4.6 Real-Time Monitoring and Flood Outlook for Reduced Flood Risks

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Photo: DPNet-Nepal

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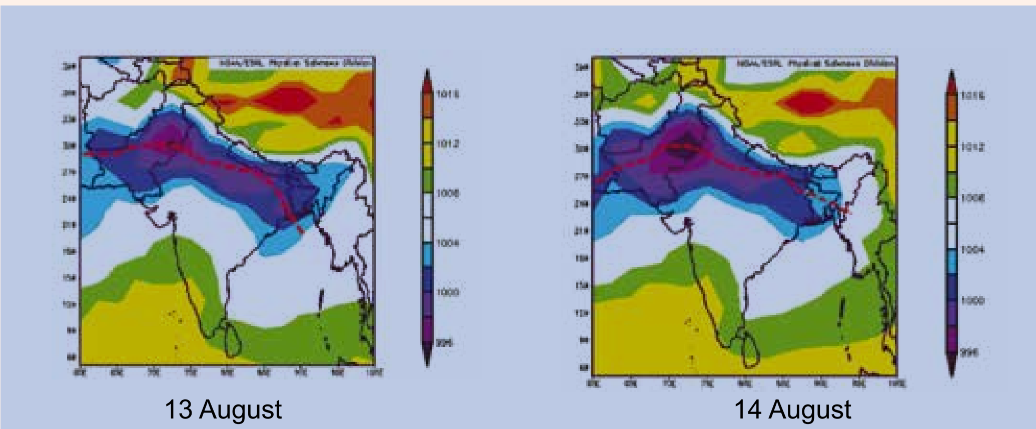
Introduction

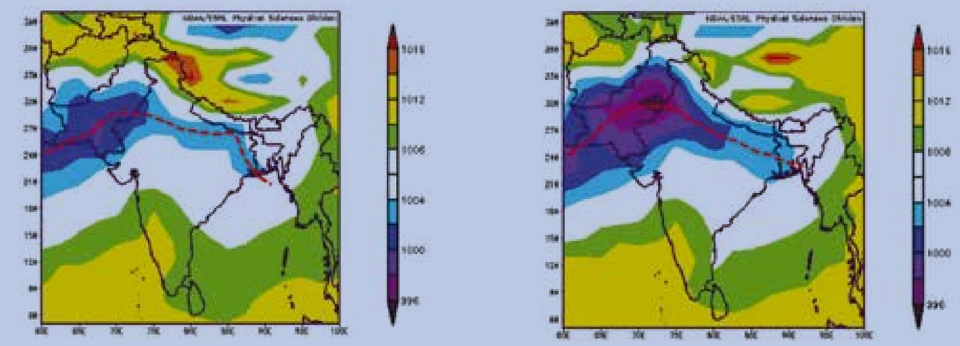
The 2014 monsoon season started with rainfall below normal. According to the Department of Hydrology and Meteorology (DHM), rainfall deficit in the Mid and Far Western region of Nepal for the month of June was around 50 percent. Experts predicted below normal rainfall for South Asia during the 2014 monsoon. Consensus on this was developed at the 5th South Asia Climate Outlook Forum based on an expert assessment of prevailing global climate conditions and forecasts from different climate models from around the world (SASCOF 2014). Weak El Niño/ Southern Oscillation (ENSO) conditions prevailed over the Pacific Ocean. The ENSO is a global climate phenomena that has a significant influence on the year-to-year variability of the monsoon over South Asia. While the month of June and July saw very little rain with less that 50 % of the normal worrying farmers the month of August painted a different picture. In contrast to the June and July rainfall, in August many parts of Nepal received heavy rainfall. The month started with the Sun Koshi landslide disaster killing 160 people and displacing thousands. While this was still fresh in people's minds the country was hit by yet another large scale disaster. Three days of continuous rainfall from 14-16th August brought about devastation throughout Nepal. This paper describes the floods and landslides that occurred due to the three day intense rainfall, real-time monitoring and the flood outlook that provides increased lead time to minimize the adverse impacts of flood disasters.

