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Lightning Environment in Burundi

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***Abstract*—This paper presents preliminary studies on the lightning accident details in Burundi, a landlocked country in East Africa. The reported lightning incident record in 2012 and 2013 depicts that there are 52 human deaths, 94 human survivals with injuries and 40 deaths of livestock. Makamba province recorded the highest human casualties with 14 deaths and 69 injuries whereas Nyanza-Lac commune of the same province topped the list with 8 deaths and 52 injuries. The statistics do not justify the 1:10 ratio of death : injury as it is reported in USA. The statistics may be a gross underestimation as many lightning accidents are not reported due to lack of communication, especially in the rural areas. Gomes-Kadir equation estimates the death rate as 52 per year, a figure twice as high as that was observed in this study. The analysis of information for incidents over few more years reveals that seeking shelter under ungrounded metal-roofed buildings is extremely dangerous as multiple deaths may occur in the event of a lightning strike to the roof.**

Keywords-Burundi, West Africa, lightning, deaths, injuries

I. INTRODUCTION

Burundi is a landlocked country in South East African which borders with Rwanda in the north, Tanzania in the east to south and the Democratic Republic of the Congo in the west. The country can also be categorized as a part of Central Africa due to its somewhat mid-continental location. The disadvantages of being in a landlocked country has somewhat eased by the fact that much of the southwestern border of the country is adjacent to Lake Tanganyika. The location of the country in Africa and its more detailed division of provinces are depicted in Figure-1.

Burundi lies on a rolling plateau named Albertine Rift, which is the western extension of the East African Rift. The average elevation of the central plateau is 1,707 m, with lower elevations at the borders. The source of the Nile River is in Bururi province, and is linked from Lake Victoria to its headwaters via the Ruvyironza River. The country has a land area of 27,830 km^2.

Burundi has a tropical highland climate, with a significantly large range of daily mean temperatures over the country, which may mainly be attributed to the variation of altitude. The elevated plateus of central region has average daily temperature of around 20° C whereas the high mountains may be as cool as 16 °C mean daily temperature. The landscapes along Lake Tanganyika records daily mean temperature around 23° C. Rain is irregular, falling most heavily in the northwest. The annual meteorological variation of the country can broadly be categorized into four seasons: the long dry season (June–August), the short wet season (September–November), the short dry season (December–January), and the long wet season (February–May). The country experience long draughts sporadically. The country receives on average an annual rainfall between 130 cm to 160 cm (Information issued by Institut Geographic Du Burundi).

As of 2012, Burundi recorded a population of 10,557,259 people, out of which 87% lives in rural areas. The literacy rate of the country was 67.2% in the same year [1].

Despite its relatively dry weather, Burundi has produced several cases of severe lightning accidents for the last few years. Among them, the worst is the death of seven high school students who were seeking shelter inside their class room which has been struck by lightning. However, due to the total lack of information on lightning statistics and also lightning safety environment in Burundi has prevented safety workers and scientific communities in formulating risk reduction modules for the country. This study is the first attempt of filling this gap of knowledge in the literature.

In the absence of a lightning detection system either in Burundi or in neighbouring countries, there are no data or information on the accurate figures of lightning density distribution statistics for the country.

II. METHODOLOGY

Data presented in this study has been collected through verious sources such as news items, informents that have contacted the Department of meteorology, personal communications and scientific /medical reports. All attempts are made to verify and reconfirm the authenticity of data. Most often cross information sources were used for reconfirmation of the data. The data given are pertinent to the year 2012.

In the absence of a lightning detection system either in Burundi or in neighbouring countries, there are no data or information on the accurate figures of lightning density distribution statistics for the country. Hence for the calculation done through Gomes-Kadir equation [2], a rough approximation of ground flash density (Ng) of 4 yr^{-1} has been used. This figure has been extracted from the lightning density maps provided by NASA [3]. The other lightning parameters

such as peak current, multiplicity, ration between positive and negative ground flashes etc. are not known for the region.

