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The Most Effective Methods for Delivering Severe Weather Early Warnings to Fishermen on Lake Victoria

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***Abstract*— Introduction: It is estimated that five thousand people die on Lake Victoria every year by drowning, mainly due to severe weather hazards. The northern part of Lake Victoria experiences one of the highest numbers of thunderstorm days and lightning strikes in the world. The unpredictable and severe weather conditions, as well as the socio-economic dimensions resulting from loss of life, affect the people's abilities to deal with poverty, disease, gender-based marginalization, and violence.**

Objectives: Ultimately, our goal is to save lives of fishermen and others who use Lake Victoria for their living by delivering timely and effective Severe Weather Early Warnings (SWEW) via smart phones to those at risk. There have been several attempts to deliver severe weather alerts to fishermen in the past, the last one being the Mobile Weather Alerts (MWA) supported by the World Meteorological Organization (WMO). Previous SWEW trials died with the end of the grants so developing a sustainable business model is essential to the ongoing success of any program. It is also necessary to determine what improvements are desired by the service population in order to make the system most effective.

Methods: An assessment was conducted between March and May 2015. A convenience sample of respondents was gathered and interviewed during impromptu visits to landing sites on Lake Victoria where community members had participated in an earlier pilot of MWA by the WMO. The questionnaire was digitized using Open Data Kit (ODK) software for convenience and timeliness. Questions were administered to fishermen and others who work around the Lake to gather both individual and community views. Their ideas for better design, implementation of SWEW and use of smart phones, as well as their ability and willingness to pay for such a service, were gathered. Results were reported to a central server and frequencies summarized by trained personnel.

Results: Two hundred fifteen respondents from fourteen landing sites (communities) on the Islands of Bubeke, Bukasa, Kachanga, Misozi, and Bulaga were interviewed. Respondents noted that the major cause of death on Lake Victoria is drowning. Over 50% of the respondents (113/215) were aware of at least one community member who had been injured due to lightning on the Lake in the past year.

Ninety two percent (198/215) of the respondents reported using mobile phones as their main tool of communication but only 4% had smart phones that could receive Early Warning Alerts through internet connectivity. Seventy-five percent of respondents said they would welcome a system that could deliver commercial weather alerts, while 65% were willing to pay for such a service.

Conclusions: A Severe Weather Early Warning System is feasible in this community but must be accompanied with public education on risk, a message system that fits the basic phone functionality, and a system that the majority will be willing to pay for on a continuing basis to help ensure a sustainable Early Warning System in this community.

Keywords—Early warning system, severe weather, Lake Victoria, fishermen, injury prevention, lightning safety, lightning injury prevention

I. INTRODUCTION

According to the recent study, an estimated 5,000 people per year die from severe weather on Lake Victoria [Mary and Gomes, 2014]. Fishermen are at special risk, not only from high winds, waves and lightning but from poorly maintained boats, lack of life saving equipment and navigational aids. In addition, gale size winds can move inland rapidly to destroy vegetation, property and human settlements including schools and health centers (Badjecka, 2010).

The loss of life impacts more than fishermen by affecting their families and communities both economically and socially. Persons who feel they have little control over their lives may become resigned to their fate. They may be less likely to listen to warnings of other risks such as HIV and more likely to choose life's pleasures rather than pursue education for their children and other self-improvement activities that require time, energy, money, and sufficient hope that delayed gratification becomes a viable behavior. The communities surrounding Lake Victoria are among those with the highest levels of HIV infection, poverty, disease, gender-based marginalization, lack of education, and violence [Asiki, 2011].

By providing weather information and warnings to fishermen, they are able to make informed decisions about when and where to fish, whether to go out onto the Lake or seek shelter in safe areas. This not only helps save many lives, but also enhances the livelihoods of the communities around the Lake, as many fishermen are the sole providers for large families.

