Climate Change and Incidence of Lightning in Odisha: An Exploratory Research

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ABSTRACT

Climate change has brought in frequent incidence of disasters and lightning is one of them. The geographic location of Odisha is vulnerable to frequent disasters and every year it faces many such disasters. It affects the poor and marginalized the most and as it is primarily an agrarian society and as most of the population are engaged in agriculture, they get exposed to lightning while working in the paddy field. It brings death or make people disabled in many sense challenging the survival of the families who operates at subsistence level. The deaths occurring due to lightning was never covered under the ex-gratia payment and the contribution of academics to drive home the fact that these are celestial phenomenon and needs to be treated as disasters have made the policy makers to introduce compensation since 2010-11. This has brought in some relief to the affected families. The intervention of the state of Odisha to address the vulnerability of people in cyclone, floods and heat wave is appreciated globally and similar interventions are required to address the vulnerability of the people to lightning. The early warning system in lightning is introduced in Odisha in 2019 and this has brought in less number of deaths. This calls for further research and progressive policy interventions, so that the lives and livelihoods of the people can be saved.

Keywords: *Climate change, Disasters, Vulnerability, Risk mitigation and Policy interventions.*

1. Introduction

Odisha is vulnerable to disasters and every year it faces the brunt of destruction of property and loss of lives. 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. Lightning, are a sudden electrostatic discharge during thunder storm. This discharge allows charged regions in the atmosphere to temporarily equalize them, when they strike an object on the ground. This celestial phenomenon releases about 100million volts of electricity within a thousandths of seconds. The strike discharges around 1-10 billion joules of energy and produce a current of 30,000-50,000 amp..

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 grows in size. The top of the clouds where the temperature is below freezing point water vapors turns into ice. The cloud turns into a thundercloud. Lots of small bits of ice collide with each other as they move around. All these collisions cause a buildup of electrical charge. Eventually, the whole cloud fills up with electrical charges. Lighter, positively charged particles remain at the top of the cloud while heavier, negatively charged particles sink to the bottom of the cloud. When the positive and negative charges grow large enough, a giant spark - lightning - occurs between the two charges within the cloud. Most lightning happens inside a cloud, but sometimes it happens between the cloud and the ground. A buildup of positive charge builds up on the ground beneath the cloud, attracted to the negative charge in the bottom of the cloud. The ground's positive charge concentrates around anything that sticks up - trees, lightning conductors, even people and livestock. The positive charge

from the ground connects with the negative charge from the clouds and a spark of lightning strikes. Basically lightings are of three types. Intra-cloud lighting (IC) takes place between electrically charged regions of a cloud. Cloud-to-cloud (CC) lighting occurs between two functional thunder clouds. Thirdly, Cloud-to-ground (CG) lightning primarily originates in the thunder cloud and terminates on an earth surface (but may also occur in the reverse direction). CG lightning is the best known because it terminates on a physical object mostly on the earth and therefore, lends itself to being measured by instruments. In addition, it poses the greatest threat to life and property.

It is found that poor people are most vulnerable to lightning. Globally the tropical areas covering land mass of Africa, South America and South Asia, having hot humid climate are vulnerable to lightning strikes. These countries mostly inhabited by the population engaged in agriculture and allied activities. These activities are being done in the age old manner of traditional way making people vulnerable to lightning strikes. Other than the nature of job few other factors put the poor people at risk of lightning.

Nature of job: The nature of job of farmers working in hot, humid and moist climate put them in an unprotected situation. They do work in open agricultural field with holding metal equipment thus putting their life in danger. 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 times.

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.

Unsafe house structure: 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 lighting deaths in the United States dropped significantly after adapting better home construction, a shift in labor practices, and the spread of lightning arresters.

Unsafe traditional equipment: Agricultural workers in the developing economy mostly use the traditional practices instead of modern equipment. The modern mechanisms like tractors are safer in comparison to hand holding tools. In rich and developed countries farmers use tractors for big agricultural operations. These tractors are fully enclosed, making it as safe as a car during a storm. These big mechanical interventions in agriculture operations 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 due to lightning.

Vulnerabilities of nomads and herds man: Animal herds and the herdsmen 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 are reports of animal death like cattle herd but this has not been properly enumerated to ascertain the loss of animal life.

Loss of tall vegetation in rural areas: Cutting down of tall tree like palm and coconut tree add to the sufferings in peril. 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 risk factors in the rural areas has increased.

