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Lightning generation correlation with widespread irrigation and means of protection

Miah M. Adel

Department of Chemistry and Physics, University of Arkansas at Pine Bluff, Pine Bluff, AR 71601, USA.

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India's lightning fatalities correlate with her spatial extent of water bodies. Evaporation from reservoirs and irrigated lands provides moisture for cloud formation. Hot and humid air flowing overland can rise over mountains where it expands under reduced pressure, cools down to promote condensation in contact with sea salt, dust particles, soot from forest fires, bacteria, etc. Agitation within the cloud leads to inter- and intra-cloud charge separation. The cloud -to-ground voltage makes the aerial path conducting and charge neutralization occurs in which the ground or subject on the ground acts as a source of upward-moving positive charge. Also, hot and humid air can rise high, cool down, and result in condensation. Further, a cold and dry air mass can meet a warm and moist air mass, resulting in the saturation of the warmer air to produce clouds. India's plan to pirate the flood season Ganges water, implementation of the Grand River linking project, and deprivation of Pakistan of the Indus water make her more vulnerable to lightning strikes. All physical postures; standing, sitting, lying-carry risk of lightning strikes either because of being tall and/or having large inter-limb separation with a large voltage difference favoring a fatal current flow. But the prostration posture in Muslim prayer when several parts of the body touch the ground carries the least risk of lightning hit because of the shortest body height and the shortest inter-limb separation ensuring low inter-limb voltages and so low current. Prostration drill can protect one from lightning strike.

Key words: Lightning, irrigation, reservoirs, evaporation, cumulonimbus clouds, river networking, the Ganges, the Indus, buoyancy, Muslim prayer posture.

INTRODUCTION

One estimate shows about 2,000 active lightning storms around the planet at one time giving birth to 100 lightning strikes per second. Majority of lightnings are intra-clouds. A 10 to 20% lightning strikes the ground (http://www.aharfield.co.uk/lightning-protection-services/about-lightning). Out of this less than a quarter percent cloud-to-ground lightning, the estimate of 24,000 worldwide annual lightning deaths is made (Holle and Lopez, 2003). Holle (2008) reports the country-wise annual rates of fatalities and provides references to works of country-based studies. In 2014, more Indians were killed by lightning than by any other natural disaster

E-mail: adelm@uapb.edu.

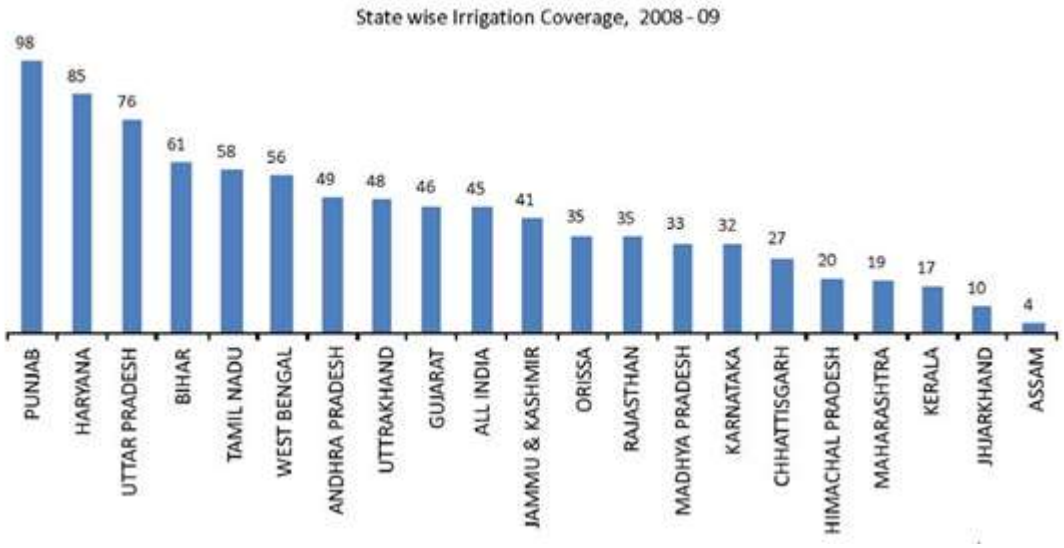

Figure 1. India state-wise percentage of irrigation.
Source: http://shodhganga.inflibnet.ac.in/bitstream/10603/19593/10/10_chapter3.pdf.

(Radhakrishnan, 2015). Anthropogenic activities have exploited water resources obstructing their natural flows and confining them in artificial reservoirs and spreading them widely in irrigation. Distributed water resources enhance evaporation, the principal ingredient of cloud formation. Solar heating can form an updraft of moisture-laden air which cools and expands due to a decrease of air pressure with height. When the rising air reaches saturation, condensation starts in contact with sea salt, dust particles, soot from forest fires, bacteria, etc. to form clouds. There has been the report of the mechanism of involvement of objects and personnel in lightning disasters (Das, et al., 2009). There has not been any attempt to relate the cause of lightning fatalities to any anthropogenic activities. This article relates the increasing fatalities with the anthropogenic activities of promoting widespread supply of the thunder clouds ingredients. For reasons of unavailability of the actual number of cloud-to-ground strikes, the increasing fatalities data have been used in the correlation study.

Further, the article explores all possible physical postures (standing, sitting, lying down, etc.) for protection from lightning strikes in all terrain of lands. It is found that none of those postures ensure as much as protection like the prostration position on the ground offers due to the low voltage differences between limbs consequent upon the shortening of inter-limb distances.

Data

About three decades (1980-2009) of lightning fatalities data were available from the works of Singh and Singh (2015) and irrigation data were available from (http://www.indianstatistics.org/irrigation.html). Indian irrigation revolution started about the beginning of this period with the introduction of tubewells. Figure 1 shows the state-wise irrigation coverage for 2008-2009: Punjab being the highest (98%) and Assam the lowest (4%). The net irrigated area has been estimated to be 141,000,000 hectares. Some irrigation water bodies are presented in Figures 2 and 3. India's political map is given in Figure 4.

METHODOLOGY

Data on water exploitation and lightning for India have been used in this study. Data on dams and reservoirs for irrigation resources are presented. There are thousands of reservoirs that are used for both fisheries (Table 1 and Figure 5) and irrigation (Table 2 and Figure 6). A brief picturesque discription of the exploitation of the world's 8th largest River Ganges has been shown. Apart from the dry season exploitation of the Ganges water depriving neighboring Bangladesh of her due share of the Gages water, its wet season exploitation via different canals has been mentioned. India's yearwise increase of irrigation that is the progression of irrigation has been plotted. Also, India's yearwise lightning fatalities have been plotted. A correlation has been established between these two. It has been warned that India's plan of rivernetworking that makes Indian land the sources and sinks of rivers carries even a greater risk of increased lightning generation, and thence, the fatalities.

In support of the increased lightning strikes from the formation of lightning clouds from distributed water bodies, a theoretical discussion on the increased evaporation from distributed water sources was presented.