In order to decrease the loss of lives, we propose to design a Severe Weather Early Warning System (SWEWS) utilizing lightning detection and other weather data in cooperation with the Uganda National Meteorological Administration, Earth Networks, and other agencies to deliver SWEWs by smart phone technology to fishermen and others who work around the Lake. Previous SWEWS have been piloted in this area by the World Meteorological Organization (WMO) and Grameen Foundation in 2011-2012 but tended to fail when grant funds and personnel left. Most of these projects are no longer operating for a number of reasons, including problems with delivery to the end users, timeliness of information, and lack of sustainability. Other projects utilizing different segments of this idea have been implemented in the region including one for farmers to search for advice on managing crops and livestock [Angelica and Richard, 2010], for weather data and market prices for fishermen [Byarugaba, 2014].

In summary, we propose a SWEWS with accurate and timely weather reports delivered to cell phones in languages appropriate to the user. Many components are involved:

- Accurate weather data collection
- Skilled interpretation to provide reliable forecasts and timely warning
- Delivery of warnings in a timely and effective manner to the end-user
- Education on how to interpret the information delivered
- Implementation of other income producing activities for fishermen when they choose not to go on the Lake to prevent being forced to choose between income and survival
- Assurance that the SWEWS is economically sustainable

Before any of these can be effective, it is essential to determine what the end-users, the fishermen and those living around the Lake, see as important to its effectiveness as well as whether an adequate number are willing to support the system with subscriptions once it is implemented.

II. METHODOLOGY

This study focused on the fishing community of Lake Victoria in Kalangala District, a major group at risk from severe weather. Kalangala District is located on the northern shore of Bugala Island, the largest of the Ssese Islands in Lake Victoria.(Fig.1) Kalangala is approximately 60 kilometers across water, southwest of Entebbe the largest and nearest mainland town. In 2011, the Uganda Bureau of Statistics (UBOS) estimated the mid-year population at 5,200. People settle mostly in villages made of temporary structures with each village having approximately 200 households. The principal economic activity on the Island is fishing. Nile Perch is the species primarily fished with most of the catch processed on the mainland for export. Other economic activities include agriculture, crop and animal husbandry, logging and tourism.

Twenty four villages spread across five islands of Bubeke, Bukasa, Kachanga, Misozi and Bulagain Kalangala District provided a convenience sample gathered during impromptu visits to interview those found on site. Respondents were sampled from those 1000 participants who had participated in the earlier pilot of Mobile Weather Alerts supported by World Meteorological Organization that ended in early 2011. They

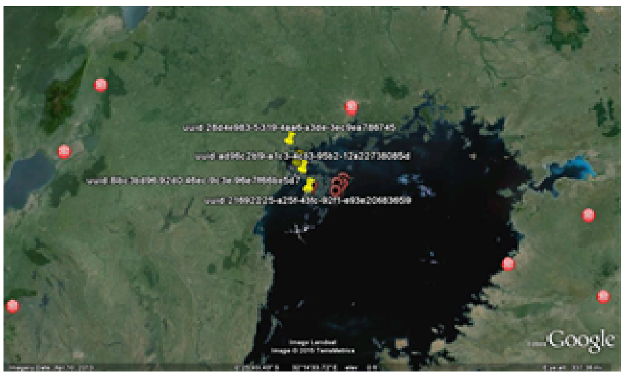

Fig. 1. Lake Victoria from Google Maps showing sampled areas in yellow and red marks.

were specifically solicited, when possible, because their experiences were felt to be valuable in planning an improved approach and in enhancing use by the target population.

The information collected was aimed at determining the elements of a people-centered EWS, i.e.

- risk knowledge
- monitoring and warning service
- dissemination and communication
- response capability

Written informed consent was sought from each individual before the questionnaire was administered. Because this assessment was part of a follow up of the work done by the World Meteorological Organization to inform adjustments in the intervention, approval was sought from the Uganda National Meteorological Authority. The assessment was conducted under supervision of Makerere University School of Public Health

Respondents were assessed for socio-demographic characteristics, experience with the Mobile Weather Alert pilot, extent of use of the mobile phone as an information source, knowledge and perceptions about lightning and severe weather, and the features they desired to be part of a mobile weather alert system. Quantitative data was collected using a pretested semi-structured questionnaire which was developed based on the information gathered from previous pilots and included questions on personal history, exposure to the Lake, perceptions about Severe Weather and Early Warning Systems, and their willingness and ability to pay for such a system.