2. Impacts of Lightning

Impacts of lightning from three important perspectives such as human health, economics & infrastructure, and climate change are discussed in this section.

Table 1. Impacts of lightning on human body in percentages.

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.			

2.1 Health Perspective

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.

Many survivors report memory issues, trouble with concentration, and severe headache, all of which last decades after initial strike. Aside from impacting on long term brain function, lightning strikes are also known to blow out ear drums, prompting constant muscle twitches and moderate to severe nerve damage. Overall the effects of a lightning strike may range from inconvenience to a debilitating life long struggle (Table 1).

2.2 Economic and Infrastructure Perspective

Lightning is a major natural hazard in many different environments, from power utility companies, to civil aviation, to golfers and more. Thousands of people are killed every year by lightning bolts, while tens of thousands are injured as well. 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. Tens of thousands of fires are also ignited by lightning every year. 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 $6-7billion dollar/year due to the unprecedented celestial affairs. The sources of lightning consequences include 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 reduces 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 Rs1 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 has already distributed BDT1.8 million among families of lightning victims. However, the scanty literature restricts the proper assessment of economic loss.

2.3 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[1] 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. Using different models, scientists are ascertaining the fact that warmer conditions associated with climate change are causing more water evaporation from the water bodies. This process increases the chance of cloud formation at a lower altitude of atmosphere creating potential ground for lightning strikes.

Water vapor in the atmosphere is the primary natural greenhouse gas, influencing the climate of the earth. Since water vapor absorbs infrared radiations emitted from the earth's surface, increases in water vapor in a warmer climate would result in amplifying the initial warming (Del Genio, 2002). In another hypothesis, Sato and Fukunishi (2005) established connection between tropical lightning activity and high cloud coverage in the tropics, strong connection between lightning and upper tropospheric ice water content (Petersen et al., 2005) and ice crystal size (Sherwood et al., 2006).

Surface temperature is another potential cause of lightning strikes. Studies have proved high positive correlation between surface temperature and lightning activity (William et al., 2005; Price and Asfur, 2006a; Sekiguchi et al., 2006). It is evident from the scientific model that for tropical lightning centers, temperature is a key driving factor of daily lightning activity.

It should be noted that not all tropical continental thunderstorms are intense lightning generators[1]. Intense lightning activity prefers a somewhat dry environment, which may explain the difference between African and South American lightning activity (William and Satori, 2004). William et al. (2004) showed that the main difference between Africa and South American lightning activity was due to African being hotter and drier than South America. In addition, William et al. (2005) showed that as the height of thunderstorms cloud base increased, so did the lightning activity. Higher cloud base implies drier surface condition which would support these observations. In all, it is ascribed by the lightning experts that in tropical areas drier and hotter the climate, possibility of lightning strikes increases.

Lightning itself influence the climate via producing heavy amount of nitrogen oxides followed by

