POLICY BRIEF

Impact-based Flood Forecasting for Effective Anticipatory Actions in Dodhara-Chadani Municipality

INTRODUCTION

Flooding is recurrent, often catastrophic and result into significant internal displacement annually in Nepal, mainly in the lowlands of Nepal (Terai). Severe land use changes, unplanned urbanisation, and floodplain encroachment have aggravated loss and damages due to flood. Dodhara-Chadani Municipality located in the lower basin area of the Mahakali River in the Far West is an example facing such situation. Selected wards (8, 9 and 10) of the municipality is impacted by the local stream -Jogbuda which originates in the Indian Siwalik hills and enters Nepal and is impacted by the overflow in Mahakali River. In order to better understand the impacts of flooding and to issue warnings, scenario modeling is required. However, the limitedly available hydro-meteorological data has challenged the timely and accurate early warnings on flood, thereby resulting into the poor planning and design of appropriate anticipatory actions.

Department of Hydrology and Meteorology (DHM) has installed a sensor to monitor the water level of Mahakali Level in Parigaon and has installed a manual gauging system few years back. Despite this, the warnings are made on ad-hoc basis as there is no measured discharge and established rating curve. To complement this effort, DCA and the Institute of Himalayan Risk Reduction (IHRR), as part of DCA's "B-Ready" Project, has developed a representative flood hazard model utilising the exising hydro-meteorological data. Besides, household (HH) surveys in 60 HHs was conducted to assess the vulnerability. Considering the data scarcity, three different approaches were taken to model the flood hazard: (i) Event-based Model based on the flood on 21st October 2021 flood, (ii) Scenarios of flood return period estimated by transposing the instantaneous flood of Karnali River to Mahakali, and (iii) Flood hazard assessment under climate change scenarios.

CONTEXT: MAHAKALI RIVER BASIN AND HISTORICAL FLOOD EVENTS

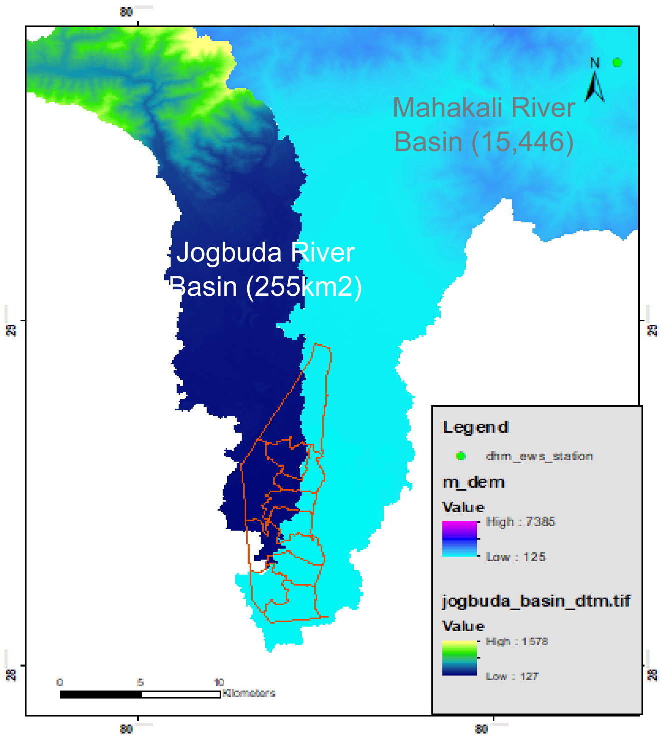
Mahakali River basin has 15,446 km^2 of area, out of which about 35% (5,945 km^2) is in Nepal. The Lower Mahakali Watershed is located within Kanchanpur District and borders India to the west and south. Most of the reaches of Mahakali River represent the border between Nepal and India, expect in some sections such as in Dodhara-Chandani. Jogbuda is a small tributary of Mahakali River that passes through a village called Kutiyacover close to the Nepal-India border. During intense rainstorms in the upstream, discharge increases and often overtops the banks. Besides, Mahakali River also blockes Jogbuda creating backflow, thereby flooding the settlements (Figure 1).

