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Challenges and Prospects of Flood Early Warning Systems: A Study of Narayani Basin

Chandra Lal Pandey* and Anoj Basnet[1]

Department of Development Studies, School of Arts, Kathmandu University, Kathmandu, Nepal
[1]Lutheran World Federation Nepal, Chun Devi Marg-4, Maharajgunj – 44600, Kathmandu, Nepal
✉ chandra.pandey@ku.edu.np

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Abstract: Floods are the most dangerous and detrimental hazards in Nepal. Communities inhabiting the Narayani basin are getting affected by floods every year. However, no studies have been conducted to analyze the existing early warning system's functional capacity and community feedback. Literature on disasters and calamities indicates that an efficient and effective flood early warning system is crucial for making communities flood resilient but we note that unless 'community capacity for response' is also strengthened, early warning technology alone cannot protect against losses and damages. Employing a qualitative approach, we explored the existing status of a community-based flood early warning system, and the challenges and prospects of these technologies for building flood-resilient communities in the Narayani basin of Nepal. We found that the existing warning system in the basin is fragmented, unreliable and cannot contribute to building flood-resilient communities. This study concludes that making communities flood resilient, at least, needs five components inclusive of the installation of more reliable early warning technologies; promotion of community-based early warning systems; timely communication of early warning alerts; training on preparedness and response; flood and climate-proof livelihood options.

Keywords: Flood, climate, EWS, Nepal.

Introduction

Nepal is one of the most disaster-prone countries in the world. It ranked the seventh most climate-vulnerable country in Global Climate Risk Index (Kreft et al., 2016) and around 74% of all disasters are primarily linked to concentrated rainfalls and climate change, resulting into floods and water-induced disasters (UNWWDR, 2020; DHM & LWR, 2018; GoN, 2019; Pandey, 2019). Among multiple-disasters, floods—'too much of water'—have impacted the lives and livelihoods of Nepali people as statistics suggest that around 74% of all disasters are primarily water related (MoHA, 2018; DHM & LWR, 2018; UNWWDR, 2020; Pandey et al., 2022). The water-induced disasters such as landslides, debris flow, river bank erosion, soil erosion, snow avalanches, glacier lake outburst floods (GLOF), and slope failures are inalienably linked to concentrated monsoon rainfalls, climate change and floods (GoN, 2019; Pandey, 2019). While water-induced disasters such as soil erosion, landslides, debris flows, snow avalanches, GLOF, and slope failures frequently occur in the hills, mountains and the Himalayas, river bank erosions, floods leading to inundation occur in valleys and plain regions of Terai (GoN, 2013; MOHA, 2018; Pandey and Basnet, 2021).

Reports revealed that about 2023 deaths were caused by water induced disasters in a decade period in Nepal but the damages caused by them have significantly increased (*RastriaSamacharSamiti*, 1 August 2021).

*Corresponding Author

These water-induced disasters have always caused domino effects on human lives, property, agriculture, critical infrastructure and the overall resiliency of the communities (Joshi et al., 2008; Pradhan, 2013). The existing literature widely acknowledges the ability of community-based flood early warning systems (CBFEWS) to mitigate vulnerabilities from flood risks (Pandey et al., 2022; Pappenberger et al., 2015; UNDRR, 2004; WMO, 2013), however, the operational effectiveness of CBFEWS is mostly unknown and the challenges communities confront on the ground in terms of response capacity are not well spelled out and relate to how much they contribute to SDG goal 11 and Sendai Framework targets in terms of minimising flood-related impacts and making resilient communities (Pandey & Basnet, 2022; Perera et al., 2019; Tarchiani et al., 2020). In this background, we investigate two interrelated questions: What is the existing status of CBFEWS in the Narayani basin? What are the challenges and prospects of CBFEWS technologies in the basin for making communities flood resilient?