The questionnaire was administered to the adults with the aid of a local language (Luganda) translator by trained research assistants utilizing iPads/tablet computers for data entry. Data was summarized using Microsoft Excel spreadsheets to obtain frequencies in each category of questions and data was presented by appropriate tables, figures and text.

III. Results

A total of two hundred fifteen respondents from twenty five landing site communities and five islands were interviewed as summarized in Table 1. The table also highlights their socio-demographic characteristics. Most of the respondents were men (84%) and most were from Bulaga village. Over a half (52%) had attained primary education and 48% reported that their main occupation was fishing in the Lake.

A. Community exposure to the Lake

In the study population, 27.9% (60/ 215) of the respondents reported that they owned their own boats. Boats were nearly equally split between those with motors versus those without (48.1 vs 51.9%). Over half of the respondents reported that they traveled by boat on Lake Victoria on a daily basis (Fig. 2).

TABLE 1 - DEMOGRAPHICS OF STUDY POPULATION

VARIABLE	N=215	(%)
Island Villages		
Bubeke	25	11.6
Bukasa	66	30.7
Misozi	22	10.2
Kachanga	2	0.9
Bulaga	100	46.5
Sex		
Male	180	83.7
Female	35	16.3
State of occupancy		
Natives	158	73.5
Migrants	57	26.5
Age (Years)		
<20	10	4.7
21- 30	68	31.6
31 – 40	58	27.0
41- 50	48	22.3
>50	28	13.0
No response	3	1.4
Highest education level		
None	4	1.9
Primary	111	51.6
Secondary	91	42.3
Post-secondary	9	4.2
Occupation		
Fisherman on the lake	104	48.4
Does not fish in the lake	111	51.6
Marital status		
Married	106	49.3
Single	53	24.7
Separated	25	11.6
Widowed	20	9.3
No response	11	5.1
Average Daily Income (USD)		
<2.0	83	38.6
2.0 – 6.0	35	16.3
6.1 – 10.0	5	2.3
>10.0	13	6.0
No response	79	36.7

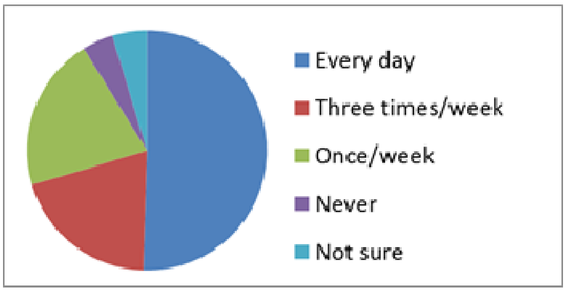

Fig. 2. Frequency of travel by boat on the Lake.

TABLE 2 - PERCEPTIONS OF THE COMMUNITY IN RELATION TO SEVERE WEATHER

VARIABLE	N = 215	%
Time traveled on boat		
Day time	93	43.2
Night time	32	14.9
All time of the day	58	27.0
No response	32	14.9
Weather related hazards known to the respondents		
High wind	90	41.9
High waves	93	43.3
Lightning	14	6.5
Thunderstorms	5	2.3
Others	13	6.0
Mentioned causes of lightning		
Scientific cause	155	72.1
Non-scientific cause	26	12.1
Do not know	34	15.8
How often does lightning occur?		
Everyday	52	24.2
Every week	37	17.2
Every month	28	13.0
Every three months	33	15.3
>than three months	62	28.8
No response	3	1.4
In which months does lightning occur?		
December-February	10	4.7
March-May	96	44.6
June-August	66	30.7
September-November	25	11.6
No response	18	8.4

When asked about community perception of severe weather, the majority of respondents (91.7%) cited a combination of different hazards, mainly high winds and thunderstorms. The same group noted that high winds come with high waves, while thunderstorms come with lightning, making it difficult to quantify each of these hazards separately (Table 2). Lightning injury alone was cited by only 6.5% as a major hazard. However, up to 54% of respondents could recall lightning strikes on a regular basis (24% everyday; 17% every week; and 13% every month).