In the second part of this article, a discussion on the means of protection against lightning strikes was presented. It has been concluded that staying inside modern cars, standing, sitting, or

Figure 2. Indian revolution making groundwater irrigation (Courtesy of Jimmy O'Keeffe, November 11, 2015 available from http://waterforfood.nebraska.edu/blog/2015/11/11/understanding-agricultural-water-use-in-north-india/).

Figure 3. Another scene of Indian irrigation system. Tank (a reservoir of any specific size) irrigation in India(http://www.indianetzone.com/45/tank_irrigation_india.htm).

even lying down is not as effective as the prostration poisture used in Muslim prayer when the different limbs of the body are close to one another. This makes the interlimb distances shortest, and so, the voltage difference between different limbs, allowing little current to flow in the limbs. On top of low current flow, this posture makes the body height lower than standing and sitting, and even lower than the heights of background objects. Since a human object height is important in being struck by a lightning, the prostration posture, is the best shelter against lightning strikes.

On top of these widely spread water bodies from irrigation that provides hot and humid air to the atmosphere, India has thousands of reservoirs for fisheries (Table 1 and Figure 5) and irrigation

Figure 4. The political map of India (http://www.mapsofindia.com/maps/india/india-political-map.htm).

(Table 2 and Figure 6). The reservoirs adds more moisture to the air than if there were rivers in their place.

Indian reservoirs are mostly for irrigation purpose. Just a few are for both irrigation and hydroelectricity. A distributed water body evaporates more than a localized one.

Possibly, more danger lurks over India as it plans to pirate the wet season Ganges water at its upstream, to develop the grandriver networking, and to hold the Indus River breaking the Indus Water Treaty with Pakistan. Hillary, a traveller on the Ganges, reports that during the dry season almost all the water is taken by India at Hardwar (1979). Now, India is implementing plans to pirate the wet season water from the Ganges depriving the downstream

Table 1. State-wise distribution of all sizes of fisheries reservoirs in India.

States	Total Number of Reservoirs	Total area (ha)
Tamil Nadu	8,906	358,740
Karnataka	4,679	437,291
Madhya Pradesh	32	460,384
Andhra Pradesh	2,937	458,507
Maharashtra	------	273,750
Gujarat	711	286,230
Bihar	125	96,695
Orissa	1,442	198,198
Kerala	30	29,635
Uttar Pradesh	66	334,840
Rajasthan	423	153,444
Northeast	6	8,074
Haryana	4	282
West Bengal	6	15,732
Total	19,370	3,153,366

Source: (http://www.fao.org/docrep/003/v5930e/V5930E01.htm).

Figure 5. Duck Valley Indian Fisheries Reservoir (https://southwest-fly-fishing.myshopify.com/blogs/features/34339653-duck-valley-indian-reservation-id-nv).

Bangladesh.

In the upper reaches of the Ganges (Figure 7), there are the Upper Ganges (total length 6582.22 km) and the Madhya Ganges Canals (Figures 8a, 8b, 8c, and 8d). People use the monsoon season excess water of the Ganges for cultivating 64,000 ha paddy in dry pockets within the Upper Ganges Canal area. Also, paddy cultivation is developed in 114,000 ha in the command area under the Upper Ganges Canal, and the Eastern Ganges Canals (a CCA of 2333,000 ha and an irrigation potential of 105,000 mha) are meant to use the monsoon season excess water from the Ganges for irrigation Bijnor and Moradabad districts of Uttar Pradesh. The canal network's total length is 203.09 km. Also, the Lower Ganga Canal consists of a 1,158 m long weir across Ganga at Narora to raise the winter Ganges discharge by 3.05 m to be fed into the canal that emerges from the right bank of the river. It irrigates 0.5 million ha in the districts of Mainpuri, Etah, Farrukhabad, Etawah, Kanpur, Fatchpur, and Allahabad in Uttar Pradesh.

The main canal and branches in the Lower Ganges canal

Table 2. States' areas and the total number of dams and reservoirs in them.

State	State capital	Total area (km^2)	Number of dams and reservoirs
Andhra Pradesh	Amaravati	160,205	129
Arunachal Pradesh	Itanagar	83,743	4
Assam	Dispur	78,438	4
Bihar	Patna	94,163	24
Chhattisgarh	Raipur	135,194	250
Goa	Panaji	3,702	5
Gujarat	Gandhinagar	196,024	506
Haryana	Chandigarh	44, 212	6
Himachal Pradesh	Shimla	55,670	16
Jammu and Kashmir	Srinagar (Summer) Jammu (Winter)	222,236	9
Jharkhand	Ranchi	79,714	84
Karnataka	Bengaluru	191,791	252
Kerala	Trivandrum	38,563	58
Madhya Pradesh	Bhopal	308,252	763
Maharashtra	Mumbai	307,713	1684
Manipur	Imphal	22,327	4
Meghalaya	Shillong	22,429	7
Mizoram	Aizawl	21,081	2
Nagaland	Kohima	16,579	1
Odisha	Bhubaneswar	155,820	181
Punjab	Chandigarh	50,362	14
Rajasthan	Jaipur	342,239	231
Sikkim	Gangtok	7,096	6
Tamil Nadu	Chennai	130,058	116
Telengana	Hyderabad	114,840	165
Tripura	Agartala	10,492	1
Uttar Pradesh	Lucknow	243,286	97
Uttarakhand	Dehradun	53,483	15
West Bengal	Kolkata	88,752	33

Source: (http://www.india-wris.nrsc.gov.in and http://natureconservation.in/list-of-indian-states-and-union-territories-updated/, Wikipedia).

measure about 1,060 km, and distributaries 5,015 km. The combined service of the Upper and the Lower Ganges Canals form the world's largest irrigation system – no less than 12,240 km long to irrigate an area of 1 million ha (Adel, 2013a). All these water works will have an additional effect on the generation of lightning. The works of the author present a snapshot, but not an exhaustive account of India's mega projects of water exploitation (Adel, 2013b, 2015).

Also, India has taken a grand plan to interconnect her rivers (Figure 9). The project has three components – the Himalayan component in the north, the Peninsular component in the south, and an intrastate component (Adel, 2013b). India plans to keep all the river waters within herself. She already changed the course of the world's 8th largest river the Ganges that flowed through neighboring Bangladesh under the pretext of a so-called Ganges Treaty that Bangladesh government was forced to sign following a marathon number of meetings between the two parties and intermittent deprival of water to Bangladesh for longer and longer periods.

Further, there is the dispute between India and Pakistan in the Indus River basin on the Jhelum River that Pakistan has exclusive rights on. India is diverting water from its tributary the Kishenganga river. Without understanding the widespread effect, the judges in the International court passed verdict in favor of India.

