# African Centres for Lightning and Electromagnetics Network (ACLENet)

## Progress Report

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***Abstract*—ACLENet (https://ACLENet.org) is a pan-African network of centres dedicated to decreasing deaths, injuries and property damage from lightning.**

**Lightning is more common in tropical and subtropical climates and 90% of sub-Saharan buildings are not 'lightning safe', leaving families at risk 24/7. Lightning damage to infrastructure such as utilities, aviation, mining, banking and small businesses hampers development of already economically challenged African countries.**

**ACLENet works at all levels of education to promote lightning safety and injury prevention, improved forecasting, and adoption of internationally recognized lightning protection codes (IEC62305-1,2,3,4) by governments. ACLENet actively promotes improved undergraduate, graduate and ongoing professional training of engineers with respect to lightning impacts, working in partnership with national universities, professional organizations and standards setting groups, as well as writing proposals for grants to support training, research, and disaster management.**

**ACLENet welcomes volunteers, advisors, partners, and donors who want to be part of decreasing deaths, injuries, property damage from lightning (https://ACLENet.org/how-to-help/overview.html).**

***Keywords-Lightning injury, lightning injury prevention, lightning risk assessment, electromagnetic compatibility, lightning protection, property damage from lightning, education, lightning in Africa***

## I. INTRODUCTION AND ORIENTATION TO AFRICA

Most ICLP attendees live in developed countries. Unless they have spent significant time working or traveling in developing countries, especially in the urban fringes and non-urban areas, they will have little understanding of the risk of lightning injury faced, often 24/7, by those who live in developing countries. Table I notes factors that have been identified as affecting risk of death from lightning. [1-3]

Lightning density is higher in tropical and subtropical climates which increases the risk to those who are outside safe areas [4]. Table II shows the rural population of several African countries as reported in lightning papers for those countries. The majority of sub-Saharans live in rural areas (65%) as opposed to Europe, where 74% of European Union citizens live in urban areas, and the United States, where over 81% are city dwellers. [5,6]

TABLE I. FACTORS THAT AFFECT THE RISK OF LIGHTNNG INJURY AND DEATH

| **Factors that INCREASE Risk** | **Factors that DECREASE Risk** |
|---|---|
| High lightning density | Low lightning density |
| Large rural population | Urbanization with high quality building construction |
| Labor intensive work such as farming, fishing and animal husbandry | Mechanized farming and stricter laws governing work conditions |
| Lack of lightning safe areas for easy evacuation; lack of proven individual actions that individuals can take to decrease risk | Easy availability of lightning safe buildings and vehicles within easy reach |
| Lack of reliable and timely weather forecasts or forecasts that are only available to specific sectors (primarily aviation) of the economy | Weather forecasting system with high quality forecasts available to the public on a free and real time basis |
| No or little lightning detection data or non-availability to the public | High quality lightning detection data incorporated into forecasts |
| Delayed or nonexistent access to high quality medical care. | Easy access to high quality medical care |
| Low literacy rate | High literacy rate |
| Little or no valid public education on lightning safety; strongly held beliefs that injuries are inevitable, regardless of personal behavior, that lightning is called down by witches and other cultural reliance on myths | An active media; news reports of injuries; enthusiastic public education with access to lightning safety information |

TABLE II. URBAN VS RURAL POPULATION

| Country | % Rural Population | Reference |
|---|---|---|
| Burundi | 91 | 7 |
| Malawi | 85 | 8 |
| Swaziland | 69 | 9 |
| Uganda | 69 | 10 |

Even Africans who have moved to urban areas looking for emplyment are often no safer than they were in their rural dwellings. As well said in Elsom's paper [2]:

> 'The transformation of traditional labour-intensive agriculture to a modern mechanised industry and a shift of previously-employed agricultural labourers to employment in construction, energy, industrial, manufacturing and service industries in urban areas, where many buildings offer safety from lightning, will take considerable investment which is not available given the relatively limited national income of many developing countries. Moreover, some urban residents have little or no choice but to live initially in *informal settlements (shanty towns) located at the periphery of cities. They are characterised by poor quality improvised dwellings, often made of corrugated tin and plywood, and lack electricity, water and sewerage systems and so offer no better protection from lightning for their occupants than the rural dwellings they left.(Fig 1b; italics added by current author)* Increasing employment opportunities for such residents will eventually enable better quality homes to be built or acquired but this may take many years and slow down the effects of other factors in decreasing lightning fatality rates.'

