Workshop Report

Dynamic Flood Topographies in the Terai, Nepal: Community Perceptions and Resilience (DISTAL)

Nepal – 18th August 2017

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Introduction

The research project entitled-Dynamic Flood Topographies in the Terai, Nepal: Community Perceptions and Resilience (DISTAL) was undertaken through a joint collaboration of the University of Edinburgh, Practical Action Consulting (PAC) and supported by Department of Hydrology and Meteorology (DHM), Nepal. The research was focussed in the Karnali flood plains, a Midwestern region of Nepal to understand flood risk through a team of local practitioners and international experts. The University of Edinburgh led the research project while PAC facilitated the field visits, supported engagements with local partners, and supported access to relevant data and creation of knowledge products.

Karnali River is a trans-boundary, snow-fed, perennial river which divides into two main channels, Geruwa Karnali on the left and Kauriala Karnali on the right. The distribution of flow in these distributaries is attributed to the geomorphology of the region. Karnali is unique in terms of its highly dynamic nature with high capacity to erode and aggrade. Nevertheless, similar to other Himalayan rivers, Karnali river supports lives and livelihood of people in the region and the floods provide irrigation supplies to the crops. However, due to existing land use pattern, increasing unplanned modernisation and lack of proper disaster risk governance, Karnali people have suffered a huge loss of lives and livelihood during major floods in 1983,2000,2009,2013 and 2014.

Incorporation of both physical and social science in disaster governance is an entry point for creating a flood resilient community. The research was undertaken with an aim to understand how geomorphology of the catchment influences flooding and how flooding, in turn, influences local topography and how community perception of risk impact on developing resilience in Karnali flood plain. The research pooled together physical scientists and social scientist with an aim to create a strong network of an interdisciplinary research team. For flood hazard mapping, an attempt has been made to use a high-resolution Digital Elevation Model (DEM) and incorporate sediments in hydraulic modelling. On the other hand, the social scientists have attempted to understand people's perception to the past and future floods and their daily interactions with the river.

Objectives

The objectives of the sharing workshop are highlighted below:

- Provide an overview of the interdisciplinary research project on Dynamic Flood Topographies in the Terai, Nepal: Community Perceptions and Resilience (DISTAL)
- Orient participants regarding the existing national level flood early warning systems.
- Share the results of physical science and social science research.
- Discuss on factors that contribute to flood risk in the Karnali region.
- Discuss the importance of incorporating sediment dynamics in the understanding of floods.

Introductory Sessions

The introductory sessions provided an overview regarding the DISTAL project, the status of flood early warning system in Nepal and the need for understanding the geomorphological behaviour of the catchment to fully understand flood risk. The workshop started with welcome remarks from Mr Ram Gopal Kharbuja, deputy director general, DHM, which was followed by an introduction round in which each participant introduced themselves. The three presentations in the session came from the University of Edinburgh, Department of hydrology and Meteorology (DHM) and Institute of Engineering (IOE).

Presentations:

1. Overview on DISTAL (Dynamic Topography of the Terai, Nepal: Community Perception and Resilience)

Prof Hugh Sinclair, University of Edinburgh

Prof Hugh's presentation provided insights in the understanding of flood risk by drawing upon his experiences in Leh, Ladakh,2010, Uttarakhand,2013 and in Karnali, Nepal,2014. His presentation included details on sediment flux, abrasion and the role of sediments in flood risk. He ended his presentation by stating the objectives of the project and setting the stage for rest of the presentations. This project was envisaged to bring together academicians and practitioners, local and international experts to create an interdisciplinary network. The physical scientists were involved in creating a high resolution digital topographic map, predicting floods for varying conditions and understanding the sediment dynamics in the region. The social scientists of the project were focused on synthesizing on community perceptions.

