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RESEARCH ARTICLE

LIGHTNING DURING GOLDEN SPIKE OF THE ANTHROPOCENEEPOCH: THE STUDY OF VULNERABILITY ODISHA, INDIA IN THE GLOBAL CONTEXT.

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Abstract

Lightning is the science of random, uncertain, capricious celetial phenomenon. The earth is created and sustained by nitrogen fixation and ozonisation due to lightning but it has become a apocalytic event for last 20 years in the tropics and sub-tropics. Indians are highly susptible to lightning particularly the eastern India. Odisha, a coastal state in India, have special geoclimate, regularly struck by thunderstorms. The present study is probed to find the history, myths, origin, types, physics, chemistry and impacts of thunderstorms and its impact to the ecosystem and habitats of the earth. Lightning fatalities and trauma were under reported as fedral bodies were less aware of the catastrophe and were less alert till 2015. India, specially eastern zone including Odisha and Bihar are prone to the increased lightning hits which has raised the fatalities in 21st century. The average fatalities 2001- 2017 of India was 2207 and that of Odisha was 295 which is 13.36 % due to lightning whereas area wise, the state is only 4.87 % and population wise 1.005% of India. According to LIS/OTD observations of TRMM satelite of NASA, India has 17 hotspot areas of lightning with flash rate density is 121.41 fl/Km^2/yr (highest at Rajaury, J&K) against earth's highest at Lake Maracaibo, Venjuela, as 232.52 fl/Km^2/yr. Odisha is tending towards a lightning hub as Bhadrak and Banapur are already included where as Mayurbhang area is awaiting the list. Observing the rate of mortlity of NW Odisha in North Eastern India, some management procedures are discussed to combat the disaster, paerticularly harnessing electricity from Lightning.

Introduction:-

Lightning is an electrical discharge phenomenon during an electrical storm that occurs between huge accumulated +ve and -ve charges within the clouds or to ground particularly in the Cumulonimbus (Cb) **Fig 1.** During momentary discharge lightning splashes occur and later cause sound as speed 343 m/sec is much less than the speed of light 3X10^8 m/sec. The spark during discharge can develop a temperature ≈ >24,000 ^{0}F in a fraction of a second. Momentary heating and cooling of atmosphere in the lightning rim create vibrant or rumbling sound within the expanse of sudden electrostatic discharge during an electrical storm striking ground or conducting objects called thunder http://www.physics-and-radio-electronicsCom /blog/lightning-lightning-works/.

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The globe faces 2,000 thunderstorms at any instant, ≈ 14 million lightning events annually (NASA). It is implausible that ≈24,000 deaths, ≈240000 injuries occur due to lightning events in troposphere of the earth annually **Fig -2** https://www.factslides.com/s-Lightning. About 50 lightning hits occur globally/second and 20% of them hits the ground https://www.outsideonline.com/1912401/lightning-deaths-and-injuries-numbers.The fatalities of human, animals, birds that lightening causes is ≈20-30%, some cause injuries and mostly unaffected etc.

Fig 1:-The Aura of lightning so colorful but deadly, (Source: Odisha sun times, 23rd Oct, 2018)

Lightning is unexpected, momentary strike and kill people at random and mostly it is poor mans disaster. Lightning caused 80 dead, 136 injured in five states in India on 14 May, 2018 in India. Odisha recorded 1,256 deaths for last three years whereas natural disaster caused 4689 deaths. North eastern states are the worst affected including Odisha. In an average 325 persons are dying due to lightning hits per year in Odisha. It is calculated that 1069 deaths (27 % of total fatalities are due to all disasters) are due to lightening in Odisha in the months during May to Sept in last successive 3 years http://timesofindia.indiatimes.com/ articleshow/ 59864429. The highest casualities occure due to lightning in Mayurbhanj district of NorthWest Odisha.

Geological Anthropocene age

At present the mother earth is in the Quaternary period, Cenozoic era, Phanerozoic eon, the Anthropocene epoch and the great acceleration period (golden spike) in geological time scale compartmentalization. The Anthropocene epoch, is within official mandate of ICS and yet to be stamprd. It is tentatively accepted with priming period from 3000 years BP to 1850 years BP., the margin (1851-1944), the fundamental shifts(1945-1980) and the great acceleration (1981 to till date). India is passing through the golden spike period (the great acceleration period) with much human activities and intervention to nature Mishra S. P.2017[48].

Review of Literature:

In late 20th century, lightning in USA has death statistics of unreported (40%), open fields & liesure areas (27%), under trees (14%), lacustrine areas (8%), Golf/ trees in gulf course (5%), equipment & machinery-related (3%), telephone-related (2.4%), electronic equipment's concerned (7%). Holle et al.,1997. NASA, March 2003 accepted that 77 million lightning strokes occur in USA annually and the occurrence is accompanied by generastion of oxides of nitrogen in air. Chemeides W. L. 1986 discovered that ≈3tg /year nitrogen (N_2) is converted to NO due to lightning. Gasses like HCN, CO, O_2, N_2 and many hydrocarbons are generated due to lightning in pre-biological terrestrial, cytherian and Jovian atomosphere. Tie X & Zhang R. et. al., 2003[1] (supported by NASA) reported that lightning can generate 90% of the NO_x in summer and also raises ozone level by 30% in the troposphere, extending upto 5-13Km above the earth in USA. Urban air pollution contribute more lightning. In 2015-16 there was 10,510 deaths in India due to natural disasters out of which (2638 people) 25.1% deaths were due to 'Lightning hits', 18.2% of deaths due to 'Heat/Sun Stroke' and 10.9% deaths due to 'Exposure to Cold' NCRB-2015[2] against the death toll in 1990 was 1757 people, due to lightning NCRB report, 1990 page 12. NCRB report 2000[3] reported lightning deaths in India were 1621 and 1472 in the year 1999 and 2000 (Page21). The report of NCRB -2008[4] recorded 2790 and 2553 deaths in the year 2007 and 2008, and the highest record was77.7% (241 out of 310 deaths) due to Lightning in Chhattisgarh in 2008. Mukhopadhyay et al, 2009[5], mentioned that the thunderstorm (TS) or Norwester

over West Bengal and Odisha generate from Satpura hills range situated in NW of WB and Odisha and cause thunder squalls during pre-monsoon period. Murugavel et al, 2014[6] mentioned that the spatial distribution of CAPE (convective Available Potential Energy) is more favorable for criterion of lightning events.Tinmaker et al., 2010[7] mentioned that the lightning activity is more in TN and AP areas during months of May and September but it is hitting during monsoon (SW and NE) due to low level of easterly and westerly jets. The TS activity is associated with SST, upper air cyclonic circulation and convection.

Holle et al., 2008[8], and 2016[9] reported that the less developed countries are reducing their numbers of lightning fatalities due to urbanization but the poor, outdoor workers and agricultural workers are the worst sufferers.Pfortmuelleret. al., 201[10]2 reported the injuries caused by lightning hits are affecting mainly to the nervous system (paresthesia, paralysis, vertigo and unreactive pupils), cardiovascular system (arrhythmias, thoracic pain) and skin burns. Jensen et al., 2017[11] estimated that the globe is having 50 lightening events/sec, 20% of it hit the ground causing 24000 fatalities annually. Washington Post, of 19th May, 2017 has reported that 469 people were burnt to death when an oil tank fire caused by lightning at Dronka, Egypt, on Nov. 2nd, 1994. Lightning occur both inland and ocean. With 250 lightning/Km2, Lake Maracaibo (Venezuela) is the highest followed by DR Congo (Central Africa) and the Brahmaputra valley, India https://ghrc.nsstc.nasa.gov /home/micro-articles/lightning? The mean global FRD was accepted earlier as 46 fl /sec Cecil et. al., 2012[12] and 2014[13] confirmed the old record and reported that the maximum FDR in Congo basin was 160 fl/Km^2/ yr

Causes for study:

According to NCRB report 2007-15, the reported annual deaths at present due to lightning in India has been increased to >2500persons/year against 2000persons in 20th century. .Lightning deaths in India in average is accounting for 39% of the total fatalities due to natural disasters.The average annual deaths reported during 1979 to 2011 was 159 in India. Omvir Singh et al., 2015, 387[14] in China Zhang et al., 2011[15], and 90 in USA Curan et al., 2000[16]. Present death rate due to lightning is alarming. Odisha has lightning death (reported) much higher in 21st century than in late 20th century.

NLSI (National Lightning Safety Institute, USA) reported that increased global warming and meteorological extremes, the lightning activities shall increase 2 to 3 times or more than present by 2050. Martin Uman, Florida University, New York Times 9th Sept. 2001. Osmar Pinto Junior, 2008[17], ELAT, from China Met Department and INPE, (National Institute for Space Research) Brazil, 2008 have warned that each degree rise of average temperature shall increase the lightning events by 10 to 20% http://lightningsafety .com/nlsi_lls/ ListofLosses14.pdf. India (NE India) has become one of the lightning hubs in the globe. The study of the cause, impacts and the ameliorative measures has become urgent. Few studies about the statistics of lightning events have been done prior. The present study is an attempt to probe into the rare studies of lightning events and their impacts in India and specially Odisha.

Methods and methodology:

Ancient homospiens, were considering the TS as an act of almighty and later an atmospheric natural phenomenon from 18th century. Lightning, the weapon of Zeus was the belief of Greeks, thunder was created by goddess Athena. The temples constructed by Greeks and Romans were at lightning hit spots considering pious. African, Bantu tribe believe lightning is a bird God (Umpundulo). The Thurs day was in the name of the god "Thor" by Sacndinavians who used thunder to drive away the demons. The Christians observe the lightning activity dramatized as Donner and Blitzen during Christmas by Santa Klaus. Indian worship Indra as the rain god and thunderbolt (Bazra) as his weapon.The supersttions around the globe is that lightning never strikes same place repeatedly, has been proved false. The Greek Philosopher Socrates claimed the lightning was not the god Zeus but a vortex of air. Genghis Khan, India (1162 –1227 AD), prevented his subjets to wash clothes during storms in fear of lightening deaths.