The Rattle Hydroelectric Plant (133-m tall gravity dam and two adjacent power stations of installed capacity 850 MW) is currently under construction on the Chenab River (Figure 10) that Pakistan holds exclusive right over according to the Indus Water Treaty (Adel, 2013b). India's Modi Government will not allow water to flow through Pakistan (http://www.dawn.com/news/1298575/water-belonging-to-india-cannot-go-to-pakistan-says-modi), a stance that breaks the Indus Water Treaty signed by the two countries in 1960. India will accelerate its building of new hydro-power plants along three rivers that flow into Pakistan (http://www.dawn.com/news/1286433/india-to-speed-up-hydropower-building-on-rivers-flowing-into-pakistan).

RESULTS

The Indian irrigation progression is shown in Figure 11 and the increase of lightning fatalities in Figure 12.

Figure 6. India's irrigation reservoir (http://www.indiaspend.com/sectors/down-the-drain-indias-costly-and-losing-irrigation-battle).

The correlation coefficient between the irrigation progression and fatalities progression is 0.798 that is about 0.80.

DISCUSSION

Increasing evaporation

Behind every dam there is a reservoir. Water loss from a reservoir exceeds that from the parent river which flowed in the reservoir's place. The loss depends on the climate of the area, and the size, shape, and depth of the reservoirs. Reservoirs affect climate. They add more humid air than used to be there in their absence.

The open air evaporation from large water bodies in mm/day is given by combination of Penman and Priestly-Taylor equations (de Bruin's, 1978),

$$E = (\alpha/(\alpha + 1))(\gamma/(\Delta + \gamma))f(u)(e^*_{\alpha} - e) \quad 1$$

Here, $\alpha = 1.26$, Δ is the slope of the saturated vapor pressure-temperature curve and γ is the psychometric coefficient (or c_p/λ), and

$$f(u) = (5x10^6/A_s)^{0.05} (3.6 + 2.5u_3) \quad 2$$

Where, u_3 is the wind speed measured over the water at 3 m above the surface, A_s is the area of the water surface in m^2, and e_s * and e are the saturated vapor pressure of the air at the water surface temperature and the vapor pressure of the air at the reference height. Daily evaporation amount can be found out from the weather-related data and the reservoir information.

In India most of the western coastal states (Uttar Pradesh which has a different physical feature is an exception) rank among the top 5 in terms of lightning fatalities. Among these, Maharashtra ranks 1, West Bengal 2, Uttar Pradesh 3, Kerala 4, and Karnataka 5 (Singh and Singh, 2015). The population densities in Maharashtra, West Bengal, Uttar Pradesh, Kerala, and Karnataka are 365, 1029, 828, 859, and 319 per sq km. In 2010, Maharashtra had 1,687 dams (http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Dams_in_Maharashtra). Maharashtra has an area of 303,713 sq km. Its nearest size state Madhya Pradesh with an area of 308,245 sq km has only 763 dams (http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Dams_in_Madhya_Pradesh). The state of Rajasthan with an area of 342,239 sq km has only 231 dams (http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Dams_in_Rajasthan;https://en.wikipedia.org/wiki/List_of_dams_and_reservoirs_in_India;https://www.mapsofindia.com/top-ten/geography/india-area.html). The rivers of Maharashtra are the Chapora River, the Daman Ganga River, the Godavari River, the Hiranyakeshi River, the Indravati, the Koyna River, the Krishna River, the Kundalika River, the Mithi River, the Mula-Mutha, the Narmada River, the Panchganga River, the Purna River, the Savitri River, the Shivaganga River, the Tapti River, the Wainganga River, the Wardha River, and the rivers of the Western Ghats. The area of Karnataka is 191,791 sq km and has 252

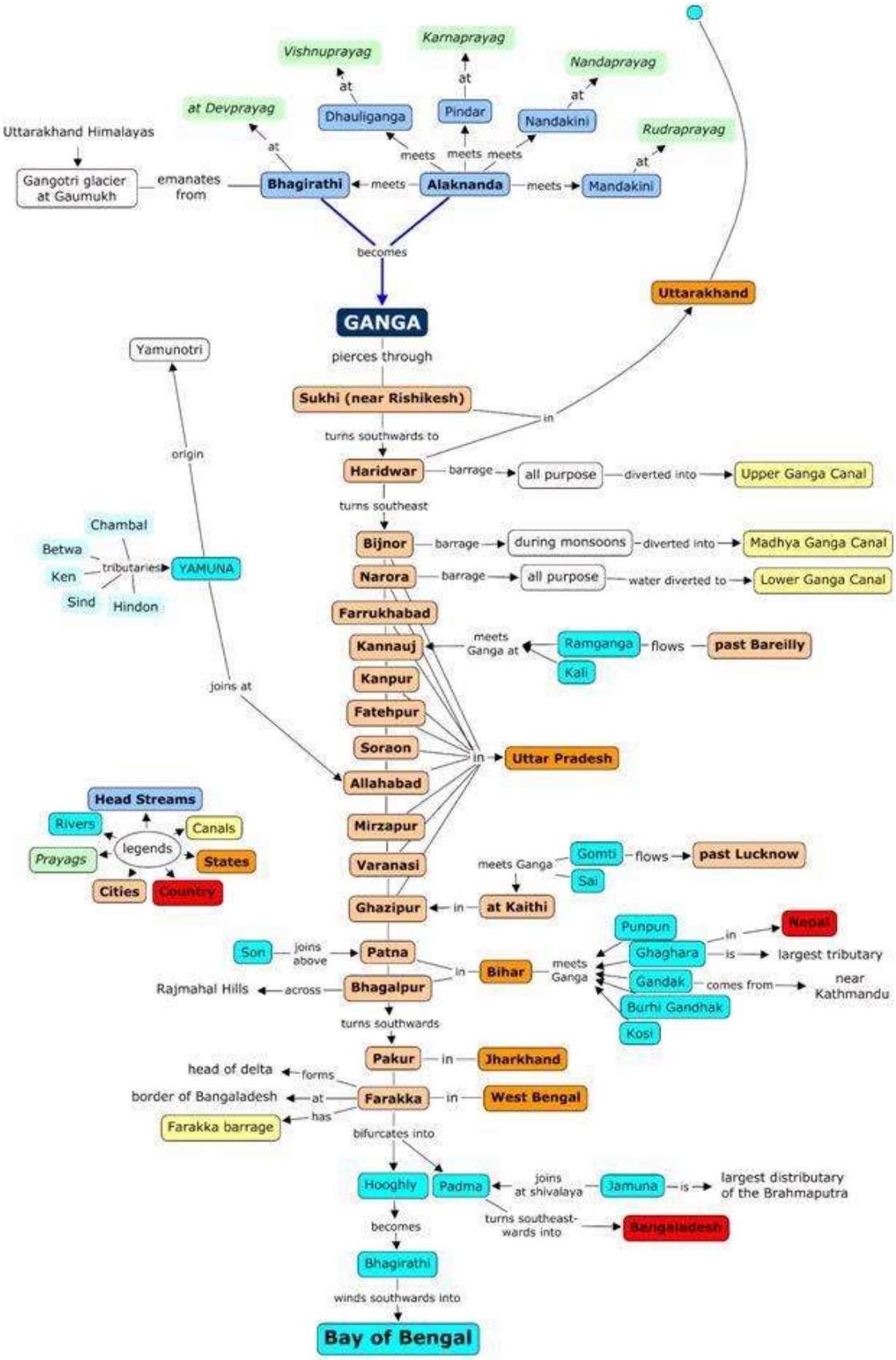

Figure 7. The course of the Ganges (http://nmcg.nic.in/courseofganga.aspx).