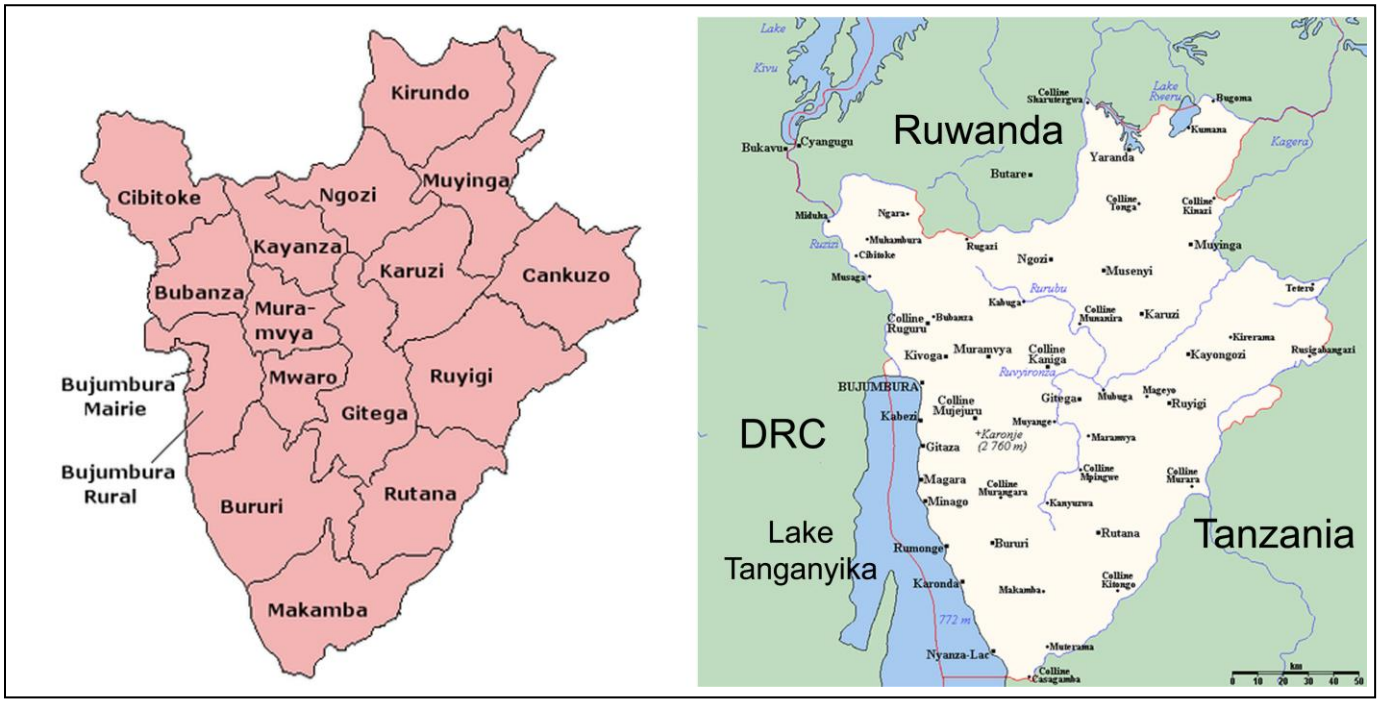

Figure-1: Burundi map: The provinces of the country (left) and its location in Africa (right)

III. Results and Discussion

The Table-1 depicts the no of human deaths, human survivals with injuries and death of livestock categorized under province and commune for the two years, 2013 and 2014. Each year 26 deaths have been reported whereas the survivals with injuries have a marked difference in the two years. Both overall figures and individual incidents clearly show that the human death, human injury and livestock losses are sporadic. There, seems almost no direct correlation between these parameters.

Except for two cases in 2012, there were no reports of extensive damage to properties, where the accidents have been taken place. One reason may be the fact that a significant number of reported cases are outdoor accidents. The other reason may be the tin-roofed (ungrounded) structures on brick walls where the accidents have been occurred. In such cases, the occupants may severely be affected due to side flashes and step potential hazards whereas the building may remain unaffected except for a small puncture in the roof in some cases.

The worst case was the death of 7 high school students when lightning struck their tin-roofed building while they were taking shelter in a classroom. The accident left 51 affected students who did not succumb to their injuries. The situation is very similar to the death of 18 school students and their teacher by a single lightning strike in Uganda in 2011 [4, 5].

There were many similar accidents, reported in Burundi during the last decade. In 2008, three people were killed and 22 injured when lightning struck a metal roofed church building in southwest Burundi. The incident was repeated in 2010, as four people including the preacher were killed by a lightning while a congregation was attending Sunday Mass in an Anglican Church in Buruhukiro area in the Southern Burundi. In this case too, the church was installed with ungrounded metal roofing.

The lightning accidents in ungrounded metal-roofed buildings continue even further. In 2011, 12 people, including 10 students, were killed when lightning struck a school building in Nyabikere, Central Burundi during a heavy storm. Around 50 other students sustained injuries after the lightning struck the school. The entire African continent is well known for the prevalence of such indoor accidents which usually causes multiple deaths and injuries [4-7]. This is an important aspects of the pattern of lightning injuries in Africa that should be taken into account in developing safety schemes.

The above statistics provide vital information on the risk of death and injuries in seeking shelter under ungrounded metal roofed structures in the presence of approaching thunderstorms. A comprehensive guideline and low-cost technique is urgently need in this part of the world to curb any further accidents of similar fashion, especially in areas of high exposure to lightning.

TABLE-1: Distribution of lightning victims over Burundi.