In reality, about 90% of sub-Saharan buildings are not 'lightning safe', leaving families at risk 24/7, regardless of their activities (Figs. 1a, 1b, 2). The vast majority of homes, even if they have electricity, are unlikely to have metal structural components or in-wall plumbing or wiring to provide safety. In many countries in Africa, electricity and internet services are intermittent and unreliable, band width low, and communication services of any kind expensive.

While each of the 55 countries in Africa has varying levels of development, education, and combinations of risks, the fact remains that the majority of sub-Saharan Africans live every day with nearly every factor listed in the left column of Table I. Farmers, fisherfolk, herders, those walking to market, chruch attendees, and school students are among those at risk [7-15].

## II. THE BEGINNINGS OF ACLENET

At a 2011 NAM S&T conference in Kathmandu, Richard Tushemereirwe, Senior Science Adviser to the President of Uganda, found that over 75 of his fellow Ugandans had been killed by lightning during the past few months. He returned to Uganda determined to do something about it. With the help of


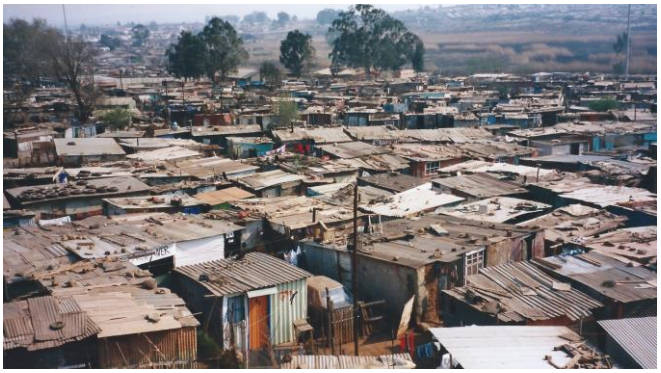

Fig. 1. Typical African dwellings and work areas, particularly in rural areas. Fig. 1a. Mudbrick with generations-old thatch roofs or sheet metal held down by rocks. In some areas, chicken wire may be cast over the thatch to prevent monkeys and baboons from disrupting the roof. In others, car tires may be placed on the roof because it is thought that their 'rubber' will protect the building from lightning. Fig. 1b Soweto shantytown. Soweto is a million-plus populated South West Township near Johannesburg and the birthplace of Nelson Mandela. (courtesy Derek Elsom)

those he had met in Nepal, he organized another NAM S&T lightning meeting in Uganda in 2013, where participants resolved that Africa should have a multi-faceted organization to address lightning injuries, deaths and property damage. The African Centres for Lightning and Electromagnetics Network (Table III) was founded in 2014.

## III. MISSION AND MULTI-FACETED OBJECTIVES

ACLENet is a pan-African Network of Centres dedicated to decreasing deaths, injuries, and property damage from lightning across Africa. There are at least hundreds of deaths and thousands of injuries every year from lightning in Africa. Lightning also causes property damage to utilities, aviation, mining, and other business infrastructure that threatens already economically challenged countries (Table IV).

## IV. PROGRAMS AND ACTIVITIES

### *A. Gathering Baseline Data - Availability and Sources*

To influence change-makers such as governments, funding agencies, and donors to do something about lightning deaths,

TABLE III. HISTORY OF ACLENet

| Year | Event |
|---|---|
| 2011 | Kathmandu, Nepal, NAM S&T – Kathmandu Resolution. |
| 2013 | Kampala, Uganda, NAM S&T meeting - Resolution to Establish African Center for Lightning Information and Research (name changed to African Centres for Lightning and Electromagnetics).<br><br>Makerere University offers to host ACLE headquarters. |
| 2014 | First Scientific Symposium, Entebbe, Uganda. |
| 2015 | First national centre, ACLE-Zambia, formed.<br><br>ACLE changed to ACLENet as the international parent organization, reserving ACLE-country/region for national or regional organizations.<br><br>Second ACLENet Scientific Symposium held in Lusaka, Zambia, August 2015. |
| 2016 | Award of United Nations Global Resilience Partnership grant for $1,000,000 in partnership with four other organizations to bring Severe Weather Early Warnings to those living around Lake Victoria.<br><br>Incorporated in Uganda and in the United States with US tax-exempt status granted.<br><br>First schools installed with lightning protection (DEHN). |
| 2017 | ACLENet staff trained by DEHN to do installations.<br><br>Uganda Ministry of Education and Sports requests assistance on design of lightning protection for new schools.<br><br>Gold GuideStar level awarded for transparency. |
| 2018 | University of Zambia announces and begins recruiting students for new graduate program in electrical engineering, high voltage and electromagnetic compatibility.<br><br>Monthly newsletter begun to collect and communicate English news reports of lightning injuries across Africa.<br><br>Website (https://ACLEnet.org) translated for common non-English languages. |