2. Status of Flood Forecasting and Early Warning System in Nepal.

Binod Parajuli, Flood forecasting section, DHM

The presentation focused on the existing capabilities of the flood forecasting section of DHM, Nepal. Early warning system came into existence in Nepal in the 1990s when the communities started using the big tower to warn the people of approaching flood and the lead time would be few minutes. In 2000s manual gauge based warning provided lead time up to one hour and now, the real-time telemetry can generate warning few hours before the flood. Current status of flood forecasting and early warning system was discussed in line with recent advances in flood forecasting such as Global Flood Awareness System (GLoFAS), probabilistic and deterministic flood forecasting during 2016 and 2017 monsoon. DHM has managed to pilot mass SMS in 2016 and the ongoing 2017 flood. A toll-free service (1155) is available to disseminate the information on the next 24-hour flood risk. Similarly, DHM is using different social media, such as facebook and twitter to disseminate the flood and rainfall forecast. Real time observations can be viewed via www.hydrology.gov.np.

He discussed that the flood forecasting section at DHM is striving to increase the lead time and make the warning systems more effective in the future.

3. Geomorphological Control for Flooding in Nepal

Dr Basanta Raj Adhikari, Institute of Engineering(IOE)

Dr Basanta Raj Adhikari focused on how geomorphology and river dynamics play a crucial role in understanding the river hydraulics and past flood events. The presentation provided a basis to understand the challenges and complexities in the current scientific tools for forecasting the extent and depth of inundation in complex Himalayan geomorphological channels. Flooding is not just about the hydrology and hydraulics of river flow but the terrain characteristics and the geomorphology of the catchment govern river dynamics equally. Thus, it was discussed that a holistic approach in the understanding of flood hazard at a catchment scale is needed to fully understand and predict flood events.

Technical Sessions

The second half of the workshop was aimed to provide technical details of the project. The four sessions were focused on sharing the research outputs of the project. The physical scientists at the University of Edinburgh presented their results of hydrodynamic flood modelling of Karnali region incorporating the changes in bed level for different sediment conditions. The PAC team presented on how the maps can be used to better understand the risk. The social scientist at the University of Edinburgh presented on community resilience and perceptions.

Presentations:

2.1 Sediment Export from the Himalaya and the flood risk in the Terai

Lizzie Dingle and Mikael Attal, University of Edinburgh

The presentation highlighted the sensitivity of modelling tools (HecRAS, Delft 3D) and resolution of digital elevation models (SRTM 30 and TanDEMX 10) to flood maps. The functionality of Acoustic Doppler Current Profiler (ADCP) in the measurement of channel characteristics such as cross section geometry, velocity, water depth, etc. was discussed. Sediment dynamics was discussed as one of the main contributing factors of channel migration and switching in Karnali region. The satellite images of Karnali river from 1977 to 2016 were displayed, which clearly proved that Karnali river channel has been highly mobile in the past and continues to be mobile in the present. OSL dating would give estimates of timescales over which channels migrate but detail study of processes involved would be required to forecast future evolution.

2.2 Hydraulic Modelling of Dynamic fluvial system

Maggie Creed, University of Edinburgh

Maggie's presentation explained the details on how she set up the model in Delft 3D to acquire the flood inundation maps for different scenarios. She used the 2D model in Delft 3D using an average value for vertical velocity as processing is much faster than a 3D model. To understand the effect of sediment aggradation and degradation in the flood extent and channel switching in Karnali, she changed the bed level at the bifurcation point as per the field sediment condition during her field trip in October 2016. She highlighted that modelling required pre-processing of data, especially the choice of grid and resolution, and post processing of the results to generate legible maps. Challenges lay in the choice of parameters, boundary conditions and the validation of the data. She discussed that it was easy to change the bathymetry data, sediment data and roughness value in Delft 3D and the complexity came mostly in setting up the initial grid of the model.

2.3 Social Context of Flooding, Initial Observation

Remo Pedreschi and Jeevan Sharma

The presentation was focused on the lives, livelihood, construction technology and people's perception of the river. Karnali is undergoing social transformations with ideas of modernity. However, it was discussed that vernacular houses could be made flood responsive by incorporating resilient construction practices. People interact with the river for livelihood purposes and not just as a threat to flooding. While the physical scientists are concerned about the flood risk, Karnali people perceive river through a completely differently lens. Thus, the presentation highlighted that it is important to understand community's interaction with the river for flood risk mitigation.