What Caused the Floods?

The timing and amount of precipitation and its distribution across Nepal are controlled fundamentally by the annual monsoon system (Kansakar et al.,2004). When rainfall was at its lowest the previous two months in June and July the question is what type of climatic event has brought about this disaster? This phenomenon is not new but has happened many times in the Himalayas with differing magnitude and duration. When the axis of the monsoon trough which is the low pressure from the Bay of Bengal remains parallel to the Himalayan foothills it brings in a change in the rainfall pattern. At the time of this occurrence there is intense rainfall above

Figure 1 Surface level atmospheric pressure from 13-16 August based on NCEP/ NCAR reanalysis data





15 August 16 August

the Himalayan foothills like what happened in 1993. This phenomenon is also known as the monsoon break in India. In Figure 1 the position of the monsoon trough is indicated with a red line over the four day period from 13-16 August 2014 which brought in intense rainfall in many parts of Nepal.

Real-Time Flood Monitoring

Real-time observation of water level and rainfall are key input to flood monitoring. Real-time monitoring can immediately notify decision makers about dangerous water levels through telemetry. Real-time monitoring also provides continuous datasets for better understanding the variation of flows at daily, monthly and seasonal basis. The DHM has a network of real-time hydrometeorological stations across Nepal. More than 50 real-time hydrometeorological stations provide the rainfall and water level of the major rivers such as the Koshi, Karnali, Narayani. The DHM has identified different warning and danger levels for stations in major rivers depending on the volume of water discharge. Warnings are issued as soon as the water levels exceed a given threshold or the alert level. The real-time stations transmit data on a regular prefixed interval and are available in a web-based platform (www.hydrology.gov.np).

Between 13 and 14 August within a period of 48 hours high rainfall was observed in the Koshi basin with Chatara receiving 191.2 mm, Mulghat 129.2 mm and Rabuwabazar 113.6 mm. On 15 August 2014 in many areas of western Nepal rainfall exceeded 100 mm rainfall within 24 hours with Birendranagar receiving 423.1 mm, Chisapani (Karnali) 493.8 mm and Beljhundi (Dang) 346 mm (Regmi 2014). Many of the rivers Koshi, Narayani, West Rapti and Karnali were flowing above alert level resulting in large areas to flood. The flood levels in the Koshi went above the alert level with discharge exceeding 7000 m3/sec at 6.37 m close to the 6.8 m danger level (Figure 2). Around midnight on 14 August the water level in the West Rapti river crossed above danger level and remained above this level for 30 hours (Figure 3) creating inundation and widespread flooding. To enable timely preparedness alerts were posted by DHM on its website which provided the water levels in the Koshi, Rapti, Karnali and Narayani rivers.

Figure 2 Water level and discharge at Chatara, Koshi (14 -16 August)

