THE GOVERNANCE OF NEPAL'S FLOOD EARLY WARNING SYSTEM

OPPORTUNITIES UNDER FEDERALISM

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Acronyms

ADPC	Asian Disaster Preparedness Center
CDMC	Community Disaster Management Committee
CWC	Central Water Commission
DDMC	District Disaster Management Committee
DEOC	District Emergency Operation Centre
DHM	Department of Hydrology and Meteorology
DIPECHO	European Commission Humanitarian Aid Department's Disaster Preparedness Programme
DRRM	Disaster Risk Reduction and Management
EWS	early warning system
GLoFAS	Global Flood Awareness System
ICIMOD	International Centre for Integrated Mountain Development
LDMC	Local Disaster Management Committee
LEOC	Local Emergency Operations Centre
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoFAGA	Ministry of Federal Affairs and General Administration
MoFALD	Ministry of Federal Affairs and Local Development
MoHA	Ministry of Home Affairs
MoIAL	Ministry of Internal Affairs and Law
MoSTE	Ministry of Science, Technology and the Environment
NCRS	Nepal Red Cross Society
NDRRMA	National Disaster Risk Reduction and Management Authority
NEOC	National Emergency Operations Centre
NGO	non-governmental organisation
NOAA	National Oceanic and Atmospheric Administration
PDMC	Provincial Disaster Management Committee
PEOC	Provincial Emergency Operations Centre
UNDRR	United Nations Office for Disaster Risk Reduction

Executive summary

Flood early warning systems (EWS) are extremely complex, with multiple layers of communication and relationships between stakeholders, across different scales of governance. With the development of weather and flood forecasting models, Nepal's EWS has advanced significantly in recent years, but warnings can still fail to reach downstream communities in the low-lying Tarai plains.

Recent governance reforms devolve considerable authority for delivering EWS services to municipal governments. This should result in improved communication of warnings and enhanced flood response capabilities. However, critical challenges and questions remain around whether municipal governments will have the funds and technical capacity to do this.

This paper looks at the institutional mechanisms for assessing, monitoring, communicating and responding to flood risk information and warnings across three river basins in eastern and western Nepal, and identifies opportunities for enhancing these services under the new federal structure.

Decentralising government responsibilities and resources could bring huge benefits, including higher-resolution risk maps, investment in local monitoring stations, a greater focus on response planning and engagement with communities and marginalised groups. To ensure that these benefits are realised, community-based and non-governmental organisations (NGO) initiatives will need to be better integrated within the national system, and local agencies will need substantial training and capacity development to meet their new responsibilities.

1. INTRODUCTION

IMAGE: FLOOD-PRONE CHITWAN PROVINCE. PICTURE TAKEN BY: NARESH NEWAR/THOMSON REUTERS FOUNDATION

An EWS is defined by the United Nations Office for Disaster Risk Reduction (UNDRR) as an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, and communication: 'Effective "end-to-end" and "people-centred" early warning systems may include four interrelated key elements: (1) disaster risk knowledge based on the systematic collection of data and disaster risk assessments; (2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (3) dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and (4) preparedness at all levels to respond to the warnings received. These four interrelated components need to be coordinated within and across sectors and multiple levels

for the system to work effectively and to include a feedback mechanism for continuous improvement. Failure in one component or a lack of coordination across them could lead to the failure of the whole system' (UNISDR, 2017). An EWS can also be categorised according to the source of information – forecast-based or real-time based. The former can help in mobilising resources before and during a disaster, whereas the latter tends to be more reactive. For example, in Nepal a three-day forecast from the Department of Hydrology and Meteorology (DHM) can trigger action by national and provincial stakeholders to anticipate and prepare for floods, whereas information from local gauge readers with a four- to five-hour lead time can enable communities to evacuate safely.

Flood EWS have tended to focus on monitoring and communicating water levels, but do not consider response capabilities or communication with downstream communities. International frameworks and agreements[1] have pushed for EWS to be 'people-centred', focusing on the needs and priorities of people living in flood-prone areas. Since the early 2000s, NGOs have supported this agenda by creating community-based EWS (Smith et al., 2017), but these have generally run in parallel to official systems. In recent years, there has been a concerted effort to connect with national systems and help national agencies (such as the National Emergency Operations Centre (NEOC) in Nepal) to communicate messages and build response capacities at local level.

How these different institutions and systems contribute to, and take responsibility for, flood EWS through a period of changing governance in Nepal is the subject of this paper.

1 The Sustainable Development Goals (SDGs) (Target 3.D), the Sendai Framework for Disaster Risk Reduction Target G and the Paris Agreement.

1.1 Methodology

The paper analyses institutional arrangements for assessing flood hazards, and for monitoring, communicating and responding to early warnings; examines the interaction and coordination between government and non-government agencies delivering these services; and makes recommendations for how these arrangements could be strengthened under Nepal's new federal system of governance.

The study builds on BRACED research looking at the role of NGOs in supporting climate services (Jones et al., 2016; Kirbyshire and Wilkinson, 2018.). Drawing on lessons from EWS in Nepal over the last 15 years, the authors examine institutional arrangements, coordination, communication and decision-making processes in flood EWS. The analysis centres around four key elements of an EWS (UNISDR, 2006):

1. **Risk knowledge –** systematically collecting data and undertaking risk assessments.
2. **Monitoring and warning services –** developing hazard monitoring and early warning services.
3. **Dissemination and communication –** communicating risk information and early warnings.
4. **Response capability/capacity –** building national and community response capabilities.

An additional element in the study captures:

5. **The governance arrangements and institutional relationships** that shape flood EWS.

The research was designed in partnership with regional and country stakeholders, building on issues identified through BRACED research and engagement activities, including:

- A workshop on 'Strengthening local-level EWS with improved local-level governance and gender and diversity inclusion', held in November 2017.
- Findings from a scoping report on 'Strengthening flood early warning in Nepal in the context of the new constitution', which includes an assessment of existing and new polices and governance structures for flood early warning, preparedness and response.
- A workshop on 'Strengthening flood early warning in Nepal in the new governance structure' and a scoping trip to Provinces 5 and 6 in the Tarai in October 2018.

Research questions were designed to focus the study on the different roles and responsibilities of, and relationships between, relevant stakeholders, how these are changing, and the potential outcomes for flood EWS in Nepal:

1. What are the major institutional blockages to an effective flood EWS in Nepal, and how can they be overcome?
2. How can horizontal and vertical coordination between different actors (including vulnerable communities) be improved and sustained for effective flood EWS across scales?
3. Following the federal governance restructure and the modernisation of hydro-met observations and services, how can the government of Nepal and non-government actors contribute to flood EWS?

The research looked at three river basins: the Kankai basin in the east and the Karnali and Babai basins in the west. All three sites were affected by monsoon floods in 2017 and 2018. The Karnali, a transboundary river between China, India and Nepal, is the longest river in Nepal, with a total catchment area of approximately 45,000km^2. The Babai river basin is a tributary of the Karnali, with a total catchment area of around 3,380km^2. The Kankai basin, which starts in the Mahabharat range in eastern Nepal, covers an area of 1,284 km^2. Short-duration and high-intensity precipitation in the basin frequently leads to flash floods downstream.