2.4 Connecting Pixel to People (Making use of flood inundation maps: Research into use)

Madhab Uprety and Sanchita Neupane

The presentation discussed on the participatory framework of using flood inundation maps to identify flood risks in the Lower Karnali region and the way of communicating those risks on the ground. The potential of open street maps in getting the exposure data and then utilizing them as base maps for the inundation maps developed in the project were explored. The land use details were drawn in open street map by using satellite images and field papers while the field staffs validated the details drawn in maps. Overlaying flood inundation maps over land use details in open street platform could answer critical questions, such as how many buildings and roads would be inundated and to what extent if a 20 –year or 100-year return period flood occur in Karnali. Also, using this method, maps generated from different modelling technique and approaches could be compared and validated on the ground. The land use details of Karnali can be viewed at www.openstreetmap.org

Discussion:

Q. Were the sediment characteristics along the channel incorporated in flood modelling? (DHM)

A. The sediment characteristics were considered only at the bifurcation point. By changing the bed level at the bifurcation point in Karnali, the subsequent downstream impact in flood extent, depth and channel switching were visualised. There is a provision of incorporating sediment flow in Delft 3D if reliable sediment data are available. (Maggie, UoE)

Q. Did you incorporate the geo-morphological conditions of the field while producing flood maps? (Basanta Raj Adhikari, IoE)

A. It would be useful to incorporate the geomorphology of the catchment in producing flood maps but this was not under the scope of this short- research and the research was focussed only into the hydraulic modelling of the river. (Maggie, IoE)

Q. Are reinforced concrete buildings less functional that resilient vernacular buildings in Karnali? (DHM)

A. Modern Reinforced Concrete buildings are safe only if they are built with engineering standards and are expensive. Alternatively, vernacular houses can be made flood resilient through local materials, a local technology and in a cost-effective way. (UoE)

Q. Will the maps be validated in the field? How? How will you engage the maps with the communities? (UoE)

A. Yes, the maps will be taken to Karnali and the features will be validated as per field observations and with the help of local people. (PAC, Nepal)

Q. What are the major take- away from this research?

A. The model is highly sensitive to how we set up the model, the parameters used and the inputs fed into the system. It is important to pre-process the input data. For example, the DEM considers tree-tops as the terrain height which needs to be processed to subtract the height of the trees to represent the actual terrain and assign the relevant roughness value to the forest while routing the flow. (Lizzie, UoE)

A. If the schools in Karnali teach mapping in open street maps, the students would be able to understand the risk by being involved. This could be a way forward to disseminate the knowledge about floods and raising awareness. (Maggie, UoE)

APPENDIX

List of Participants

SN	Sector	Participant	Organisation	Email
1	**Government**	Raju Shrestha	DHM	
2		Dinkar Kayastha	DHM	dinkarkayatha@gmail.com
3		Sunil Pokharel	DHM	pokh-sunil@yahoo.com
4		Suresh Chandra Pradhan	DHM	Pradhansuresh11@hotmail.com
5		Rajendra Sharma	DHM	Rajendra-706@hotmail.com
6		Hare-Ram Lamichhane	DHM	lamichhanehr@yahoo.com
7		Saket Kikam	DHM	
8		Rudra Puriyar	DHM	rudrapariyar84gmail.com
9		Ram Gopal Kharbuja	DHM	rgkharbuja@gmail.com
	Research/ Academia			
10		Basanta Raj Adhikari	IOE	bradhikari@ioe.edu.np
11		Hugh Sinclair	UoE	Hugh.sinclair@ed.ac.uk
12		Mikael Attal	UoE	Mikael.attal@ed.ac.uk
13		Lizzie Dingle	UoE	Elizabeth.Dingle@ed.ac.uk
14		Maggie Creed	UoE	m.creed@ed.ac.uk
15		Jeevan Sharma	UoE	Jeevan.sharma@ed.ac.uk
16		Remo Pedreschi	UoE	npedreschi@ed.ac.uk
17		Mikael Attal	UoE	Mikael.attal@ed.ac.uk
	NGOs			
18		Santosh Dahal	LWF	sdahal.lwr.org
19		Ramesh Shrestha	Mission East	ramesh.shrestha@missioneast.org
20		Bibek Karki	Mission East	
21		Dipendra Gautam	SERI	dipendra.gautam.seri@gmail.com
22		Dr. Kalpana Devkota	Oxfam Nepal	kdevkota@oxfam.org.uk
23		Sushila Pandit	CARE Nepal	Sushila.pandit@care.org
24		Pradeep Dangol	ICIMOD	pdangol@icimod.org
25		Keshab Pokhrel	Mercy Corps	kpokhrel@mercycorps.org
	PAC			
26		Mirianna Budimir	PAC-UK	mirianna.budimir@practicalaction.org .uk
27		Sumit Dugar	PAC	sumit.dugar@practicalaction.org.np
28		Madhab Uprety	PAC	madhab.uprety.pac@gmail.com
29		Dilip Gautam	PAC	dilip.gautam@practicalaction.org.np
30		Sanchita Neupane	PAC	sanchitanpn@gmail.com

