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Wi-Fi network at Imja Tsho (lake), Nepal: an Early Warning System (EWS) for Glacial Lake Outburst Flood (GLOF)

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Abstract

Early warning system (EWS) is an integral component of risk management for natural threats as societal catastrophes many of which are attributed to climate change is on the rise. It has been listed as one of the five priorities under Hyogo Framework for Action (HFA) for building disaster resilience nations and communities. However, to put in place an operational and reliable technical Glacial Lake Outburst Flood (GLOF) EWS in the Himalaya, characterized by hostile terrain and climate, despite the urgency in view of the climate change is a challenge. It needs a robust and unique yet simple manageable and replicable system considering the number of potentially dangerous glacial lakes.

As a collaborative pilot initiative between International Center for Integrated Mountain Development (ICIMOD) and Kieo University, Japan, has put in place a Wireless Fidelity (Wi-Fi) based lake monitoring system in Imja Tsho (Lake) of Dudh Koshi basin, Nepal. The uniqueness of this system is in the extended utility offered by internet connectivity and opportunity thereby for different actors to pull resources thus making replication viable financially. Other unique feature of this system is the possible on-line services (distance education, tele-medicine and communication) to rural populace which is critical for inculcating ownership necessary for functioning of such instrumentations in rural set up. In view of these possibilities, Wi-Fi based lake monitoring system has huge potential to be adapted for GLOF EWS in future.

KEY WORDS: Early Warning System, GLOFs, glacial lakes, Wireless Fidelity

1. Introduction

Himalaya with large concentration of glaciers outside the polar region is aptly termed as "third pole" and represents both opportunities and potential natural threat which evokes concerns from increased risk of GLOF hazards in view of this present climate change. 33 GLOF events have been recorded in the Himalaya (Richardson and Reynolds 2000) and are likely to increase being induced by climate change (Bajracharya et al 2007).

While there is looming danger waiting to break loose at the upper riparian, disaster management practitioners are finding different ways to manage GLOF hazard which is rather complex due to inherent uncertainties, huge capital investment, terrain characteristics, modeling limitation, etc. One aspect that is seriously looked at is the EWS for GLOF which has to be uniquely designed to overcome many problems associated with terrain, climate, and remoteness. Wi-Fi based monitoring of glacial lake using web camera is certainly a potential application for GLOF EWS. This paper put in perspective the potential application of Wi-Fi system installed as pilot case study in Imja lake, Nepal as an innovative initiative for GLOF EWS.

2. Glacial Hazards in the Himalaya

The spectacular receding of mountain glaciers worldwide is one of the most reliable evidences of the changing global climate since mid 19th century (Horstmann, 2004) which evokes concern as it gives rise to glacier related hazards. Although there are two main types of glacial hazards: snow/ice avalanches and GLOFs (Richardson and Reynolds 2000) the latter has caught attention of disaster management practitioners as it is more catastrophic due to the distance and nature of propagation.

The GLOF is not a recent phenomenon in the Himalaya. As per Richardson and Reynolds (2000) the Himalaya has witnessed 33 GLOF events. Bajracharya et al. 2007 reported 15 events in Nepal, 6 in the Tibet Autonomous Region of China (with consequences for Nepal) and 5 in Bhutan. GLOFs represent one of the main natural hazards in the mountain areas with destruction extending as far as 200 km downstream from the source (Richardson and Reynolds 2000) resulting huge financial liability.

The recent study by ICIMOD recorded over 15,000 glaciers and 9000 glacial lakes in Bhutan, Nepal, Pakistan and selected basins of China and India (Mool et al. 2001). 204 out of 9000 lakes have been identified as potentially dangerous. Enhanced retreat rate reported as high as 70m/year in the case of Imja glacier in Nepal (Bajracharya et al, 2007) only reinforces the threat of GLOFs in the context of present global warming.

3. Impact of GLOFs – cases of the Himalaya

The Zhangzhangbo GLOF of 1981 destroyed the Sun Koshi Power Station and the Friendship Bridge at the Nepal-China border, as well as two other bridges and devastated extensive sections of the Arniko Highway; losses accounting over US $3 million (Mool et al. 2001a). In 1985 the Dig Tsho GLOF event destroyed the nearly completed Namche Hydropower Plant (with an estimated loss of US $1.5 million), 14 bridges, trails, and cultivated land. In 1998, the outburst of Tam Pokhari in Nepal killed two people, destroyed more than six bridges and washed away arable land. Losses worth over 150 million rupees have been estimated. The Luggye Tsho GLOF event of 7th October, 1994 in Lunana Complex of Bhutan partially burst, causing the Pho Chhu to flood. It killed 23 people in the Punakha valley and cost the government more than Nu. 43 million on flood relief measures (Kuenselonline: http://www.kuenselonline.com).