The study used the following methods to help answer the research questions outlined above:

- Stakeholder mapping of key state and non-state actors working on EWS in Nepal at national, district and community levels (under the previous and new governance structure). This identified institutions, communication flows and gaps in communication (and/or interpretation of information), resource flows, response capacities and decision-making.
- Semi-structured interviews at national, district and municipal levels, based around the five elements of an EWS, with a focus on elements 3–5. The research team tried to ensure that an equal number of women and men were selected as key informants. Interviews were conducted in Nepali, with an interpreter providing real-time translation into English.
- An EWS assessment framework, developed by the Asian Disaster Preparedness Center (ADPC) (Dutta and Basnayake, 2018), to help assess different components of the flood EWS (under the five key elements of an EWS highlighted above) in the Kankai, Babai and Karnali basins. This assessment was conducted at national and district levels through a structured

questionnaire that allowed participants to consider and rank the functions of the EWS in question.

- Analysis of experiences of flooding among women and men of different ethnicities/castes in Bardiya district (Lovell et al., 2019). This includes women and men from disadvantaged groups (the ethnicity/caste groups that belong to the categories of Dalits, disadvantaged Janajatis and disadvantaged Madhesis) and women and men from other groups (all caste/ethnic groups that do not fall under the category of disadvantaged groups). The fieldwork took place in Bardiya district using a household survey to understand people's resilience to natural hazards and climate change, based on four components of resilience: economic, social, infrastructural and institutional. The full methodology and survey results are available online.[2]

2 See www.odi.org/publications/11339-building-resilience-all-intersectional-approaches-reducing-vulnerability-natural-hazards

2. GOVERNANCE REFORMS AND THE EVOLUTION OF THE FLOOD EARLY WARNING SYSTEM

IMAGE: NEPALGANJ AT HIGH WATER. PICTURE TAKEN BY: ::ERWIN, FLICKR

Recent governance and policy reforms in Nepal have restructured the state into three levels of governance (federal, provincial and local). Powers and functions have been devolved to seven autonomous provinces and 753 local government authorities (Metropolitan Cities, Sub-Metropolitan Cities, Municipalities and Rural Municipalities).

The Disaster Risk Reduction and Management (DRRM) Act of 2017, which replaced the 40-year-old Natural Calamity (Relief) Act (1982), opened the way for decentralising responsibilities and resources for assessing, monitoring, communicating and responding to flood risk information and warnings. At the federal level, a National Disaster Risk Reduction and Management Authority (NDRRMA) is to be established under the Ministry

of Home Affairs (MoHA). The Authority will carry out functions[3] related to disaster management in coordination with the NDRRM Council, Executive Committee and other government ministries; monitor whether ministries are meeting their DRRM responsibilities; and provide cross-sectoral leadership for DRRM. The NDRRMA is also intended to lead on the establishment of a national disaster management information system, and to operate and manage the NEOC, overseeing the dissemination of and response to early warnings and the coordination and mobilisation of search and rescue and relief.

In addition to the DRRM Act (amended in 2019), DRRM governance in Nepal is underpinned by the National Policy for Disaster Risk Reduction (2018) and the accompanying Disaster Risk Reduction National Strategic Plan of Action (2018–2030). Responsibility for delivering on these national plans currently falls to MoHA and the NEOC (although this responsibility would likely move to the NDRRMA once it is formed). In the new federal structure, MoHA's ability to implement the national DRRM plan will depend on action taken at provincial and local levels, and it is unclear how the national plan will relate to plans developed and budgeted for at provincial and local level. There are also questions around the role, remit and management of the NEOC, and whether federal entities with greater technical understanding of disaster risk reduction, flood forecasting and EWS (such as the NDRRMA and the DHM) will provide coordination across provinces and support capacity (e.g. the development of standard operating procedures (SOPs)) at sub-national level.

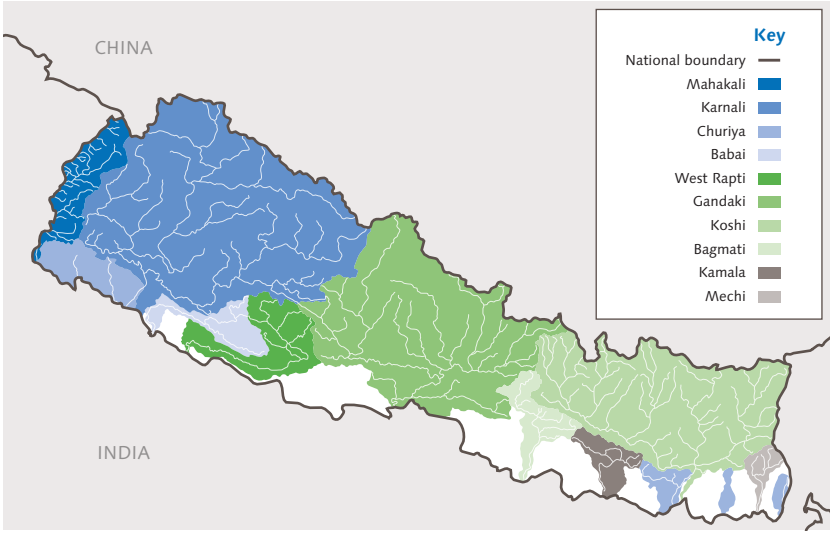
3 Chapter 4 of the NDRRMA Act details the remit and responsibilities of the NDRRMA.

The National Policy and Strategic Plan of Action cover the policy aspects of EWS. Policy 7.42 states that 'Natural hazards like flood, landslide, drought, thunderbolt, windstorm, hot wave, cold wave, fire, epidemics and glacier lake outburst will be monitored and forecasted regularly and Forecast-Based Preparedness and Response Plans will be developed and implemented by developing early warning systems'. The Strategic Plan of Action includes 'Developing [a] Multi-Hazard Early Warning System for Disaster Preparedness' under priority area four on 'Enhancing Disaster Preparedness for Effective Response and to "Build Back Better" in Recovery, Rehabilitation and Reconstruction', and defines strategic activities for the short, medium and long term. While it also sets specific indicators and targets related to EWS, directives or guidelines for establishing, operating and managing multi-hazard EWS are lacking. There is an ongoing discussion within MoHA to produce national guidelines clarifying roles and responsibilities in this regard.

2.1 Evolution of the flood early warning system

Nepal is a mountainous country with a total land area of 147,181km^2 covering five physiographic regions: the Tarai, Siwaliks, Middle Mountains, High Mountains and High Himalayas. Elevation varies from 60 metres above sea level in the south to 8,848 metres in the north. The country's fragile geology, rugged terrain and intense monsoon precipitation mean that it is prone to floods, landslides and glacial lake outburst floods. Most of the country's more than 6,000 rivers and streams flow from the northern mountainous region towards the southern Tarai plains, generally with high velocity due to the high river gradient. In 2017, heavy monsoon rains triggered floods and landslides that affected some 1.7 million people across the Tarai (Lovell et al., 2019: 28).

Figure 1: Major river basins in Nepal



Flood early warning work began in Nepal in the early 2000s, with the support of Practical Action, the International Centre for Integrated Mountain Development (ICIMOD), the European Commission Humanitarian Aid Department's Disaster Preparedness Programme (DIPECHO) and other organisations (Smith et al., 2017). The system relied on manual watch stations, with river level observations reported to the DHM manually. This 'watch and warn' system generated some degree of early warning for communities living downstream, allowing people to evacuate themselves and their possessions to higher ground, but lead times were short and the system was prone to reporting gaps and errors because it required someone to manually monitor and report readings. Automatic collection and transmission of rainfall and river level data began in 2008.[4]

4 See Smith et al. (2017) for a more detailed overview of the development of EWS in Nepal, including efforts to increase early warning lead time.

