteit Amsterdam, who conducted the work said, "We found that it is not just a matter of more burning with higher temperatures. The reality is more complex: higher temperatures also spur more thunderstorms. Lightning from these thunderstorms is what has been igniting many more fires in these recent extreme events."

Lightning and its Impact in Odisha

Odisha is an agriculture based economy. More than fifty percent of the population is engaged in the informal sector of agriculture and the allied activities. This important sector of the state suffers hard due to frequent natural vagaries like flood, drought and cyclone. The growth rate of this sector remains at a very subsistence level due to the increased frequency of natural calamities. The economic condition of the small and marginal farmers is fragile. Affordability becomes a factor that restricts the use of modern tools and techniques by these vulnerable farmers. Along with this the issues of irrigation, power supply, supply of good quality seeds at right time, marketing of agricultural goods at a remunerative incentives for the farmers are various factors that hit hardest the small and marginal farmers of the state.

Asian Resonance

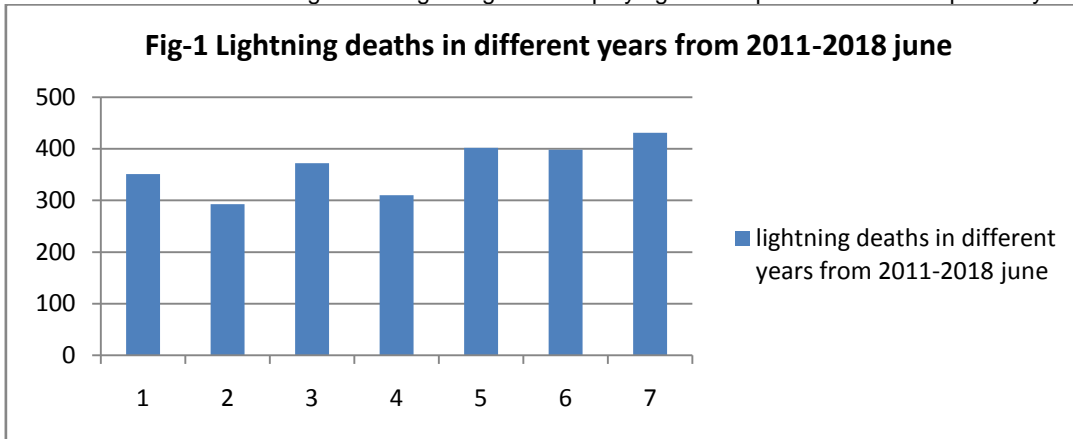


- There is a steady rise in the death toll over the year 431 in 1017-18
- It is the second highest killer in Odisha next to snake bites 509
- The district with urban population and higher literacy shows less deaths, Khurda - 11 and Jagatsinghpur-10 in 2017-18
- Occurrence of deaths in 2017-18 Mayurbhanj 51, Balasore 36, Keonjhar 31 and Ganjam 30

Poverty stricken farmers use cattle and plough to do the various kinds of backbreaking agricultural work. Adding to this, one third of the state population are tribal people living at a subsistence level. Mostly they are engaged in plucking Kendu leaves as a source of income. They do the shifting cultivation to satisfy their food requirement. Other than agriculture activity people are engaged with keeping cattle and cattle herds. As per 2011 census data, 83.32% of total population lives in rural area. Education and awareness with regard to lightning

occurrence is very limited along with number of superstitious beliefs.

Lightning is a major natural calamity of the state. On an average it kills around 365 people per year. Other than the case of snake bite and drowning more people are dead due to lightning strikes. Reports of lightning strikes indicate that the people doing work in the agricultural field receive more brunt. Simultaneously cattle and herds man are the second group to receive the wrath of celestial strike. Children playing in the open field are not spared by the strikes.



Source: Odisha State Disaster Mitigation Authority, Odisha Government

Table-2 Number of Death Due to Different Disaster in Odisha during 2011-12 to 2017-18 (up to 14.11.2017)

S.N	Calamity	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
1	Lightning	351	293	372	310	402	398	431
2	Fire	36	24	30	29	37	92	38
3	Sunstroke	22	83	16	40	60	52	34
4	Cyclone	0	0	72	3	0	0	0
5	Flood	72	4	38	64	9	1	2
6	Hailstorm	6	1	4	1	5	7	7
7	Drowning	NA	NA	NA	NA	246	418	351
8	Boat Capsize	15	35	8	34	19	7	3
9	Snake Bite	NA	NA	NA	NA	427	542	509
	Total	502	440	540	481	1205	1517	1375