4. EWS for GLOF in the Himalaya – a challenge

Warning system is an essential component of risk management for natural threats (Einstein and Sousa 2007) and building disaster resilience nations and communities

Figure 2: Photographs taken during GLOF events: Dig Tsho GLOF, Nepal (left) and Luggye Tsho GLOF, Bhutan (right).

through EWS is one among the five priorities listed in the Hyogo Framework for Action (HFA). EWS in itself is an explicit term; a system to warn people of the impending disaster allowing people to respond to avoid the threat or at least to reduce the consequences. Its significance in disaster management can be reckoned by painful event of 26 December year tsunami of Banda Aceh which at least accounted for 165,000 deaths and over half a million injured (www.un.org). The high fatalities during tsunami of Banda Aceh is attributed to absence of tsunami EWS in place.

With regard to GLOF EWS it is always a challenge to operationalize due to remote terrains, harsh climatic condition, inaccessibility, maintenance issues, security, and high operational cost. It is hugely capital intensive (US $ 1,032,000 in case of Tsho Rolpa EWS, Mool et al. 2001). The only two technical EWS (TEWS) installed in the eastern Himalaya are Rolwaling valley and Tama Koshi valley GLOF Warning System, are both in Nepal. Manual warning system is still in place in Bhutan, and in the past was adopted in Tsho Rolpa as an intermediate measure (Richardson and Reynolds 2000).

5. Technical Early Warning System (TEWS)

5.1. Tsho Rolpa EWS

Tsho Rolpa EWS was installed in 1998 after rapid expansion, degrading ice-cored moraine ridge, ice avalanche activity from adjacent Trakarding glaciers was noticed during the 1994 survey and identified the lake as one of the potentially dangerous. The Tsho Rolpa GLOF EWS as in every EWS constituted of two components: sensing system and warning system. Sensing system consisted of six water level sensors located at elevations between 0.4 and 2m above the high water marks just downstream of the outlet at Sangma Kharka (Bajracharya et al. 2007, Bell et al. 2000). Shielded and armoured cables connect these sensors to the transmitter station comprising of a data logger, remote transmitter and a battery sourced by solar energy mounted in a weather proof enclosure located 80m above the sensors. The sensor constituted of a ground water reflectometer mounted in air which produces an output frequency/period that is a function of the dielectric surrounding its two probes (Bell et al. 2000). Although the system was designed to minimize false alarm by discriminating between dry and wet states, and assigning weights for each of the three states (dry, wet and failed) and comparing sum values to pre-set threshold, there has been few instances of false alarms (Bajracharya et al. 2007).

The relay of warning signal from sensing system to 19 warning stations is based on Extended Line of Sight (ELOS) embedded within Meteor Bursts. Each of the warning stations constituted of Meteor Communications Corporations (MCC) 545-transceiver, battery, an air powered horn backed up by an electric horn, and antenna. The air horns are capable of producing 80dB sound up to a minimum distance of 150m under the most adverse conditions (Bridges 99, 2001).

The system had a monitoring provision from data monitoring stations at Khimti and in Kathmandu.

Figure 4: Components of Tsho Rolpa TEWS: the transmitting station at Sangma Kharka outside Tsho Rolpa (left) and warning installation (right).

5.2. Manual Early Warning System

Often TEWS is capital intensive and require detailed investigation prior to implementation due to which it takes a while to be operational. Manual early warning system is adopted as an interim measures while permanent solution is being worked out. Manual warning system was put in place in Nepal once for Tsho Rolpa in 1997 (Mool et al. 2001), while manual EWS is still operational for GLOF threat in Lunana complex in Bhutan.

5.3. Manual EWS in the Lunana region, Bhutan

As manual early warning mechanism two staffs of Department of Energy (DoE) are stationed in the Thanza village in Lunana (see Fig. 5) equipped with both HF communica-