Methodology

This study has used a qualitative approach to explore and analyze past and current practices of flood early warning systems. The communities in Khairahani Municipality of Chitwan, and Pratappur Rural Municipalities of Parasi districts in the Narayani River basin formed the population under the study. Primary data have been collected using field observations, key informant interviews (KII) and focus group discussions (FGDs) (Palinkas et al., 2015). We conducted 26 KIIs and 8 FGDs and all these activities were carried out in wards 3, 5, 6, 7 and 8 of Pratappur Rural Municipality of Parasi and wards 7, 10, 11, 12, and 13 of Khairahani Municipality of Chitwan district in Nepal. The wards were purposively selected because they have historically been the most vulnerable and flood-prone wards of both municipality and rural municipality and possess high levels of risk to multiple disasters. We conducted a number of interactions with four different types of stakeholders, which included formal stakeholders—officials from local government, people from communities, academicians, representatives from civil society organizations to collect data related to floods, early warning system (EWS), CBFEWS and disaster risk reduction responses. Secondary data have been collected by reviewing existing bodies of literature in the field. Secondary data comprised of literature data reflecting local, national and global practices of flood early warning and community-based flood early warning systems. Journal articles, books, government and non-government reports, review articles, case studies, and websites were reviewed and analyzed. We employed the thematic data analysis method as it is a powerful and flexible method for analyzing qualitative data seeking to understand experiences, thoughts and behaviours to search across a data set to identify, analyse and code repeated patterns of themes aligned with the two research questions of this study (Braun & Clarke, 2006; Kiger & Varpio, 2020).

Study Sites

Khairahani municipality, comprising 13 wards, is one of the most flood disaster-prone municipalities of Chitwan district due to Rapti and other seasonal rivers. Khairahani municipality is in the Bagmati Province of Nepal. It is located at an altitude of 190 meters from sea level and the Rapti River functions as its southern regional border of it. The Rapti River has not only been a boon as it is the source of water in the region but also a source of frequent and dangerous floods and flood-induced disasters every year (Khairahani Municipality, 2022). Another study site known as Pratappur is a rural municipality. It is located in the Parasi district of Nepal, comprising 9 wards. The municipality is located in Lumbini Province at an altitude of 300 meters from sea level (Prataappur Rural Municipality, 2022). Geographically, it is located on the bank of the Narayani River which is also a source of water and a source of frequent floods making the rural municipality one of the most flood-vulnerable rural municipalities of Nepal.

Community-Based Early Warning Systems

Early warning is a fundamental aspect of disaster risk reduction and management. EWS and enhancement of risk monitoring are the second major priorities of the Hyogo Framework for Action (HFA) 2005–2015 (United Nations, 2005) and a primary component of the Sendai Framework for Action 2015–2030 (United Nations, 2015). The major goals of early warning systems are to protect the lives of people; to reduce losses of property; promote development; and improve information dissemination (Shrestha et al., 2014). CBFEWS is a people-centric approach, helping communities use local resources and capacities to effectively prepare for and respond to flood hazards (Smith et al., 2017). It enables communities to reduce their vulnerability against floods for their active participation not just in the design phase but also in the ongoing monitoring and management processes of EWS (Mercy Corps and Practical Action, 2010). The HFA, the global blueprint for disaster risk reduction prioritised the development of people-centered EWS encompassing four critical components. They were i) Risk knowledge; ii) Monitoring and warning; iii) Dissemination and communication; iv) Response capability (UN, 2005; IFRC, 2010).

The latest theory and practice of the CBFEWS puts an emphasis on community actors to bring a wider level of awareness and understanding of flood risks (vulnerability, capabilities, exposure and hazards) (IFRC, 2010; Mercy Corps and Practical Action, 2010). In CBFEWS, community-employed trained gauge readers calculate warnings and dangerous levels of the river height at gauge stations (upstream of flood-vulnerable communities) and correspond to the water volume levels of the river to downstream communities (Mercy Corps and Practical Action, 2010). Disaster Management Committees (DMCs) are also established to monitor and record information on flood levels, duration and impacts (Gautam and Phaiju, 2013) but studies show that the accurate spatial prediction of impacts is very challenging and subject to significant uncertainties (Smith et al., 2017).