With the development of weather and flood forecasting models, EWS in Nepal has advanced significantly in recent years, but warnings can still fail to reach communities, for three main reasons:

1. Early warning and forecast information is not detailed enough to accurately predict the precise location and timing of floods. The river system is very dynamic, flood hazard maps are often inaccurate and monitoring stations are sparse or absent, particularly on medium/smaller rivers and in more mountainous terrain. In addition, there is limited understanding of risk at all levels, from national to community.

2. There are barriers to accessing and understanding warning messages and forecast information. For example, the DHM daily bulletin is not tailored to a non-technical audience, warning messages do not reach everyone in at-risk communities, and even when they do they are not always understood or acted on (see Brown et al., 2019; Budimir et al., 2019, in review).

3. Response capability is greatly influenced by whether communities (as first responders) have developed plans, received training and are confident enough to carry out those actions when they receive a warning message. This is heavily reliant on local NGOs and short-term projects.

Pre-federalisation, the DHM's responsibilities ended at the release of a warning, and responsibility for ensuring that warning messages reached everyone in the community was shared across multiple actors, with no institutionalised feedback mechanisms to evaluate whether warning messages were accessed, understood or used. Although MoHA is the mandated agency for building response capability, no institution in Nepal worked seriously to ensure this, and no country-wide, regular government-mandated training or capacity-building structures were in place.

2.2 Institutional arrangements for EWS

Since 2017, important institutional changes have created new roles and responsibilities for flood early warning in Nepal. The DHM is still the main organisation responsible for hydrological and meteorological activities, with a remit for hazard mapping and monitoring, flood forecasting and early warning. During the recent governance restructuring, the DHM moved from the then Ministry of Science, Technology and Environment (MoSTE) to the Ministry of Energy, Water Resources and Irrigation (MoEWRI). Within the DHM, responsibility for EWS has shifted from a small flood forecasting section to a larger flood forecasting Division, accompanied by an increase in staff. Each provincial administration is responsible for developing and implementing its own DRRM policy and plan, including the allocation of funds. Local governments develop Local Disaster Management Plans, and provinces can establish their own Provincial Emergency Operation Centre (PEOC).[5] These fall under the remit of the Ministry of Internal Affairs and Law (MoIAL), and report to the Provincial Disaster Management Committee (PDMC). As at July 2019, five (out of seven) PEOCs had been created, although they were not operational. Each local government is mandated to establish Local Disaster Management Committees, which run Local Emergency Operation Centres (LEOCs).

Figure 2 shows the organisational hierarchy, relationships and lines of communication for EWS, before and after recent governance reforms.

5 The Act does not specifically mention PEOCs, though there is a clear provision for establishing LEOCs, which will be managed by Local Disaster Management Committees.

Figure 2: Roles and responsibilities pre- and post-federalisation

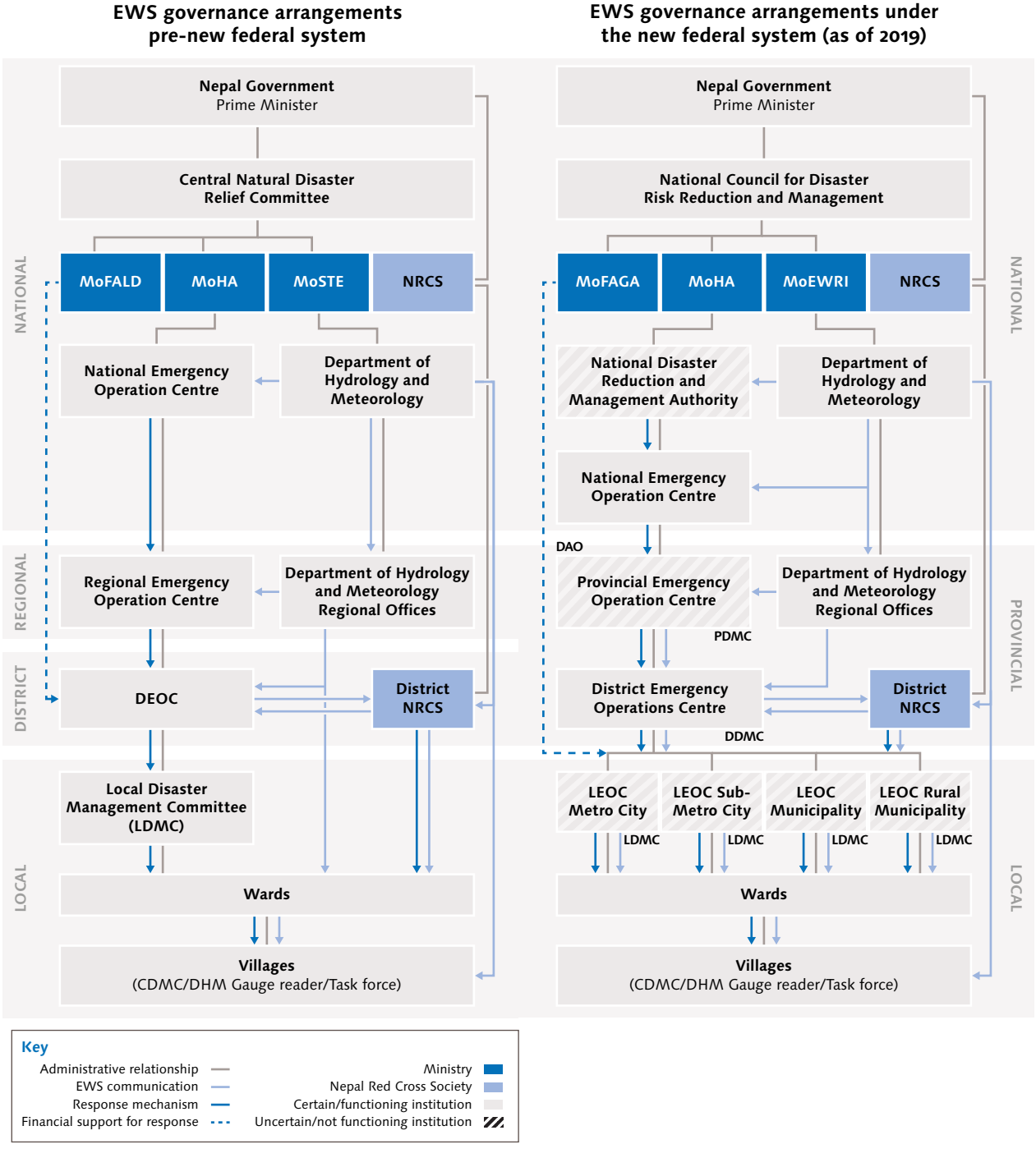


Figure 2: Acronyms

CDMC	Community Disaster Management Committee
CNDRC	Central Natural Disaster Relief Committee
DAO	District Administrative Office
DEOC	District Emergency Operations Centre
DHM	Department of Hydrology and Meteorology
LDMC	Local Disaster Management Committee
LEOC	Local Emergency Operation Centre
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoFAGA	Ministry of Federal Affairs and General Administration
MoFALD	Ministry of Federal Affairs and Local Development
MoHA	Ministry of Home Affairs
MoSTE	Ministry of Education Science and Technology
NCDRRM	National Council for Disaster Risk Reduction and Management
NDRA	Natural Disaster Relief Act
NDRRMA	National Disaster Reduction and Management Authority
NEOC	National Emergency Operation Centre
NRCS	Nepal Red Cross Society
PEOC	Provincial Emergency Operation Centre
REOC	Regional Emergency Operation Centre

