Bulletin of Department of Geology, Tribhuvan University, Kathmandu, Nepal, vol. 20-21, 2018, pp. 87-92.

Community based flash flood early warning system: a low-cost technology for Nepalese mountains

*Basanta Raj Adhikari and Nagendra Raj Sitoula

Department of Civil Engineering, Institute of Engineering, Tribhuvan University, Nepal

ABSTRACT

Every year, flood impose substantial economic, social and environmental cost on Nepalese community through direct damage to residential, commercial, educational and structures. Moreover, the flood destroys animal farm, commercial stock and records and other content of the building and pollutes the water. Early Warning Systems are important to save such lives and properties which involves computer, satellite data and high accurate operating system but this system is very costly in terms of installation as well as operation and maintenance leading to hindrance in the sustainability of the system. However, high-tech technology is very expensive and not feasible in Nepal and therefore low-cost and easy operating system is needed in the rural parts of Nepal. The system includes Solar panel, Siren, Ultrasonic sensor, processing unit, and battery. The ultrasonic sensor sense water level and the siren will automatically start. The threshold can be set up according to the space and time.

Key words: Flash flood, Early Warning System (EWS), Nepal Himalaya

Received: 17 April 2018 **Accepted:** 13 June 2018

INTRODUCTION

Natural disasters are increasing day by day due to global climate change and population increase. Recent hurricanes, floods, landslides and mud flows have illustrated the differences between the developed and developing countries. Recent flood disaster in South Asia has taken more than 1000 lives with lots of destruction. In this context, Nepal is considered one of the most disaster-prone countries in the world (NRRC 2011). Nepal has experienced many flood events in the past including 1993 central Nepal flood events (NCVST 2009), Koshi embankment breach in 2008 (Dixit 2009) and 2017 flood event in Terai. Many researchers have studied the flood hazard in Nepal and proposed different kinds of community based early warning systems (Brown 2014; Practical action and Mercy corps 2012; Shukla and Mall 2016; Gautam and Phaiju 2013; ICIMOD 2016; Practical Action 2016). Most of those study are concentrated on perennial river flood and little study has been done on community based flash flood warning system. Flash floods are very common in the southern part of Nepal especially Churia originating rivers. Intense rainfall and river bed level rising are major factors for destruction of life and property. Application of Early Warning System (EWS) can reduce significantly the loss and damage. Good early warning system comprises of identification and estimation of hazards, monitoring, communication, dissemination and response of the community and related stakeholders. Several early warning systems have been developed for a wide range of natural hazards such as flood, volcanic eruption, landslide, snow avalanches etc. There are very recent computer modelling, precipitation sensing and communication technology advancements are making flash flood EWS increasingly affordable, effective and sustainable. But it must also be noted that the present time even with the most robust of forecasting schemes employing dense rain gauge networks, radar coverage, satellite algorithms, high resolution computer models of atmospheric processes and distributed hydrologic models. Many flash-flood prone countries with vulnerable populations have a range of options for creating local or regional early warning systems for flash floods. Some of them are: (a) Heavy rain event detection via rainfall/stream flow gauge networks, radar networks, satellite sensors, or some combination of the three, (b) Manual or computerized short-fused now casts of imminent flash floods from diagnosed heavy rain events, (c) Atmospheric fine-scale models, possible coupled with distributed hydrology models, to forecast the risk of flash flooding in a basin or basins a short time in future (FFEWSRF 2010). Such kinds of high-tech EWS are not feasible in the context of Nepal because of having low literacy rate and economic condition. Therefore, an attempt has been made to develop the community based early warning system for flash flood in the Nepalese Himalaya focusing on Churia originating rivers (Fig. 1). The study area lies in the eastern part of Nepal consisting of 5 rivers including Ratu (Mahottari), Gagan (Siraha), Khando (Saptari) and Kong and Hadiya (Udayapur).

METHODOLOGY

Extensive field work was carried out for the community based early warning systems for flash flood including surveying, mapping and gathering of geological and geomorphological

*Corresponding author
Email: bradhikari@ioe.edu.np (B. Adhikari)