Grey literature record that the community systems of manual river-gauge monitoring have evolved to become integrated with national systems of DHM as well (Practical Action and Mercy Corps, 2012). This practice connects with the automated systems of DHM data collection and dissemination on the one hand while the risk information on water levels can directly be communicated in local languages to the local communities through the community gauge readers on the other. The real time data, according to DHM, is transmitted to the government's server system every 15 minutes but the dissemination and communication to reach out the warnings to all "at-risk" communities in understandable language to act upon on time, utilising the lead time and the role of CBFEWS is also equally pertinent (UNISDR, 2004).

Status of CBFEWS: Insights from the Field

We found[1] that the communities of Narayani basin were having three major limitations in the flood management practices: 1) very short lead-time, 2) poor and time consuming communication and information dissemination system and 3) inadequate level of response preparedness against flooding. To overcome some of these constraints, communities implemented a project called the 'watch and warn system' in Bhandara village of Chitwan in 2002 with the construction of a 40-meter-tall iron angle tower, fixed with a ladder and a roofed platform from where a watch person could monitor the river upstream. The community people appointed one individual flood monitoring for the monsoon period, especially from the month of July to August every year. And then, the connection between the upstream river gauge stations including the telemetric system of DHM and the community was established at later stages. The CBFEWS has also been set up in collaboration with District Disaster Relief Committee in the Devchuli, Divyapuri and Pragatinagarin Nawalpur/Parasi for disseminating warning information to the communities, various agencies responsible for disaster management and district-level authorities (http://www.hydrology.gov.np/#/community_outreach?_k=r262js). The DHM has also set up a number of meteorological stations, hydrological stations and real time data stations (see Figures 1 and 2 for details).

However, the coverage of the DHM system is inadequate and there are a number of limitations of CBFEWS.[2] The end-users shared that they often did not get information promptly. The findings suggested that alert messages communicated for warning through the governmental channel are slow and often unreliable. The community gauge readers often ignore their voluntary responsibilities and the upstream-downstream communication linkages are very weak.[3]The data suggested that the communities encountered floods almost every year and that rivers' (East Rapti and Narayani) beds are gradually rising due to increased sediments deposited by the rivers. The communities shared their grievances that the lead time used to be often very short from 15 to 30 minutes and in rare cases it was extended to 1 hour and in some cases they would receive the information even after the flood had actually occurred affecting transportation and mobility, educational, cultural and socio-economic activities; causing difficulties in delivery, communication, and other human errands.[4]This has forced the basin to be

[1] Composite summary information from the data collected in Khairahani Municipality.
[2] Analysis of data collected from the field.
[3] Analysis of data collected from the field.
[4] Interview with DMC member (Kadiran Ali Ansari) in Nawalparasi, 28 November 2020, Male1.