Agenda for Workshop

Sharing Workshop on Karnali Flood Research Project

Dynamic Flood Topographies in the Terai: Community Perceptions and Resilience Nepal (DISTAL)

(Joint Collaboration of University of Edinburgh(UoE), Practical Action Consulting(PAC) and Department of Hydrology and Meteorology (DHM**)**

Date: August 18, 2017
Venue: Hotel Shangri-La, Lazimpat, Kathmandu, Nepal

Time	Session
08:30-09:00	Registration with tea/coffee
09:00 -09:15	Introduction and Welcome (PAC)
09:15-09:45	Overview of the Project (UoE)
09:45-10:00	Presentation by DHM
10:00-10:15	Geomorphological Flooding (PAC/ UoE)
10:15-10:30	*Coffee break*
10:30-10:50	Floods and Sediment dynamics (UoE)
10:50-11:10	Modelling flood prediction (UoE)
11:10-11:30	Social Context to Floods (UoE)
11:30:11:45	Connecting pixel to people (PAC)
11:45-12:30	Discussion/Remarks
12:30	*Lunch*

Photos

Presentation by DHM

Presentation by Prof Hugh Sinclair

Presentation by Dr.Basanta Raj Adhikari

Presentation by Mikael Attal

Presentation Slides

The slides for presentations are in chronological order

DISTAL: Dynamic Topography of the Terai, Nepal: Community Perception and Resilience

UoE staff: **Prof Hugh Sinclair**, **Dr Mikael Attal**, Prof Alistair Borthwick, Dr Noel Gourmelen, Prof. Simon Mudd, Dr Kanchana Ruwanpura, **Dr Jeevan Sharma, Prof Remo Pedreschi**, Dr. B. R. Adhikari

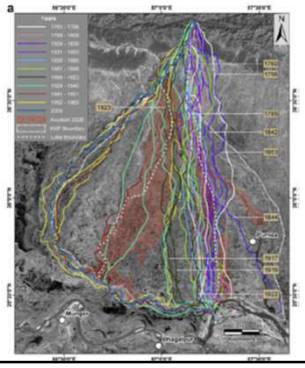
- Flora Weissgerber – postdoc– 2 months Dec 2016 and Jan 2017
- **Maggie Creed** (PDRA) 3 months Feb-April 2017
- **Lizzie Dingle** (PDRA) 4 months Feb- May 2017

PAC staff: **Dr Dilip Gautam, Dr Mirianna Budimir, Dr Sarah Brown, Mr Sumit Dugar, Puja Shakya, Madhab Uprety, Sanchita Neupane**,

Tribhuvan University: **Dr. Basanta Adhikari**

Aspects of flooding recognised by communities:

1. Gentle inundation
2. Waterlogging
3. Devastating floods (high flow, depth and sediment)

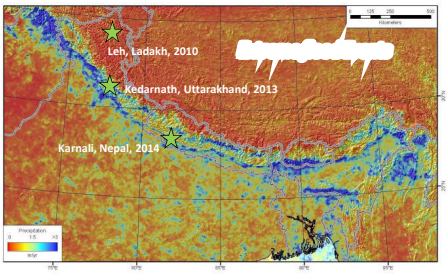


2008 Kosi floods 3 million people displaced – (Chakrobarty, 2010)

Three studies – Ladakh, Uttarakhand, and Nepal

- Precise *reconstruction* of extreme floods
- Calculation of *recurrence* interval for events
- *Prediction* of the nature and distribution of future risk

How can we use geomorphic data to understand the nature and relative magnitude of these events?