Benjamin Franklin in 1752[19], Cavendish in 1785[20] and Cohen B 1941[18], had explained the lightning phenomenon through his kite-Key expt. and spark discharge in a glasses. Cavendish, 1785[20].Dasgupta et. al., 1946[21]conducted the pragmatic study, the cloud chamber experiment, where the particle detectors were ditected by the presence of ionized radiation. Stanelly miller's biblical experiment, 1953[22]invented the the chemical source of life in initial earth by using electrical sparks and claimed the lightning is the cause of formation of life on earth.

The Lightning Imaging Sensor/Optical Transient Detector (LIS-OTD) of TRMM satellite mission,NASA, has initiated observing lightning characteristics from Nov, 1998 and was in task till Oct. 2014. The LIS/OTD was working efficiently and was transmitting reliable data as a low earth orbit satellite and was de-launched from April

2015, Hollen R, 2016[23]. The data taken from LIS/OTD was analyzed. The ranking of lightning hotspots was made considering the lightning hotspots in the globe. Since the lightning deaths/injuries are increasing in Odisha and Indiain last 20 years, the cause and management of the natural hazard is probed in to find the ferocity of the event.

Science behind Lightning:

The temperature of tropopause and the lower stratosphere is < -10^0C where the water vapors are in ice form. The upper zone of the large ice patches possesses accumulated +ve charges which moves up due to circulation/updraft within the clouds and leave lower region with –ve charges due to streamer action and gravity. Some clouds behave as a capacitor and due to polarization; the electrical potential is developed within. The polarized field within the cloud starts stretching. The insulated air column is converted to conductive plasma. Finally the –ve charge cluster attracted by earth's surface or with the adjacent cloud of opposite charge and form lightning splashes. When the electrical resistance collapses, the lightning activity starts being triggered by subsequent strokes. The neutral water molucles formed within the process, having radius >1µm, form the water droplets and fall to the ground as precipitation. The intensity, frequency and distribution and impacts of a TS depends upon the topography, elevation, positioning, magnetic anomaly, upper air CYCIR, RH, proximity to warm/cold fronts and surface temperature (ST) of an area. The tropic and subtropics of mid-latitudes are prone to lightning by (≈70%).

The basics behind the lightning was based under assumptions, capricious and transitory events in nature as the science is beyond direct physical measurements. Generally the thunder bolt phenomenon is associated with the PD developed within CB clouds of value 105 V/m https://www.hko.gov.hk/education/article_e.htm?title=ele_00014. It is believed that tall structures, trees act as lightning rods and the electrostatic discharge are explained by the lightning dissipation theory, lightning diversion theory developed by Franklin. The OTD and LIS were employed conjointly to estimate total lightning flash rate by making grids. The satellite data were received from TRMM, Tropical Rainfall measuring Mission of GHRC, NASA. The GHRC, NSSTC of NASA has recorded the LIS/OTD measures the lightning features. The result of LIS/OTD observation has been utilized for hotspot areas in the tropical and subtropical areas of the globe for the period 1998 to 2015 http:/dx.doi.org/10.5067/LIS/LIS-OTD/DATA311 **Fig 2 and Fig 3**.The LIS, identical to ISS LIS instrument, a space borne operational camera, and is a lightning sensor used by the TRMM (Tropical Rainfall Measuring Mission) satellite which record lightning occurrence time, location, measure the radiant energy with high efficiency of detection round the clock at an orbital height 350Km. It is observed that South Africa, North India, Thailand, South America and some zones of North America are lightning intensified areas. The intensity and frequencies of lightning splashes as observed NASA in 2015 is in **Fig-3.**

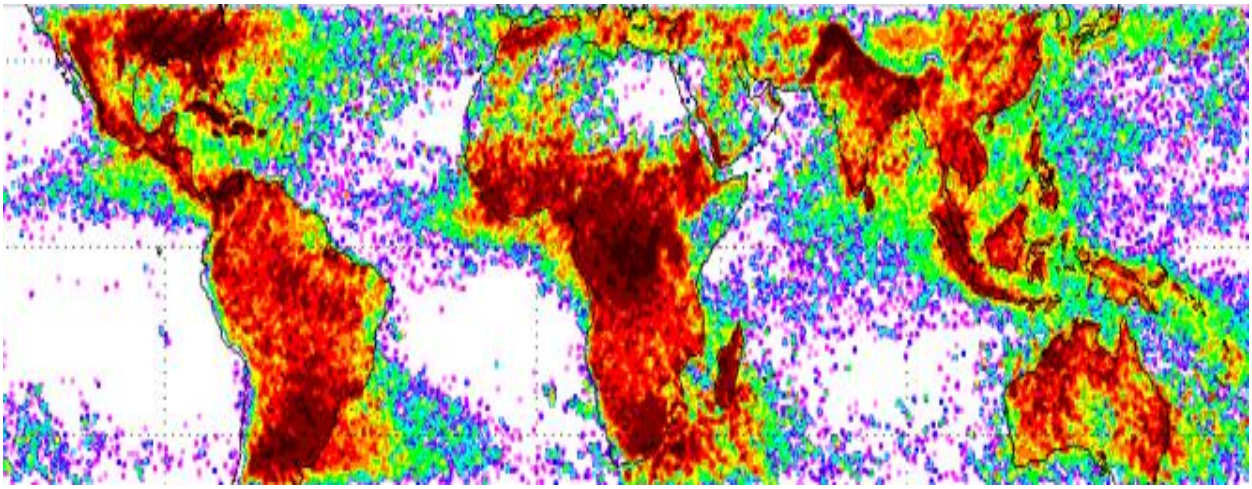

Fig 2:-Occurrence of Lightning (frequency) on earth observed by the Lightning Imaging Sensor (LIS), NASA's Earth Observing System (EOS), Source: GHRC: https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_trmm.html

3.1.0 Phases of lightning:

Lightning occur mainly in three phases. The first phase is the spark of light generated at small area called the head of lightning. Just after the spark, the flash of light jumps towards earth with a speed 0.001C (C=Vel of light = 3 x 10^8 m/sec),Ivan Sarajčev et. al., 2008[24], creat a path to the earth for conduction, called *stepped down phase*. The

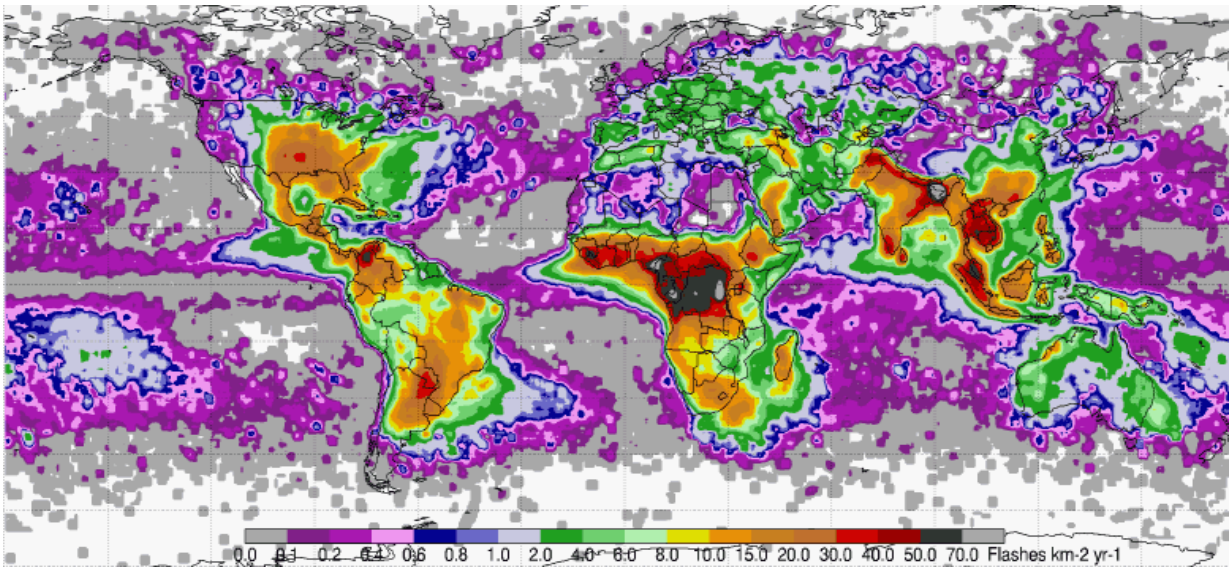

Fig 3:-Lightning flashes and it's intensity & frequencies strikes on the globe year 1998-2014. Source: https://ghrc. nsstc.nasa.gov /home/sites/default/files/HRSC_COM_FRMO03-800x400.png

second phase of lightning process comprises of transfer of charges between cloud and earth consisting a large volume of current of order ≈KA which happens with a speed of ≈ 0.1C called *the charge transfer stage* followed by a silent phase for few micro seconds. After the pause, the pre-ionised channel formed during stepped down phase triggers first moving of charges to earth surface from cloud taking a very high speed 1.0C. The final stage of lightning is the *return stage* where transfer of some small amount of charge from earth to cloud.