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TABLE 3 - KNOWLEDGE ABOUT INJURIES AND FATALITIES FROM LIGHTNING ON THE LAKE

VARIABLE	N =	%
Awareness about community members who have been injured in the past year	**N = 113**	
Knows about 1 incident	20	**17.7**
Knows about 2 incidents	46	40.7
Knows about 3 incidents	14	12.4
Knows about 4 incidents	8	7.1
Knows about 5 or more incidents	25	22.1
Awareness about community members who have died on the lake due to lightning in the past year	**N = 70**	
1 person died	19	27.1
2 people died	24	34.3
3 or more people died	27	38.6

Respondents noted that the major cause of death on Lake Victoria is drowning When asked specifically what they believed was responsible for these deaths, multiple responses were given including high winds (88%; 62/70), and 30%(21/70) cited poorly maintained boats. Over 50% of the respondents (113/215) were aware about at least one community member who had been injured due to lightning on the Lake in the past year. It was also noted that 32.6% (70/215) of the respondents knew at least one community member who had died on the Lake due to lightning (Table 3).

B. Level and extent of mobile phone use in the fishing community

All respondents reported using mobile phones. Ninety-two percent (198/215) mentioned the mobile phone as their most useful tool for obtaining information, while 8 % mentioned the radio. The majority of the respondents 85.1% (183/215) paid for their own mobile usage fees. On average, the respondents reported that they spend USD 8 per month for mobile phone services. In the study population 96% of the respondents (206/215) had phones with basic functionality and only 4% (9/215) had advanced features.

C. Use of mobile alert systems

It was reported that 30.7% (66/215) of the respondents were currently receiving mobile phone weather alerts. When these respondents were asked how the mobile phone alerts were helping them, 80.3% (53/66) said that the alerts were helping them in planning, 2.8% (6/66) said that the alerts informed them about the weather conditions. However 70.2% (151/215) of the respondents were not receiving any mobile phone weather alerts. Seventy-five percent of respondents said they would welcome a system that could deliver commercial weather alerts, while 65% were willing to pay for such a

TABLE 4 - PREFERRED CHARACTERISTICS OF SEVERE EARLY WEATHER WARNINGS

VARIABLE	N =	%
Ways of making alerts on mobile more effective	**N = 66**	
Being Accurate	5	7.6
Being Timely	47	71.2
Diversify languages	5	7.6
Diversify the media	5	7.6
Sensitize the users	2	3.0
No response	2	3.0
What is the most suitable language(s) for the mobile based early warning system	**N = 215**	
English	15	7.0
Luganda	163	75.8
English & Luganda	26	12.1
Others*	11	5.1
Most appropriate notification systems on phone	**N - 215**	
Sound alarm	120	55.8
Color code	23	10.7
SMS Text	16	7.4
Combination of colour and text	53	24.7
No response	3	1.4
Consideration of usefulness for mobile phone weather alerts	**N = 215**	
Very useful	93	43.3
Useful	86	40.0
Fairly useful	31	14.4
Not useful	3	1.4
No response	2	0.9
Trust in weather information received through mobile phone weather alert service	**N = 215**	
All the time	6	3.0
Most of the time	93	43.3
Sometimes	112	52.1
Not at all	2	0.9
No response	2	0.9
Actions taken when danger alert has been received about high winds and widespread thunderstorms when fisherman is in the middle of the lake	**N = 215**	
Anchor the boat	43	20.0
Call police and beach management unit for rescue	10	4.7
Call colleagues and relatives on land	31	14.4
Move to nearby island	95	44.2
Wait for whatever happens	25	11.6
Reduce the load	8	3.7
No response	3	1.4
Organization respondents thought should be notified in case of danger	**N = 215**	
Marine police	107	49.8
Beach Management Unit	80	37.2
Red Cross	13	6.0
No organization	15	7.0

*Swahili, English Swahili Luganda, EnglishSwahili

service. Table 4 also illustrates how respondents thought that alerts on mobile phones could be made more effective.

IV. DISCUSSION

The health of fishing populations is of high economic importance in Uganda's economy since fishing industry contributes 2.48% to the country's GDP [Odongkara et al., 2006]. The fact that so many respondents could recall more than two incidents of deaths on the Lake within the past year speaks to the loss of life and to the many productive years that these people could have contributed to the economy and to the support of their families had they not suffered premature death. It also supports our plan to encourage risk reduction through early warning [United Nations, 2011]. In addition, the fact that over half of those studied travel on boats every day points out the risk these people are exposed to on a daily basis.