Note: The Natural Disaster Relief Act (1982) established a CNDRC to formulate and implement disaster relief work. MoFALD, MoHA and MoSTE were the main ministries involved in EWS. The NRCS worked closely with government from national to local level. REOC and DHM regional offices supported the DEOC, with the district-level NRCS office playing an auxiliary role. The LDMC worked with DEOC to respond to disasters at ward and village levels, in cooperation with CDMCs, DHM gauge readers and task forces within each village. The Disaster Risk Reduction and Management Act (2017) set up the NCDRRM (replacing the CNDRC). At the national level, MoFALD is now MoFAGA. MoHA remains the same, and the NDRRMA (under MoHA), once it has been set up, will work closely with the NEOC. The MoSTE has changed to MoEWRI, and DHM has been placed under the MoEWRI. At the provincial level, DHM regional offices communicate with the PEOC and DEOC. There is a new stakeholder – the LEOC – operating at municipal level. The LEOCs will work with different wards and the CDMCs, DHM gauge readers and task forces in villages.

3. GOVERNANCE OF FLOOD EWS

IMAGE: WATER DIVERSION FOR AGRICULTURE NEAR BARDIA NATIONAL PARK, NEPAL. PICTURE TAKEN BY: OLAF ZERBOCK, USAID

The new federal structure distributes power and resources to sub-national and local levels (urban and rural municipalities), offering an opportunity to improve all components of flood EWS in Nepal. This section reviews the roles and responsibilities of, and coordination between, the government and NGOs, and offers suggestions regarding how EWS can be improved under the new federal structure. Roles and responsibilities are assessed at the national, sub-national and local levels – in the Karnali, Babai and Kankai river basins – including the role of NGOs in developing community-based EWS.

3.1 Risk knowledge

The DHM in Kathmandu is responsible for preparing flood hazard maps using hydraulic modelling techniques, with (limited) support from regional offices. The DHM maintains a library of flood hazard maps for most major river basins in Nepal. These can be used by the central DHM office to get a sense of areas likely to be affected by flooding when river levels begin to rise or pass a certain threshold. These flood hazard maps can be accessed by DHM regional offices through the DHM website. However, national-level maps are not widely used by communities or decision-makers below the regional office level – most use maps produced locally by NGOs or community projects. Current flood hazard maps used by the DHM are based on freely available digital elevation data acquired during 2001,[6] which do not account for recent changes to the river system due to the movement of sediment during the monsoon or recent embankment construction (Sinclair et al., 2017). The use of outdated maps limits the effectiveness of flood risk management planning and could undermine confidence in the reliability of flood hazard maps (Delalay et al., 2018).

No actor is mandated to collect systematic vulnerability and exposure information at national scale. The DHM is not involved in developing risk maps showing hazards, vulnerability and exposure at the local level. Ad hoc activities at local scale create vulnerability and exposure information and convert this into risk maps, but this is mostly driven by NGO projects, such as the Zurich Flood Resilience Alliance participatory digital mapping of exposure information on Open Street Map (Wei et al., 2018).

6 Some flood hazard maps for river basins use updated Digital Elevation Models from 2013, 2014, 2015 and 2016, but this is not consistent across the whole of Nepal.

Validation of flood extent after a flood event is not systematically carried out to evaluate accuracy and calibrate hydrological and hydraulic models in order to improve flood hazard maps. There is no systematic feedback from district to national level to improve hazard maps (Government of Nepal, 2018).

Risk knowledge for the Kankai, Karnali and Babai river basins is limited by the lack of connection between the 'official' hazard maps produced by the DHM and participatory flood vulnerability maps produced by the Nepal Red Cross Society (NRCS). DHM maps are based on flood modelling, but do not seem to be used for decision-making at the local level: the gauge reader at Kankai station, for example, did not know that a flood hazard map existed. Vulnerability maps have detailed information on population, disabilities and gender and are used for planning evacuations, but lack information on flood extent, depth and velocity, and do not cover the whole basin. Produced as part of projects, they cannot be regularly updated or improved.

In the east of the country, the new local administrations are keen to increase their capacity to map flood risk. They collect data on the vulnerability and exposure of households at ward level, and will combine vulnerability information with the DHM flood hazard maps in the future, but this information is not yet digitised. Risk information is used for planning between agencies in western Nepal through a pre-monsoon workshop, using information available on river flood watch warning levels on the DHM website.

Since the floods in Karnali in 2014 and 2017 and Kankai in 2008 and 2017, risk knowledge in communities has improved significantly, albeit from a very low base, specifically with regard to what to do when early warning information is received (see Box 1).

Box 1: Risk knowledge in Bardiya district

Households surveyed in flood-prone communities in Bardiya district were asked whether they felt they lived in a safe location, and what kind of information they used to cope with disasters. Most respondents (67%) reported that their house was in a location that was not safe from disasters, while 18% thought they lived in a safe area. There are substantial differences in terms of access to formal information between men and women – only 33% of women, as against 77% of men, reported that they receive such information (Lovell et al., 2019).

Changes to the governance structure in Nepal may not directly affect the work DHM does nationwide – it is expected that this will continue under the new system. However, greater resourcing and accountability at provincial and local level does provide an opportunity for more sub-national investment in and use of more detailed hazard and risk maps, which would help build trust and ownership, educate communities and enable better decision-making. Validation of models and hazard maps could also be done by local government using the new resources and mandate.

3.2 Monitoring and warning

The DHM is responsible for a range of manual and automated rain and stream gauges across the country, and for the production of national and sub-national forecasts (including probabilistic forecasts) and the incorporation of regional and global forecasts, e.g. the Global Flood Awareness System (GLoFAS) (Smith et al., 2017). All stream gauges fall under the authority of the DHM, which provides a payment to manual gauge readers. The DHM is in the process of upgrading the network of automated river gauges (Government of Nepal, 2018).

A warning is triggered when river gauge readings exceed pre-agreed thresholds, prompting the DHM to release an official alert. Monitoring stations in each river basin have predetermined warning and danger levels for 'watch', 'warning' and 'evacuation' (or 'normal', 'alert' and 'danger'), based on flood hazard mapping in that location. When a level is exceeded, alerts are sent to the DHM. During the monsoon season, the alert system is monitored 24 hours a day by the DHM, where the bulletins are displayed constantly, and an alarm sounds in the office if warning and danger levels are reached.

At the district level, the District Emergency Operations Centre (DEOC) is responsible for monitoring the flood situation, based on the DHM's water level, rainfall and discharge information. Officials communicate warning and danger levels provided by the central DHM, but do not use any weather forecast information for forecast-based planning in the district. The DHM regional office in Nepalgunj has little climate and hydro-met modelling expertise, and interviewees there highlighted the need for capacity-building and training to understand advanced hydro-met data and technology, as did other district-level actors. Another major concern raised was the lack of funding to pay gauge readers and maintain stations.