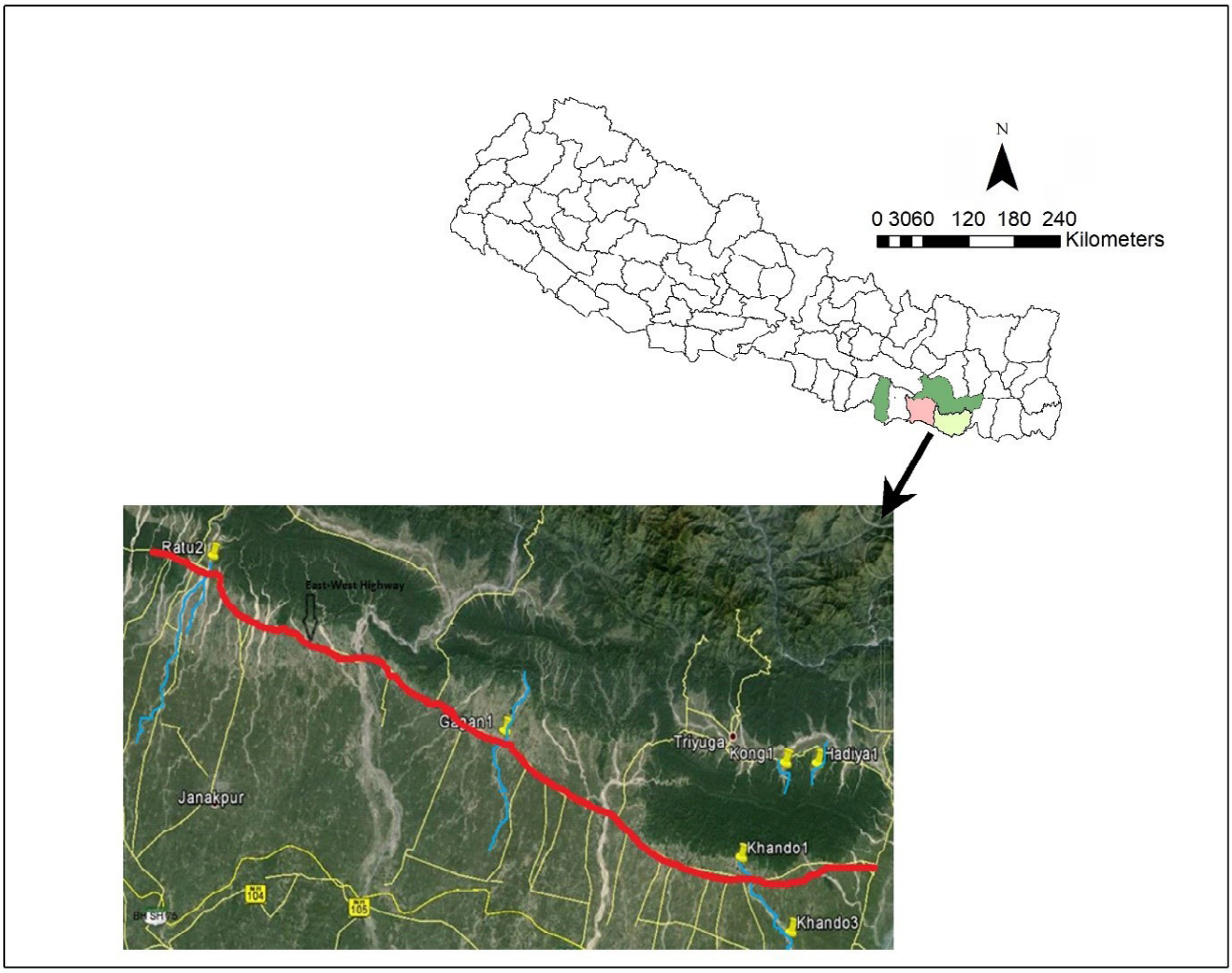

Fig. 1: Location map of the study area.

data for the EWS establishment. Key informant interview (KII) and focus group discussion were carried out to identify the possible EWS system in the area. Geomorphic evidence of the past flood events are collected from the Google Earth images and verified in the field. Field work is supported by the Development of Physical Prototype in the Institute of Engineering, Tribhuvan University laboratory.

DESCRIPTION OF THE STUDY AREA

Altogether 5 rivers were studied for the establishment of community based early warning systems and they lie in the south-eastern part of Nepal (Fig. 1). The detail description of the individual rivers are given below:

Kong River: Kong River lies in the eastern side of the Gaighat, Udayapur which is relatively flat and has braided system. This river originates from Churia and flows from south to north (Fig. 2). The bank height is 1 m in average and the bed material consists of silt, sand and gravel (Fig. 3).

Hadiya River: Haidya River lies on the eastern site of Gaighat of Udaypur District consists of braided river system. The bank height is around 1 m (Fig. 4). The bed level is almost same with flood level because of aggrading river condition.