Source: Odisha State Disaster Mitigation Authority, Odisha Government

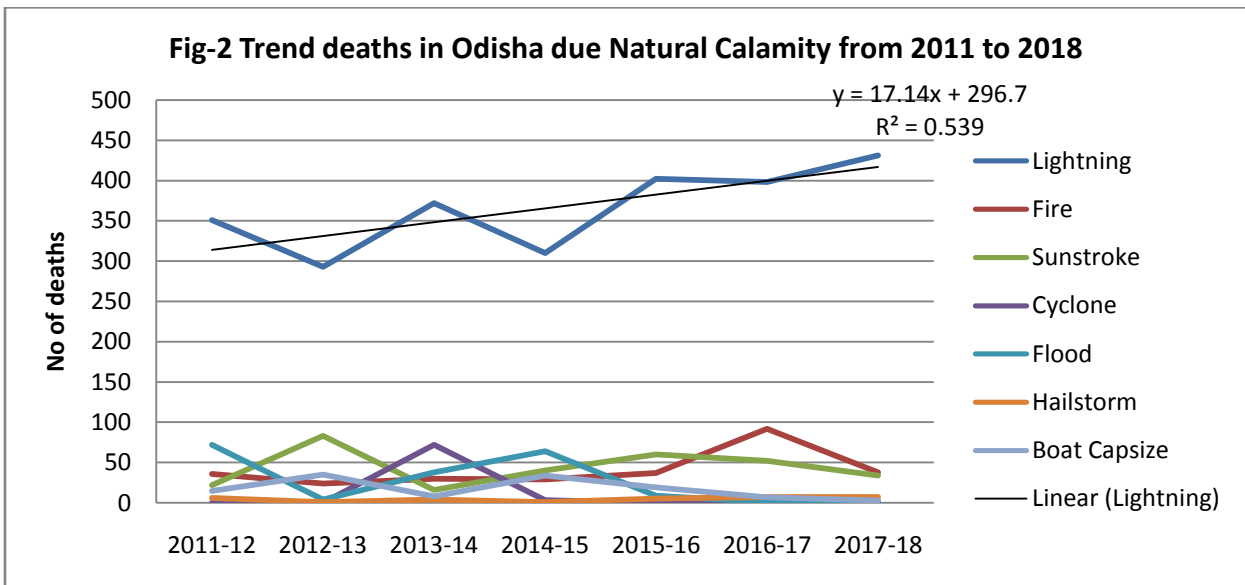


Table-2 and figure-2 shows that lightning has increasing trend as the coefficient is 17.14. The trend shows that the death has been highest because of the lightning in Odisha. The support has been for the deaths but not for the people who are injured in the lightning.

Steps taken by the Government of Odisha

Government of Odisha has been doing pioneering work in disaster management and risk reduction. The Super- cyclone of 1999, which killed more than ten thousand people developed urgency with the state administration to collaborate with UN agencies, civil society organization, academic institutions and disaster policy makers to develop progressive state institutions to address the policy requirements and also build infrastructure to address the disaster vulnerabilities. In this regard, the state has come up with State Disaster Management Plan and also the department wise disaster plans. This has helped the state to stay prepared for any such disasters. In this regard, when cyclone Phailin hit the coast of Odisha, the state was well prepared to shift one million population to safe places and cyclone shelters. However, this preparedness in terms of infrastructure, policy statements, capability of the state institutions and awareness amongst the masses is limited to handle disasters like flood and cyclone. The public discourse on lightning in Odisha is very recent and also at the nascent stage. In this regard, the state has come up with policy provision to respond to such situations and have also come up with policy changes in the "Odisha Relief Code". The following provisions are made to address the issues of lightning victims.

1. State government has declared lightning as state specific disaster and extended ex-gratia amount from 1.5 lakh to 4 lakh rupees.
2. Adoption of superior technology for early lightning warning system from year 2018. It has become effective in reducing the number of victims.
3. OSDMA spreading awareness campaign about lightning myths and precautionary measures.

4. The government is seeking the help of SHG's to reach out the remote areas with regard to precautionary measures.

Building a Case for further Research

It is important and pertinent that the state of Odisha must initiate further research in collaboration with various academic organizations to develop better understanding about the causes and the ways to mitigate the risk. The way it has built more than five hundred cyclone shelters to save lives from floods and cyclones, similarly the state has to invest more resources in developing a common understanding about lightning and come up with infrastructure to mitigate the risk. The technology in the recent era is an important enabler to reach out to people with early warning within short period of time and especially in this situation it helps the people who are at risk to move to safe location to save their lives. In any democratic state, people play an important role in determining the policy provisions and when a large number of people are affected, no state can ignore this issue for ever. In this context, the recent phenomenon of deaths and disabilities arising out of lightning strikes should be a wake-up call for the state of Odisha to do further research and come up with progressive policy provisions.

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