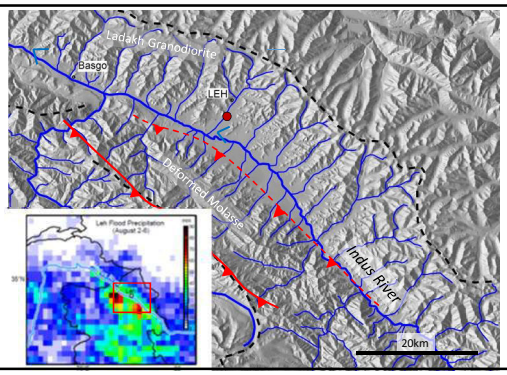
Bookhagen and Burbank, 2006, Geophys. Res Letts.

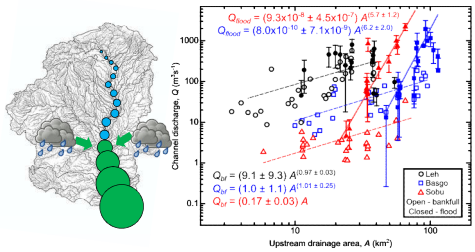
Geomorphic Flux From Ladakh Flashflood Equates to >1000 yrs Average Erosion Rate

[1]Sinclair, H. D., [1]Mudd, S., [1,2]Hobley, D., [1]Naylor, M., [1]Dallas. K.,,[1]Le Divellec, T., [1]Grieve, S.,

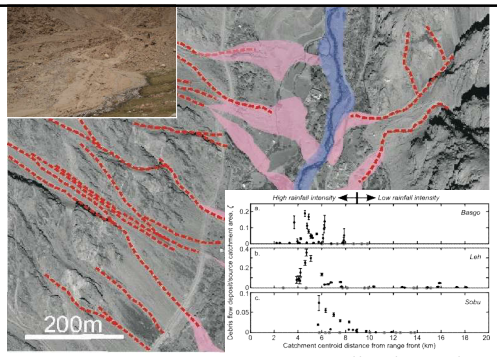
[1]The University of Edinburgh, Edinburgh, UK.
[2]University of Colorado, Boulder, US

On Aug 6th 2010 a 'cloudburst' devastated the region – one rain gauge recorded just 28mm of rain in 24 hrs.



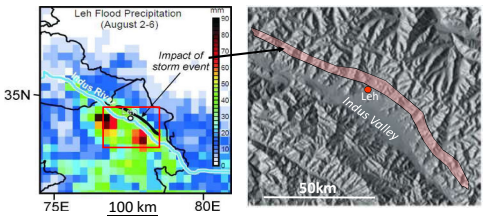


Hobley et al., 2012, Geology

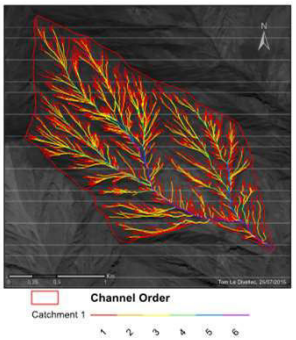


Hobley et al., 2012, Geology

Geomorphic data relocates highest impact storm to northeast of Indus River



But how significant was this event?



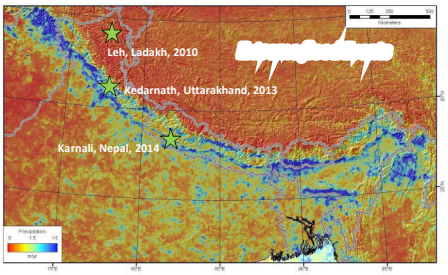
70 mm equates to
~3900 yrs erosion

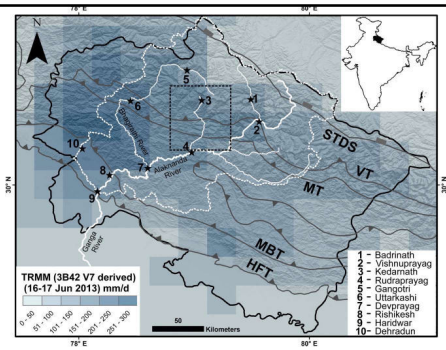
Uttarakhand floods represent
greatest floods since ca. 13,000 yrs.
Impact was predictable