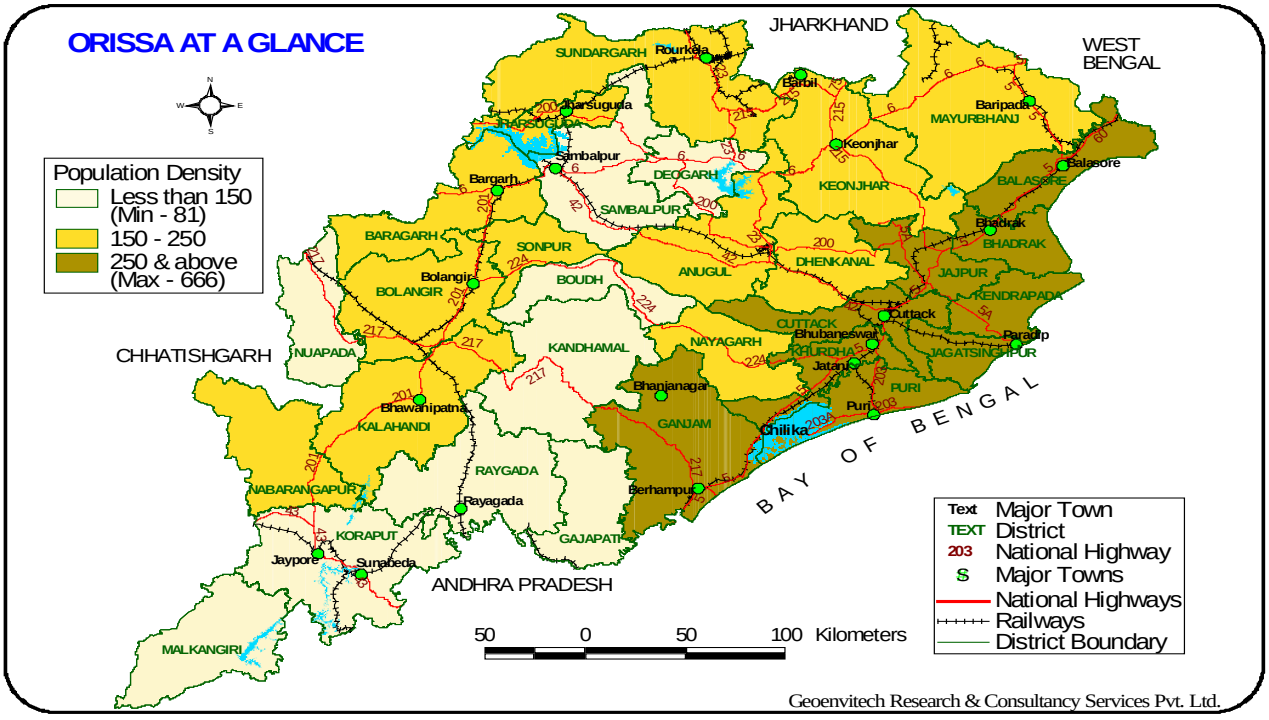

Figure 1: Map of Odisha along with population density and infrastructure network.

production of ozone (Schumann and Huntrieser, 2007). The global amount of nitrogen oxides produced by lightning and thunderstorm is still highly uncertain but it is believed that the nitrogen concentration in the upper troposphere plays important role in earth's climate (Price et al., 1997).

3. Lightning and its Impacts in Odisha

Odisha is an eastern coastal state of India lying in the tropical zone. Its varied geographical conditions expose the state to multiple climate risk. Long coast line of 480 km along with big lakes, rivers and tributaries mark the existence of huge water bodies in the state. On the other hand, the presence of middle mountainous and high land region along with central plateau and western rolling upland make the state vulnerable to hot and dry climate, a comfortable breeding ground for the lightning strikes (Figure 1).

3.1 Vulnerability to Lightning

Lightning has been the biggest killer in the State. During last 7 years lightning has taken 2,557 lives more than any other natural disaster during the period. On an average it takes around 365 lives each year. Most deaths occur during the months from May to August (about 71%). High occurrence of deaths has been observed in Mayurbhanj, Ganjam, Keonjhar, Sundergarh, Cuttack, Balasore, Dhenkanal, Jajpur, Khordha and Nawarangpur districts. About one third of lightning deaths took place while working in paddy fields.

3.2 Susceptibility to Lightning

Susceptibility to lightning in the state increases due to the nature of economy and the stage of development. Odisha is an agriculture based economy. More than fifty percent of the populations are 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. 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

Table 2. Number of deaths in different calamities during the period 2011-12 to 2017-18.
(Source: OSDMA, Government of Odisha)