Measurements from automated river gauges are recorded regularly and are reliable: rainfall and water level information is collected every 15 minutes. This is transmitted to the DHM central server, where it is combined with models provided by research institutes (such as ICIMOD and Regional Integrated Multi-hazard Early Warning System (RIMES)) and satellite data (the US National Oceanic and Atmospheric Administration (NOAA) and others) to produce three-day flood forecasts. The DHM then issues warnings down to sub-national level through a bulletin, mobile phone messages (through mobile

network operators NCELL and NTC) and other media outlets. It also communicates with government actors responsible for early warning and emergency response, and shares information with the Central Water Commission (CWC) in India (see Box 2). Decisions on when to issue a warning are the remit of the central DHM, and are clearly linked to water level thresholds.

Box 2: Cross-border governance of the flood early warning system

By Gehendra Gurung

Floods in the Karnali River affect the plains downstream of Chisapani in Bardiya and Kailali districts, as well as neighbouring districts in India. River flow data from the last 30 years indicates that extreme flood events are becoming increasingly frequent. In 2014, a 1-in-100-year flood occurred. Prior to that, the largest recorded event was in 1983 (a 1-in-50-year event).

There is no formal real-time communication of flood information between the district authorities in Nepal and India. However, security forces across the border are in regular contact, and informally exchange information. Display boards have been installed at community disaster management centres and district disaster management offices in India to monitor real-time flood information for the Karnali River. The cross-border flood EWS network includes members of the community disaster management committee (CDMC), the Journalist Association, local business associations, humanitarian organisations (such as the NRCS) and NGOs. Because the network is informal there is no government representation. The network exchanges flood information using mobile phones and SMS. A communication chart with details of contact numbers has been prepared and shared. Network members from downstream communities in India also verify flood levels in Nepal with gauge readers by phone. Communities in India contact

their district/sub-district government authorities and regularly monitor flood levels at their local gauge station. If communities see the flood level in nearby stations rising, they inform their Panchayat leader (Pradhan) to get approval to disseminate the information to households using megaphones, sirens, door-to-door visits and flags.

Cross-border government-to-government flood information communication

Sharing of flood information between the governments of Nepal and India takes place formally at federal level. During a monsoon, information is shared between the DHM in Nepal and the CWC in Patna in India three times a day. The new federalised governance system in Nepal will have no significant effect on formal EWS with India, but it is not yet clear how informal interactions will be affected.

Monitoring and generating forecasts is the responsibility of the DHM, and this will not significantly change under the new federal structure. However, local administrations will be responsible for monitoring tasks such as station maintenance and paying gauge readers' salaries and will have to allocate resources to these activities out of their own budgets. It is not clear what these budget allocations will be, and it is likely that federal funding will still be needed to respond to major events – principally from the Ministry of Federal Affairs and General Administration (MoFAGA), previously the Ministry of Federal Affairs and Local Development (MoFALD).

If sub-national and local governments want to prioritise improving flood monitoring or establishing a local early warning system (particularly in smaller river basins), they will have to convince the DHM to expand the coverage of sensor networks in their area. Additional rainfall sensors could enhance the capabilities of the system, improving early warning at local levels. Under

federalisation there is likely to be increased variability between local administrations regarding how much they invest in disaster risk management and EWS, including budget allocations for improving local EWS infrastructure and resourcing (depending on how much is funded by the DHM federally). Funding is currently limited.

3.3 Dissemination and communication

The DHM is responsible for issuing flood warnings (Government of Nepal, 2018). The central Kathmandu office issues two formats of warning information: daily bulletins published on the DHM website (www.hydrology.gov.np) and sent to relevant stakeholders, such as federal government agencies, humanitarian response agencies and local governments; and SMS messages disseminated to the general public. This will not change in the new system. The daily bulletin contains text-based information on flood hazards, highlighting river basins and districts at serious risk of flooding, produced in Nepali and sent via email and fax to national, sub-national and local stakeholders, including the media. The bulletin is also shared through the DHM website, Twitter, phone/SMS, radio and Facebook (Nepal Flood Alert). DHM regional offices support dissemination to sub-national and local actors, including the DEOC, the NRCS, municipalities and CDMCs in each ward. The DHM's role ends at this point in the process. In the previous structure, the DEOC played a significant role in coordinating local-level response, distributing warnings to district-level clusters, the police, response teams, the army and community focal points, such as the chair of the CDMC.

DHM dissemination and communication methods have improved significantly in recent years, and they are a trusted source of information for the authorities and the public, but problems remain in ensuring that appropriate information reaches end-users in ways and formats tailored to their needs (Kafle, 2017; Government of Nepal, 2018). There are no methods currently in place for recalling warning messages or for tracking and evaluating whether warnings have been received, effectively communicated and resulted in appropriate action. Nor are there systems for gathering and responding to feedback from the local or district level to national level to improve the dissemination and communication system (Government of Nepal, 2018).

The SMS text alerts are credited with saving many lives, particularly in the 2017 monsoon floods. However, there are still barriers to understanding and using SMS warnings, including issues related to literacy, language and access (particularly for marginalised groups such as women and ethnic minorities) (Budimir et al., 2019, in review).

Flood warning mechanisms in the Kankai basin are generally thought to be good. There are a large number of communication channels and bottom-up and top-down information flows, which means that people are made aware of flood warnings, though at times the multiple flows of information can be confusing. The regional DHM office receives a bulletin by fax and via the central DHM website, and the gauge reader provides a water level reading (every hour during the monsoon season, to the DHM and to CDMC members). After receiving the bulletin from the central office, the DHM regional office disseminates the information to the DEOC, which works with the NRCS, CDMC and task force

groups[7] in each ward. In the future, this will also go through the PEOC at the provincial level, and the LEOC at the local level.

The DEOC plays a pivotal role in communicating early warnings to sub-district level, but it is not clear what will happen to this institution under federalisation, or how any changes will affect the chain of analysis and decision-making from observation to early warning. One challenge in terms of dissemination is that there is no official communications plan at the district level, so there is no standard practice in terms of how government officials communicate the information they receive from the DHM; NGOs are the only entities that have developed SOPs for communicating flood information. The DHM is planning to improve its SOPs for flood early warning communication at the local level, but has said that it needs more support from NGOs in terms of best practice.

At the local level, people seem to trust and give credence to the messages they receive directly from the DHM, though some will not receive these messages because they do not have a phone, radio or internet access (see Table 1). Local-level early warnings appear to work better, but only where there is NGO engagement: once an early warning has been received, CDMC leaders disseminate the information through a siren and flag. Where there are fewer or no NGOs, as in Tappu (downstream) in the east, the first information to arrive in communities comes from the gauge reader (not from the government or NGOs). In many communities, illiteracy levels are high and people only understand early warning information if it is provided verbally.

7 A taskforce is a 'component of an early warning system. Under a flood early warning system, there are generally five taskforces (needs assessment; search and rescue; first aid; recovery; communication)' (Lovell et al., 2019: 23).