The mechanism of thunder-bolts:

TS, when hits, initiate transferof electrons in zig-zag path till their neutralization. This builds enoromous heat energy (temp. dif of > 24000^0 F or even more in an ionised plsma state in the lightning channel) and produce expansion local air coloumn. During expansion vacuums are created. Afterwards the vacuumes filled up rapidly causing the thunder. The shock waves generated during this giant spark and sonic boom generation process the O_2 to react with N_2 to produce NO_X (NO+ NO_2) molecules and also oxygenes isomerize to Ozone (O_3) in the troposphere. The amount of NOx evolved ≈50(±25)×1012gm N yr−1 Logan et al., 1983[25]. Thw % of NOx are also obtained from other sources like anthropogenic uses of fossil fuels (~40%) and human/nature induced burning of biomass (~25%), soil microbial activities and the rest from lightning (2- 10%).The troposphere act as sink for NO_X and there is constant transfer from stratosphere to troposphere in the tpropopause (subtropical Jet). The reaction during day and night are different Dentener and Crutzen, 1993[26]:

(i) During day

$O3 + hv \ (\lambda < 340nm) \rightarrow O(`D) + O2$ (1)

$H_2O + O(`D) \rightarrow 2OH + 2O_2$ (2)

$OH + NO_2 + M \rightarrow HNO_3$ (3)

$HNO3 + hv \ (\lambda < 420nm) \rightarrow HO + NO_2$ (4)

$NO_2 + O_3 \rightarrow NO_3 + O_2$ (5)

and photolysed in day rapidly as

$NO_3 + hv \ (\lambda < 590nm) \rightarrow NO_2 + O(`P)$ (6) [Where [O(`D) and O (`P) are highly energised and ground state oxygens]

(ii) ***During Night***: During night there remain a steady state between NO_3 and N_2O_5

$NO2 + O3 \rightarrow NO3 + O2$ (7)

$NO_3 + NO_2 \rightarrow N_2O_5$ (7a)

The mixture of NO_3 and N_2O_5 are less reactive. Later N_2O_5 is hydrolysed by aerosols present in atmosphere and form NO_x which is added to troposphere Cruzen et al 1970[27].. The NO_x produced due to lightning activities contribute 30-40 megatonons which is 50% of the total NO_x present in earths atmosphere Chameides et. al., 1977[28]. There is increased NO_x mixing ratios covering an area >$10Km^2$ and @0.1–0.8 nmol/ mol, Luke et al.1992[29]and in

the anvil shape of the Cb cloud it is >70% than the nearby atmosphere during lightning Huntrieser et al., 2002[30], 2007[31].

A fresh smell is emmited after a thunder shower of low level ozone. Since the light wave is converted to sonic waves, the thunder is heard after 4-5seconds based on the height of the lightning area. Accoding to the IEC 62305-1,[32] 90% of the charges transferred from the cloud is –vely charged i.e. electron and rest 10% is +-ly charge (proton). Jensen et al., 2017[11] reported that lightning event drops a voltage of > 10 million volts and current between 30000A to 110000A.

The Types of lightning:
Mainly electrostatic discharges in clouds occur within intracloud charged areas (IC), two isolated clouds (CC) and the cloud vs. the ground (CG). The broad classification of different types of lightening are: (https: //www.weather.gov/media/pah/WeatherEducation/lightningsafety.

Intra-Cloud (IC):
The IC, or sheet lighening is the most common and an intracloud activity where the sparks jumps from one concentrated region to other inside the cloud and the sky is lighted only. The intra-cloud discharges (CIDs) are formed within a thin band of charges (Bipolar), occur with multiple reflection, propagation and generation of high to very high radiation frequencies. These CIDs are teristrial ***γ-ray*** flashes (TGFs) or Transient Luminous Events (TLEs) on cloud tops Dwyer et al, 2014[33].

Cloud to Cloud (CC):
When transfer of charge occure from the upper layer of Cb cloud or between different isolated Cb clouds, lightning occurs. About 25-30% of thunderstorms are CC-type which is caused by discharge of –ve charge, like climbing down a ladder style.

Cloud to Ground (CG):
When the huge charge body inside the cloud discharges to the near by infinite source (ground) or a conducting target, lightning occurs. CG-type, lightnings causes maximum threat to life and devastations.

Cloud to Air (CA):
Discharge of electronic charges over the water drops inside the cloud when discharged to the surrounding inside or air with opposite charge, lightning occurs called CA.

Bolt from the blue:
During oceanic disturbances, the positive lightning is originated within the updraft of the disturbance (Lowpressure, depression and CS etc.), typically travel horizontally a large distance and strike the ground and cause lightning. Such lignings are unpredictable and cause destructions.

Anvil or Spiderl Lightning:
Depending upon shape of the Cb cloud and pattern of lighting it is called anvil or spider.A positive charged zone is formed within a Cb cloud like an anvil or spider, travel and dischage by striking the ground and cause lightnig.

Volcanic Lightning:
About 200 volcanic lightning are recorded in last two centuries within the ash plume during volcanic erruption. The cause and impact is yet unrevealed. The lattest was the Colima Volcano, photographed on 29th Mar, 2015, Photo: César Cantú https://phys.org/news/2015-07-lightning.html#jCp **Fig-4.** The reported history was in 79 AD by Tacitus in form of a letter to his uncle, describing volcano lightning events of Mount Vesuvius, Pompeii https:// weather-challenge.com/blog/what-is-volcanic-lightning-volcanic-lightning-definition/. Depending upon ferocity, volcano produced TS are classified as single-cell ed,multi celled cluster, multi cell (or squall line) and super cell. The super cell being the most affecting and designated as severe when the thunder storm has a gusting wind >50 Knots (92.6Km/hour). The supper cell can produce a localized atmosphere of temperature 300000C due to dicharge. This lightning involves ≈30000MVolt and 100000MA and total energy involvement in a strong lightning phenomenon is about the energy generated in an atom bomb, Live Science, down to earth 2005, https: //www. Live science .com /3803-science-lightning.html and Weirup L., 2010[34]

Fig 4:-Lightning on Jupiter, Image: of Michel A., 2018, flashes-in-eclipse-shadow-photos.html one of the largest of length 500KM, in October, https://www.quora.com/Does-lightning-occur-in-other-planets-in-our-solar-system

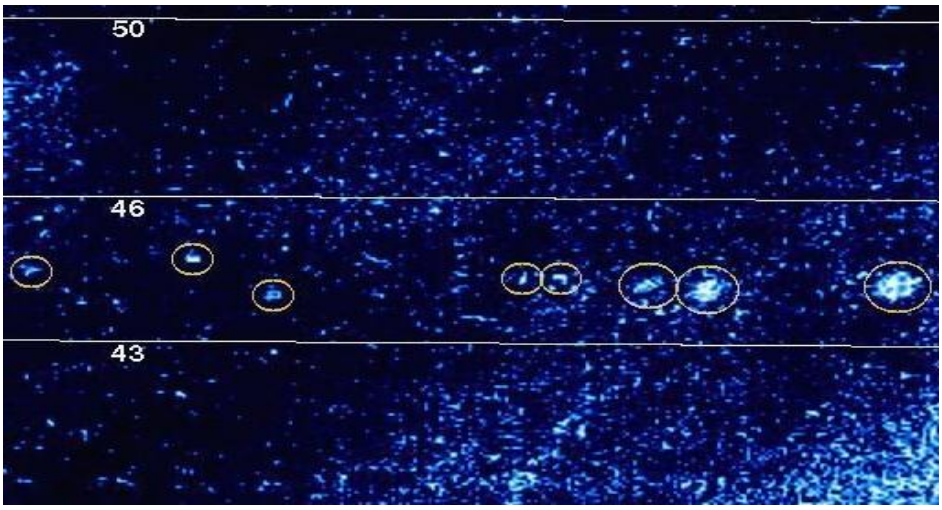

Fig 3 (a):-The lattestEyjafjallajokull volcanic erruption, Iceland, 17th April 2010, Photo: Marco Fulle, http://volcano.oregonstate.edu/volcanic-lightning, Fig 3(b) The Colima Volcano photo taken on 29th Mar, 2015, Photo: César Cantú https://phys.org/news/2015-07-lightning.html#jCp

Lightning in extra-terrestrial, cytherian and Jovian atmosphere:

Borucki et. al., 1982[35] reported about some lightning activity in the atmosphere of the Jupitor like earth with ratio of the energy dissipated rate by lightning was less, @ 0.27×10^{-4} and 0.5×10^{-4} compared to the terrestrial value is 1×10^{-4} of earth. According to NASA, the Earth, Jupiter and Saturn have similar type of lightning.The lightning on atmosphere of Venus is different to that of earth. Lightning on Jupiter and Saturn is not allied with clouds. NASA also reported that the lightning in atmosphere of Venus, is linked with clouds of H2SO4 https:// www.nasa.gov/vision/uni verse/ solar system /venus-20071128.

Receipt of continuous radio signals and optical flashes from from venus, Jupitor, satrun, Urans and neptune points towards lightning pheno-menon in the planets of our solar system according Gibard et al, 1995[36]to Michel A., 2018[37]. The status of lightning occurances in coplantes of the solar system are Venus (under controversy), Mars (No report), Jupitor Uranus, neptune and saturn (Telescopically Visible, low/high freq. radio waves), 28.Borucki et al 1982[38], Loren Petrich2018[39]https://www .quora .com /Does-lightning-occ ur-in-other-planets-in-our-solar-

system**,** by the Galileo orbiter. Each of the circled dots indicates lightning on Jupiter, Image According to Michel A., 2018[37], one of the largest lightning of length 500KM, in Octoberwas observed by the Galileo spacecraft now orbiting Jupiter **Fig 3(a)**. The observations of the obervatory in Galapagos Island have observed lightning events Hawaii's volcanic erruption, 2018 and Lightning splashes during Solar Eclipse's shadow 2017,https://www.livescience.com/60208-lightning–

Lightening, the creater, saver and destroyer:

The LNOx (lightning-induced oxides of nitrogen) is considered significant for nitrogen fixation and ozonization in the troposphere of the earth's atmosphere. Various researchers have worked on quantification of LNO_x and NO_x and present estimated values are 2-8 $Tga^{-,1}$Schumann et. al 2007[40]) and 42.1 Tga^{-1} (M¨uller and Stavrakou, 2005[41]). The LIS flash data due to anthropogenic activity during the Anthrpocene epoch for the study period 1995-2000 iwas 5 Tga^{-1} LNO_x molecule for each lightning flash. There is least study in Indian subcontinent for this type of data. The chemical life time for NO in the tropopause is 10days (Schumann et al 2007[40])

Nitrogen Fixation (the creater):

During the discharge process of lightning, it strikes the nitrogen atoms present in air and energies of the notrogen atoms leaves one or more electron from it make a conducive state for formation of NO_x and O_2.