[1]Sinclair, H. D., [1]Mudd, S., [2]Devrani, R., [2]Singh, V.,

[1]The University of Edinburgh, Edinburgh, UK.
[2]University of Delhi, India

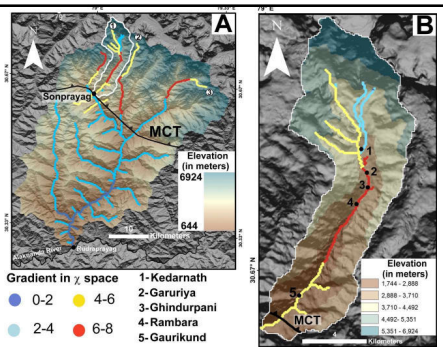
Ladakh event was extremely localised and represented a return interval of >3900 years



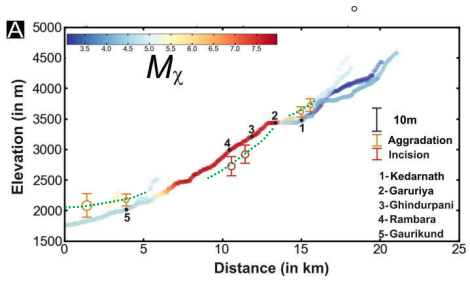


Kedarnath, Uttarakhand, 2013 Devrani et al., 2015, Geophys. Res. Letts

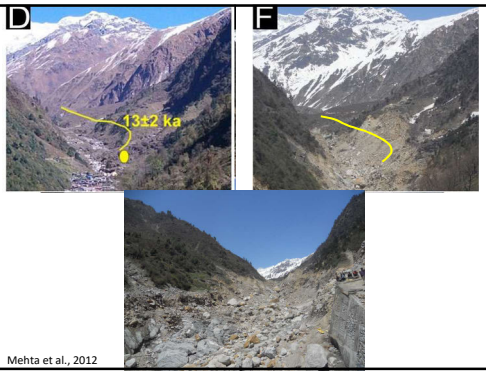
June 16 2013 – Catastrophic floods killed at least 3000 people



Devrani et al., 2015, Geophys. Res. Letts



Devrani et al., 2015, Geophys. Res. Letts



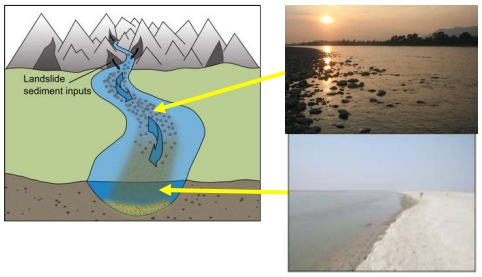
Mehta et al., 2012

So largest floods in upper Ganga since ca. 13,000 yrs

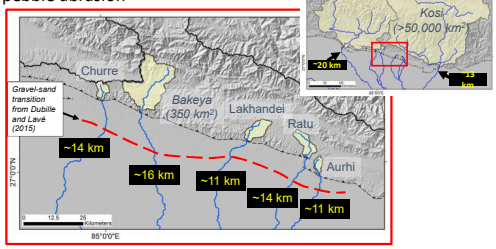
Biggest in main Gange for at least 600 yrs

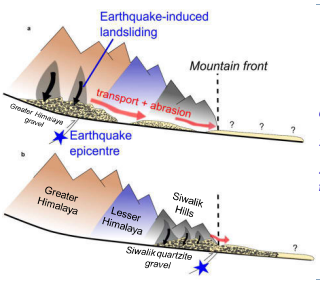
Grain size of sediment leaving the Himalayas impacts flood risk

[1]Sinclair, H. D., [1]Dinge, L., Attal, M.
[1]The University of Edinburgh, Edinburgh, UK.