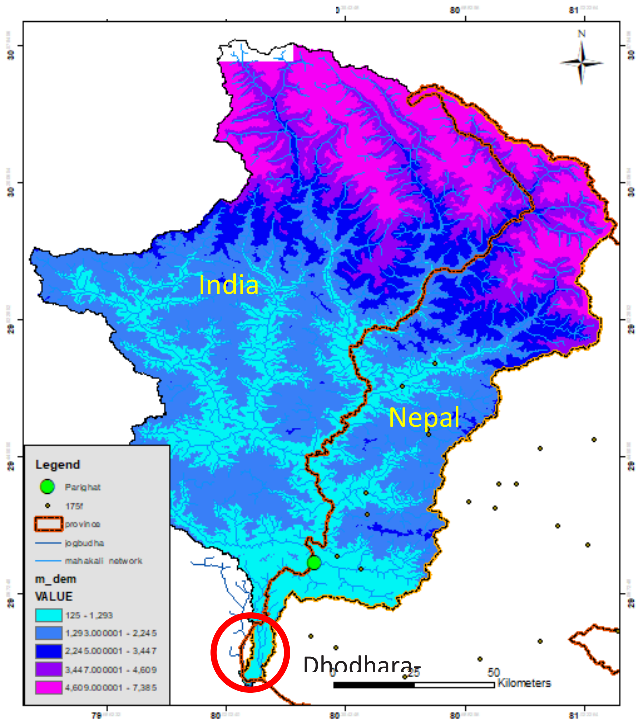
HISTORICAL FLOOD HAZARD AND DISASTERS

Although there is no systematic database of flood disasters in the region, the locals have reported flooding to be common in Dodhara-Chadani. There are some flood situations that have impacted the municipality and settlements in the low-lying areas (Table 1).

The October 2021 flood was very unusual for the locals as they didn't have flooding incidents in October in the past.

Floods (in the year)	Damages in the past
2028	Massive floods and people displaced to other places.
2040	More than 40 houses were washed away.
2065	More than 1000 cattle were swept away.
2070	More than 10 wooden bridges damaged.
2072	Sweeping of agricultural land and erosion.
2078	More than 9 death tolls.