Figure 8a. Head of Ganges Canal. (https://en.wikipedia.org/wiki/Ganges_Canal#/media/File:Headworks_ganges_canal_haridwar1860.jpg).

Figure 8b. Cleaning of Upper Ganges Canal (http://www.hindustantimes.com/noida/cleaning-of-upper-ganga-canal-begins-no-water-supply-till-oct-21-jal-nigam/story-R3MFqtlr3nNwHJeEpwh43J.html; (Photo by Sakib Ali /Hindustan Times).

dams. Both Maharashtra and Karnataka are coastal states, but the former outnumbers the latter in terms of the number of dams per unit area. It seems there are more distributed sources of water in Maharashtra than in Karnataka to back up in evaporation. If the irrigation coverage is increased from the current 18 to 40% (https://timesofindia.indiatimes.com/city/aurangabad/area-under-irrigation-in-state-will-be-doubled- gadkari/article show/61349059.cms), it will increase the lightning generation, strikes, and fatalities.

Table 3 compares population density, reservoir areas, and the percentages of the land area. It is found that the state ranking # 1 on lightning has the least coverage with water. Variations in the fatalities primarily should be dependent on the nonuniformity of the state of the subjects. That is targets of one year will not be involved in the same situation as the targets of another year. The important pieces of information for a thorough study

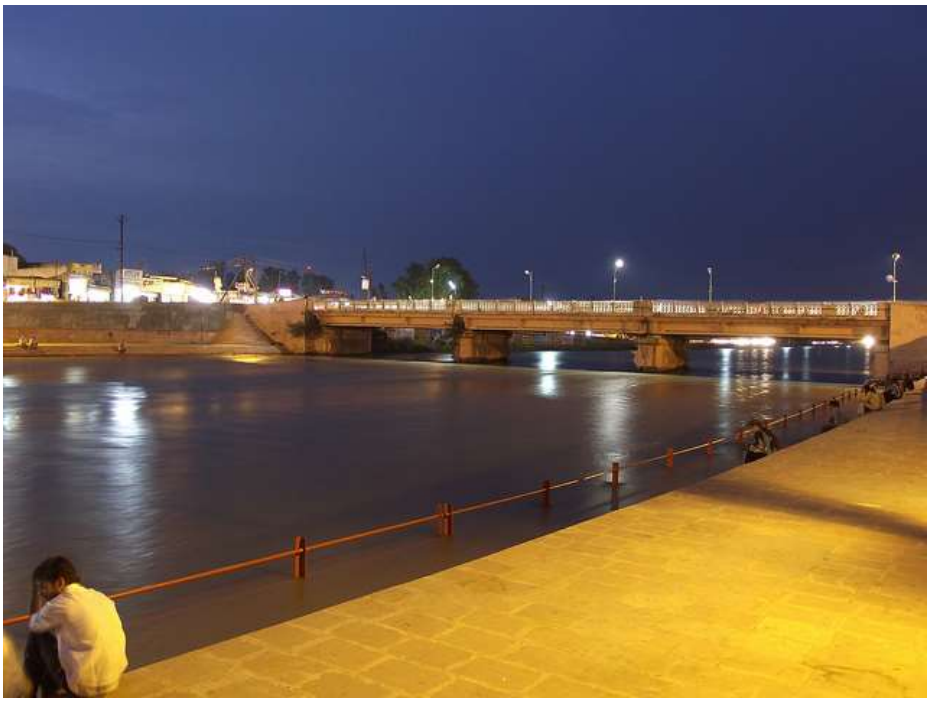

Figure 8c. Upper Ganges Canal (Courtesy of https://www.flickr.com/photos/mohanshreshth/5691882603/).

Figure 8d. Madhya Ganga Canal (http://wikimapia.org/9563571/Madhya-Middle-Ganga-Canal).

of the mechanism of striking a subject are (i) what the subject was carrying like any metal items - jewelry, watch, keys, knife, sickle, umbrella, etc., (ii) what the subject's posture was - standing, walking, sitting, lying,