S. No.	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

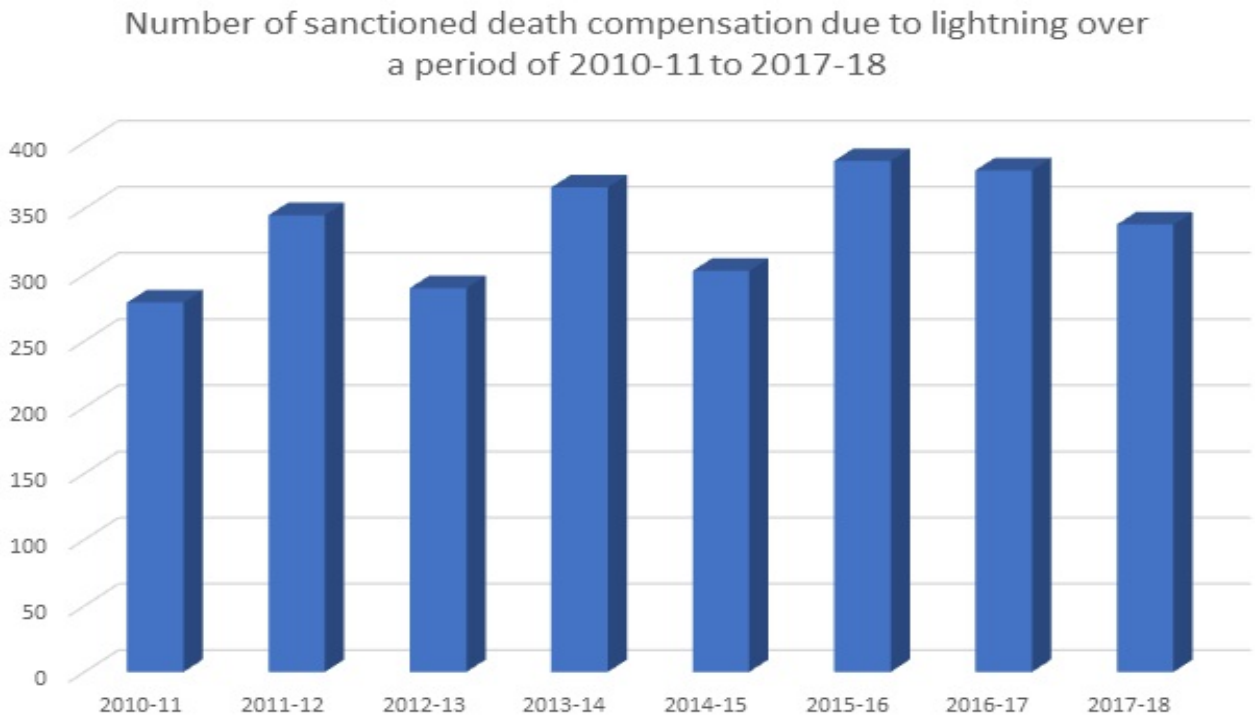

Figure 2: Sanctioned death compensation by Government of Odisha.

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 as is evident from Table-2. Agricultural farmer receives more burnt and injuries due to lightning seconded by cattle herds and herdsman. Even the children playing in the open field are not spared by the strikes.