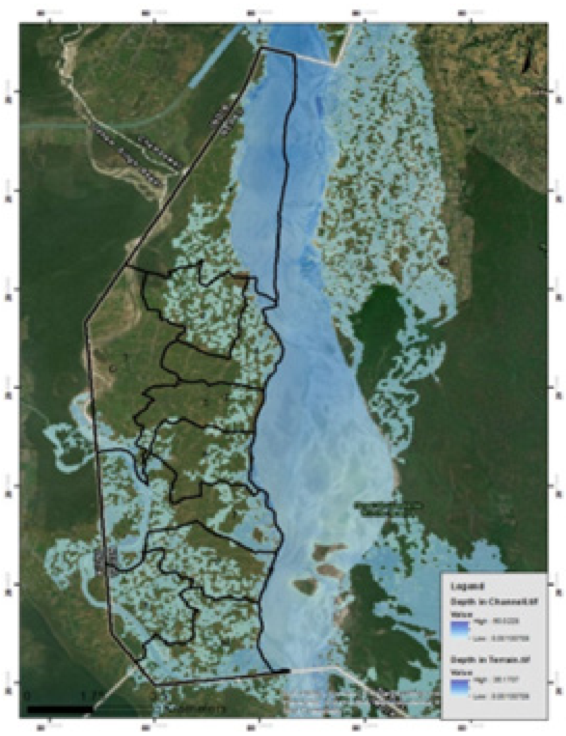


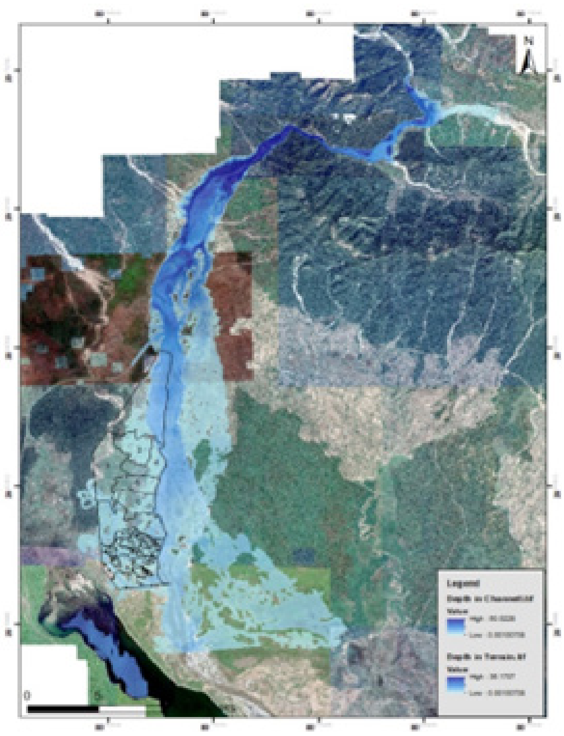


According to the District Police Office in Kanchanpur, over 24 families of Kutiyakabhar in Dodhara-Chandani Ward No. 10 were displaced. The locals received SMS notifications about the rise of water levels, but most of them ignored it as they never anticipated flood in October. Most of the rain gauges in the Mahakali basin recorded some amount of rain on 18, 19 and 20th Oct 2021. The recorded rainfall in some of the rain gauge stations was over 300 mm on 18th Oct (i. e. 24 hours of rain). The flood reached the settlement at midnight on 19th October. The time required for flood to reach the settlement was equivalent to the time of concentration.

RESEARCH METHOD

The event-based flood model was performed to estimate the runoff and peak flood discharge. The model clearly indicated that the flooding in Oct 2021 was over 100 Years return period (15,500 m^3/sec). The water level in Mahakali River was measured at Parigaon Gauge Station of DHM indicating that the flood water level was about 9 meters from the normal river level. The increased water level at the Mahakali-Jogbuda blocked the flow of Jogbuda, which caused inundation and flooding in the settlements in wards no. 8, 9 and 10. The analysis of CMIP6 GCM model (SSP245)



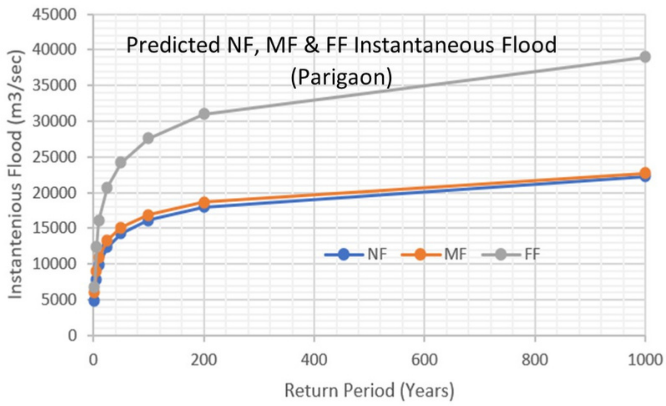


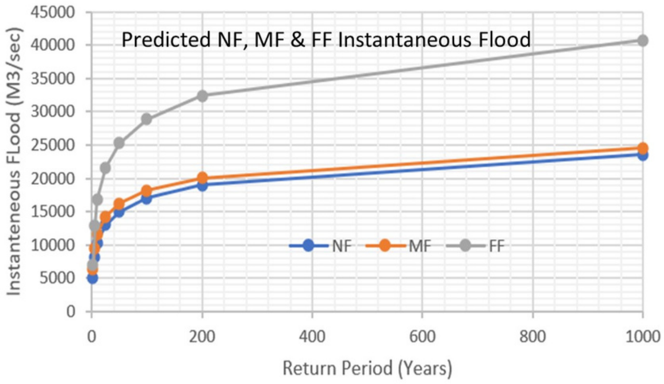
depicted that the changes in the climatic pattern had caused increased rainstorms, causing the river discharge to increase in the Mid-Future (2051-75) and Far Future (2071-2100). This is equivalent to 50 years return period, meaning that the future flooding will increase the number of vulnerable households in the municipality.