TABLE IV. ACLENet's MULTI-FACETED GOALS

| |
|---|
| To assess the impact of lightning on each nation's citizens and economy. |
| To work with governments to assure that code-compliant lightning protection systems are designed for new schools and other important buildings. |
| To improve the availability of accurate and timely lightning data, weather forecasting, and warnings. |
| To educate teachers, parents, pupils and the public on lightning safety. |
| To improve engineering training and professional qualifications in lightning protection. |
| To advise on code-compliant lightning protection of utilities and other economically important industries. |
| To work with universities to train Africa's own lightning experts for the future. |

injuries and property damage requires that they must first be aware of the problem - and that takes data.

Before the development of the internet, lightning injury data in the United States (Storm Data) and other developed countries depended largely on newspaper clipping services, with 20-70% of injuries and deaths being unreported [15-18]. With the development and constant growth of the internet along with the nearly universal use of mobile communication devices, lightning incidents involving deaths or multiple injuries have become available on-line within hours of their occurrence and it unusual for any to escape media awareness, at least in the United States [15,19]. While it is easy to set up daily internet searches to collect these reports, 95% of citations are about sports teams, commercial products, and other non-casualty uses of the word 'lightning' so that the daily lists must be visually scanned, culled and individually opened to see where they occurred. Unfortunately, using terms like 'lightning injury' to narrow the focus eliminates too many reports since the word 'injury' is seldom used by reporters or in titles.

However, in developing countries, news reports may be written days after an incident, often by journalists who have no first-hand knowledge of the incidents. Reports involving multiple casualty incidents, children or curiosities like animal deaths seem more likely to be reported than single deaths and injuries. Despite these problems, internet news reports of lightning injury remain one of the best sources of data for developing countries and certainly across Africa where ACLENet operates. These reports can be useful in raising awareness with governments, granting agencies, donors and in

newsletters (https://aclenet.org/news-publications/country-news/).

ACLENet hopes to develop a mobile app so that citizens can report incidents, as well as potentially check forecasts or find other useful information (https://aclenet.org/how-to-help/report-an-incident.html). Reports such as these will allow ACLENet staff to investigate incidents when time, funds, and travel conditions allow (https://aclenet.org/how-to-help/lightning-srike-at-kifumura-primary-school-in-hoima.html).

### *B. National Centre Development*

ACLE-Zambia – This is the first national centre outside Uganda and was launched in August 2015 at ACLENet's 2nd Scientific Symposium in Lusaka, Zambia. ACLE-Z's coordinator, Mrs. Foster Chileshe Lubasi, trained as an electronics engineer, has technical experience hardening electronics from lightning damage. We are happy to announce that through her efforts and those of Chandima Gomes, the University of Zambia (UnZa) has approved and begun advertising for students in a new graduate program on high voltage engineering and electromagnetic compatibility. ACLE-Z's leadership team has been consulting with key stakeholders on lightning protection.

ACLE-Malawi, at the Malawi University of Science and Technology has committed to organizing and hosting ACLENet's Third Scientific Symposium in October 2018 where ACLENet's newest national centre will be launched. Research is underway on lightning casualty studies within Malawi [14].

Other countries, including Kenya, Rwanda, and South Africa have expressed interest in forming national centres. The differing talents, challenges. resources, opportunities, and priorities in each country add to the depth and diversity of the network.

### *C. School Protection Program*

When lightning hit a school in Zimbabwe on January 25, 2018, two students were killed, 26 admitted to the hospital and 57 others treated and discharged. The next day, only six students came to school [https://www.herald.co.zw/lightning-kills-2-pupils-injures-85/].

Frightened children, who have seen their friends die, and wary parents may avoid an impacted school for days, weeks, or even permanently abandon it after a lightning incident.