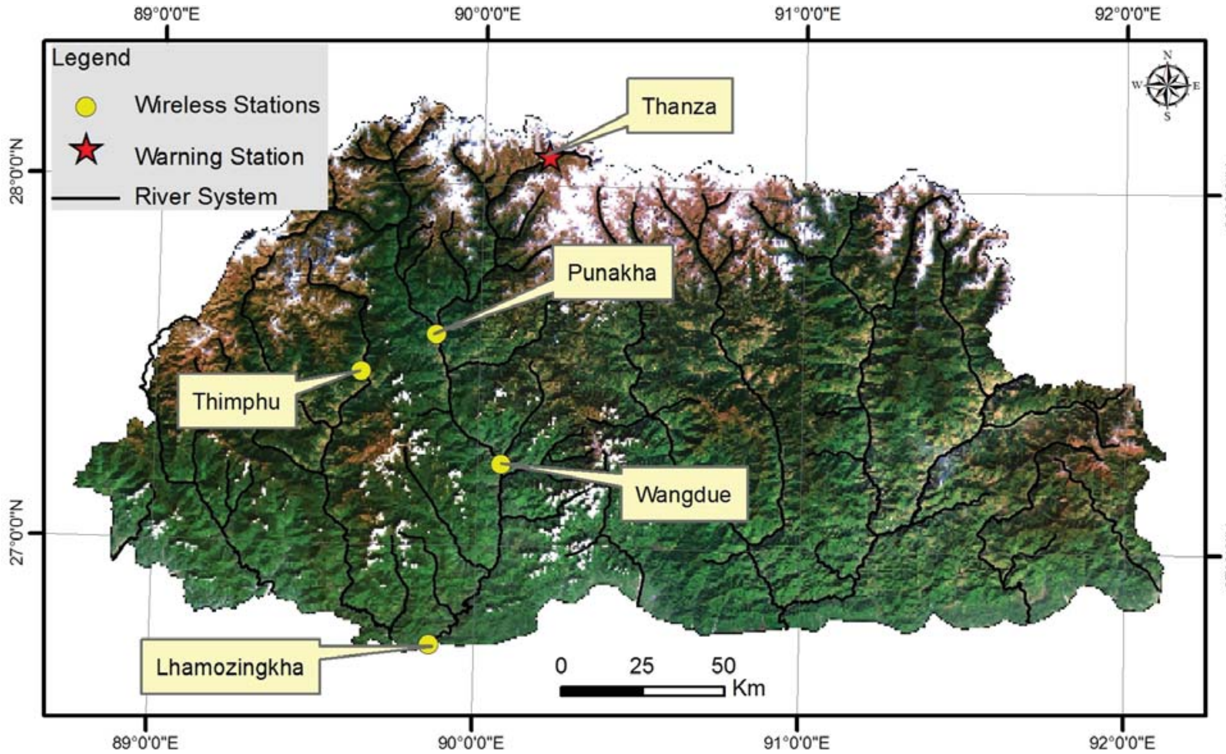

Figure 5: Information flow chain adopted in Bhutan as a manual GLOF EWS.

tion set and a satellite telephone as a backup. They monitor water level of 4 glacial lakes (Raphstreng Tsho, Luggye Tsho, Thorthormi Tsho and Besta lake – personal communication) once every week and at the confluence regularly which is compiled and reported to the head office (DoE) at Thimphu. The information from Thanza is transmitted to control station at Wangdue from where the information is disseminated to the relevant dzongkhags (districts): Punakha, Gasa, Wangdu and Thimphu. A number of gauges have been installed along the main river and at the lakes which are monitored regularly.

5.4. Tsho Rolpa Manual EWS

Erstwhile His Majesty's Government of Nepal (HMGN) implemented a manual early warning system at the end of June 1997 to provide timely warning to the people after reporting of possible GLOF in the media in Rolwaling and Tama Koshi Valleys (Mool et al. 2001). An army camp and police post was established on the lakeside at the village of Naa, approximately 3 km downstream from the lake with another police post established in Beding, approximately 9 km downstream from the lake. Each of the army and police posts was provided with a HF radio transceiver and the army post at Naa had a back-up set. The two police posts and the army post in Naa were in regular radio contact with their respective headquarters in Kathmandu. In addition the two army posts were provided with satellite telephones. The army post at the lakeside used one of the phones to contact the disaster prevention cell at the Home Ministry twice a day to deliver a status report. In the event of a GLOF, Radio Nepal, the national broadcaster, would broadcast a warning. Radio Nepal can be received in most places along the valleys that are at risk.

5.5. Wi-Fi based monitoring system at Imja Lake – a case study

As a pilot study ICIMOD in collaboration and KEIO Research Institute at SFC (KRIS) have put in place a system comprising of web-camera (0.3 – 8M pixels, see Fig. 6) with 24 channels (sensors) setup at Imja Tsho, Nepal, which has been connected through Wi-Fi network. Five (Air temp, Humidity, Solar Radiation, UV Radiation & CO_2 concentration) of the channels has been deployed. The Imja Tsho with one of the highest expansion rate represents the threat with regard to GLOFs – an important criteria for site of this case study.

The monitoring system consists of two web cameras (0.3 – 8M pixels): one at the right lateral moraine near the "Island Peak" and the other near the end moraine. The camera with 360° view angle relays image of the lake through internet every 10 minute along with atmospheric data from the sensors. These data are being regularly transmitted and can be accessed through internet interface (http://fsds.dc.affrc.go.jp/data4/Himalayan/). The data

Figure 6: Field server equipped with web-camera enclosed within a protective shield (left) installed close to the end moraine of Imja Tsho (middle). On the right is the transmitting station.

is being uplinked through ISP facility in Namche Bazaar which is networked with the monitoring unit through relay points at Chhukung ri and Quangde (see Figure 7). The link between ISP in Namche Bazar and installation at the Imaj Lake operates based on the principal of line of sight because of which relay station was established at strategic points.