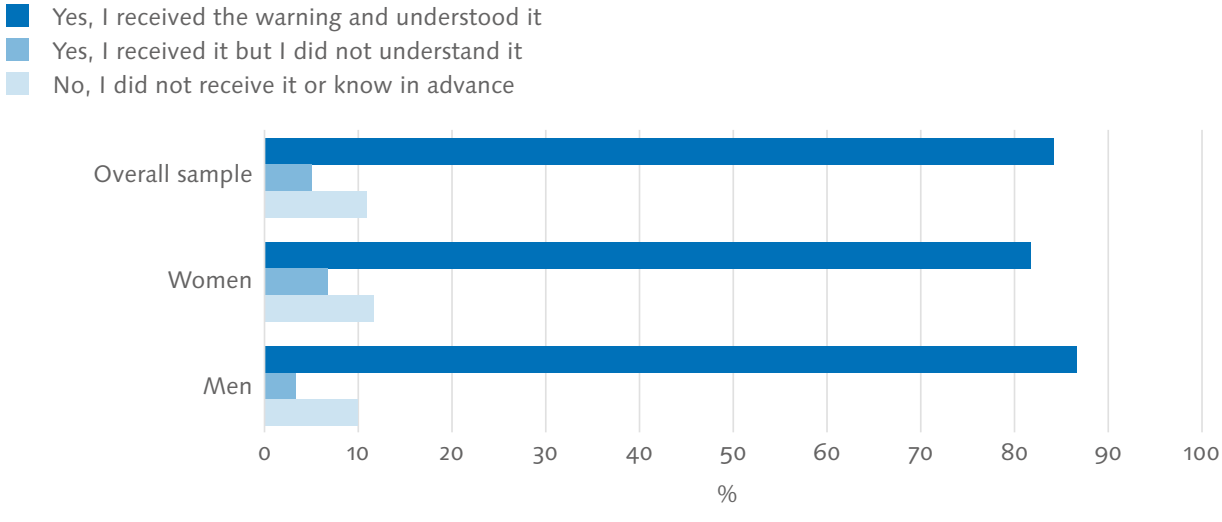
Table 1: Access to early warnings in Bardiya

CATEGORY	QUESTION	OVERALL SAMPLE	WOMEN	MEN	DISADVANTAGED GROUP	
					Women	**Men**
Access to communications technology	Do you have access to a phone you can use?	74%	62%	87%	56%	89%
Access to communications technology	Do you have access to a radio	39%	28%	50%	26%	51%
Access to communications technology	Do you have access to the internet?	13%	5%	22%	3%	20%

Note: The bold print highlights variables for which differences between groups are most pronounced (i.e. are statistically significant). Blue indicates a positive response (i.e. 'Yes' in answer to the question).

Source: Lovell et al., 2019.

Figure 3: Timeliness of warnings in Bardiya



Source: Lovell et al., 2019.

In the new government system, provincial and local government authorities will be key recipients of the daily bulletin and will need to use this to make decisions and take action within their jurisdictions. The content of the bulletin could be improved to make it easier to understand and use in decision-making (Budimir et al., 2019, in review). There is also an opportunity for provincial and local administrations to invest in and prioritise reaching households most at risk (Danish Red Cross, 2019).

3.4 Response capability

The DHM is responsible for disseminating flood risk information and early warnings, but not for ensuring that people receive, understand and respond to them. Response capacity has been one of the largest gaps in Nepal's flood EWS. Agencies such as the DEOC, the police and taskforce committees have difficulty interpreting the information in order to take suitable action, and no government agency has responsibility for raising awareness, carrying out training or developing SOPs for responses. There are examples of awareness-raising and capacity development in the river basins studied, but these are not comprehensive and only reach some communities. At the local level, response measures are coordinated by the District Disaster Management Committee (DDMC) but led by the Armed Police Force, with DDMC members distributing aid to communities. The NRCS and (I)NGOs have provided training, drills and awareness-raising, developed preparedness plans and identified evacuation routes in communities across the Kankai, Karnali and Babai basins, but this is done on an ad hoc basis, or by very proactive sub-national government officials. CDMC and the taskforce committees carry out first aid, early warning and search and rescue in communities where (I)NGO and/or NRCS projects have been implemented.

Local government response capabilities are weak, particularly in the east, where there is less NGO engagement. Stakeholders in the east described the low response capacity for the 2017 floods, particularly in defining evacuation locations and routes. There are safe places in communities, but not enough to accommodate all at-risk households, and there are no evacuation maps and few flood drills or simulations in the Kankai basin. Where drills have been conducted this has been as part of NGO projects, which rely on external funding. The NRCS is particularly stretched in Birtamod, with only six focal points to cover the whole district. In the 2017 floods, some 22 communities were left without any help.

Evacuation plans are more common in western districts, including flood drill simulations and training. Village taskforces are stronger than in the east because NGO projects are more common, but even so household survey respondents in Bardiya reported having very limited preparedness plans and a lack of evacuation routes and safe places (see Box 3).

Box 3: Flood response capacity in Bardiya district

Response capabilities depend on the availability of appropriate infrastructure, especially escape routes and shelters, as well as the readiness of individuals to make use of them.[8] In Bardiya district, only 6% of respondents said that they could leave their village by car or boat throughout the year, while 13% reported feeling safe using these routes. Only 31% of those surveyed said there

8 Access to escape routes refers to the ability to get from one place to another, on a path which is trusted and has been well maintained. Access to shelter and/ or safe places refers to respondents knowledge of an accessible place that they can go to before, during or after an emergency, and the condition of that building (Lovell et al., 2019).

was an easily accessible shelter/safe place in their area (in terms of distance, and spaces which are women- or child-friendly and accessible for older people and people with disabilities).

Overall, 75% of respondents said they would know what to do during a disaster, and 17% have received training on disaster preparedness. In total, 76% of respondents felt that, if a disaster occurred, their household would be well-prepared to face it in advance, but only a third said that their household would be very or extremely likely to be able to change its source of income and/or livelihood to be better prepared for climate change or natural hazards in the future (Lovell et al., 2019).

Under the new governance arrangements, provincial and local governments have authority for planning and resourcing and leading planning, preparedness and capacity-building to improve response and early action. Whether they do so will depend on whether they prioritise this, and on their capacity to understand and apply information and take action. Local and sub-national actors are likely to have varied levels of technical capacity and understanding regarding how to plan and prepare, especially for more complex forecasts. There is an opportunity for NGOs and other actors to support local authorities in this, rather than directly providing these services to communities, as they have tended to do in the past.

National institutions and operating agencies, including the NDRRMA and (I)NGOs, could also play a role in supporting sub-national actors (OPM, 2019). Action at sub-national level can also align with plans to further pilot forecast-based early action (and forecast-based financing), including through the NRCS and NGOs. At a national level there could also be opportunities to engage with newly empowered sub-national

municipal authorities via national entities, such as the National Association of Municipalities, to demonstrate and share best practice and guidelines.

3.5 Taking forward new responsibilities under the federal system

Municipalities have new responsibilities under the federal system. In terms of risk knowledge, they will have to support local communities in understanding flood risk, help build capacity and mobilise local task forces, and help prepare community-level risk assessments and maps. They will have to manage the physical infrastructure of the hydro-met stations that generate flood information, supporting local gauge readers, and will be required to develop, operate and maintain monitoring systems in the smaller river basins. Municipal governments will play a vital role receiving flood information from river gauges and federal and provincial governments, which they will then communicate to communities. Finally, to improve response capacities, which are currently very weak in the river basins studied, municipalities will need to establish LEOCs and develop preparedness and evacuation plans with communities. There might be duplication of relief activities between different government levels, and hence municipal governments will likely have an important coordination role in the delivery of aid.