Village schools in Uganda, where the school protection program started, are usually a collection of five to 20 individual small buildings with two to four classrooms connected in a row, eating halls, an administration building, and sometimes dormitories, with some buildings connected with breezeways (Fig. 2). This arrangement adds to the complexity of planning lightning protection and to the cost of materials and installation. Protecting only a few buildings which all students could reach for an evacuation would

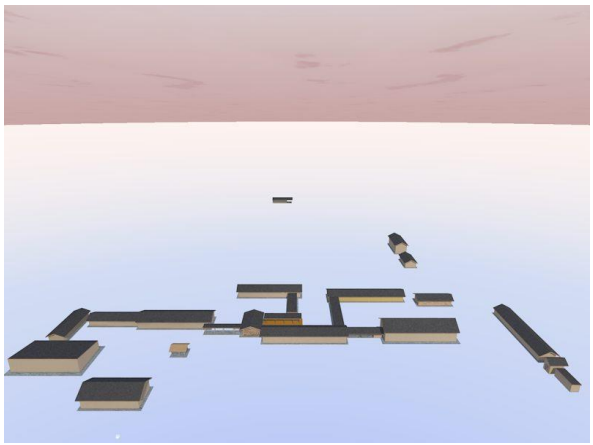

Fig. 2. Diagram of a larger rural school in Uganda.

decrease cost but is undesirable because it would put the children at risk during the transfer across open areas between the buildings, frighten them and interrupt their studies for perhaps hours. No one learns well when they are frightened or anxious. ACLENet's goal with LP is to give the children a feeling of safety and relieve them and their parents of worry about this common tragedy (Fig. 3).

Due to the high incidence of deaths and injuries at schools, ACLENet challenged the international lightning community to protect school children at ICLP-2014 in Shanghai. The German-based lightning protection company DEHN, along with DEHN-Africa, stepped forward, providing the designs and materials to protect four schools plus giving training programs in lightning protection and material use for installations.

The first school protected was Runyanya School, in central Uganda, where 18 children were killed and 38 others hospitalized from one strike (https://aclenet.org/news-publications/country-news/uganda-injuries/uganda-2011.html and http://www.telegraph.co.uk/news/weather/8606238/Lightning-strike-kills-18-children-in-Uganda.html) in 2011 (Fig 4). Another strike less than a decade earlier had injured others and the building where these incidents occurred had been abandoned as a 'death trap.'


Fig. 3. Thank-you picture from one of the schools protected by ACLENet and DEHN-Africa.

Fig. 4. Upper photo: Classroom building at Runyanya School. Lower photo: Closeup showing IEC compliant rod and old multipronged rod commonly found on many Uganda schools that ACLENet staff have visited and measured.

ACLENet has become recognized throughout Uganda for their work protecting schools. The Ugandan Ministry of Education and Sports (MoES) requested training for their engineers and installers and for consultation on LP designs for 184 new schools they plan to build this year with funding from the World Bank. Several nonprofits (NGO's) have contacted ACLENet for advice and assistance on lightning protection for the schools they support.

### *D. Focused Public Education*

Each time a school is protected, an educational program is given to parents, teachers, school officials and other local leaders. On November 27, 2017, an expanded program was given as a pilot to 50 parents, teachers, district education officers, farmers and other opinion leaders at Shone School in Uganda's Hoima District. Lectures incorporating animations and other materials from NOAA's lightning safety site (https://www.weather.gov/safety/lightning-safety#) included how lightning forms, mechanisms of injury, discussion of some non-threatening myths and Q&A session [report available at https://aclenet.org/programs/education/countering-myths.html]. Questions helped speakers learn the attendees' greatest concerns and give them a chance to respectfully address long held myths. It also catalyzed research questions on individual actions that might be taken to mitigate or reduce lightning injury (See section IV-E)

Other lessons learned from this pilot program will be incorporated into a second, larger conference planned for Runyanya School, where district officials have donated the 'death trap' building to ACLENet to rehab and use as a science and weather teaching center. Not only will local people and officials be invited, but also central Uganda officials from MoES, the Uganda National Council on Science and Technology (UNCST), Uganda National Meteorological Authority (UNMA), and other appropriate ministries and organizations. In addition to the lightning lectures, a seminar on the basics of lightning protection and a walk-around are planned to point out IEC62305-compliant LP versus the locally available 'lightning arrestor' that had been installed (Fig. 4).

### *E. Graduate Training*

With some notable exceptions, many colleges and universities were established in Africa to serve the people, similar to the land-grant universities established in the United States in the mid-1800's, concentrating on engineering, agriculture and other needed areas. Few have developed graduate programs.

In 2016, Chandima Gomes visited the University of Zambia. Together with the ACLE-Z National Coordinator Foster Chileshe Lubasi, he worked with university officials and visited multiple stakeholder sites and installations throughout Zambia. As the result of their work, the University of Zambia has instituted and begun advertising graduate studies in electrical engineering, high voltage and electromagnetic compatibility. ACLENet hopes to encourage graduate training at other National Centres, most of which are affiliated with universities.