Gagan River: Gagan River lies in the Siraha District of eastern Nepal (Fig. 5). This river originates from Churia range consisting of gravel, sand and silt. This river is very hazardous for the communities in the downstream because of bank cutting and sediment generation. Altogether, three sites namely: EW Highway, Shiva Chowk and Tulsipur ward no. 2 were studied in detail from upstream to downstream.

Khando River: The Khando River originates from the Churia range and flows in to the Indo-Gangetic Plain in the Saptari District (Fig. 6). Three sites namely: EW Highway, near Terhota and between Pakarii and Digdaha were studied to identify the possible sites for the establishment of EWS. The river is almost flat in both three places and with 0.75 m average bank height (Fig. 7).

Ratu River: Ratu River is one the major tributaries of Ganga River which originates from the Churia range. Three sites namely: B.P. Highway, EW Highway and Sarpallo were studied in detail (Fig. 8). This river is relatively flat with having 200 m width. The river has braided river system and the river bed consists of boulders and gravel. According to local people, there are continuous flood in past years but the number of flash flood events are increasing year by year.

Fig. 2: The overview of Kong River (Google Earth Image).

Fig. 3: Flood plain and braided river system of the Kong River.

Fig. 4: Flood plain braided river system of the Hadiya River.

Fig. 5: Gagan Khola showing different studies sites.

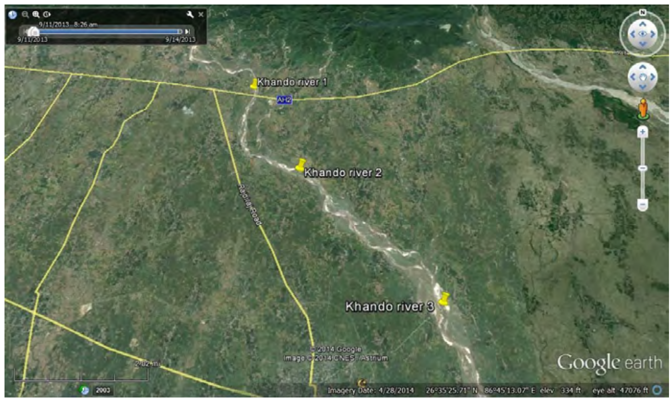

Fig. 6: Khando River showing different studied sections

Fig. 7: Flat Khando River where EWS can be established on the pier of bridge on the left side of the river.

DEVELOPMENT OF LOW-COST EWS

The low-cost EWS system is developed after analyzing the field condition and community interaction. This system includes a set of rainfall and water lever measuring stations set up over key points in a watershed or its sub-basins. Every station transmits its information in real time to repeater stations which are linked to a master station where data from all basins

Fig. 8: Ratu River showing the three study sites.

Fig. 9: Flat River with concrete bridge where EWS can be established in the pier of bridge.

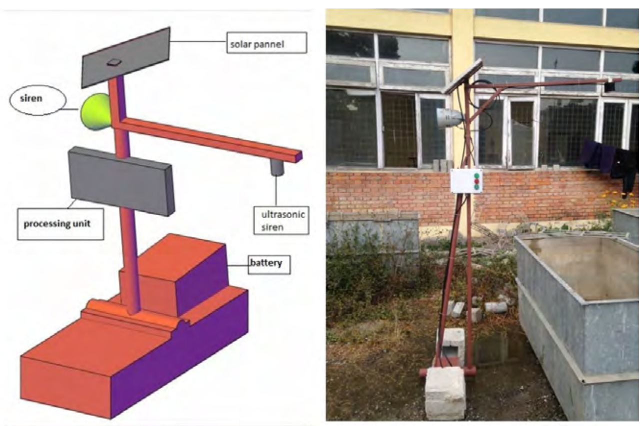

Fig. 10: Sketch and physical prototype of the EWS.

are received and processed and the change in water level at different points of interest can be closely watched. When flooding is likely to occur, a flood warning will be issued by the central unit and appropriate action taken to reduce damage and save lives.

Working mechanism of the sensor

The ultrasonic sensor sense the water level and the siren will automatically start (Fig. 10). The threshold can be set up according to the space and time. This system has different options. First, the sensor detects the first water level and automatically siren will start and stop for 5 seconds and repeat again. The sensor detects the second water level and siren will start and stop for 5 seconds which will repeat again. The final water level (the danger water level) will be detected by the sensor and the siren will automatically start and repeat in every 2 seconds (Fig. 11). When the siren is on then the gauge reader near by the station will transfer the information to the downstream community or in the Nagarpalika/Gaunpalika office (Fig. 12).