This paper demonstrates the importance of coordination between stakeholders to effectively monitor and deliver flood warnings. For this, the new CDMCs need to be strongly connected to the LEOCs, which will be providing a great deal of the information they need (replacing the former DEOCs). Rivers flow across municipal boundaries, and there is an urgent need for coordination and

communication of flood information between municipalities. The provincial government can enhance these information flows.

Municipal governments will need to build on the structures and experience of the previous district administrations as they develop their role in flood early warning. Longstanding operational and capacity challenges restricting district office capacity to engage in DRRM are likely to persist, at least in the short term. As described above, staffing and activities at district level have often been project funded, rather than publicly funded, and there are high levels of staff turnover. Related to this, a lack of government capacity for engaging with communities around early warning has led to a reliance on NGOs, which have been working at community level to ensure that citizens understand flood risks and are aware of what happens when a warning is issued, and the actions that need to be taken – seeking out safe places and routes, for instance.

The potential for these issues to be addressed under the new federal structure will become clearer going forward, after the budget is released, with designated resources for provincial and local governments, including for DRRM. There are critical challenges and questions around whether municipal governments will receive (or be able to raise) enough funds, and how these governments can gain the technical capacity necessary to effectively deliver flood EWS at the local level.

Finally, work will be required to ensure that diverse voices are heard, and that all EWS components are informed by and respond to the needs of those most likely to be excluded from formal structures. The needs of marginalised groups (including communication and evacuation preferences and needs during response) must be central in EWS plans, investments and governance (Brown et al., 2018).

4. TOWARDS A MORE INTEGRATED FLOOD EARLY WARNING SYSTEM

IMAGE: REGIONAL HANDS-ON TRAINING ON A COMMUNITY-BASED FLOOD EARLY WARNING SYSTEM. PICTURE TAKEN BY: ICIMOD KATHMANDU

Nepal has made tremendous strides to improve disaster response and relief, but all aspects of the flood EWS need attention. Community-based flood EWS has proved effective and has saved lives, but these systems are externally funded and outside the national EWS. With a shift to decentralised government under federalisation, there is an opportunity for provincial governments to engage with community-based systems and encourage alignment with the national system. Bringing together local and national scales in a more integrated way means that NGOs will play more of a supportive role, rather than being the only stakeholder delivering EWS at the local level.

In summary, the new governance system could provide opportunities for improving the flood EWS by:

- Decentralising budgets, planning and decision-making, creating an opportunity to use new information at higher spatial and temporal resolutions, to develop and improve hazard and risk maps.
- Upgrading existing manual records to make them automatic, to feed into national weather and river forecasting systems.
- Increasing the spatial density of stations to provide better warning, particularly on medium- and smaller-sized rivers that currently do not have gauges.
- Developing local EWS in small river basins, which will be owned, operated and maintained by local governments.
- Improving impact-based flood forecasting for early warning messages and information with impact outlooks to district and local decision-makers, tailored to users' needs.
- Providing regular, tailored training and capacity-building for responders and community members on what to do when they receive warning information.
- Engaging with the community locally to ensure that EWS is people-centred and considers marginalised groups.
- Communicating complex forecasts – this can be done by improving the DHM bulletin and developing SOPs at different governance levels, where under federalisation there will be more responsibility but less technical expertise in key decision-making roles (Budimir et al., 2019, in review).

To help ensure that these benefits are realised, community-based and NGO initiatives will need to be better integrated within the national system, rather than creating duplication. Local agencies will need substantial training and capacity development to fulfil their new responsibilities, including guidance on best practice – and it is currently unclear where this will come from in the new government structure. Horizontal and vertical feedback and coordination mechanisms also need to improve, to enhance EWS service delivery across scales.

Over the coming years, there is an opportunity for public and private entities and NGOs to work with local, municipal and provincial authorities to develop and implement plans for EWS and forecast-based early action, building on and extending expertise and capacity at the national level down to these new units of government.

CASE STUDIES

IMAGE: WOMEN ARE AN ESSENTIAL PART OF THE VILLAGE DISASTER MANAGEMENT TEAMS. PICTURE TAKEN BY: PRACTICAL ACTION

Case study 1: Seti River EWS in Pokhara Metropolitan City

By Gehendra Gurung

The Seti is a glacier-fed perennial river in Pokhara. The average annual discharge measured at Phoolbari is 49.5m^3/second. The velocity of the river is very high and flash flooding is common. Intensive rainfall is the main cause of flooding, alongside avalanches and landslides. On 5 May 2012, rock fall and an avalanche from the west flank of Annapurna IV blocked the mouth of the river and resulted in a debris flood that lasted for several hours. The flood killed over 70 people, and destroyed houses, assets and infrastructure. Increased glacier and permafrost melting in the mountains due to global warming has increased the risk of further similar floods.

The government established the Seti River flood EWS in 2013. The hydrology station is located at Jyamire bari in Machhapuchhre rural municipality. The warning and danger levels are 5m and 6m respectively. A gauge reader appointed by the DHM monitors the station and verifies the information. Similar to the Karnali River EWS, flood information is communicated using telephone, internet and display boards in Karuwa village, Kaski DEOC, the DHM Regional Office in Pokhara and the NEOC. The display boards are accompanied by automatic sirens that are triggered once the river reaches warning and danger levels. Once the NEOC and DEOC receive the confirmed flood information from DHM, it is disseminated to the mayor and metropolitan officer, and then to ward chairs and the chairs of CDMCs. The task force members under the CDMCs disseminate the information to vulnerable households and individuals through home visits, hand mics, radios and other mechanisms. Flood information is published on the DHM website, and SMS are sent to key government officials at municipality, district and federal levels. A flood information communication mechanism links upstream and downstream communities, building links between municipalities for flood information communication for early warning and strengthening and highlighting the need for coordination and collaboration between municipalities on EWS.

Case study 2: A local EWS on Mohana River

By Chakra Bahadur Bam

Mohana River in Kailali and Kanchanpur districts floods every year, causing riverbank cutting, flash floods and extended periods of inundation. Flooding affects communities along the river through damage to fields, livestock, roads, schools, services and property, and can result in loss of life, livelihoods and assets. Roads linking these communities with major markets and services are also disrupted.

Disaster preparedness is limited. A gauge station has been set up upstream at Malakheti, to help provide early warning information to downstream communities with a four-to-seven-hour lead time. This has ensured that those communities most at risk of flooding receive timely information and can safely evacuate. Since the gauge station was set up in 2017, there have been no fatalities due to flooding and damage to property has been limited. However, the lack of human and financial resources at municipal and district levels remains a challenge. Local governments will have to take ownership of the EWS and operate the gauge stations, but they have little expertise and will have to work closely with the DHM for some time in interpreting and communicating flood early warnings.

The local government has already allocated a budget to pay the gauge readers during the monsoon period and has provided equipment to help communities respond to flooding.