This system creates a field of internet connectivity depending on the line of sight at every relay points which can be set up for internet access. The rural connectivity it creates makes it a unique system with extend utility by linking rural facilities such as schools, health post, tourist post, hotels, and other government and public facilities. This creates an opportunity for pulling resource from different sectors to share the usually high establishment cost which in other system is not possible. Rural services such

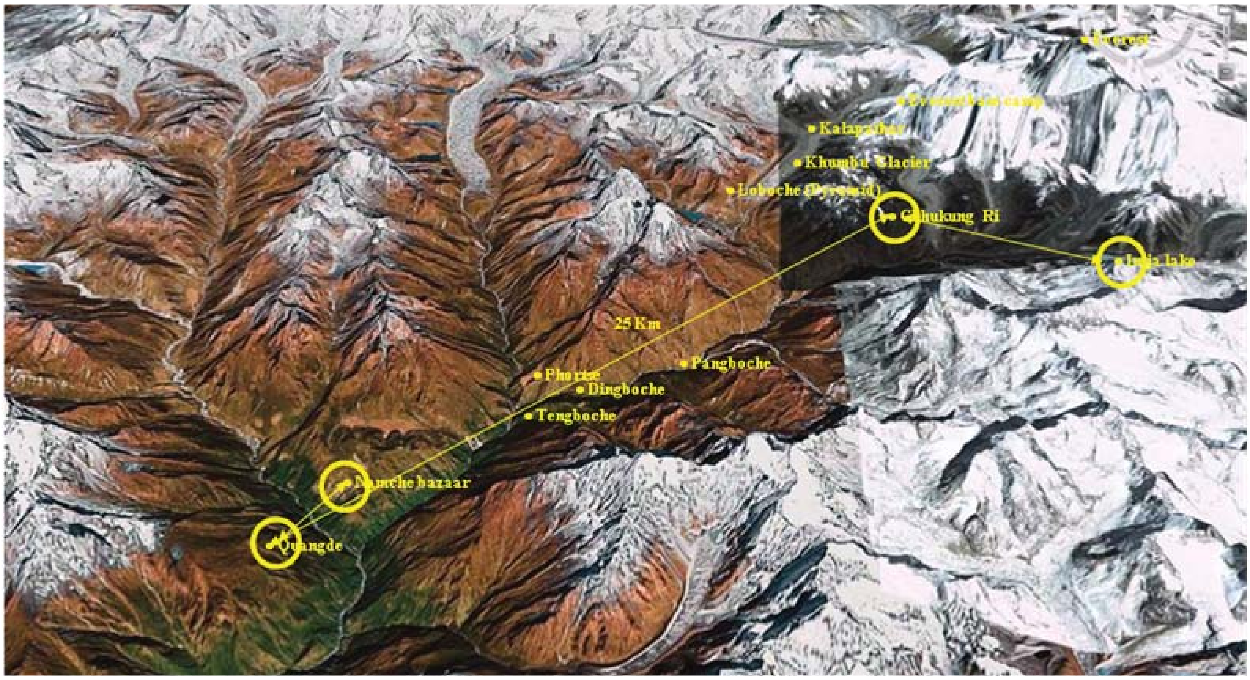

Figure 7: Networking of field server and transmitting stations from Imja Tsho to Namche Bazar from where it is uploaded to internet through ISP. (Source: GoogleEarth application)

as distance education, tele-medicine, and communication which rural populace can avail will inculcate an atmosphere of ownership which is critical in operationalizing the system in remote sites.

Figure 8: View (12:04 dated 02.03.2009) of Imja Tsho transmitted by the system over the network. Source: http://fsds.dc.affrc.go.jp/data4/Himalayan

6. Conclusion

The rising threat from GLOF hazard to communities cradled in the basins of river emanating from glaciers in present global climate change context has compelled disaster management practitioners to look for disaster reduction strategy. Different measures are being adopted and EWS is high on the agenda. However, challenges both financial and technical has been real set back in replicating Tsho Rolpa like EWS in other sites of potentially dangerous glacial lakes.

The Imja Tsho pilot case study by ICIMOD and Keio University is unique and has potential to be adapted as GLOF EWS as it is fairly simple instrumentation and yet multipurpose. The rural benefit (telecommunication, telemedicine, distance education, information hub, etc.) is one critical factor in assessing the feasibility of this system especially in far flung areas.

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