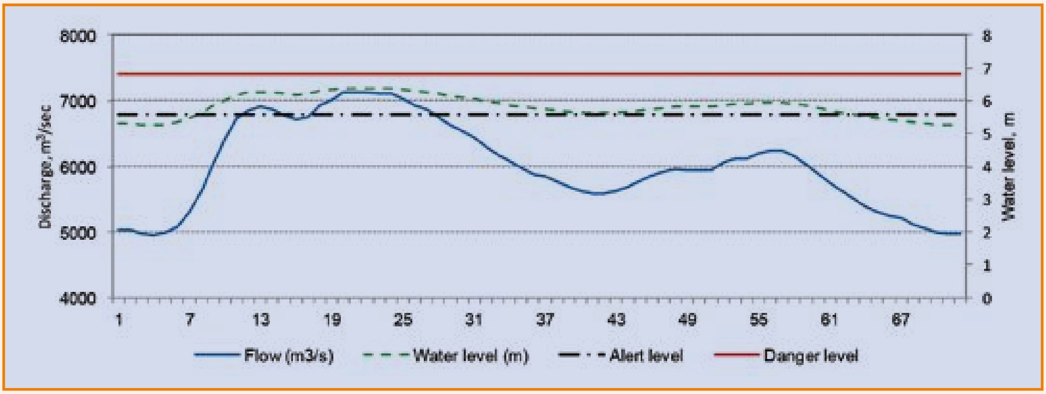
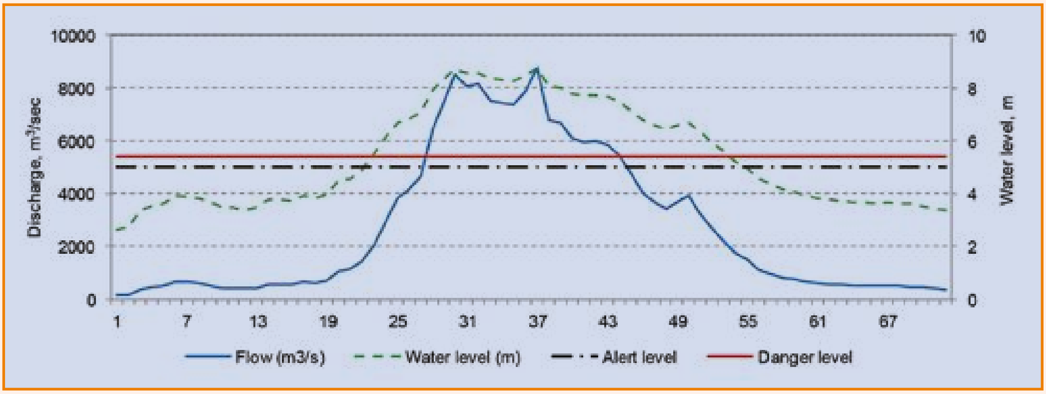


Figure 3 Water level and discharge at West Rapti, Kusum (14 -16 August) (Source: www.hydrology.gov.np)



Impact of Floods

Over 48 hours of torrential rainfall, from 14-16 August triggered numerous floods and landslides, disrupting normal life in 23 districts throughout Nepal. According to the Nepal Red Cross Society and Ministry of Home Affairs a total of 202 people were reported dead, 149 injured and 248 reported missing due to the disaster. Similarly, 36,949 families (184,745 people) were affected and 10,193 families (50,965 people) displaced. Women, children and elderly were reported to be amongst the worst affected. The highly impacted districts were Banke, Bardiya, Dang and Surkhet. Highways were damaged obstructing transportation. In Surkhet 34 bodies were recovered. In Bardiya 33 people were killed and 15 missing. In Dang 14 people were killed with five missing and in Banke 15 were killed with five missing. The major infrastructure of Babai Irrigation Project and some parts of the Sikta Irrigation were damaged. The summary of the damage incurred during the event is provided in Table 1.

During the floods in the Karnali and the Babai river basins in August 2014 coordination amongst various organizations in responding to the disaster was found to be poor (Zurich Insurance Company 2015). Chhetri and Bhattarai (2001) also indicated the lack of coordination among

Table 1 Summary of people killed and affected during the floods from 14-16 August, 2014

Districts	Number of people			Number of families		Number of houses destroyed	
Banke	15	5	2	2889	11,699	2889	8810
Bardiya	33	15	2	17,376	17,376	3859	13,517
Surkhet	34	91	26	3132	3132	1978	1054
Dang	14	4	2	872	872	511	361
SubTotal	96	115	32	33,079	33,079	9237	23,842
Other 19 affected districts	106	133	117	3870	3870	956	2914
Total	**202**	**248**	**149**	**36,949**	**36,949**	**10,193**	**26,756**

Source: Nepal Red Cross Society

various organizations related to disaster management along with technological gap as problems of inadequate preparedness against impending flood disasters. Despite this lack of coordination the local responses were found to have been effective which contributed to minimizing the losses. Floods washed away the gauging station in Chepang on the Babai river. However, the gauge reader was able to inform the people downstream about the high flood conditions though with some delay due to poor mobile network connectivity.