The aim of this study was to gather information to be used to improve the delivery of potentially life-saving weather warnings that would enable fishermen and others in their community to make informed decisions about their work and exposure to severe weather. For that reason, it was good news to note that most of the respondents in the sampled villages were natives, making it easier to build a trusted and sustainable business model for the warning delivery. It is much more difficult to build a sustainable enterprise with migrant workers and their dependent populations [Janjuha-Jivraj, 2003]. In order to assure sustainability in building EWS, choosing a warning communication technology is dependent on considering who the recipients are, their location, their activity, the systems they rely on to receive local news and information, any special needs they may have and how they understand and respond to warnings [UNISDR, 2006].

In this study, all respondents owned mobile phones, relied on them as their most common source of information, and spent more than 8 USD per month on average for airtime credit. This presents the opportunity to harness the mobile phone alerts to their willingness and ability to pay for severe weather alerts in order to support a sustainable EWS. However, for this particular project to succeed, it will be necessary to consider the functionality of the phone and to either fit the EWS to basic phones or to make smart phones available at a low cost.

The study revealed some parts of the population at risk during all hours of the day and night as they routinely traveled and worked on the Lake. This supports the need for an effective EWS that incorporates risk knowledge, appropriate monitoring of the warning service, timely dissemination to the populations at risk and enhanced response capacity of the community [UNISDR, 2006; Sorensen and Sorensen, 2007] As far as risk knowledge, the majority of respondents were aware of severe weather related hazards on the Lake and believed a scientific explanation for lightning, rather than a superstitious or supernatural explanation for its source, implying that they will see scientific methods as reliable for giving them warning and improving their control over lightning risk. The proposed severe weather now-casting early warning system aims to use lightning as a proxy measure of severe weather, a sound and scientific basis for early warning on the Lake that regularly provides hazards like heavy winds, waves and thunderstorms (Anyah et al., 2006).

Concerning dissemination and communication, respondents reported that they rely heavily on mobile phones for information. The few people who had experience with mobile phone weather alerts in earlier projects had found the alerts useful, especially in planning, showing that warnings reached the intended users, were understood and usable.

Most respondents preferred an alarm as a warning system over color codes or text. This may be due to the work that they do fishing and the low literacy levels, which could prevent reading text warnings to ensure timely response. They also agreed that timeliness was a most important factor and that they preferred the use of local language for EWS.

Most of the time the community trusted in the early warning system, speaking to the validity of the warning message. In addition, authorities like the police were perceived as the responsible body that should issue the alerts. This is in agreement with the incident command operations that call for a clear chain of information flow.

The most common response action to a severe weather alert reported in this community was moving to a nearby island for safety and anchoring the boat. Although validation of this response was not tested as part of this study, the use of such indigenous local knowledge, if effective, may improve the effectiveness of response to an early warning system. As part of the warning dissemination, such information should be widely available so that there is organized response capacity in the community.

There are some limitations to this study worth mentioning. The number of respondents was too low to make final conclusions about the perceptions of this community regarding the use of mobile phone weather alert services. In addition, some communities had few respondents compared to others. Nevertheless, we believe that the information can aid in the design of an acceptable tool for early warning with the best delivery mechanisms, given that we interviewed the population that is aware of the hazards and risks associated with the Lake and severe weather.

The study sample was not chosen randomly and this may have caused reporting bias. In addition, a portion of the population targeted had participated in the pilot study of testing a mobile phone weather alert service. However, since the pilot interventions had ended over a year ago, we believe that the experience of the respondents and their responses may actually enhance the next system and that the results of this assessment are valid enough to guide an improved approach.

V. Conclusion

The overall aim of doing this study is to increase the safety of those who depend on Lake Victoria for their livelihoods by helping in the design of an Early Warning System of Severe Weather Now-casting based on Total Lightning Detection for Lake Victoria water vessels and delivered by mobile phone. We believe that this study will be instrumental in aiding the design of the proposed system, particularly if the survey can be broadened to include other portions and populations along the Lake.

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