4. Steps taken by the Government of Odisha

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

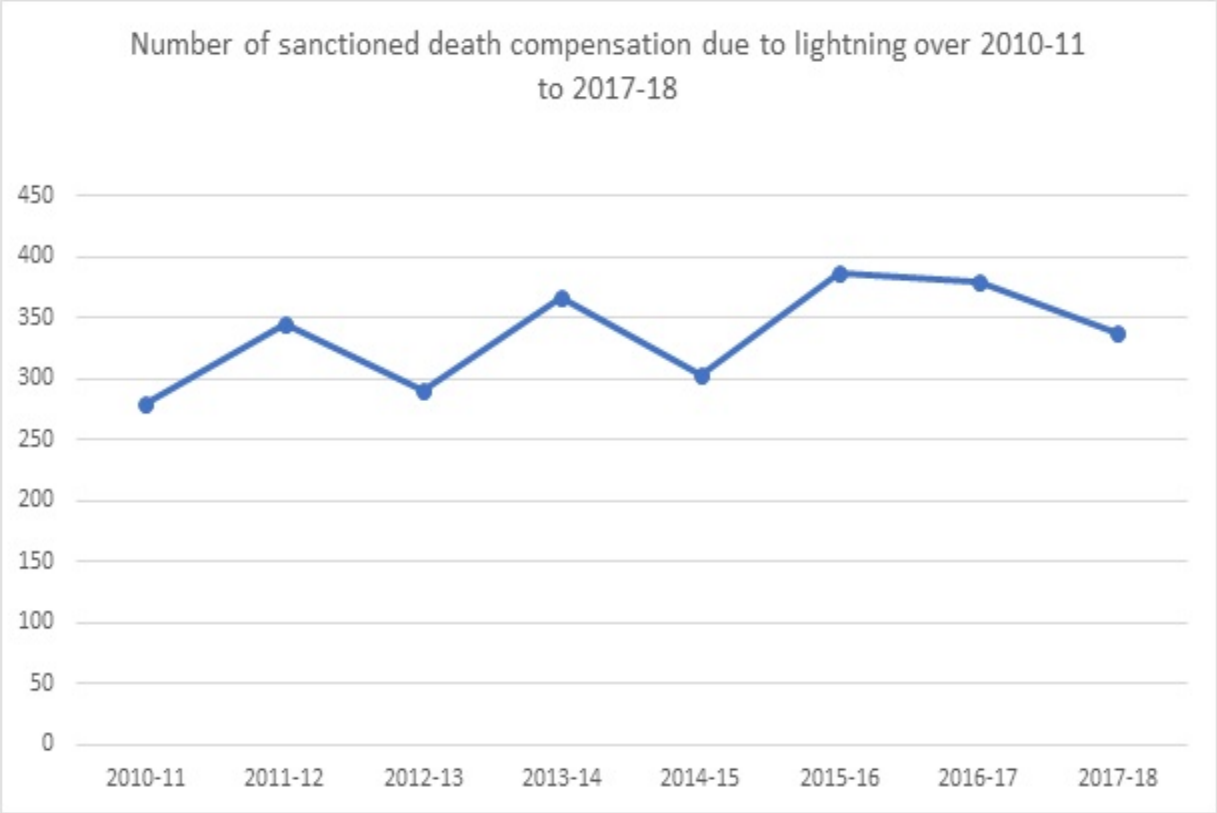

Figure 3: Trend of lightning deaths in Odisha 2011-2018.

with policy changes in the "Odisha Relief Code". The following provisions are made to address the issues of lightning victims.

(i) State government has declared lightning as state specific disaster and extended ex-gratia amount from 1.5 lakh to 4 lakh rupees.

(ii) Adoption of superior technology for early lightning warning system from year 2018. It has become effective in reducing the number of victims.

(iii) OSDMA spreading awareness campaign about lightning myths and precautionary measures.

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

Figure 2 shows number of sanctioned death compensation over the period of 7years. The state government accepted lightning as a state specific disaster and extended monetary compensation since 2010-11 to the deceased family members. Prior to that period no formal enumeration with regard to lightning causalities was happening in the state. Only reporting was made with regard to lightning strikes. So there is dearth of factual data to establish the fact that with the progress of time as climate change is getting its strong hold on the humanity so also the lightnings are becoming intense.

Figure-3 shows the trend in the number of death compensation covered under government of Odisha's ex-gratia payment for the deaths occurred due to lightning. The trend indicates slow and steady increase in the death toll over the period. Another significant aspect of the trend is that each upraised death is followed by fall in the number of death in the subsequent year. It can be attributed to the increased awareness drive by the government officials. Early lightning warning system installed in the metrology department in the year 2019 and subsequent dissemination of information via smart technology is now reducing the lightning hazards in the state.

Lightning is a major natural disaster for the state of Odisha, but the whole geographical location of the state is not equally susceptible to lightning strikes. Figure-4 shows that the interior highland areas of northern and southern zones of the state along with