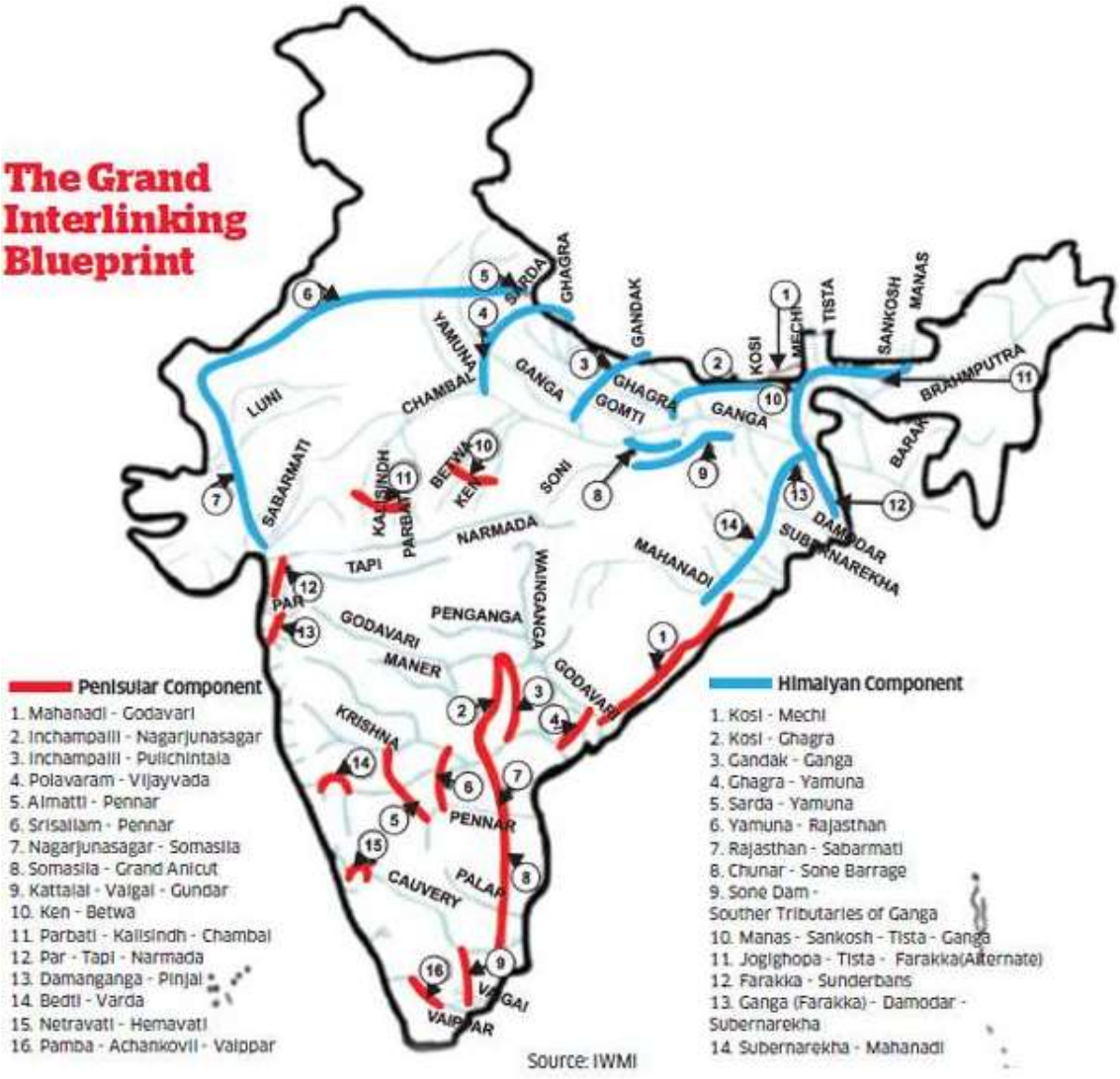

Figure 9. India's River Networking Plan(http://economictimes.indiatimes.com/news/economy/infrastructure/will-governments-grand-plan-to-link-37-rivers-be-nothing-more-than-wishful-thinking/articleshow/49208462.cms, 2015).

etc, (iii) where the subject's location was - indoor,outdoor highland or lowland, etc. (iv) what the subject's surroundings were - nearness to a tree, building with or without electrical wiring, water bodies, metal fence, etc., (v) what the subject was doing - pumping water from a tubewell, cleaning utensils sitting near a tubewell or in a pond, raising water from an open well with a metal pot, talking in a corded telephone, etc. All these situations favor the subject to be an upward-moving positive charge source. Also, there could be a bolt from the blue depending on atmospheric condition. Adel (2016) reported that date trees are very lightning-friendly because of long structure, watery body, and the special root characteristics. This tree may be planted in the field. More people are lightning struck in the field because of having metallic tools with them.

The best study of the lightning generation with the distributed water sources will be done if lightning events are observed via satellites and land water coverage is found from remote sensing. Satellite studies are very helpful in finding out the true number of lightning that occurs over some land area (Astafurov, et al., 2016); Volkova and Uspenskii, 2007). These sources are Blakeslee, 1996, 1998; Albrecht et al., 2016. Satellite remote sensing of land-use and land-cover changes data will be helpful in finding the inland water coverage (Rahman and Saha, 2008, 2009; Rahman et al., 2014)

Cumulonimbus cloud formation

As the sun heats up the ground in the warm season, the

Figure 10. The Kishenganga Dam site (http://sg.wsj.net/public/resources/images/AI-BC654_INDIPA_NS_20100520152427.gif, reproduced with permission).

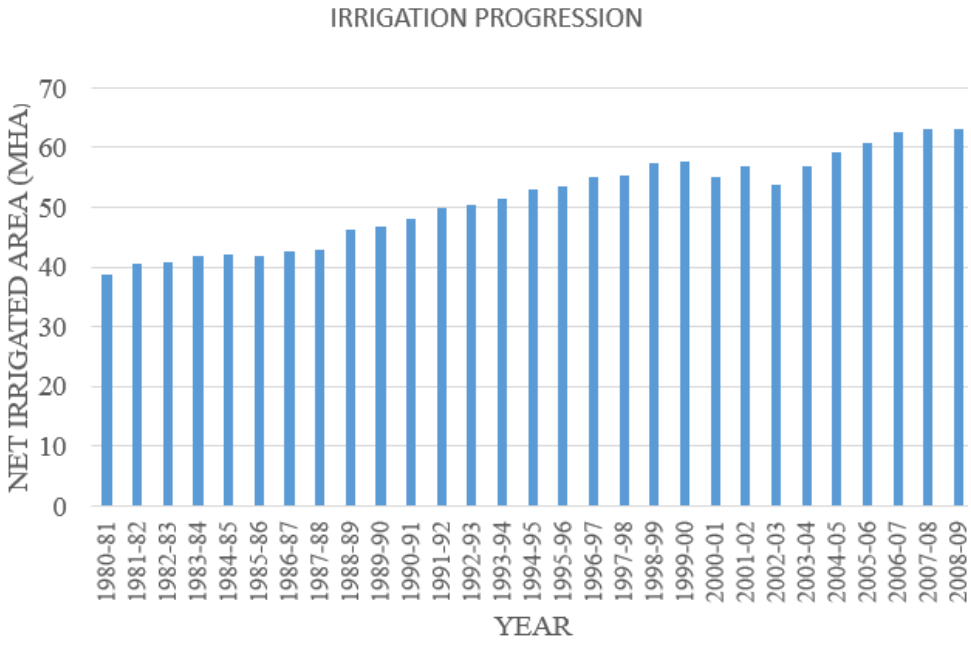

Figure 11. Progression in irrigation (http://www.indianstatistics.org/irrigation.html).

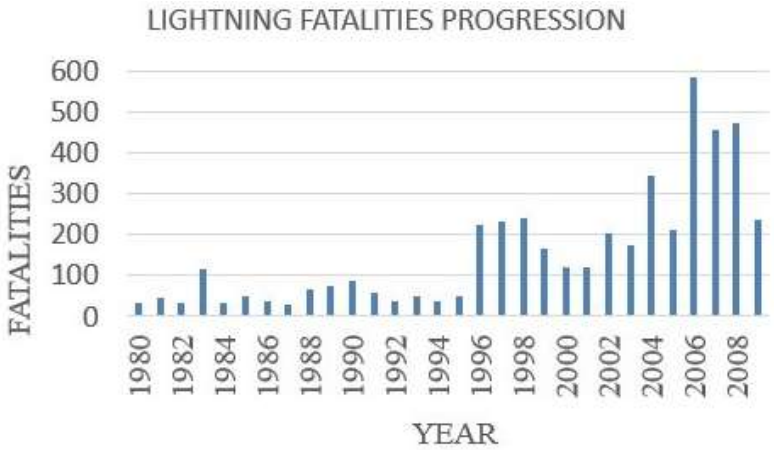

Figure 12. Increase in lightning fatalities (Singh and Singh, 2015).

Table 3. First five states' areas, reservoir areas and population densities.

State	Pop density (per sq km)	Medium + large Reservoir Areas (sq km)	Land area (sq km)	Reservoir area (percent)
Maharashtra	365	2,738	307,713	0.89
Karnataka	319	4,273	191,791	2.23
Madhya Pradesh	236	4,604	308,350	1.49
Uttar Pradesh	828	3,348	243,290	1.38
West Bengal	1029	1,573	88,752	1.77

Source:(https://en.wikipedia.org/wiki/List_of_states_and_union_territories_of_India_by_population;https://en.wikipedia.org/wiki/List_of_states_and_union_territories_of_India_by_area;(http://nihroorkee.gov.in/rbis/India_Information/dams.htm).

rapidly increasing environmental lapse rate (5 K/km) surpasses the dry adiabatic cooling rate (9.8 K/km) in a shallow layer that becomes turbulent. As the day advances, the layer grows deeper (Henry and Heinke, 1996).