$N_2 + O_2$ +Lightning sparks→ 2NO (Nitric Oxide); (8)

$2NO + O_2 \rightarrow 2NO_2$ Oxidation (Nitrogen peroxide) (9)

$2NO_2 + H_2O \rightarrow HNO_2 + HNO3$; (10)

$HNO_3 + Ca \rightarrow CaNO_3$ Nitrites or $HNO_3 + K \rightarrow KNO_3$ (Directly used by plants)(4)

The clouds carry those oxides of nitrogen (NO_X) in the troposphere and down drifts to spreads over the soil on the earth surface with the water particles as rain. By the process of infiltration the oxides of nitrogen mixes with substrata of soil and make it enriched in presence of soil microorganisms either by Biological nitrogen fixation (BNF), Gilchrist et al., 2017[42],Schumann et al, 2007[40],or Chemical nitrogen fixation (CNF) . BNF is possible in case of nitrogen fixing bacterias like nonsymbiotic type i.e. Cyanobactrias or Blue green alage or Clostridium and Azotobacter) and the other type is symbiotic bacterias that are present in roots of plants as genus Rhizobium.

Ozone Fixation (the saver):

Lightning in air helps in generating Ozone in atomosphere from Oxygen which further changes air chemistry. It is furtherup lifted to Ozonosphere to repair the layer which shields the earth surface from killer effects of UV lights from COSMOS. Ozone is toxic near the earth surface (troposphere) and good (protects UV radiations) in stratosphere. The Ozone also can negotiate chemical activities as a GHG in the air and accelerate climate changes in the universe http://www.gsfc.nasa.gov/topstory /2003/0312 pollution. html.. The ozonisation and deozonisation process during lightning is given by Sydney Chapman's (1930) mechanism applying to lightning process are:http://www.columbia.edu/itc/ chemistry/chem-c2407/hw/ozone_kinetics.pdf

$O_2 + h\nu$ (498 kJ/mol, λ<242 nm) → [O] + [O] (rate k_1 in S^{-1}) (11)

O_2 molecule can have photolysis reaction caused by photons generated to form oxygen radical and K_1 depends on light intensity of the spark during lightning.

$[O] + O_2 + M \rightarrow O_3 + M$ {K_2 (cm^6 molecule-2 s^{-1}} (12)

Where M is one nonreactive receiving agent (N_2) which receives energy generated, K_2 depends upon light intensity and energy. The huge temperature generated in the stratosphere resulted from the 2nd reaction.

O_3 + hv/visible light → [O] + O2 {k_3 (s^{-1}) } (13)

The 3rd reaction O_3 is disintegrated to O_2 molecule and oxygen radical. The energy,depends on the light intensity and altitude. The reaction is continuous and maintains the ozone-oxygen equilibrium in air.

$[O] + O_3 \rightarrow 2\ O_2$ {K_4 (cm^3 $molecules^{-1}$ s^{-1}} (14)

The ozone formed by Chapman's cycle protects the Ozone layer by constant formation and segregation of Ozone molecules in Ozonosphere.

Urban smog formation (the destroyer)

Zhang&Wang R. et al., 2016[43] reported that the haze formation during winter has been aleviated due to more conversion of SO_2 (g) to SO_4as aerosols which is the fine SPM and exists in haze. The aqueous SO_2 oxidation by NO_2 is triggered underpolluted atmospheric haze and fog conditions, presence of micro aerosols having RH > 60 to 70% and neutral condition. At higher levels of SO_2 and NO_2 combined condition the sulphate formation is spontaneous and aqueous **Eq^n. (9).** The aqueous SO_2 oxidation reaction is increased in presence of NH_3. The reactions are

$$SO_2\,(g) + 2NO_2\,(g) + 2H_2O\,(aq) \rightarrow 2H^+ + SO_4^{-2}\,(aq) + 2HONO\,(g) \quad (15)$$

$$2NH_3\,(g) + SO_2(g) + 2NO_2(g) + 2H_2\,(aq) \rightarrow 2NH_4^+\,(aq) + SO_4^{-2}\,(aq) + 2HONO\,(g) \quad (16)$$

Mystry of London fog (SO_2 conversion by NO_2 in air) is unvieled by the reaction given by Zhiang et al, 2016[35] Huang et al 2016[44],explainedthe current increased smog of China. Delhi and few major cosmopolitan cities in India are also facing acute smog events in 21st century. The phenomenon of smog formation is one of the impact of anthropogenic activities alied with lightning activities. The intense haze formation includes a switch from photochemical to aqueous phase processes. The NO_2 which is the main reacting species for smog or haze formation with the SO_2 released under heavy fossil fuel consumption mostly in thickly populated urbans and cities are under heavy smog. The year of more lightning events induces more smogy conition in atmosphere.

Oxidant generation and other benefits:

The lightning generate more oxidants and purify the atmosphere Zhiang 2003.Ozone is used as anti-bacterial, germicidal and fungicidal agent and commercially water purifier and odor reducer. The lightning also used to exploring earth's early atmosphere such as atmospheric composition of early earth and early geological activities, average temperature of earth. Formation of fulgurites occur when lightning strikes sand and earth Paseka et. al., 2016[45]. When a lightning hits a sand patch, the sands melt, forming decorative tube-shaped fulgurites.

Geo-spatial variation of lightning in India

To calculate thunder storm distance, it is calcualted between flash and thunder. For every 5 seconds the storm is 1.61km away from the observer. East Indian receives lightning strokes @ 40-50 flashes/Km^2/year https://ghrc.nsstc.nasa. gov/home /sites/default/files/HRSC_COM_FRMO03-800x400.png . The FRD is 1.2 times higher than the winter days and generally occur during after noon or evening. The thunder stroms occasionally occur during dawn and early morning. The Dopler Radar operators in India has a notion that the thunder squalls shall occur if the average speed of updraft inside the cloud reaches 6-8m/sec, but independent of the depth and extension of the Cb cloud.

Cause for increased present Lightning occurances:

According to *IPCC report (AR-4[46] and AR-5[47]),* the modern Homosapiens are stimuli to change in the climate system and increasing the energy level. Global warming is univocal. Atmosphere and oceans becoming warmer and mean sea level is rising (20cm in past century) and polar ice amount is depleting (4% decrease from 1980-2010). Time series data of past decade reveals 1^0C rise in temperature have caused global warming, and ocean acidification (pH decline by 0.1). The drivers are Homosapiens and their activities in domination earth**,** nutrition, water and air. The confirmation of commencement of Anthropocene epoch due to change in stratigraphy andgeo-chronology of the earth may be cause of increasing frequency and intensity of TS Mishra S. P. 2017[48] and 2018[49].

Injuries, Squeals, and Treatmentof lightning injuries:

Considering the lightning as electrical phenomenon, the injuries caused are physical, psychological and neurological. The ailments associated with lightning injuries are physical burns, impotency, psychic, hyper sexuality etc. The positive effects may be healing of physiological and neurological damage which are yet to be proved. Lightning cause fatality or causality due to direct hit,contact hit, (touching a conducting object), side flash **(**lightning current flows to the ground), Ground strike **(**Lightning hits the earth and the current propagate in all directions from the slam point), blast damage(the victims exorcised viciouslyduring rapid shock due to supper heating and immediate cooling), Upward streamer **(**When low electrical charges of low strength streams upward after hitting the earth, carry huge current and cause injury due to electrocution at a nearby place.

Zafren et al 2005[50] reported that about 70% of lightning hits are not lethal it is due to discharge of less electric energy through the body for momentary contact. Survival from a lightning hit victim is major chance to go for squeal. Immediate death after the strike is a chance of irregular heart beat or sudden central respiratory paralysis.

Jensen et al., 2017[11] mentioned that a lightning victims exposure to lightning is 1/1000 sec to 1/ sec.Lightning injuries are not analogous with high-voltage damages or treat patients when deep burns are not reported. Occasional lightning patient need belligerent fluid revival, alkalization of urine, or keeping them in burn unit. Prolonged Cardio-pulmonary resuscitation (CPR) was conducted for survival prior to admission in hospital. The overall prognosis is poor. In case of positive resuscitation, it is still doubtful about recovery of the patient and the Survival need extensive critical and rehabilitative procedures https://emedicine.medscape.com/article/770642-treatment.

Lightning and human trauma:

About 70-80% of bolts of thunder reaching ground and in contact of ground objects are harmless but the rest are devastating and apocalyptic. The most vulnerable places are the work places such as corn fields, joggers, gulf courses, play grounds, hikers, construction sites, and camps. Lightning causes trauma due to electrocution, burn (electrical or thermal), and fall/strike due to shock wave or muscle contraction. Direct hit causes immediate death due to cardiac or respiratory arrest. Chance of damage to central or peripheral nervous system may occur with temporary paralysis or sympathetic nervous system instability. Burns trauma may be superficial (Common), may also be severe and charring. Ocular injuries like hyphema, vitreous hemorrhage, and optic nerve injury may occur.

Lightning may cause injury to the audio-vestibular system, rupturing tympanic membrane and Sensory-neural deafness may occur and may also affect lungs. The immediate attention to the patient must be given on airway, breathing, circulation, vaso-spasmand CPR if necessary.Medical assistance are given when the victim is unconscious, paralyzed, getting cardiac pain, lowering of breath, back or neck ache, deep burns and fractures Davis et al 2014[51].

Manifestations related to lightning human deaths and trauma are identified from skin, vascular, cardiac, neurologic, renal, Pulmonary, eye, ear,abdominal, other injuries, ruptures and burns, Cooper et al 2001[52], Nagesh et al 2015[53]. At times controversy occurs between the doctors and the insurance people about the cause of death due to lightning or anything else in case of livestock's and bovines. The circumstantial evidences and the causes of death described earlier to be considered for final decision for death of the animal Brightwell A. H. 1968[54].