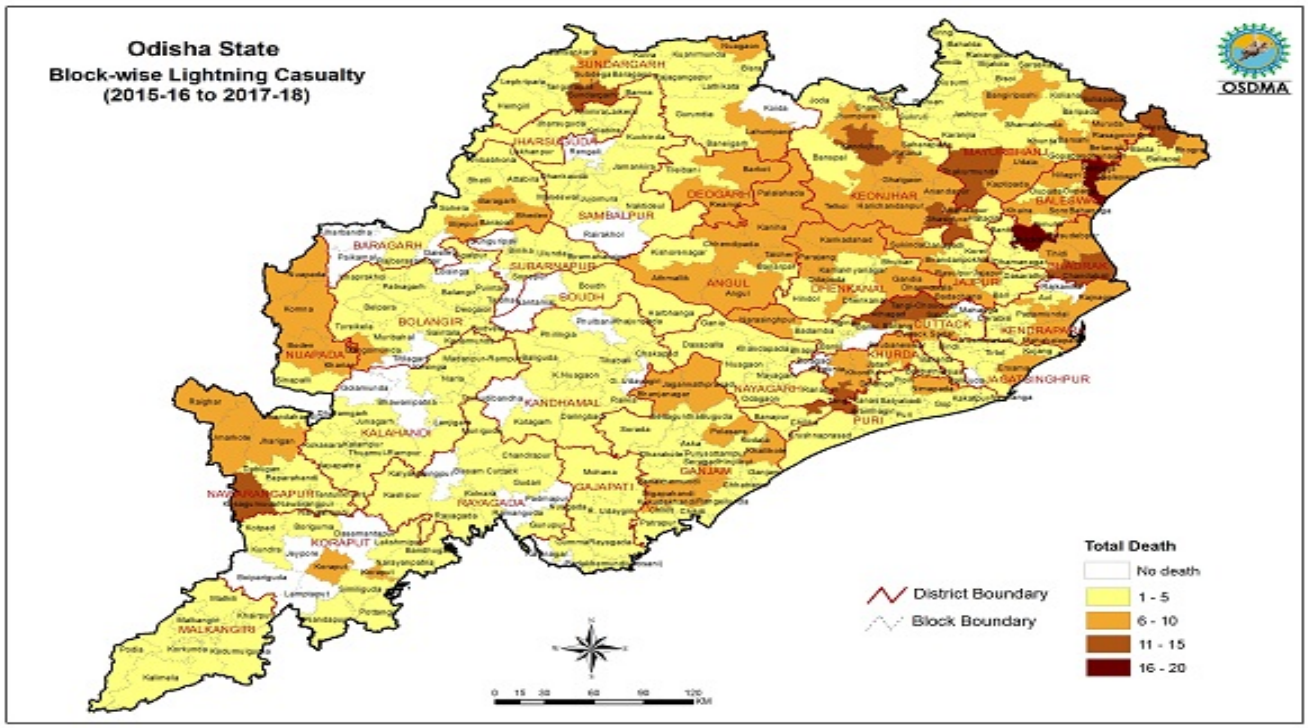

Figure 4: Blockwise lightning Ccasualties in Odisha.
(Source: OSDMA, Government of Odisha)

Table 3. District wise sanctioned ex-gratia to lightning deaths during 2010-11 to 2017-18.
(Source: Special Relief Commission, Government of Odisha)

District	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Total Over a Period
Angul	9	15	8	17	2	18	17	13	99
Balasore	10	4	21	9	17	22	32	29	144
Bargarh	11	18	9	11	11	9	16	13	98
Bhadrak	7	10	13	6	9	15	20	23	103
Bolangir	8	15	4	22	12	11	14	5	91
Boudh	4	2	3	2	1	2	0	2	16
Cuttack	9	11	16	25	16	27	15	7	126
Deogarh	3	13	4	9	2	8	4	5	48
Dhenkanal	16	31	16	16	15	16	13	6	129
Gajapati	1	0	1	3	7	1	8	2	23
Ganjam	18	25	15	18	17	27	29	15	164
Jagatsinghpur	6	9	7	8	11	11	4	4	60
Jajpur	16	18	22	19	21	15	6	12	129
Jharsuguda	6	10	4	3	1	3	6	7	40
Kalahandi	7	7	5	2	6	8	8	7	50
Kandamal	1	1	0	6	1	7	7	3	26
Kendrapada	6	10	12	10	12	5	10	13	78
Keonjhar	22	29	13	19	19	30	28	27	187
Khordha	13	18	14	12	10	12	16	10	105
Koraput	6	3	13	17	10	8	10	12	79
Malkanagiri	0	4	4	9	4	4	2	5	32
Mayurbhanj	30	23	34	46	41	43	35	48	300
Nawrangpur	10	8	9	12	14	19	19	16	107
Nayagada	7	2	3	2	4	6	8	5	37
Nuapada	6	8	1	5	4	10	9	12	55
Puri	3	7	6	9	4	9	5	4	47
Rayagada	13	7	4	7	14	8	6	8	67
Sambalpur	9	11	8	11	2	7	6	10	64
Subarnapur	5	5	1	4	3	4	3	0	25
Sundargargh	17	21	20	27	13	21	23	15	157
Total	279	345	290	366	303	386	379	338	2686

coastal upland areas are more prone to lightning strike. This is evident from Table-3, which gives district wise break-up of lightning casualties compensation ex-gratia by the government of Odisha over the period 2010-11 to 2017-18. Mayurbhanj, Balasore, Keonjhar, Bhadrak, Sundargarh are the districts with high fatalities due to lightning strikes. These are the districts having moist and humid climate due to the presence of water bodies or are placed in hilly mountainous dry region. Both the zone creates conducive environment for lightning activities in the event of rise in temperature. However, awareness, education, dissemination of information about lightning and improved technology can reduce the vulnerabilities of the people. This is evident from Table-3. Jagatsinghpur, even though a coastal district could avoid celestial injuries because of high awareness and education drive in the region. So also Khordha district having state capital, engulfed smart technology and hence could avoid the lightning strikes even though it is having proximity to the coast line and existing on a high land zone.

5. Conclusions

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 risks related to lightning. 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. Besides, the state needs to keep the data in a very systematic manner. This will help the researchers and academicians to further research to help the state to take appropriate decision to address the need of the people. This will also help the state to initiate early warning to save lives and livelihoods of the people. 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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