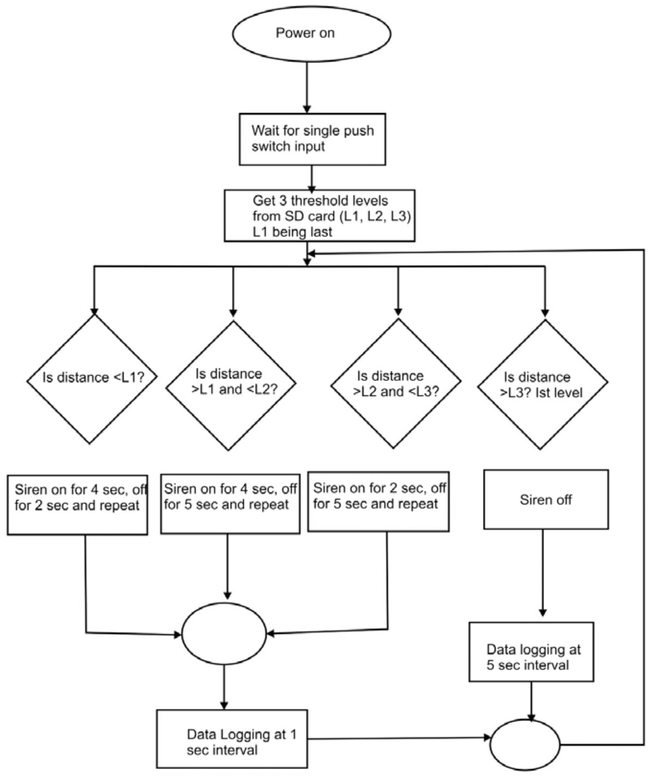

Fig. 11: Flow chart of the working system.

Description of different units

Main processor

AVR Atmega 328
- 8 bit RISC Microcontroller
- 16 MIPS @ 16MHz
- 32KB Flash, 2KB RAM

Real Time Clock (RTC)

Dallas Semiconductor DS1307
- Counts seconds, minutes, hours, date of the month, month, day of the week, and year
- Leap year compensation valid up to 2100

Data logger memory

Micro SD card (2GB)
- Adequate for storing over 5 years of logged data (logging at 5 seconds intervals before 1st level and logging 1 second after 1st level)

Water Level Sensor
HC-SR04 Ultrasonic Distance Sensor
- 40 KHz working frequency
- Detection Range: 2cm to 4m
- Measuring Angle: 15 degree

Siren
- 12V DC 1 Mile Siren

Battery
- 12V DC 7.4 Ah Rechargeable Sealed Lead Acid Battery

Solar Panel
- 12V DC 11Watt Solar Panel

Charge controller
-Protects battery from over charging and discharging
UV protection jacket for connecting wire

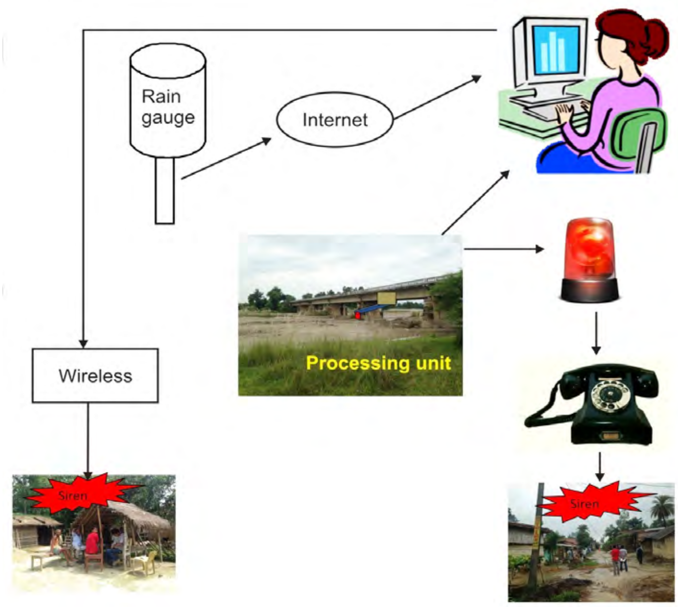

Fig. 12: Web based automatic flash flood early warning system.