Hot and humid air rises up in a number of ways. One of the ways air can rise up is by the obstruction of a mountain (This is the reason for the heaviest rainfalls in Karnataka and Goa, the Maharashtra-surrounded state, among the Indian states). Also, hot and humid air can rise high because of being light, it cools down at high altitudes, resulting in condensation. Further, a cold and dry air mass can meet with a warm and moist air mass resulting in the saturation of the warmer air to produce clouds. As the air rises up from a huge area, it expands because of the drop of atmospheric pressure. Air can hold moisture of definite amount at specific temperatures. Due to expansion, the temperature of the air mass drops according to the dry adiabatic cooling.

$$dT/dz = -g/c_p \quad (3)$$

Where, g = acceleration due to gravity = 9.8 m/s^2 and c_p is the specific heat of air at constant pressure = 1.01 kJ/kg.K.

Cumulus clouds form first from the rising hot and humid air (Figure 13). Moisture condensation increases the temperature. The inside temperature of cumulus clouds is hotter than the ambient outside temperature. This results in agitation inside the clouds promoting higher altitudes because the motion reduces pressure and increases the buoyancy according to Bernoulli's equation;

$$P + \tfrac{1}{2}\rho v^2 + \rho g y = \text{constant} \quad (4)$$

of the constancy of the sum of the pressure P, the kinetic energy per unit volume $\frac{1}{2}\rho v^2$, and the potential energy per unit volume ρgy of fluid motion.

The agitation leads to charge separation due to friction between tiny ice crystals in the cloud. Cumulus clouds give birth to cumulonimbus clouds (Figure 14).

Lightning

Agitation within clouds promotes this charge build-up and increases cloud-to-cloud and cloud-to-ground voltage.

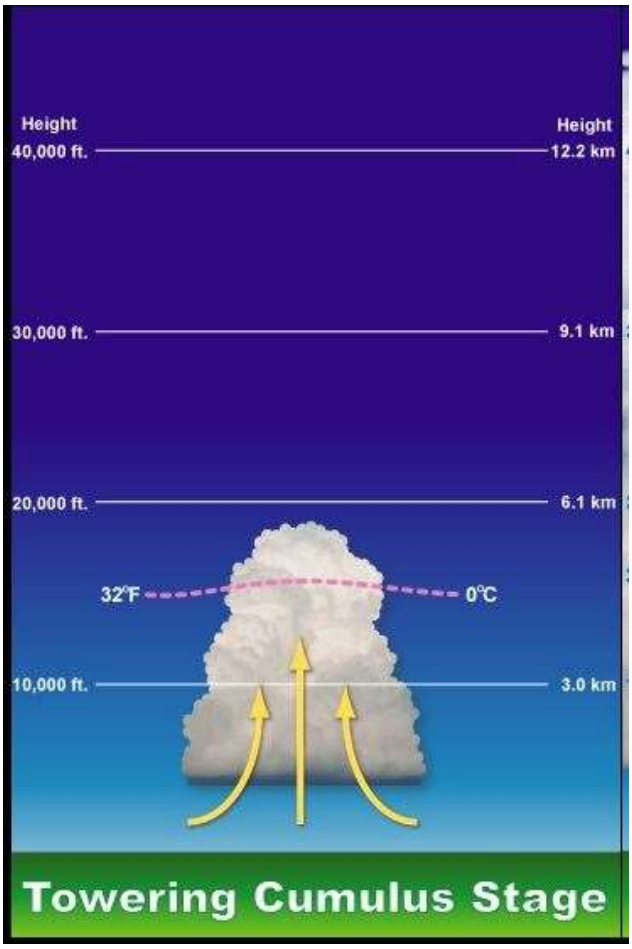

Figure 13. Towering cumulus clouds (https://en.wikipedia.org/wiki/Cumulonimbus_cloud).

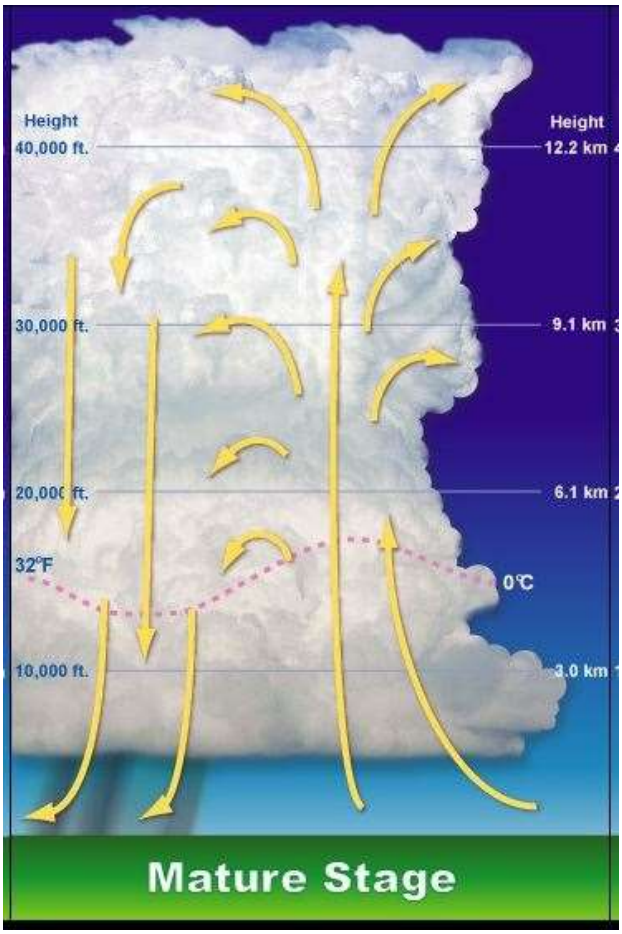

Figure 14. Agitation inside cumolonimbus clouds (https://en.wikipedia.org/wiki/Cumulonimbus_cloud).

Whenever the required voltage of about 18,000 volts is established between the cloud and ground, a flow of negative charge, called the stepped leader advances toward the ground from the bottom layer of the cloud. In a second, the front can cover about 1 km and carry 200-300 amperes of current. The stepped leader cannot advance straight down because of dusts and aerosols in the atmosphere. Rather, it follows the path abundant with ions and electrons. The downward-advancing negative charge front looks for any conducting pointed poles, animals, trees, of any metal object from which due to Coulomb repulsion electrons can be pushed down to the ground. Pushing down electrons from an upright object on the ground or hanging near the ground is equivalent to raising a positive charge front upward. Within a height of 20 – 110 m, the downward advancing stepped leader and the upward advancing positive charge front interact and set the short circuit. It results in pouring down of negative charge to the ground. About 100 million electrons carrying almost 25 Coulombs of charge creates 50,000 Amperes of current. After the first dazzling neutralization, a current front advances up with high brightness along the path of the stepped leader and its branch paths at a speed of one-tenth to one-half of the speed of light. (http://www.lightningsafety.noaa.gov/science/science_return_stroke.htm;http://www.lightningsafety.noaa.gov/science/science_electrication.htm for animation). The rapid upward motion of the eye-dazzling brightness of this return stroke is impossible for us to follow which gives the impression of uniform brightness all through. This is called lightning.