The global hotspot of Lightning areas:

From Geoname's data base of flash rate density (FRD), https://lightning.nsstc.nasa.gov/data /gedata /500HotspotsTable.pdfChristian et al., 2003[55], Boccippio et al., 2000[56], Rachel et. al., 2016[57] observed that the maximum rate of flash happen in the tropics, subtropics, along the coasts,hilly regions, mines, expanses with recurrent tropical cyclones, and convergence zones like South Atlantic, South Pacific, and inter tropical convergence zone (ITCZ). Using the LIS, NASA Tropical Rainfall Measuring Mission (TRMM) satellite took observations from 1998 to 2015. The flash rate density (FRD) in fl/Km^2/year data of the satellite was received and analyzed for different places on the earth and the top twelve places where the FRD is maximum is given **Table 1.**

Table 1:-Top 12 flash rate density (FRD, fl km-2 yr-1) around the Globe, nearest place according to Geonam ORG, from LIS data TRMM, NASA,https://lightning.nsstc.nasa.gov/data/gedata/ 500HotspotsTable.pdf

Rank Globe #	FRD (fl/km^2/ yr)	rid Lat. (o)	Grid Long.(o)	Nearbytown (PPL)	Continent location	Lat. (o) PPL	Long. (o) Distanc	PPL Distance (Km)
1	232.52	9.75	-71.65	Lake Maracaibo, Venezuela	South America	10.13	-71.26	60.1
2	205.31	-1.85	27.75	Kabare DR Congo	Africa	-2.5	28.79	136.2
3	176.71	-3.05	27.65	Kampene DR Congo	Africa	-3.6	26.67	124.9
4	172.29	7.55	-75.35	Cáceres Colombia	South Africa	7.58	-75.35	3.4
5	143.21	-0.95	27.95	Saske DR Congo	Africa	-1.57	29.04	140
6	143.11	34.45	72.35	Daggar, Pakisthan	Asia	34.51	72.48	14
7	138.61	8.85	-73.05	El Tarra, Colombia	South America	8.58	-73.09	30.9
8	129.58	5.25	9.35	Nguti, Cameroon	Africa	5.33	9.42	11.7
9	129.5	0.25	28.45	Butembo DR Congo	Africa	0.14	29.29	94.3
10	127.52	-1.55	20.95	Boende DR Congo	Africa	-0.28	20.88	141.2
11	124.26	5.75	-74.95	Norcasia, Colombia	South America	5.58	-74.89	20.4
12	121.41	33.35	74.55	Rajauri, India	Asia	33.38	74.31	22.6

From the data, it is found that Lake Maracaibo, Venezuela, South America has the highest (@ 232.52 flash rate density/Km^2 /year). The Democratic Republic of Congo (DR of Congo) has occupied five ranks in the top 10 and 52 places among the top hundred. Out of top 500 FRD dense places, Africa is the lightning capital of the globe occupying 283 sites in the list when arranged chronologically. Asia is the 2nd lightning hot spot area in the earth having 87 sites. The DR of Congo is the worst sufferer as a country whereas Lake Maracaibo, Venezuela receives flashes of lightning.

Lightning hotspot areas in Asia, Northern Hemisphere.

According to present accuracy of records HRAC data base of LIS intercepted OTD method of observations are considered to be accurate. Top 500 flash rate density (FRD, fl km-2 yr-1) grids are constructed, with latitude and longitude of the nearest township according to Geonames.org, are made and sixty of worst lightning places in Asia (Northern Hemisphere) are in **Table -2.**

Table 2:-Top flash rate density (FRD, fl km-2 yr-1) ranked list of hotspot towns of Asia in the northern hemisphere (Except India), according to Geonam ORG, from LIS/OTD data from TRMM Satellite, NASA, https://lightning. nsstc .nasa. gov/data/gedata/ 500HotspotsTable.pdf

Rank in Asia	Rank (World)	FRD (fl m^{-2} yr^{-1})	Grid Lati (o)	Grid Long. (o)	NearstTown	Continent	Lati. (o)	Long. (o)	Distfrom town ,Km
1	13	118.81	33.75	70.75	Doaba	Pakisthan	33.42	70.74	36.2
2	22	108.03	14.55	43.45	Al Hadiyah	Yemen	14.53	43.57	13.2
3	28	104.59	33.85	73.25	Murree	Pakisthan	33.91	73.39	14.5
4	42	97.02	4.75	103.05	Paka	Malaysia	4.64	103.44	44.7
5	45	95.92	1.95	103.85	Kota Tinggi	Malaysia	1.74	103.9	24.2
6	50	94.64	1.75	99.65	Tenggulun	Indonesia	3.99	98.01	27.3
7	52	93.96	3.15	101.65	Kuala Lumpum	Malaysia	3.14	101.69	4.2
8	60	92.68	4.55	97.55	Penaron	Indonesia	4.64	97.88	18
9	67	90.02	18.65	42.05	Al Majaridah	Saudi Arabia	19.12	41.91	54.7
10	87	86.27	1.75	99.65	Sipiongot	Indonesia	1.84	99.66	9.6
11	93	85.58	22.55	104.75	ThịTrấnVệtQuang	Vietnam	22.42	104.81	16.1
12	94	85.44	26.95	89.05	Samtse	Bhutan	26.9	89.1	7.5
13	97	84.32	16.85	43.15	Mashaf	Yemen	16.86	43.2	5.2
14	105	83.95	25.25	89.85	Sherpur	Bangladesh	25.02	90.02	30.7
15	107	82.37	3.05	103.25	Pekan	Malaysia	3.48	103.4	51
16	112	81.2	2.65	100.85	Serusa	Indonesia	2.22	100.82	48
17	138	75.94	3.95	101.05	TeluIntan	Malaysia	4.03	101.02	9
18	144	74.72	5.25	100.65	Kulim	Malaysia	5.36	100.56	16.1
19	154	73.37	11.75	106.85	BùĐ?p	Indonesia	11.95	106.8	23.4
20	181	69.55	5.25	115.55	Beaufort	Malaysia	5.35	115.75	24.2
21	188	68.8	32.45	69.85	Wana	Pakisthan	32.3	69.57	31
22	194	67.91	27.55	87.35	Khandabari	Nepal	27.37	87.2	24.2
23	196	67.69	15.45	43.65	Rujum	Yemen	15.46	43.63	2.1
24	198	67.6	15.65	107.65	Thạnh M ỹ	Vietnam	15.75	107.84	22.8
25	201	67.27	3.75	100.05	Lumut	Malaysia	4.23	100.63	83.7
26	230	64.94	2.75	99.15	Pematangsiantar	Indonesia	2.96	99.07	25
27	232	64.86	28.15	83.85	Pokhara	Nepal	28.27	83.97	17.4
28	234	64.71	5.85	101.95	waeng	Indonesia	5.93	101.88	11.3
29	241	64.29	7.05	80.25	HanwellaIhala	Srilanka	6.9	80.09	24.6
30	248	64.05	35.05	71.15	Karbori	Afghanistan	34.97	71.27	14.7
31	258	63.29	17.55	102.35	Suwannakhuha	Thailand	17.56	102.28	7.6
32	261	63.03	14.75	108.55	Ba To	Vietnam	14.76	108.73	19.7
33	272	62.11	24.25	90.95	Bajitpur	Bangladeh	24.22	90.95	3.8
34	274	61.92	32.55	72.15	Jauharabad	Pakistan	32.29	72.28	31.4
35	279	61.45	16.05	119.35	Mabini	Philippines	16.07	119.4	2.5

36	288	60.85	30.25	67.75	Ziarat	Pakistan	30.38	67.73	14.9
37	295	60.37	13.65	44.05	Ta'izz	Yemen	13.58	44.02	8.4
38	301	60.03	4.75	101.95	GuaMusang	Malaysia	4.88	101.96	14.8
39	310	59.46	0.45	100.35	Rokan	Indonesia	0.57	100.41	14.8
40	315	59.21	18.65	102.45	MuangPhôn Hong	Laos	18.5	102.41	17.6
41	330	58.41	18.35	103.55	BuengKan	Indonesia	18.36	103.65	10.9
42	342	57.89	31.45	70.15	Kulachi	Pakistan	31.93	70.46	60.7
43	363	56.6	3.65	114.45	Miri	Malaysia	4.41	114.01	98.1
44	370	56.41	1.15	104.45	Tanjungpinang	Indonesia	0.92	104.45	25.9
45	371	56.28	2.75	97.95	Jambi Baru	Indonesia	2.78	97.89	7.5
46	379	55.78	2.05	102.15	Malacca	Malaysia	2.2	102.24	19.1
47	382	55.5	12.35	98.75	Myeik	Myanmar	12.44	98.6	19.1
48	391	55.17	5.85	117.95	Taman Rajawali	Malaysia	5.89	118.05	11.7
49	393	54.98	11.95	103.25	KhlongYai	Thailand	11.78	102.89	44.1
50	398	54.6	29.65	69.75	Barkhan	Pakistan	29.9	69.53	35
51	407	54.27	14.65	120.95	Niugaon	Philippines	14.66	120.96	1.7
52	410	54.17	24.15	89.55	Shahzapur	Bangladesh	24.18	89.6	5.8
53	413	54.06	26.65	87.15	Ithari	Nepal	26.67	87.28	13.4
54	431	52.97	16.95	103.25	ThaKantho	Thailand	16.94	103.25	1.2
55	448	52.33	32.55	70.95	LakkiMarwar	Pakistan	32.61	70.91	7.4
56	465	51.7	1.05	103.05	SelatPanjang	Indonesia	0.99	102.71	38.5
57	467	51.6	14.85	104.05	Prang Ku	Thailand	14.86	104.04	1.3
58	468	51.49	22.75	120.55	Pingtung	Taiwan	22.67	120.49	10.8
59	474	51.25	32.65	73.25	Malakwal City	Pakistan	32.55	73.21	11.1
60	491	50.8	13.85	101.75	Kabinburi	Thailand	13.95	101.72	11.8

The Lightning hotspot areas in India,

The states like old Assam, West Bengal, Odisha and old Bihar were worst sufferer from lightning hazards. Other states like Himachal Pradesh, Maharashtra are also experiencing lightning frequently. According to LIS-OTD, GHRC, NASA observations on average annual FDR list, India occupies 17 hotspot areas.**Table 3 and Fig- 5 (a) and (b).**

Table 3:-Top flash rate density (FRD, fl km-2 yr-1) ranked list of hotspot towns of Asia in the northern hemisphere, according to Geonam ORG, from LIS/OTD data from TRMM Satellite, NASA, https:// lightning.nsstc .nasa .gov/data/gedata/ 500HotspotsTable.pdf