DISCUSSIONS

Automated system is very effective and efficient means of data and information sharing in a flash flood EWS because of low human inputs or influence by integrating rain-gauge information. The proposed employment of automated (auto-recording) stand-alone state-of-the-earth equipment for data collection, accumulation and transmission for the Flash Flood Warning System in Nepal will ensure a reliable system. The data logger keeps consistent recording which also are transmitted through the internet link to data center, district level organizations such as District Administrative Office, District Coordination Committee or to the central level originations for instance Department of Hydrology and Meteorology (DHM), National Emergency Operation Center (NEOC). The existing Short Message Services (SMS) provided by the GSM telecommunication industry is the best option for information dissemination because of less developed condition of information dissemination in the country. Although, the automated equipment would send data collected to station via transmitters, the messages containing data from the gauging stations in the community-based flood early warning system which involves local volunteers to send SMS also. S/He is responsible for sending SMS to friends downstream using the GSM mobile phone before, to send code-like messages directly to the hotline of DHM server/data center. It is obligatory DHM to provide the web-based portal through which the flow of information is to be done in a more centralized and coordinated manner. The web-based system makes it easy to follow the process from the level of forecast, monitoring and warning. Mass media including print and electronic are playing important role in informing the population most especially through radio program targeted at carrying the local communities. The role of media and the personal communication is integral part of the EWS. Ministry of Home Affairs and Department of Hydrology and Meteorology have to work together for forecast and for the evacuation plan. Information sharing would also be done by electronic advert boards which would display different information ranging from flood data, forecast and instructions, may be fashionable for the urban areas and the cities particularly prone to flood risks. Improvement of hydro-meteorological observation is still a necessity however this low-cost technology can give the better solution for the EWS in the countries like Nepal.

CONCLUSIONS AND RECOMMENDATIONS

Community based early warning system is very important and effective in the context of Nepal. The EWS considers communities as an integral part and involved then in risk management, community and dissemination and immediate response activities in a participatory way. Participation of elderly people, woman, children, and young people will make the system truly inclusive. This system is very cost effective and easy to operate and thus can be replicated in other parts of Nepal. However, the threshold values should be defined accurately in the respective areas. The basin hydrology, soil condition, river cross-section, velocity of water and rainfall measurement parameters should take in account in defining the thresholds value.

ACKNOWLEDGEMENTS

We would like to acknowledge Govinda Acharya, Technical Advisor of Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP), Department of Hydrology and Meteorology, Government of Nepal for providing financial support for this study. Moreover, we thank to Mr. Jeebnath Banjara and his colleagues for their help in the field as well as in the lab for writing a programming code for siren system.

REFERENCES

Dixit, A., 2009. Koshi embankment breach in Nepal: Need for a paradigm shift in responding to floods. Econ. Poli. Weekly, v. 44, pp. 70-78.

FFEWSRG, 2010. Flash flood early warning system reference guide. University Corporation for Atmospheric Research, National Oceanic and Atmospheric Administration, U.S Department of Commerce, 204 p.

Gautam, D.K., and Phaiju, A.G., 2013. Community based approach to flood early warning in west Rapti River Basin of Nepal, Jour. Integrated Disaster Risk Management, v. 3, pp. 155–169, doi:10.5595/idrim.2013.0060.

ICIMOD, 2016. Community based flood early warning system for the Hindu Kush Himalaya, available at: http://lib.icimod.org/record/32318/files/icimodCBFEWS016.pdf, last access, 10 May 2018.

NCVST, 2009. Vulnerability through the eyes of the vulnerable: climate change induced uncertainties and Nepal's development predicaments, Institute for Social and Environmental Transition – Nepal (ISET-N) & Institute for Social and Environmental Transition, Kathmandu & Boulder, CO, available at http://i-s-e-t.org/resources/major-program-reports/vulnerability-through-the-eyes-of-vulnerable.html, last access, 10 September, 2017.

NRRC, 2011. Disaster risk reduction in Nepal, Nepal Risk Reduction Consortium, available at: http://un.org.np/sites/default/files/2011-04-19-nrrc-background-brief.pdf, last access, 10 May 2018.

Practical Action and Mercy Corps, 2016. Community based early warning systems in south and south east Asia, Practical Action and Mercy Corps, available at: http://flagship4.nrrc.org.np/sites/default/files/documents/best-practice-learning-in-community-based-EWS.pdf, last access, 10 September, 2017.

Practical Action, Flood early warning systems in practice: experiences from Nepal, available at: d1x0je2yh2wyb8.cloudfront.net/f/l/58061b1b-d338-49f1-927d-42da0a0000be.pdf, last access, 10 May 2018.

Shukla, Y., and Mall, B., 2016. Enhancing frontline resilience: trans-border community based flood early warning system in India and Nepal, in: UNESCO Chair in Technologies for Development: From Innovation to Social Impact, available at: http://cooperation.epfl.ch/files/content/sites/cooperation/files/Tech4Dev%202016/1125-Shukla-SE08-DRR_Full%20Paper.pdf, last access last access, 10 May 2018.