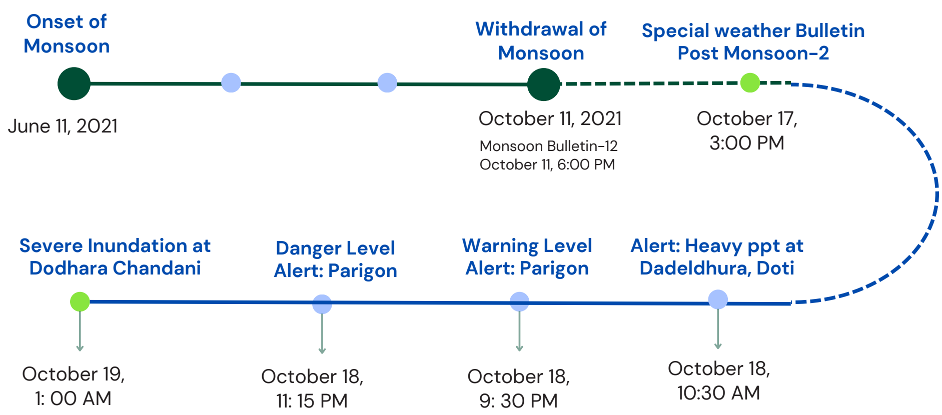
The vulnerability analysis in 2,307 HHs of wards 8 and 10 indicated 226 as highly vulnerable, 1,310 as medium and 771 as low vulnerable. During peak flood discharge, the HHs mapped under medium to low vulnerable may turn out to be high to medium vulnerable. The model depicted nearly 1 meter of flood depth in the Kutiyakabhar settlement, which is equivalent to what locals have marked in the event of the flooding (i. e. 21 Oct 2021).

FLOOD ARRIVAL TIME AND EARLY WARNINGS

The flood arrival time depends on several factors such as the discharge, river gradient, barriers across the rivers (e. g. barrages), and friction factors (e.g. the river bed materials and land use in case of overbank flow,







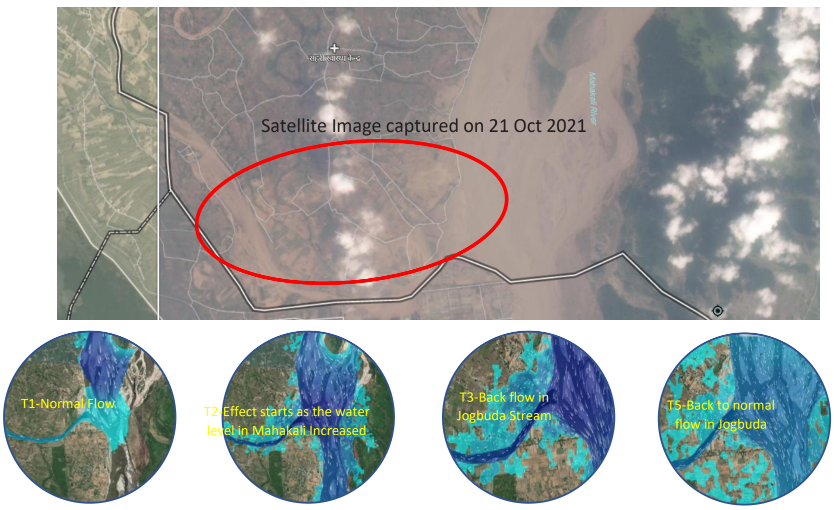
Source: Nepal Weather Forecast @DHM_Weather