Limited extent of gravel demonstrates key role of pebble abrasion





Conclusions

1) Gravel flux is independent of catchment area

2) Abrasion limits gravel flux

4) Implications for flood hazard following earthquakes

2015 Gorkha earthquake landslide distribution
(from NASA earth observatory data)

Coarse debris from earthquake unlikely to impact Terai

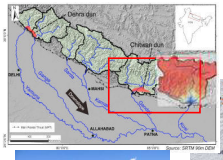
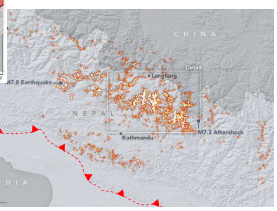
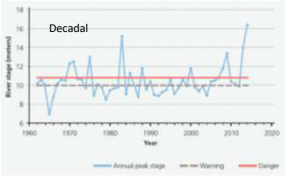


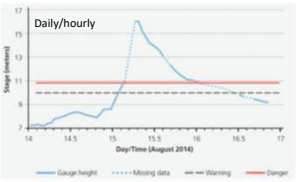
Image courtesy Kristen Cook

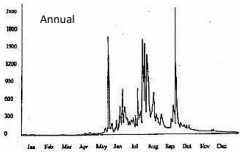


DISTAL: Dynamic Topography of the Terai, Nepal:
Community Perception and Resilience

- Creation of a new interdisciplinary academic network
- Creation of a high resolution digital topographic map
- Provision of model predictions under varying flood conditions
- A synthesis of community perceptions
- Recommendations for practitioners/government decision makers on the role of sediment in flood prediction
- A summary for local government and community leaders of building design/adaptations

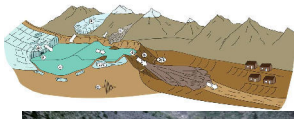


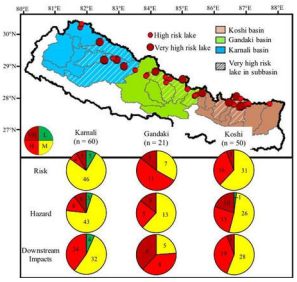




Monsoon hydrographs – The extremes are short-lived and geomorphically effective – ie. they reshape the landscape

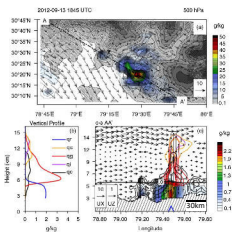
Mechanisms of extreme floods – Glacial Outburst Floods (GLOFS)





https://thehimalayantimes.com/nepal/scientific-study-finds-nepals-glacial-lakes-large-potential-flood-volumes/

Mechanisms of extreme floods - Convective storms (cloudbursts)

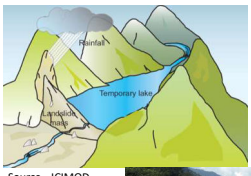


Exceedance probability for 200 mm/d rainfall for the JJAS period of at least 1.6% (underestimate)

13 September 2012 in Rudraprayag district, Uttarakhand, India (upper Ganga catchment)

Shrestha et al., 2015, Tellus A, **67**, 26031, http://dx.doi.org/10.3402/tellusa.v67.26031

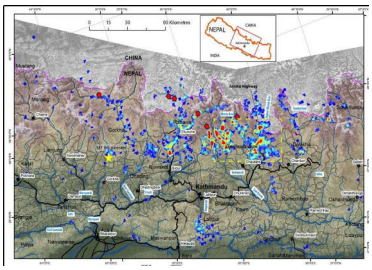
Mechanisms of extreme floods - landslide dammed lakes



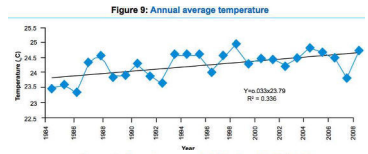
Source - ICIMOD

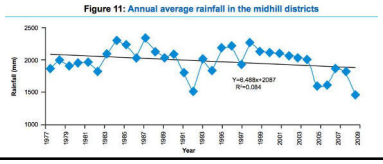
Sawadin, Tamor River (upper Kosi), 2016

Mechanisms of extreme floods - sediment choking of channels following earthquakes



Is there an underlying climate change?





MoSTE (2015).

Are communities experiencing impacts of climate change?

Table 5: Climate change experience

Response type	Frequency	Per cent
Yes	226	95.0
No	12	5.0
Total	238	100.00

Table 6: Perception regarding impact on men and woman by gender

Respondents	Climate change affects women differently than men		Total
	Yes	No	
Male	89	50	139
Female	55	44	99
Total	144	94	238

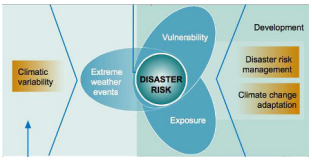
MoSTE (2015).