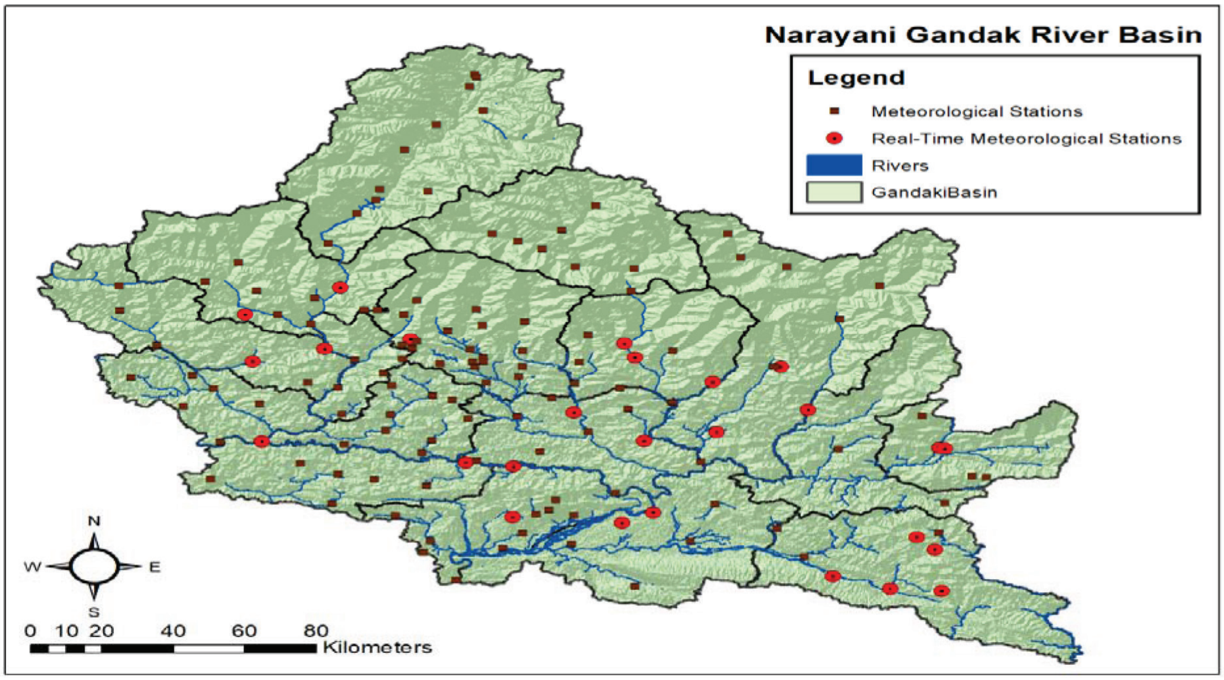

Figure 1: Meteorological stations and real-time meteorological stations of Narayani/Gandak basin. Source: Adapted from the data of Flood Forecasting Division, Department of Hydrology and Meteorology, Nepal, Available at: http://www.hydrology.gov.np/#/?_k=u35v0g

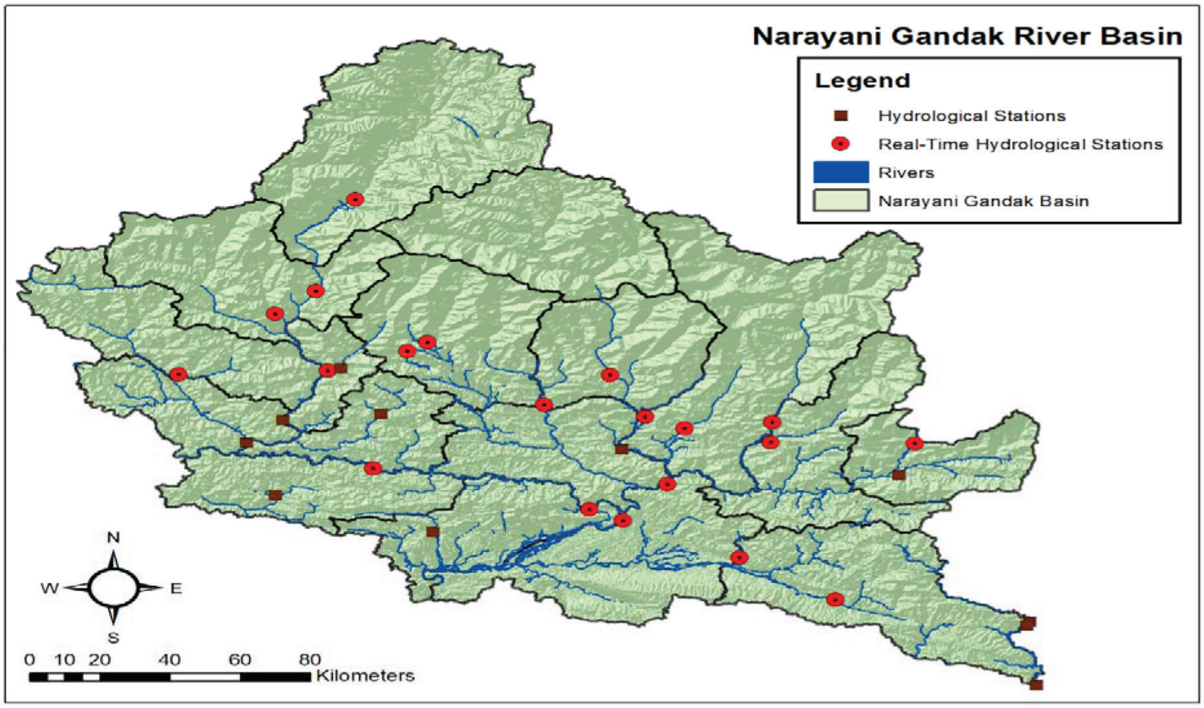

Figure 2: Hydrological stations and real-time hydrological stations of Narayani/Gandak basin. Source: Adapted from the data of Flood Forecasting Division, Department of Hydrology and Meteorology, Nepal, Available at: http://www.hydrology.gov.np/#/?_k=u35v0g