YEAR 2021 FLOODING

Warning Level: 5.8 m

Danger Level: 7.0 m

etc.) are important for the local people that can be considered as the lead time to evacuate people from flood-prone area to safer locations. For the 100-year return period flood discharge, the arrival time (or the time concentration) at Kutiyakabhar is about 2.7 hours as depicted in the model. In this research, it is suggested to install a warning sensor at the abutment of a newly built 4-lane bridge and the flood level for the warning is to be set up at 226 masl. The model also depicted that the travel time of the flood from the bridge to Kutiyakabhar area is about 32 minutes, meaning that

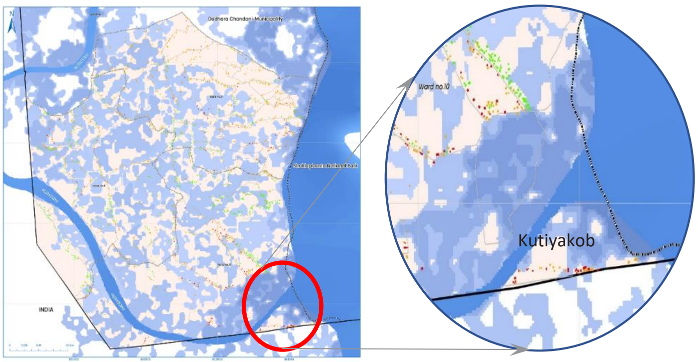


Source: PlanetLabs, 21 October 2021

the population will have 32 minutes of lead time. Further, once the flood level reaches 226 masl, at the bridge axis, it affects the normal flow of the Jogbuda Stream.

VULNERABLE HHS IN WARD NO. 8,9 & 10

HH vulnerability depends on many factors; therefore, this research identified 60 indicators other than flood depth to assess the vulnerability. The indicators were analysed using the Multi-Criteria based Decision Analysis (MCDA) adopting Analytical Hierarchy Processes (AHP) algorithm. The HH-level vulnerability model was then developed indicating the high (red), medium (yellow) and low (green) vulnerable HHs.



KEY MESSAGE

- Fine time resolution hydro-meteorological data are important to model the flood hazard using the established methods and available software;
- Lower Mahakali Basin especially the Wards - 8, 9 and 10 of the Dodhara-Chandani Municipality are highly vulnerable due to the recurrence of flooding and has considerable impacts on the elements-at-risk such as population, roads, etc.;
- Anticipatory Actions can be planned better with the availability of high-resolution data and thresholds established for the advanced flood forecasting;
- The calculation of lead time based on the thresholds and trigger can support for the timely early action such as evacuation. Longer lead time is useful and effective to evacuate the population from the flood-prone area and requires temporal and spatial hydrologic data;
- Mahakali River being a transboundary river, it is very important to establish the data sharing and flood forecasting mechanisms between the two countries; further, the amount of discharge through structure like barrage should be readily available;
- Engagement and coordination among the local governments including communities in the upstream and downstream are important and enable sharing of innovative approaches and lessons learned.
- Effective communication is important to ensure the local government and concerned assemblies work together to minimize the risk of flooding through Anticipatory Actions;
- Different households have their different characteristics and coping capacities. Therefore, the response of each household towards the crisis can be different. Thus, the HH level vulnerability and risk assessment are essential.
- Enhance the capacity of local government and communities for taking early action by responding to the available forecast information.
- It is important to consolidate evidence and learning to integrated forecast based early action approach into disaster preparedness and response framework.

This policy brief on Impact-based Flood Forecasting for Effective Anticipatory Actions in Dodhara-Chadani Municipality. This document is based primarily on the findings of flood forecasting modeling in the lower Mahakali River Basin, which has been conducted as part DCA's pilot project on Anticipatory Action – "B-Ready". The project is being implemented through a consortium of DCA, IHRR, and NNSWA; and in close coordination with the Local Government authorities in Dodhara-Chadani Muncipality.

Implementing Partners

DCA actalliance

NNSWA Estd. 1990

Institute of Himalayan Risk Reduction

In collaboration with

Dodhara chandani Municipality