	Rank World	FRD (fl km^{-2} yr^{-1})	Grid Lat. (o)	Grid Long. (o)	NearstTown (PPL)	State in India	Lat. (o) PPL	PPL Long. (o)	PPl Distance (Km)
1	12	121.41	33.35	74.55	Rajauri,	J&K	33.38	74.31	22.6
2	31	101.79	25.25	91.95	Cherrapunji,	Meghalaya	25.3	91.7	101.18
3	56	92.94	9.75	76.75	Lalam,	Kerala	9.72	76.7	6.6
4	58	92.8	32.55	75.85	Dalhousie,	HP	32.55	75.95	9.1
5	103	83	24.35	92.35	Dharmanagar,	Tripura	24.37	92.17	18.7
6	133	77.33	26.25	90.25	Bilasipara	Assam	26.23	90.23	2.5
7	210	66.85	23.45	91.65	Amarpur,	Bihar	23.53	91.66	8.5
8	221	66.03	25.45	90.85	Nongstoin,	Meghalaya	25.52	91.26	42.3
9	223	65.45	22.65	87.75	Ghatal, Medinapur,	WB	22.66	87.73	2.1
10	319	59.07	32.05	76.75	Jogindarnagar	HP	31.99	76.79	7.9
11	328	58.5	21.05	86.45	Bhadrak,	Odisha	21.05	86.52	6.8
12	358	56.85	24.95	88.25	IngrājBāzār, Malda,	WB	25	88.15	12.1
13	374	55.85	23.95	87.85	Sainthia,	WB	23.95	87.68	17.2
14	399	54.59	24.95	93.25	Mahur	Maharastra	25.18	93.11	29.3
15	408	54.22	19.75	85.35	Banapur,	Odisha	19.78	85.17	19.1
16	417	53.81	22.05	86.75	Chakulia	Jharkhand	22.48	86.72	48.3
17	420	53.67	10.35	77.55	Ayakudi,	Tamil Nadu	10.45	77.55	11.1

Rajauri, J&K, India, occupies in the FRD ranking of lightning as twelfth. West Bengal is the focused area of lightning (Kalbaisakhi) followed by HP and Odisha. 12 Lightning hotspot areas are found in India **Table-3& Fig 5**

Lightning and GHG gasses:

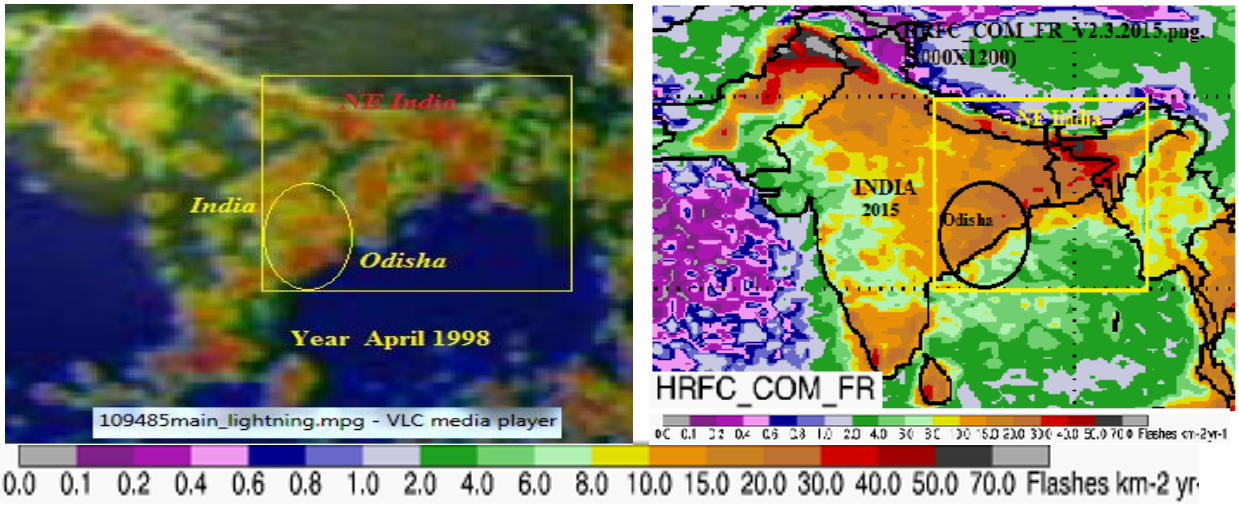

Fig 5:-LIS OTD Climatology Data Sets ,from av. global flashes in sq. Km/yr from 1998-20115 (17 years) of TRMM satellite LIS and OTD missions. Mean flash rate density images of India Odisha. Source: http:/dx .doi.org/10.5067/LIS/LIS-OTD/DATA311

Indian Thunder storms:

India is more susceptible to lightning impact due to its poisoning, topography, climate anomalies and geological setting. Lightning is unpredictable but common during pre, active and even during post-monsoon days **Fig 6**. Lightening is associated with thunder storms, thunder squalls, Andhi, Nor'wester's, Kalbaisakhi and tornadoes. Statistics has recorded more fatalities (≈ 2000 people/annually after 2005 in India whereas USA records 27 persons/year), NCRB data [3], [4] . The trauma due to lightning hits is mostly unrecorded in comparison to other natural disasters. Lightning kills more people in India than other disasters like floods, earthquake, landslides, heat-strokes, or cyclone. Record tells on 24th April, 2018, AP, India documented 36,749 lightning strikes in a period of 13-hour and a death toll of nine. Another record was 93 deaths and >20people were injured due to lightning hits in UP, Bihar (56 in Bihar in two days), MP and Jharkhand, June 2016 including 34 people of Bihar.https://www.bbc.com/news/world-asia-india-43905726.

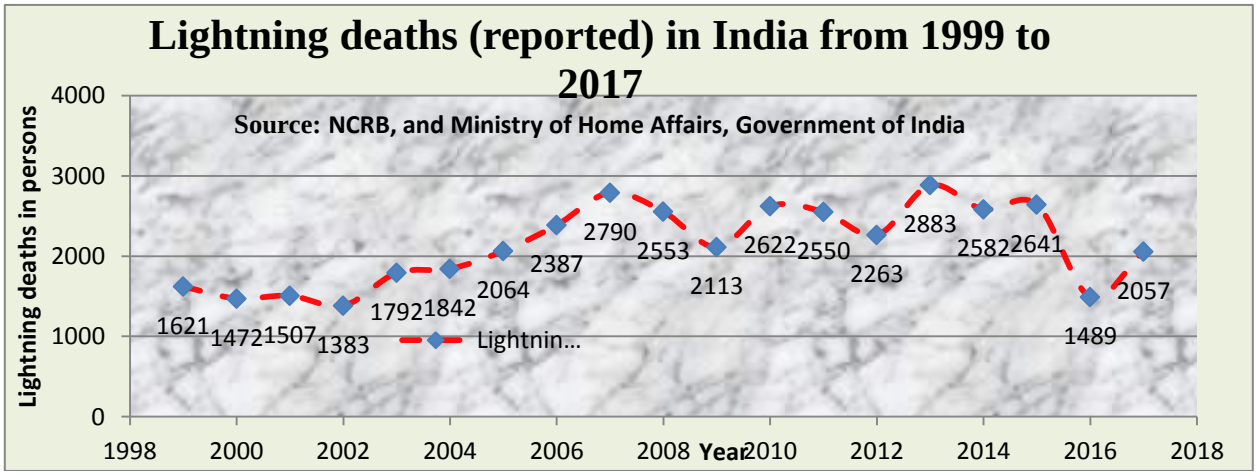

Fig 6:-lightning deaths (reported) in india: 1999 to 2017 (source : ncrb & ndma data goi)

Lightning statistics of different countries reveals that it is a disaster for the poor and 24000 people die /year throughout the globe. The rate of death due to lightning for developing countries is < 0.5persons/million (Europe and USA are 0.2 and 0.3 persons/ million). The under developed and developing countries, it is much higher like India (2persons/million) , Zimbabwe (20persons/million) and Malawi in South East Africa is (84 persons/million), https://www.the atlantic.com/news/archive/2016/06/lightning-deaths-india/488261/

More lightning in East India

Cb or Cu (Cumulus) clouds are the cause of thunder storms and tornadoes in India. They form isolated, in constellations, or along cold front squall lines. These clouds are capable of producing lightning and other dangerous severe weather, such as tornadoes. These thunder clouds can have horizontal maximum coverage of 150 to 200Km^2 and vertical coverage 5-8Km but norwesters coverage is hardly 15 to 20 Km^2. Uncertainity in lightning strokes makes it more deadly due to instantaneous impact anywhere below the Cb cloud is unpredictable. The states Jharkhand, Bihar, Odisha are with more farms, farmers and mines are the worst sufferers.

A study made by NASA (Earth Observation satellite) over 1995-2002 reported that eastern Indian states, including Odisha, prone to 20 to 30 flashes/Km^2/year and strikes are highest in May. Grounding of lightning has higher frequency in mid equatorial tropics and subtropics. Central Africa receives ≈ 150 hits/ Km^2 /year.

Synoptic features:

In general equatorial lows are formed in the doldrums areas near equator in January and with the progress of trade wind shift towards north in northern hemisphere till it reaches the sub-tropical high zone. The ITCZ moves with the advancement of the trade winds causing meteorological disturbances like tornado, thunder squalls with formation of Cu and Cb clouds in India. The intense subtropical highs, during winter descend from 35^0 Lat. to 25^0 Lat., inland towards equator. Frontal activities favor formation of Cb clouds at places that cause lightening escorted by dust storms and thunder squalls.

Along the meteorological equatorial line 5^0 N, along the equatorial trough lines within inter tropical convergence zone (ITCZ), form a spectrum of Cb clouds resulting extreme weather conditions within12 to 15^0 N. The ITCZ moves back and forth in Indian sub-continent from Himalayas to equator. Strong of West-ly winds circulate in the tropopause (at ≈12km elevation) with wind speed 18-35 kmph forming strong horizontal and vertical shears and high temperature anomaly (Hadely circulation). The Coriolis force drives the upper tropospheric geotropic wind from west to east direction in Northern Hemisphere. These jet streams can be polar front, polar night, sub-tropical westerly and tropical easterly in N-Hemisphere. The ITCZ condition mostly string-pull formation of Cb cloud formation in India.