The Himalayan Times reported the August 2014 floods also swept away the canal of Triveni Micro Hydropower Project that left the district headquarters of Bajura (Martadi)

Figure 4 Power house of the Triveni Micro Hydropower Project at risk by the Bahuli Rivulet, in Martadi of Bajura (Source: Prakash Singh) http://www.thehimalayantimes.com/fullNews.php?headline=Bajura+headquarters+in+dark+-for+five+days&NewsID=424456#sthash.77OQPrqW.dpuf

without electricity (Figure 5). (http://www.thehimalayantimes.com/fullNews.php?headline=Bajura+headquarters+in+dark+for+five+days&NewsID=424456). Due to the damage to the transmission lines the Bardia district was also in darkness. Between 2000 and 2013, according to the Ministry of Home Affairs (MOHA) a total of 3608 landslide and flood events have been recorded killing 1295 people with US$ 85 million economic loss.

Flood Outlook and Warning System

The International Centre for Integrated Mountain Development (ICIMOD) in partnership with the World Meteorological Organization (WMO) and the regional member countries from Bangladesh, Bhutan, China, India, Nepal and Pakistan developed the Hindu Kush Himalayan Hydrological Cycle Observing System (HKH-HYCOS). The aim of HKH-HYCOS is to enhance regional cooperation in hydro-meteorological data collection and sharing for flood forecasting to support disaster prevention and flood management at the regional level (Shrestha et al., 2015). Using advanced technologies for data collection and transmission the project has upgraded 38 hydrometeorological stations in four countries to transmit real-time data on river level and rainfall, 12 of which are in the Koshi Basin of Nepal. The real-time data available from the region, satellite based products and weather forecasts are assimilated into rainfall runoff model using Mike 11.

The HKH-HYCOS regional flood outlook provides real-time flood information products pertaining to the threat of potential large-scale flooding in the Ganges Brahmaputra basins to provide adequate products to the national hydrometeorological agencies to support and enhance national flood forecasting and warning services. The model includes 86 sub-catchments with 21 nodes for calibration and validation as illustrated in Figure 5. Out of the 86 subcatchments 10 are in Nepal which includes the subbasins of Karnali, Narayani and Koshi. The modelling system is based on historical data for calibration and validation so that extreme events that

Figure 5 Regional flood outlook in the Ganges Brahmaputra basin

have occurred in the past are simulated correctly. The components of the regional flood outlook system are illustrated in Figure 6. The developed model forms the basis of the real-time flood forecasting system, which will require real-time data from the various sub basins within the participating countries. The computed forecasts are based on data assimilation using the actually observed real-time data, which is found to significantly improve forecasts (Madsen et al., 2003). The real-time information allows comparison of observed and forecast data for evaluation of the performance of the developed system.

The model was piloted to simulate the flows during the 2014 monsoon. Observed discharge data were assimilated at several gauging stations up to the time of forecast. The model was used to prepare forecasts with a lead-time of 72 hours every 12 hours. From 14-16 August, when many parts of Nepal experienced continuous rainfall resulting in widespread flooding, the performance of the flood outlook model was evaluated. The performance of the model for 12 hr and 24 hour for the 2014 monsoon period from July through September are presented in Figure 7. The coefficient of determination (R2) for 12 hr forecast is 87% and for 24 hr is 78%. The model results for the Koshi basin in Chatara for a one day period from 14–15 August are shown in Figure 8. The flood outlook was found to perform well in generating flow forecasts up to 24 hours in advance. The initial conditions at the time of forecast are updated; the forecasts improved significantly for the first 24 hours, after which the predictions deteriorate. These results are based on a initial development of the model and is now being updated with cross sections and additional ground information, which is expected to significantly improve the model performance. ICIMOD is working to improve the regional model and supporting DHM to customize the model over Nepal for improved flood forecasting. With further improvement, the regional flood outlook is expected to support national hydrometeorological services in providing better forecasts, preparing timely flood bulletins, and increasing the forecast lead time for timely action by decision makers.