Subjects can be targeted for the source of upward-movement positive charge, the ground current or the lightning flash from the lightning struck spot.

Ground current and safety

Ground current reaches the ground either directly or through some object. Ideally, the ground current advances in all directions of the ground in a hemispherical space (Figure 15). The voltage drops outward from the striking point. Since the ground is not homogenous, so the ideality does not occur.

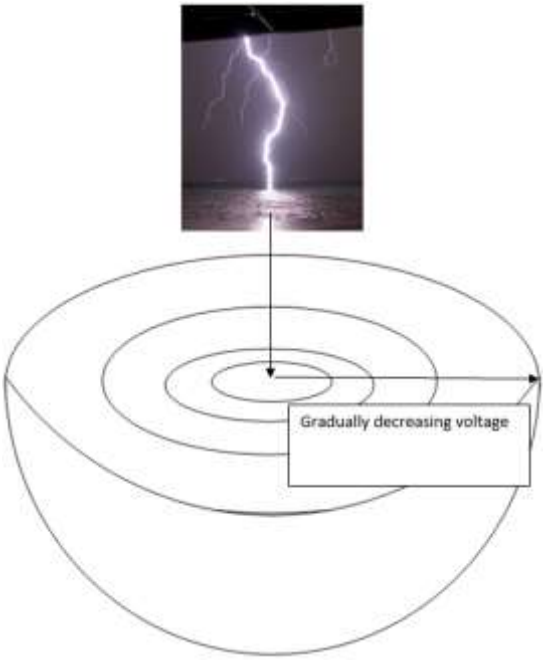

Figure 15. The ground current spreads out over a hemispherical region in the ground. The concetric circles are contours of equal voltages with decreasing voltages outward.

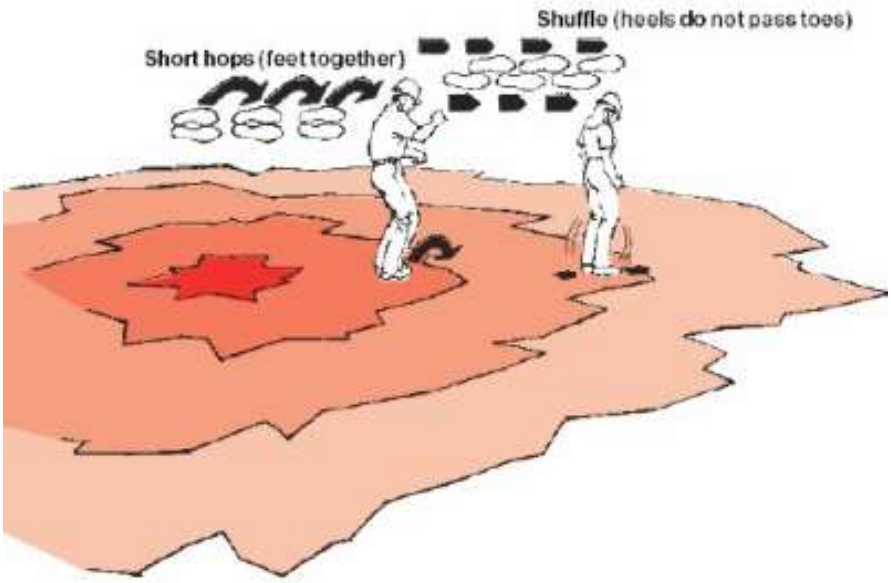

Figure 16. Outward short hops are suggested from the lightning-struck spot (https://wrwkwb.wordpress.com/2014/10/22/electrical-safety/).

For safety reason, short hops are suggested as shown in Figure 16 where the actual spreading of the voltage in non-circular contours is shown for the lack of homogeneity of the ground.

Safety in automobiles

Modern day cars cannot guarantee security because of having many electrical parts inside them. The issue of

Figure 17. Lightning upon a car (http://www.techeblog.com/index.php/tech-gadget/top-gear-what-happens-if-you-re-struck-by-lightning-while-in-a-car-).

safety in the car comes from the consideration that electric charges accumulate on the folding or raised parts on the outside of the body (Figure 17). Inside surface does not accumulate charge. Sitting on the rooftops of buses, launches, trains, etc., a scene that is observed in the Indian Subcontinent is risky. Passengers inside the car should keep the windows closed and should not touch any metal parts inside without knowing how that part connects outside. No inside wiring should be touched. During lighting, the car has to be parked. Touching of steering wheel, gear shift, radio, charger, navigating instrument, etc. is not allowed.

Standing

Standing is risky during lightning. The taller a subject, the more likely it is to be struck by lightning because of being a candidate for the upward rising positive charge front. Standing under a tree is risky, too, because the lightning flash can jump from the tree to the subject to reach the ground easily. To get rid of the ground current, both the feet should be touching each other without any gap just to minimize the voltage between the two feet (Figure 18).

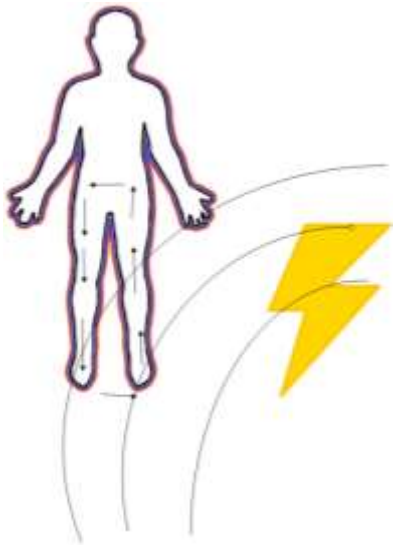

Figure 18. The more the separation between the two legs, the more the voltage difference between them, and the more current can flow in the path indicated by the arrows.

Sitting on the buttock

Height may be reduced to half, yet may be higher than many subjects in the surroundings. So, the danger of being a source upward moving positive charge still remains (Figure 19).

If the part between the knee and the ankle does not touch the ground, current can flow from the feet to the buttock. There could be three circuits in each leg: ankle to gastrocnemius muscle, gastrocnemius muscle to buttock, and ankle to buttock. If the ground is not even, there could be more risks.

Figure 19. Sitting on one's buttocks is not risk free. There are dips underneath the knees. Current paths are shown by arrows.

Figure 20. Lying down on the chect is dangerous. Ground could be uneven and there is a big dip below the abdomen. Lying down on the back is risky, too, because of the unevenness arpound the waist.