one of the most dangerous flood-impacted basins of Nepal (*Onlinekhabar*, 27 August 2021). In sum, the findings suggested that adequate responses are required for efficient and timely EW communications, stoppage of soil erosion and prolonged inundation, access to crop insurance policies, diverse training for elevated human skills building to make communities flood resilient, and access to alternative livelihood options because these are still crucial challenges for communities of Narayani basin.

Challenges and Prospects for CBFEWS in Narayani Basin

A well-designed, managed and implemented CBFEWS system can save lives and minimise damage to property by increasing lead time to prepare and respond to floods on the ground level (ICIMOD, 2016; Pandey and Basnet, 2022). However, there existed a number of challenges and prospects for making flood-resilient communities in both upstream and downstream communities of the Narayani basin and beyond. The UNISDR (2009) and International Panel on Climate Change (IPCC, 2022) highlight that EWS means the set of capacities required to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss (UNISDR, 2009). Local residents are the first disaster responders, and communities are the primary bulwarks against disasters (Harris et al., 2018; Pandey, 2019), and the UNISDR (2009) and the HFA (2005-2015) elaborate that a people-centered CBEWS must comprise four key elements: 1) Risk assessment and knowledge; 2) Risk monitoring and warning; 3) Risk information communication and dissemination; 4) Capacity building for Response. These four interconnected elements are an integral aspect of CBFEWS and these must be made available to counter flood-induced challenges and community flood-resilient prospects. If only one element is lacking, communities still become highly vulnerable (Pandey et al., 2020), therefore, we now contextualise these four elements in our study area to explore the challenges and prospects of CBFEWS.

The first element of UNISDR is 'risk assessment and knowledge' which refers to communities' awareness and understanding of hazards and vulnerabilities, however, communities in Chitwan and Parasi did not possess an adequate level of awareness about potential hazards and their vulnerabilities for their own safety and security against floods. For example, people do not have a clear understanding of safe settlement zones and risk settlement zones and when there is a flood, people go to the flooding river to catch fish and floating timber in the river instead of following safety measures to safeguard them against the impending floods (Pandey & Basnet, 2022).[5] The second important element of flood early warning system is 'risk monitoring and warning' however the research suggested that although the existing CBFEWS integrated with real time data are mostly functional, their number in terms of coverage is sparse and at times they suddenly get interrupted during rainy seasons due to their reliance on solar battery. In addition, gauge readers are also not well trained and are voluntary. They do not become fully committed to their terms of reference of the job to observe the river gauges and river levels in order to timely warn communities when water levels of the river are rising. Timely communication of flood alerts provides lead time to communities for evacuation to safer areas. However, the constraint is that voluntary gauge readers do not regularly update and inform community people about the impending floods. And the DMC members clearly acknowledge these limitations, however, they do not have any alternative to incentivize the gauge readers in order to make them work professionally.

The third important element of CBFEWS is 'risk information communication and dissemination'. People in the communities both in Chitwan and Parasi reported that the communication of early warning to the end-users was not efficient, effective and timely. They did not obtain alert messages in a timely manner. At times, the real-time data stations failed to function and even if they functioned, the bureaucratic communication system was slow and the communication was made only with key contacts of the community and often that they were not able to communicate on time to communities at risks because they were not equipped with technologies such as, inter alia, loud sirens, mike sirens, or car sirens. Mobile SMS were not circulated in bulk to every vulnerable individual and household. In addition to these perennial and Chure-originated rivers, the seasonal streams/rivers which suddenly start overflowing (flash floods) during monsoon to over flood communities in Chitwan and Parasi do not align with any EWS, and no initiatives have been taken against

[5] KIIs and FGDs summary of Chitwan and Nawalparasi taken from 25 of November to 30 of November 2020.

such dangerous seasonal rivers flash floods because until now the highlight is on perennial rivers like East Rapti and Narayani while huge damages are caused by seasonal rivers as well.