### *F. Research*

Because the lightning injury risk is so different in Africa from what most people experience in developed nations, many basic questions are amenable to research. Since the vast majority of Africans have NO 'lightning safe' areas to reach when thunderstorms are present, ACLENet is searching for what to tell people so that they can take actions to avoid injury. 'When Thunder Roars, Go Indoors,' the well- known lightning safety motto in developed countries, is the wrong advice to give when people live in flammable homes with no metal materials in the walls to channel lightning to ground more safely (Figs. 1 and 5).

It is known that 50-60% of lightning deaths are from ground current in developed countries [20]. It is suspected that ground current accounts for *at least* 50% of deaths in Africa. When some at the pilot educational seminar asked whether wearing flip-flops, shoes, or sleeping on pads or beds elevated above the floor would help, ACLENet did not have the evidence to support this. While these actions would not be recommended in developed countries because of the ubiquity of safer areas, they may well decrease the deaths and injuries for at least a percentage of the population – but these need to be tested and validated before recommending them. The Ground Current Mitigation Initiative was begun in February 2018 and will have a special meeting at ICLP2018 to discuss

Fig. 5. Another typical dwelling is the rondavel. Lightning injury commonly causes keraunoparalysis which would prevent occupants from evacuating when lightning ignited the thatch roof. Death could have been caused by either the lightning or from burns as the burning thatch fell on them.

research into these questions. ACLENet is collaborating on research projects on injury demographics, areas of large lightning frequency, and other areas of concern in Africa.

A useful addition is the recent publication of *Reducing Lightning Injuries Worldwide*, a resource book for students and others who wish to do research on lightning injury [21].

### *G. International Affiliates*

The International Affiliate is a new program being piloted in Australia by Christopher J. Andrews, one of ACLENet's Research Advisers (https://aclenet.org/about-aclenet/research-advisors.html). International Affiliates are to be recognized persons of standing in lightning research, science or protection and sympathetic to the ideals of ACLENet. It is anticipated that appointment as an International Affiliate will be highly regarded and provide an opportunity for an active contribution to international humanitarian projects. The roles and responsibilities of an International Affiliate are listed in Table V.

TABLE V. THE ROLE OF THE INTERNATIONAL AFFILIATE

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|---|
| To take responsibility in their own country for setting up a structure which allows tax deductible status for donations and to forward those donations to the United States parent body or designated national centre in a secure and accountable way. |
| To seek out and canvass donors for the purposes of ACLENet. . |
| To receive progress reports on the projects of ACLENet and ensure they are circulated to donors in their own country. |
| To maintain goodwill with the donors responding to their approach. . |
| To be available to ACLENet's directors and staff to provide opinion, advice, and input to planning, as may be requested. |

TABLE VI. PROGRAMS FOR FURTHER DEVELOPMENT IN 2018-2019

| |
|---|
| Improve and widen focused public education, develop materials for teachers and increase work with the media. |
| Improve investigation and documentation of lightning injuries, deaths and property throughout Africa. |
| Mentor National Centres in Kenya, Rwanda, South Africa and other countries. Continue to support current National Centres in Zambia and Malawi. |
| Network and mentor those interested in lightning safety and research. |
| Assist the University of Zambia in implementing the approved postgraduate training in high voltage engineering and electromagnetic compatibility. |
| Protect more schools with code complaint lightning protection. Work with other NGOs and governments to improve the quality of lightning protection design and installation. |
| Explore the feasibility of a mobile application for reporting lightning incidents and delivering forecasts to the public. |

## V. PROGRAMS FOR 2018-19

Congruent with the goals stated in Table IV, ACLENet intends to focus on expansion of current activities in 2018-2019. (Table VI)

## VI. CONCLUSIONS

There is much to be done in Africa to save lives, prevent property damage from lightning and to help raise the economic and educational level of its citizens. Many across the world have stepped forward to help. ACLENet welcomes volunteers, advisors, partners, and donors who want to be part of decreasing deaths, injuries, property damage from lightning (https://ACLENet.org/how-to-help/overview.html).


## ACKNOWLEDGMENT

ACLENet wishes to thank the many people from around the world who have volunteered their time, given of their expertise, their hearts, and their money to encourage and guide ACLENet's efforts. ACLENet gives special thanks to DEHN-Africa for piloting the school protection program and to ACLENet's Research Advisers involved in the Ground Current Mitigation Initiative.


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