Someone may sit with folding legs at the knees and supported by the buttock. This is not a comfortable position at all. Unevenness of the ground adds more discomfort. Current could be passed from ankle to buttocks. Bulky people face more discomfort in this position.

Lying down

This is the position for the lowest height of our body. This posture of the body is comfortable and stable (Figure 20). However, the ground for instantaneous lying down may not be even, and the body may not touch the ground all through because of folds, dips, joints, etc. in the body. This situation may create a high voltage difference between the head and the feet causing a strong current flow.

Prostration in Islamic prayer

In Muslim prayer prostration, 7 limbs touch the ground. These are the two toes, the two knees, the two hands, and the forehead-nose (Figure 21). The three main circuits are on the left and right sides of the body – one between the left toes via left foot and left knee, one between the left knee via the left thigh, the left side middle body, left hand, and the left palm, and one between the left palm via the left hand, left neck side, and nose. Three similar circuits are created on the right side of the body. The distance between the toes and the knee is barely a knee size (35-40 cm) and the potential difference within a knee-size distance difference cannot be that large. In a Muslim prayer position, the distance between the knee and the palm becomes less than one-half of the knee-size. So, there will be even lesser current flow through the longest path from the knee through the thigh, the middle body part, and the hand. About the third circuit, it can be said that basically no current will flow from the palm to the nose because these two parts lie on the same potential line. These could develop a circuit from left knee to right palm across the body. This path is longer and so, involves more resistance than the path of the left knee to left palm, resulting in lesser current. The two knees being on the same equipotential line, no current is expected to flow from left knee to the right knee via the front genital part. Also, the two palms will pass through the same equipotential resulting in no current flow from left palm via the hand and shoulder to the right palm. The nose and the forehead that touch the ground remain so close that little current flow may be expected. The Muslim prayer position is a very stable and comfortable position for all ages, sexes, and body weights and sizes that can be used on any terrain of land. This position reduces our height to less than sitting height. This position offers shortened inter-limb distances which reduce interlimb voltages, and consequently, the current (Adel, 2012, 2013a).

Conclusion

Irrigation is planned. Lightning deaths are accidental. Although better data are the occurrences of lightning than

Figure 21. Muslim prayer position shortens the inter-limb distances and reduces the height offering the best protection from lightning. (Prostration picture taken from http://www.wikihow.com/Pray-in-Islam).

the fatalities, the correlation of lightning fatalities with the irrigation progression indicates the effect of irrigation upon thunder cloud formation. “The world has enough resources to meet everybody’s need but not to anyone’s greed”. Too much accumulation of water is not good for a country because weather and climate does not mold it to suit this change. Nature will have a repercussion effect. The formation of cumulonimbus clouds that causes lightning is that natural reaction following this anthropogenic change. In third world countries where people perform manual work outside in the field they become easy victims of lightning because of carrying metallic working tools. Also, they become easy victims for working near water bodies. Muslim prayer posture is found to be the most reliable position against lightning. All individuals who work in risky environments should practice lightning drill. For better results, ground study has to be incorporated with the satellite study of cloud formation and lightning and remote sensing study of in-land water coverage.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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REFERENCES

Adel MM (2012). Superiority of Prostration as a Protection from Lightning Strike. Phys. Int. 3(1):9-21.

Adel MM (2013a). Seiday Abasthan Bajraghat Theke Paritran (in Bengali) meaning prostration gives the safest shelter from lightning strikes. Published by Dibbo Prakash, Dhaka, Bangladesh)

Adel MM (2013b). *Jaladasyupana* (in Bengali) meaning water piracy. Published by Dibbo Prakash, Dhaka, Bangladesh.

Adel MM (2015). The Dam-Deluged Gasping Ganges Vol. 1, published by German Academic Publishing Company Lap Lambert.

Adel MM (2016). Inference and Implication from a lightning observation. Am. Res. J. Phys. 2:1-16.

Albrecht R, Goodman S, Buechler D, Blakeslee R, Christian H (2016). LIS 0.1 Degree Very High Resolution Gridded Lightning Climatology Data Collection. Data sets available online [https://ghrc.nsstc.nasa.gov/pub/lis/climatology/LIS/] from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/LIS/LIS/DATA306.

Astafurov VG, Kuriyanovich KV, Skorokhodov AV (2016). Methods for Automatic Cloud Classification from MODIS Data, Atmospheric and Oceanic Physics, Pleiades Publishing, Ltd. 52(9):1110-1119.

Blakeslee RJ (1996). Optical Transient Detector (OTD) Lightning. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/LIS/OTD/DATA101.

Blakeslee RJ (1998).Lightning Imaging Sensor (LIS). Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/LIS/LIS/DATA201.

Das SM, Kumar GM, Sampath S (2009). Investigations into

Mechanisms of Involvement of Objects and Personnel in Lightning Disasters. J. Lightning Res. 1:36-51.
de Bruin HAR (1978). A simple model for shallow lake evaporation. J. Appl. Meteorol. 17:1132-1134.
Henry JG, Heinke GW (1996). Environmental Science and Engineering, 2nd ed. , Prentice Hall, Upper Saddle New Jersey 07458. P. 233.
Holle RL (2008). Annual rates of lightning fatalities by country, paper presented at the 20th International Lightning Detection Conference, 24–25 April 2008, Tucson, Arizona.
Holle RL, López RE (2003). A comparison of current lightning death rates in the U.S. with other locations and times. Intl. Conf. on Lightning and Static Electricity, Blackpool, England, Royal Aeronautical Soc., paper 103-34 KMS, 7 p.
Radhakrishnan V (2015). Lightning killed more Indians than other natural disasters in 2014, July 27, 2015. *Hindustantimes.* Available from http://www.hindustantimes.com/india/lightning-killed-more-indians-than-other-natural-disasters-in-2014/story-wvBwFp1fRDNzOplFvvpGkM.html
Rahman MR, Saha SK (2008). Remote Sensing, Spatial Multi-Criteria Evaluation (SMCE) and Analytical Hierarchy Process (AHP) in Optimal Cropping Pattern Planning for a Flood Prone Area. J. Spat. Sci. 53(2):161-177.
Rahman MR, Saha SK (2009). Spatial Dynamics of Cropland and Cropping Pattern Change Analysis using LANDSAT TM and IRS P6 LISS III Satellite Images with GIS. Geo Spat. Inf. Sci. 12(2):123-134.
Rahman MR, Shi ZH, Chongfa C (2014). Assessing Regional Environmental Quality by Integrated use of Remote Sensing, GIS and Spatial Multi-Criteria Evaluation towards the Regionalization for Environmental Restoration. Environ. Monitor. Assess. 186(11):6993-7009.
Singh O, Singh J (2015). Lightning fatalities over India: 1979–2011. Meteorol. Appl. 22(4):770-778.
Volkova EV, Uspenskii AB (2007). Detection of Clouds and Identification of Their Parameters from the Satellite Data in the Daytime. Russ. Meteorol. Hydrol. 32(12):723-732.