Province	Commune	No of Deaths	No of Injuries	No of Livestock Deaths
2012				
Kayanza	Matongo	1		
	Muruta	1		
Rutana	Rutana	1		13
Makamba	Kayogoro	1		
	Nyanza-Lac	3	5	
	Makamba		6	
Muramvya	Rutegama	1	2	
	Muramvya	1	1	
Cibitoke	Murwi	4		2
	Mugina			7
	Bukinanyana			2
	Rugombo			6
Bururi	Bururi	3		
	Rumonge	6		
	Buyengero	1		
	Mugamba	1		
Bubanza	Musigati	1		
	Bubanza		1	
Karuzi	Mutumba	1		
Total for 2012		26	15	30
2013				
Bururi	Songa	1		
Bubanza	Mpanda	1		
	Bubanza	2	4	
	Musigati			
Karuzi	Buhuga		1	8
	Shombo	1		
Makamba	Kibago	2		
	Kayogoro	3	3	
	Makamba		3	2
	Nyanza-Lac	8	52	
Cankuzo	Cendajuru	2	2	
Cibitoke	Bukinanyana	3	4	
	Murwi	3		
	Mugina		10	
Total for 2013		26	79	10
Total for the two years		**52**	**94**	**40**

The Table-1 shows that lightning deaths and injuries are spread over the country with Nyanza-Lac commune in Makamba province recording the highest number of deaths (10) during the two year period of data collection. Makamba province also tops the list of injuries which amounts to 69 cases (excluding those who succumbed to their injuries). The government and the province should pay their serious concern in drawing immediate action plan to curb this unacceptable level of lightning impacts on the public in the region.

The number of livestock losses may be a gross underestimation as many small-number of animal deaths are unreported. However, most often, in the rural areas of Burundi, the loss of livestock is an unbearable blow to the livelihood of the affected family. Hence action should be taken to provide awareness on low-cost protection for livestock industry in the country [8, 9].

The death rate in Burundi relative to the population is approximately 50 deaths per ten million per year (dptm yr^{-1}). Such value is extremely high compared to countries in Europe and North America and Australia [10-16]. The factor is even higher than neighboring countries such as Uganda and South Asian Lightning accident dominances such as Bangladesh and Sri Lanka [17]. One should also note that the above figure of 50 dptm yr^{-1} should be a significant under estimation as many deaths in far remote regions may not be recorded or reported.

The injury to death ratio in Burundi is 1.8. This figure is not very different from other countries in the region [4-6]. Such figures of even less than 2 is in total contrast to the same ration reported in developed countries. Reference [16] reported a figure of 10:1 mainly by considering the observations in USA and Europe. Most possibly this low number of injuries in developing countries may be the non-reporting of injuries to people who do not succumb to their injuries. This is particularly observed in rural Burundi where people without critical injuries seek indigenous medicine rather than acquiring hospital treatments.

To find the level of under/over estimation of lightning deaths in Burundi we apply Gomes-Kadir equation [2], which has been validated against data pertinent to USA and elsewhere [18, 19].

Gomes-Kadir equation, given below, is an empirical formula to estimate the annual lightning related deaths (σ) in a given country.

$$\sigma = 1.67 \times 10^{-5} \left(A\, N_g\right)^{0.6} DF$$

where Ng: Lightning flash density in $km^{-2}\, year^{-1}$

DF: Demographic factor in km^{-2}

A: Area of the region in km^2

DF = PD / UF

where PD is the population density given in km^{-2} and UF is the urban factor given as a fraction.

UF = Urban Population / Total Population

For Burundi;

UF = 0.13 (WUP, 2012)

DF = 380 / 0. 13

= 2923

A = 2.78×10^4 km^{-2}

Ng = 4 yr^{-1} (NASA, 2004)

$$\sigma = 1.67 \times 10^{-5} \left(A\, N_g\right)^{0.6} DF$$

σ = 52 deaths per year

This figure is exactly 200% of the reported number of deaths per year. Such outcome clearly justify the fact that much information on lightning related deaths and injuries in the country may not be channeled into the city limits thus they go unreported and un recorded.

IV. CONCLUSIONS

In this study we analyzed lightning accident details in Burundi, a country in East Africa, well known for sever lightning impacts on her population. The reported lightning incidents in 2012 and 2013 show that there are 52 human deaths, 94 human survivals with injuries and 40 deaths of livestock. One particular province, Makamba, recorded the highest number of human casualties with 14 deaths and 69 injuries whereas Nyanza-Lac commune of the same province topped the list with 8 deaths and 52 injuries. The statistics do not agree with the 1:10 ratio of death:injury as it is reported in USA. This may be due to the non-reporting of many cases of non-critical injuries.

The statistics may be a gross underestimation as many lightning accidents are not reported due to lack of communication, especially in the rural areas. Gomes-Kadir equation estimates the death rate as 52 per year, a figure twice as high as that was observed in this study. The analysis of information for incidents over few more years reveals that seeking shelter under ungrounded metal-roofed buildings is extremely dangerous as multiple deaths may occur in the event of a lightning strike to the roof.

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