The fourth important element of CBFEWS is ‘capacity building for response’, which is one of the most important elements of making communities able to fight and resist floods and their impacts (Harris et al., 2018; Misanya and Øyhus, 2015; Shah et al., 2019). However, the fieldwork suggested that both software and hardware-related capacities were of grave concern in the communities. In software aspects, for example, although DMCs were established in a few locations, most of the people in the communities did not know about the existence of CBFEWS and the communities’ river gauge readers communicated only to the key persons of the society who often seemed to be unable to share information among all the individuals of the communities on timely manner: right time, the right information, the right way of dissemination and right way of making responses. In the hardware aspects, when the communities had to evacuate for safety, they did not have safe places available with basic facilities. The fourth element needs to be robustly strengthened because even if we have functional ‘risk assessment and knowledge’; ‘risk monitoring and warning’; ‘risk information communication and dissemination’ systems in place but vulnerable people do not have safe hideouts during emergencies, timely alerts do not help them from saving lives, livestock and property. Early warning literature often highlights the first three elements, considering that the fourth element may be taken for granted but in Nepal, the availability of the fourth element is very crucial to make communities flood resilient.

The analysis of data demonstrated that the communities studied had more challenges than prospects at present. Communities were found to be not well prepared in terms of software aspects and not equipped in terms of hardware aspects as they do not have flood resilient gears such as walkie-talkies, sirens, life-jackets, civil defense kits and well trained gauge readers. Also, the communities studied had a high level of faith in techno-engineering. This evidence indicated that implementation of a more people-centered preventive approach to disaster risk as suggested in the HFA along with the Sendai Framework and massively revised EW tools and communication techniques in the communities of Narayani basin and elsewhere in Nepal can only contribute to SDG goals 11 and 13 related to sustainable communities and stabilized climate system.

Conclusion

Extreme flood events are more likely to occur with domino effects of water-induced disasters, making communities in developing countries more vulnerable to floods and other disasters. An efficient and effective warning system is crucial for making communities flood resilient however the communities of Narayani basin have encountered a number of prospects and challenges and unless ‘community capacity for response’ is also strengthened, early warning alone cannot protect against losses and damages. The challenges of CBFEWS included poorly built and fragmented types of EWS, lacking robustness and full functionality. The sustainability of CBFEWS also questionable as these exist in line with the project implementation of NGOs or INGOs. Once the project implementation phases out, the sustainability question arises. The challenge aspects also demonstrated other limitations such as having a robust EWS does not necessarily guarantee that communities are flood resilient because most of the communities in the study sites were more vulnerable because they lacked ‘response capacity’ even after they obtained alert messages in a timely manner.

At present, the existing warning system in the basin is not reliable and cannot contribute to building flood-resilient communities. The system is also incomplete because the existing coverage of the DHM system is inadequate and even after having received the flood early warnings the people of communities do not have any choice to go to safer places but to wait for flood-induced consequences. Three key components i) very short lead time; ii) poor and time consuming communication and information dissemination system; and iii) inadequate level of response preparedness against flooding demonstrated the fragile status of existing CB FEWS are major limitations.

However, understanding challenges provide an opportunity for the revitalisation of CBFEWS along with new methods and approaches. One of these identified was the amalgamation of CBFEWS with an automated DHM system through multiple institutions for multi-layer communications. Renewed efforts and investments are required for building resilient communities. We recommend that at least five components must be done to make Narayani basin communities flood resilient, which include: 1) installation of more reliable EW technologies for wider coverage and their regular maintenance to keep them fully functional, 2) promotion of community-based EWS which means opening avenues for community flood monitoring system and people to people communication as it is very crucial, when and if automatic systems do not work, 3) timely communication of the alerts without too much of red-tape system to provide longer lead time, 4) adequate preparedness and response training, and 5) access to all the information, training, upstream-downstream networks, alternative income sources and flood-proof insurance systems.

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