Figure 6 Regional flood outlook system

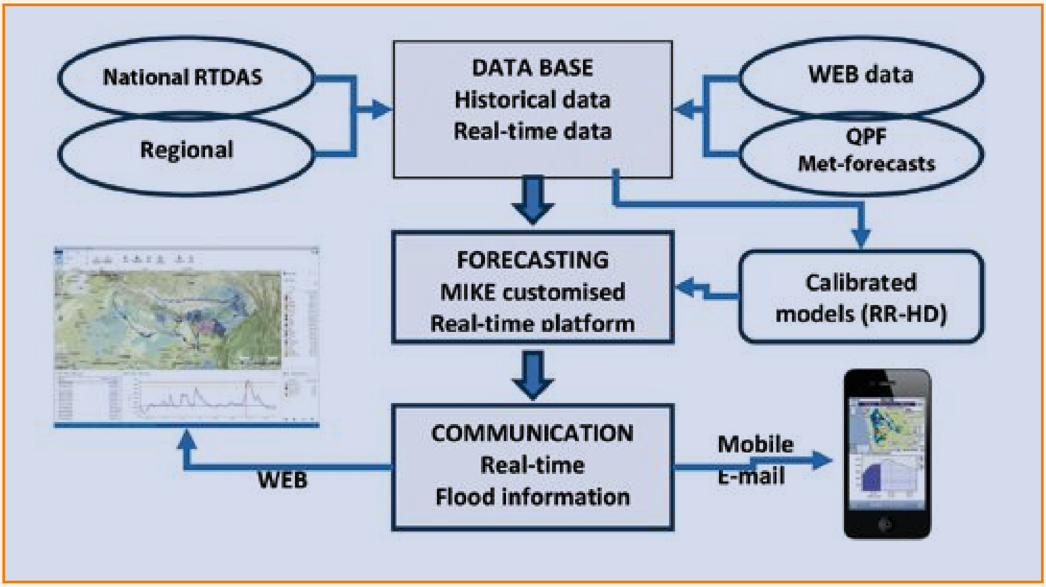


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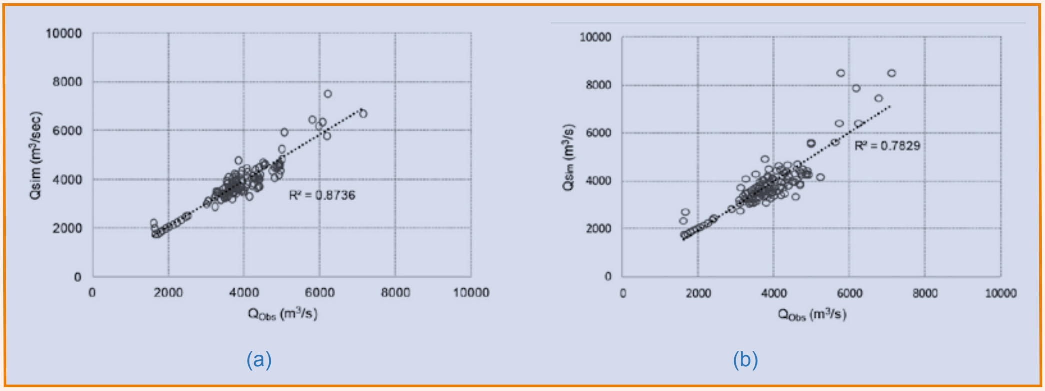
Figure 7 Performance of 12hr (a) and 24hr (b) observed and simulated discharge at Chatara on the Koshi