Monsoon lightning in India:

East India, Odisha, Jharkhand, Bihar, West Bengal and undivided Assam is constituted on hilly mountainous terrain of eastern Himalayas, the Purvanchal Range, the Satpura and Vindhaya Range, the Eastern Ghats surrounding Bay of Bengal and consisting of the major coal, iron, aluminum, copper, zinc mines which is a good conducting path. The air from the Bay of Bengal during SW- monsoon flows inland and hits the mountainous ranges. Clouds are laden with plenty of moisture and move inland from BoB. The convectional, cyclonic/frontal, and orographic/relief current forms clouds which propagates and dash against the hills range. The moisture laden air rapidly uplifts due to heat and many synoptic conditions to form upper air cyclonic circulation and develops Cumulus, cumulonimbus and Altocumulus clouds which cause more lightning situations than other regions in India.

Non-monsoon lightning in India:

Though the spatial distribution of CAPE is present during non-monsoon days, the convective available potential energy (CAPE) has less roles in forming Cb clouds in east India as in monsoon days Murugavel et al., 2014[6]. But during non-monsoon days lightning associated by localized clouds (Cumulonimbus, Altocumulus and Cumulus) are formed due to convective currents by adiabatic heating and irradiative cooling generated from high mountains mostly Himalayas. Mukhopadhyay et al 2009[5] reported that the non-monsoon thunder squalls are initiated in the Chotanagpur plateau (Kaimul and Maicala ranges) and adjoining southern West Bengal and northern Odisha. The lightening events are prominent due to localized thunder storms in the months of March to May every year.

Odisha state is more prone to Lightning:

Odisha, a coastal state with sub-tropical, peninsular hilly terrain and littoral abundance, is vulnerable to various natural disasters such as cyclones, heavy rain, landslide, floods, storm surges, lightning, tsunami and whirlwinds etc as if a disaster hub of India. Lightning is the biggest natural killer in Odisha in the 21st century.

Jensen et al., 2017[11] has reported that the uneven hilly terrain and mountains are more prone to lightning than low lying plain lands. The lightning with tsunami was included in the state disaster list within last decade and compensation @ 4lakhs/ person (Odisha relief code) is being paid to the reported victims or the deceased. In the 20th century many cases of lightening deaths were unreported or under reported. Lightning death rates by countries around the globe have been studied by Holle R. L., 2008[8] and has mentioned that lightning deaths is the third lowest deaths per million people is 2.5 for Odisha.

Lightning is considered as poor man's disaster as most of the victims are from outside workers group. Warning for lightening has been introduced by the government through multimedia but could not reach the victim as they are poor and less acess to electronic media. The sensibility about detection of lightning and micro-scale forecast with the present technological advances is less useful in Odisha and India.

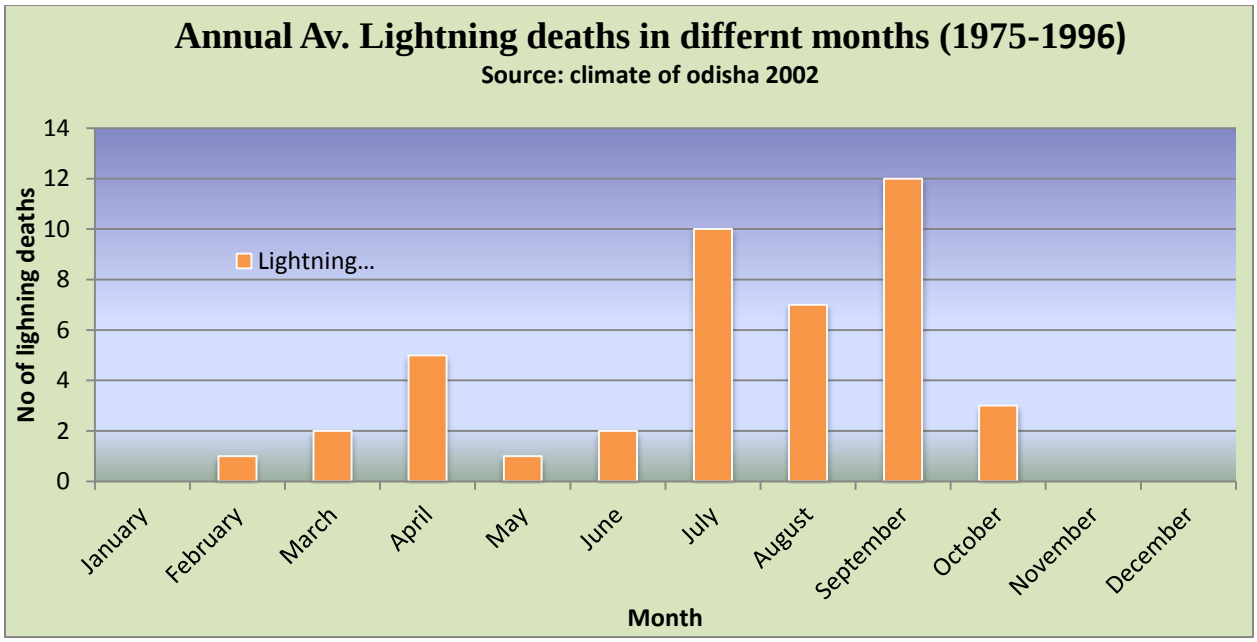

Fig 8 :-The monthly distribution of lightning deaths in Odisha, Source: Climate of Odisha 2002

Vulnerability to Lightning:

The biggest killer, Lightning in the State of Odisha has taken 2408 lives @ 350/year for the last 8years. About(71%) of lightning deaths is reported during pre and active monsoon period when the chances of formation of Cb clouds are more and farmers are in the fields. The coastal and hilly districts central and western Odisha (Mayurbhanj, Dhenkanal, Ganjam, Sundergarh, Cuttack, Jajpur and coastal districts) are worst prone to lightning. Recorded 36 lives and 37 critically injured were reported due to lightning in one day in Odisha this year 2018.Illyas et al., 2014[59] has reported that the western Odisha lie in high hazard zone having average 85 lightning days/yr.

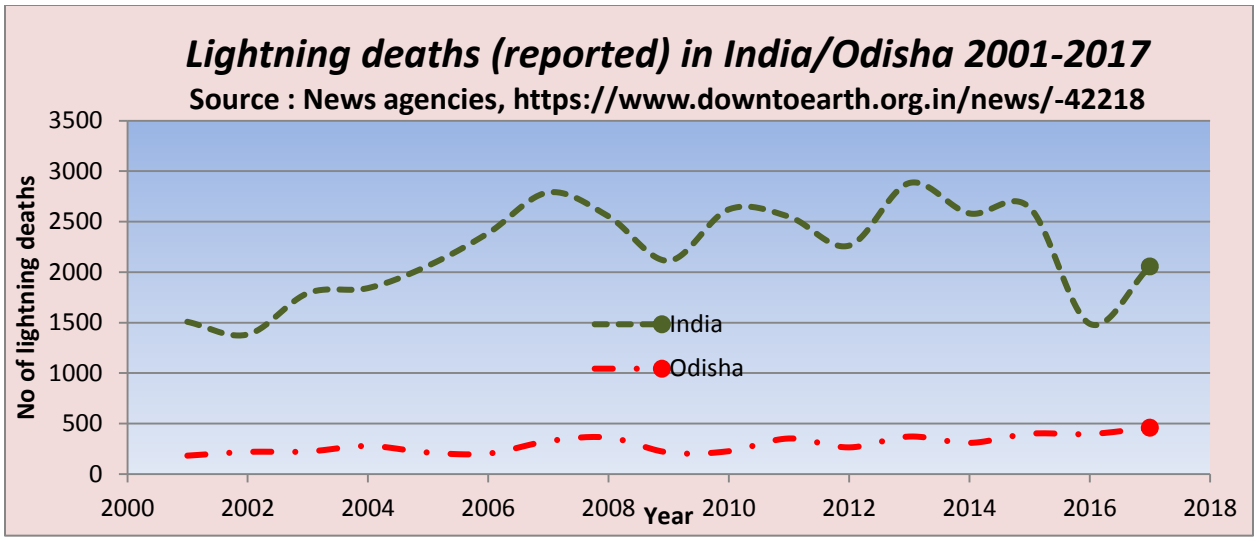

Fig 9:-The lightning deaths (reported) in India and state Odisha, Source: OSDMA, and News agencies, https://www.downtoearth.org.in/news/-42218,and multi-media news

The last 7 years lightning hazards have taken 2408 fatalities on an average 350 lives per annum in odisha. The regular disaster fatalities have been succeeded by the lightening fatalities (**Table 4**). The frequency of death toll is @71% that occur between pre-monsoon and active monsoon period (M,J,J,A months) and cyclic **Fig 8**. The intensity of hit fatalities is highest in Mayurbhanj and, Keonjhar districts as they are mines area of iron and bauxite ore, and in operation. However it is observed that 30-40 lightening death venues in Odisha are paddy fields **(Fig 9).** The LIS/ OTD observations of TRMM satellite, NASA has prioritized the Bhadrak and Banapur areas have ranks 328 and 408 in their top 500 FDR list of the globe with FDR Values 58.5 and 54.22 fl/Km^2 / year.