Case study 3: Flood EWS in the Kamala River Basin

By Dinanath Bhandari

The EWS in Kamala River Basin provides a useful, replicable example of a well-managed local EWS that can be strengthened through greater local government engagement under the new federal structure. Kamala River originates in Sindhuli district, at an elevation of 2,190m. Two major tributaries, Dudhauli Khola and Tawa Khola from Udayapur, join at Trivenidham in the Siwalik foothills, from where the river flows south to the Tarai before entering Bihar state in India. Flooding is triggered by rainfall in the river catchments. Rainfall patterns have become more erratic recently and intense land use practices in upstream catchments have increased soil erosion, heightening the risk of flash flooding. Over 36,000 people are directly exposed downstream, and another 190,000 are affected in the catchments. Rice fields and grazing land inside embankments are often inundated during the summer monsoon.

Since 2016, Practical Action Nepal and the NRCS have worked in Sindhuli, Siraha and Dhanusha to establish community-centred EWS. Flood risk monitoring and forecasting by the DHM involves a three-day rainfall forecast for the basin; 12 rainfall stations – nine across the catchments and three along the basin boundary – have been established and upgraded and measure real-time rainfall and transfer that data to the DHM server. Two monitoring stations upstream (at Titriya and Ranibas) provide real-time river level and discharge data to forecast flood risk downstream. More advanced flash flood forecasting technologies could also be used that specify the amount of rainfall that would lead to overflow of a river in a specified location after some hours of rainfall. [9] Flood levels are marked for alert, warning and danger based on flood risk mapping. Two flood gauges downstream are observed regularly during the flooding season by trained community volunteers.

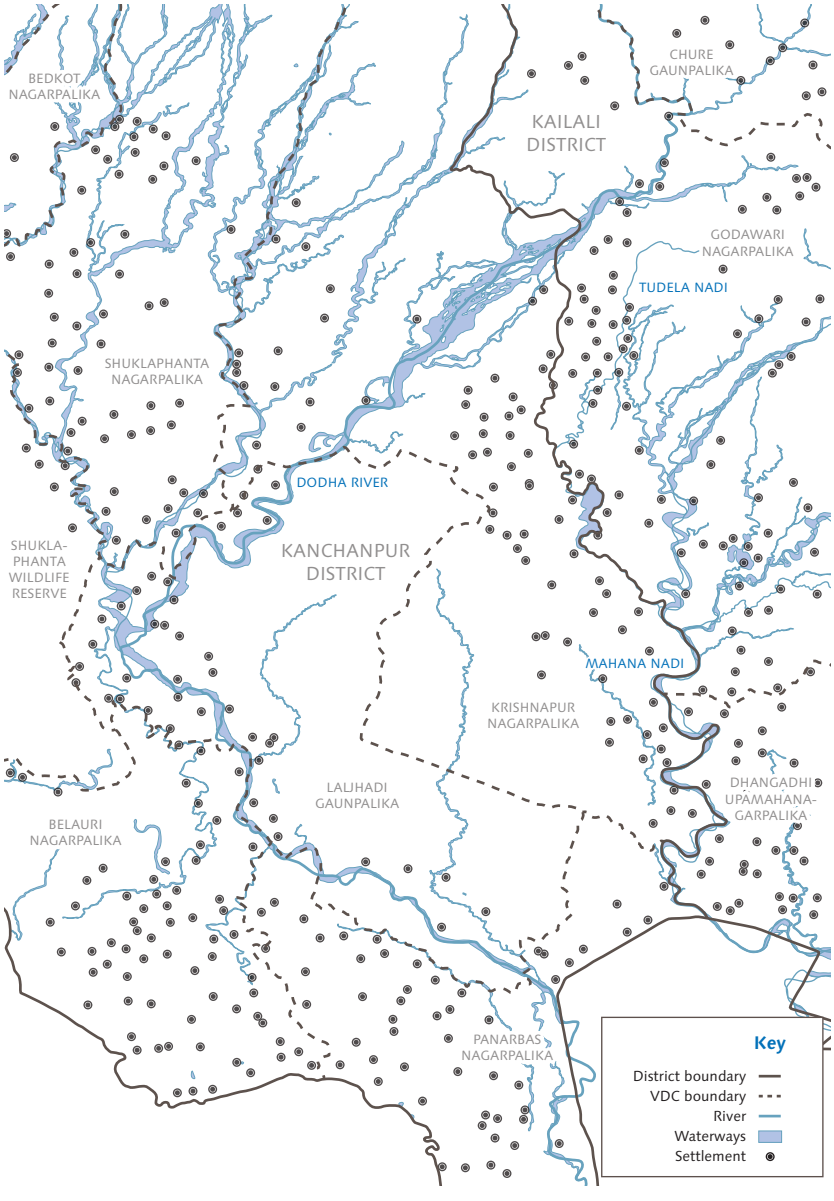
Flood alerts and warnings and advisory messages from the DHM are disseminated to key disaster management actors and vulnerable communities. The mechanism also enables communities and local responders to call gauge readers at the hydrology stations in Titriya and Ranibas, the DHM and NEOC in Kathmandu and the DEOC at its district headquarters to ask about the rainfall/flood situation and forecasts. They can also interact with the DHM and NEOC through social media.

Thirty-five CDMCs are supported by local government and district agencies, which can access provincial and federal capacities if required. Each community has three to five taskforce groups, including trained male and female volunteers, to manage communication and response actions at local level. Communities have emergency plans and undertake annual exercises, supported by and with the participation of actors across the EWS.

9 For more details see www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php

Case study 4: A trans-boundary flood EWS in Kailali and Kanchanpur districts

By Dambar Bohara



Located between two large river basins (Karnali, in eastern Kailali, and Mahakali, in the west of Kanchanpur district), Kailali and Kanchanpur districts are the most flood-prone areas of Nepal. Twelve small river systems across these districts cause flooding, river bank cutting, land degradation, inundation and sand deposition.

The Macheli river system is trans boundary, in the sense that several rivers cut across Kailali and Kanchanpur districts: upstream sections lie in Kailali and downstream parts are in Kanchanpur district, where an estimated 32,400 households face very high flood risk.

In 2014, Mercy Corps Nepal established a manual river gauge station in Sotyas (upstream in Kailai district) to provide flood early warning information to downstream communities in Kanchanpur, through the DEOC office in that district and the regional DHM field office, and the river gauge system was upgraded to a telemetric one.

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ABOUT BRACED

BRACED aims to build the resilience of more than 5 million vulnerable people against climate extremes and disasters. It does so through a three-year, UK Government funded programme, which supports 108 organisations, working in 15 consortiums, across 13 countries in East Africa, the Sahel and Southeast Asia. Uniquely, BRACED also has a Knowledge Manager consortium.

The Knowledge Manager consortium is led by the Overseas Development Institute and includes the Red Cross Red Crescent Climate Centre, the Asian Disaster Preparedness Centre, ENDA Energie, ITAD, and the Thomson Reuters Foundation.

The BRACED Knowledge Manager generates evidence and learning on resilience and adaptation in partnership with the BRACED projects and the wider resilience community. It gathers robust evidence of what works to strengthen resilience to climate extremes and disasters, and initiates and supports processes to ensure that evidence is put into use in policy and programmes. The Knowledge Manager also fosters partnerships to amplify the impact of new evidence and learning, in order to significantly improve levels of resilience in poor and vulnerable countries and communities around the world.

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