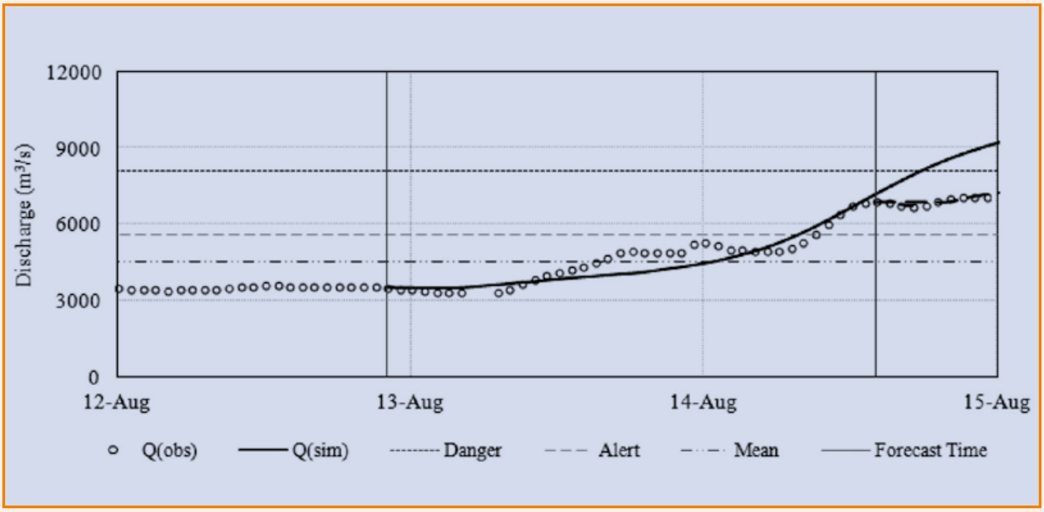
Lessons Learnt and Conclusion

During the 2014 floods huge loss of lives, properties and infrastructure was recorded. More than 200 people were killed, thousands of families affected, roads, bridges and hydropower damaged. This calls for the need to have sounder preparedness, response and planning and design of infrastructures considering the impact of changing climate and variability for improved flood resilience.

Often during such flood disasters, societal inequalities are amplified, and poor people – especially women, the elderly, and children, living along river banks and in the flood plains – are particularly vulnerable. To make early warning systems effective and efficient, we must recognize the active role that women play in family livelihood security, and efforts must be made to involve women and men equally in creating and receiving early warnings and alerts.

Real-time monitoring of water levels and rainfall, transmission of data and communication

Figure 8 Flood outlook at Chatara on the Koshi from 13-15th August, 2014



and warning are crucial in saving lives and property. Real-time monitoring systems can immediately notify various agencies about eminent disasters. During extreme events break down of the gauging station with sophisticated real-time monitoring systems and its transmission have been experienced as in the Babai river basin. Thus, even with automatic state of the art systems, observation by gauge observers are needed for providing back up in case of telemetry and instrument failure and to provide additional information of flooding conditions.

Since 2001, despite increased efforts in addressing disaster risk reduction in Nepal there are still gaps in coordination as illustrated by the 14-16 August event. There is a need to institutionalize EWS at various levels with proper governance mechanisms. The need to strengthen disaster risk governance to manage disaster risks is an important element of the Sendai 2015 framework of Disaster Risk Reduction endorsed by 187 countries around the globe, including Nepal.

The EWS that are in place in Babai and Karnali did provide timely warning during the 2014 flood event however, in some places the lead time available was very short challenging the communities to promptly evacuate and move to safer grounds. In such cases reliable and timely warning can be provided using flood forecasting models. Real-time monitoring of hydrological and meteorological variables generates valuable information that can be fed into hydrological models. These models can be used to provide information about areas at risk of inundation during a flood event. The results of the regional flood outlook piloted in 2014 indicate that it is a promising tool that may support effective flood forecasting at the national level.

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