Table.4:-The district wise fatalities (increasing trend) in Odisha due to lightning from 2001 to 2015

#	Dist name	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Angul	9	10	5	11	13	16	14	18	14	10	21	8	17	3	17
2	Balasore	11	11	15	21	3		6	13		7	4	3	10	17	23
3	Baragarh	10	4	4	2	5	4	8	7	3	11	17	7	11	12	10
4	Bhadrak	7	11	9	13	11	12	14	6	16	6	8	15	6	9	14
5	Bolangir	3	4	16	7	1	2	15	6	2	8	14	0	23	13	11
6	Boudh	2	3	4	4	1	1	1	5	3	2	2	2	2	1	3
7	Cuttack		0	14	14	23	32	27	14	5	7	13	15	23	18	31
8	Deogarh	9	2	1	1	1		1	2	3	3	15	3	9	2	8
9	Dhenkanal	16	7	8	29	19	21	38	24	9	16	34	15	17	17	16
10	Gajapati	na	na	na	na	4	2	2	2	1	0	1		3	7	1
11	Ganjam	11	10	20	13	12	5	22	38	12	18	28	14	20	20	27
12	J-singhpur	2	7	6	3	7	4	4	12	6	5	9	6	8	12	11
13	Jajpur	na	6	22	5	8	11	9	7	13	15	17	13	19	21	17
14	Jharsuguda	10	3	2	3	3	3	6	6	5	6	10	4	3	1	3
15	Kalahandi	14	6	6	7	10	2	9	5	6	7	9	5	2	5	8
16	Kandhamal	2	na	na	na	1	3	6	2	1	1	0		6	1	7
17	Kendrapada	9	16	9	15	13	13	18	15	15	6	10	14	12	10	6
18	Keonjhar	7	4	11	7	22	12	17	8	13	19	25	6	18	18	28
19	Khordha	na	5	11	12	13	7	7	8	10	5	21	7	13	8	12
20	Koraput	2	11	3	18	8	5	13	10	4	6	4	11	17	10	8
21	Malakangiri	5	na	na	4	1	na	10	1	na	na	4	4	9	4	4
22	Mayurbhanj	na	5	12	20	28	3	28	40	28	19	21	32	48	42	43
23	Nawrangpur	3	6	6	14	11	15	11	10	3	8	8	9	12	14	19

24	Nayagada	3	6	8	20	9	5	9	5	5	5	3	4	2	5	6
25	Nuapada	na	2	1	1	2	na	5	6	3	4	8	1	5	5	10
26	Puri	16	9	6	6	6	3	5	4			7	2	9	2	11
27	Rayagada	na	na	4	1	5	2	8	5	6	11	6	3	9	14	8
28	sambalpur	5	6	5	12	1	6	9	14	4	7	14	9	11	2	7
29	Sonepur	3	3	4	3	2	3	4	7	7	5	5	1	4	3	4
30	Sundargarh	15	9	12	13	20	13	15	31	14	13	25	17	27	13	27

The trend in increase in fatalities due to lightning in Odisha has gone up during monsoon months for last consecutive 5years (≈ 60%). It is duringKalbaisakhi period (April, may, September and October).. The causes being rise in average mean day temp (≈ 1- 2^0C rise in last century as per IPCC report) is causing atmospheric abrupt pressure drop towards afternoon making upper air unstable in monsoon days. Mayurbhanja, in western Odisha is the worst sufferer for lightning fatalities. It is more than 40 persons/year as it is hilly and mostly a mines area for chromite and iron ores. It lies adjacent to Maikela hills range and on the monsoon trough line and favorable for formation of cumulonimbus cloudsTable 4.

Federal rules and modes of operandi:
Considering the gravity of lightening, thunderstorms, squalls, dust storms and cloud bursts the National Disaster Management Authority NDMA, GOI, has prepared draft guidelines in 2018 to asses, predict, readiness and alleviation of devastations both physical, fatal/ injuries and economic losses by different line departments of the states and UT's. Sharing of responsibility to take measures, relief and recuperation due to the lightning impacts are the responsibility of the local federal government where the central government supports financial assistance during the localized phenomenon like lightning, cloud bursts and thunder squalls in Odisha.

The guide lines prescribed by ORC (Odisha Relief Code), (NDMA) Disaster Management Authority guidelines, Disaster Management Act, 2005 state and line department management plans under the guidance of SRC, Special relief Commissioner, Odisha. The committee of State disaster management authority shall examine vulnerability, prepare guidelines, monitor and issue instruction to the lightning affected persons. To save the high rise buildings and monuments follow the guidelines of Indian standard protection of buildings and allied structures against lightning code of practice 1991. The state emergency operation center (SEOC) disseminate early warnings from the collect gen's from meteorological centers of GOI disseminate alert information to public of the affected area by all possible (cellular, landline, internet, multimedia & finally public announcements. The state is under surveillance by four Doppler radars at Paradeep, Gopalpur, Bhubaneswar and Sambalpurfor monitoring the cloud burst and lightning activities and issue bulletins and warnings.

Harnessing electricity from Lightning:
One lightning hit to earth on average generate ≈ 1,400kWh of energy (no capture, storage and transfer loss) and ≈25% are CG clouds that only can be harnessed to harvest electricity. As lightning striking ground is instantaneous and no storage devices of electricity have been invented so far. So it is a herculean task to capture and harness lightning energy and used for human uses. However human in Anthropocene must expore the technology by a laser-induced plasma channel (LIPC) of capturing, storing and transmitting use electricity with lightning as source. https://en.wikipedia.org/wiki/Harvesting_lightning_energy.

Protective measures:
In case of death and injuries, immediately take the victims to the nearest hospital after giving primary medical first aid. The deaths and injuries of lightening events are expected to increase in future due to global warming and meteorological anomalies. The damages can be checked if people reside in lightening safe buildings, vehicles and reduction of labour intensive manual outdoor works Gomes et al. 2012[61]. To answer, some of the known facts and preventive measures are **Fig 10:**

Lightning events are vulnerable, random, untimely non-predictable. Apprehension of rain or CB clouds invites lightening. In pre, active and post monsoon, lightning occur. Constraints like evading lightning events by staying indoor; dodging outdoor activities during thunderclouds ahead has become questionable. The local govt. should identify vulnerable locations of lightning areas considering geology, geomorphology, climate and prepare a lightning hazard map and to be displayed in public places.

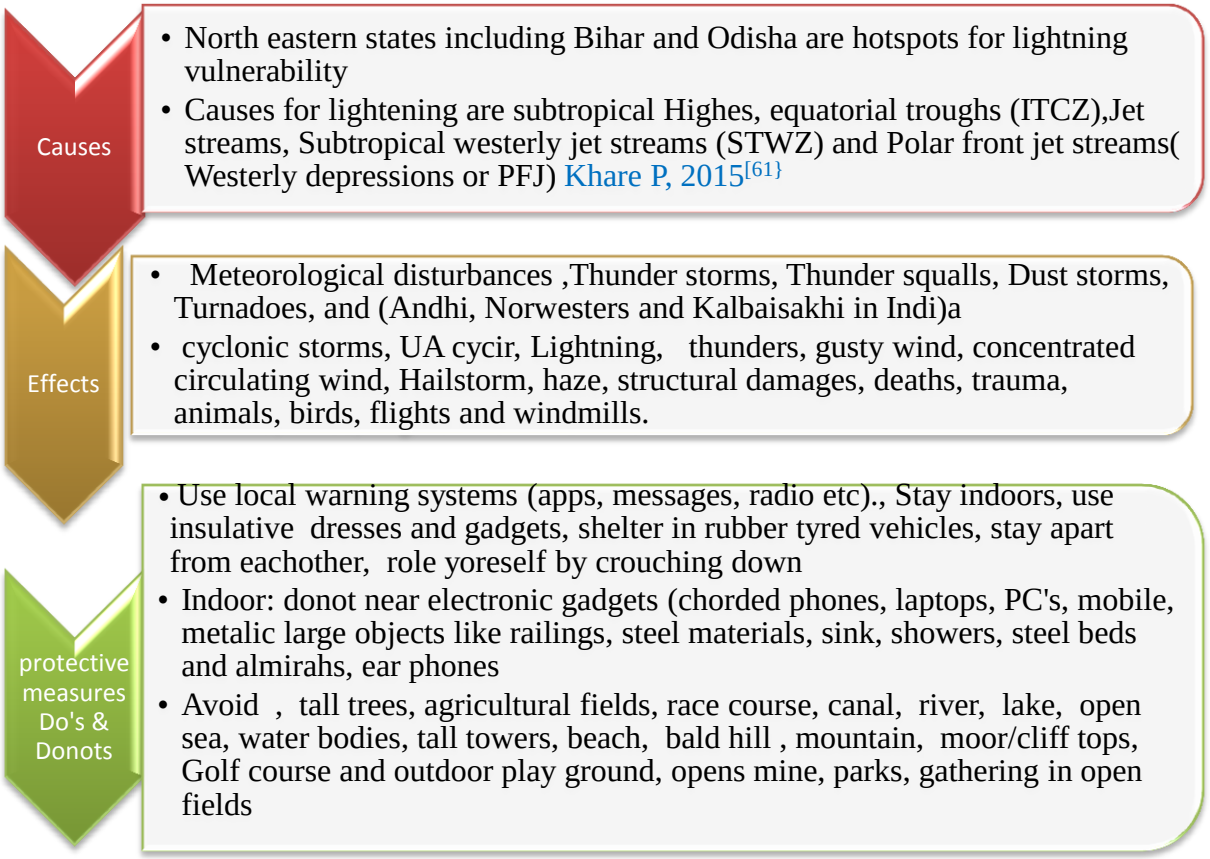

Fig 10:-The causes, effects and do's and do not's during lightning both indoor and outdoor.

The satellite imageries, RADAR observations are to be taken regularly to locate the initial position of Cb cloud. Ones detected the movement and the growth of the cloud to be monitored and corresponding warning to be widely circulated officially through electronic and wireless medium to make the vulnerable areas alert. Since no compensation were paid in 20th century, the mortality and injury report due to Lightning was not reported or under reported, Salini et al., 2017[62]. Rainfall, landslides drought, and even lightning activities must be recorded and prepare and issue guidelines of activities during TS. Normals and charts .are to be prepared should be included in the curriculum of disaster management studies.

Conclusion:-

The average fatalities 2001- 2017 of India is 2207 and that of Odisha is 295 which is 13.36 % due to lightning where as area wise is only 4.87 % and population wise 1.005% of India.Annual lightning deaths are the higher than any other natural disaster in Odisha. But during the last decade (2007 to 2017) the annual average has raised to 2413 and 335 respectively.

Lightning hit deaths are not stressed as a major natural calamity category in India till 2015. The Government of India allowed the states in 2015 to include the malady as one of the state-specific disaster and allowed compensation the deceased and his eligible family Accordingly the state Odisha has included and Odisha State Disaster Management Authority declared lightning deaths as 12th disaster and paying compensation to the deceased/affected persons from lighting hits.

The absence of a dependable warning method is rarely cited as for the high numbers of fatalities. India is basically an agricultural countryincluding Odisha, where most of the people work in agricultural fields and outdoor construction projects. Mayurbhanja in Odisha, basically adjacent to the epicenter of thunder activities as it is of mountainous hilly areas and mines area.

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