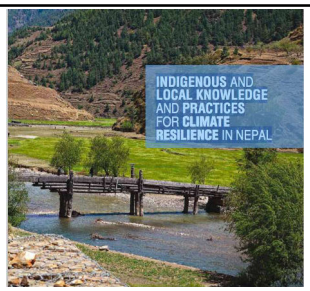
Building Resilience based on:

- Long-term cultural traditions
- Ongoing development and investment (e.g. building materials, embankments and irrigation canals)
- Early warning systems

How can the physical science contribute to building resilience, and how can the social science guide the physical science?

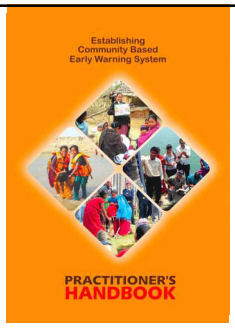
Cultural knowledge





MoSTE (2015). *Indigenous and Local Knowledge and Practices for Climate Resilience in Nepal*, Mainstreaming Climate Change Risk Management in Development, Ministry of Science, Technology and Environment (MoSTE), Kathmandu, Nepal.

Infrastructure – embankments and irrigation channels



© Mercy Corps and Practical Action 2010

The Hyogo Framework for Action (2005 – 2015)

The three strategic goals of HFA are:

Strategic Goal 1: Integration of disaster risk reduction into sustainable development policies and planning.
Strategic Goal 2: Development and strengthening of institutions, mechanisms and capacities to build resilience to hazards.
Strategic Goal 3: Incorporation of risk reduction approaches into the implementation of emergency preparedness, responses and recovery programmes.

Example of early warning

Three colored pole:

Level 1, green: Alert/Standby/Ready

Level 2, yellow: Preparation"Get Set"-

Level 3: Evacuation-Red).

http://www.hydrology.gov.np/new/hydrology/_files/9a8425b638e7ad05eb8276bc22802456.pdf

Proposed outcomes of Project

- Creation of a new interdisciplinary academic network motivated by collaboration with practitioners and communities in the Terai.
- Creation of a unique, high resolution digital topographic map of a Terai region.
- Provision of unique model predictions of dynamic topographies under extreme flood conditions and the consequent flood maps that will be converted into usable risk maps.
- A synthesis of community perceptions of scientific data and actors associated with flood resilience aimed at recommendations for best practice in knowledge transfer.
- A provision of recommendations for practitioners/government decision makers on why sediment in rivers is important for flood risk management.
- A summary for local government and community leaders of building design/adaptations for contrasting flood types using local materials.

GCRF Global Challenges Research Fund

RESEARCH COUNCILS UK

Growing research capability to meet the challenges faced by developing countries

£1.5Bn Global Challenges Research Fund

The GCRF will:

- promote the **economic development and welfare of developing countries.**
- deploy **world class research capability within the UK** to address the challenges facing developing countries.
- harness UK research expertise to strengthen **resilience and response to crisis.**
- be delivered primarily through the **Research Councils and the National Academies.**
- project selection will be managed through independent review in accordance with the Haldane principle.

GCRF – Global Challenge "themes"

Global Challenges

Health	Clean Energy	Sustainable Agriculture
To tackle diseases, strengthen health systems and reach the worlds most vulnerable.	*To provide access to clean energy, including new technologies and the behavioural insights required for successful introduction to developing countries.*	*To improve nutrition and food security, support technological innovation, and increase resilience to climate change*
Conflict & humanitarian action	**Foundations for Economic Development**	**Other potential topics**
New insights and approaches for preventing conflict and violence, build stability and strengthen humanitarian action.	To understand what works best for developing countries to build the foundations for economic development - macroeconomics, institutions, innovation and private sector growth, cities and infrastructure, education systems, jobs and skills.	Resilient systems Mass Migration and Refugee Crises

GCRF Global Challenges Research Fund

GCRF: RCUK Collective Fund

Interdisciplinary Research Hubs to Address Intractable Challenges Faced by Developing Countries

Deadline for Outline proposals: 9 November 2017, 4pm (GMT)

Summary

The Global Challenges Research Fund (GCRF) is a 5-year £1.5Bn fund and a key component in the delivery of the UK Aid Strategy: tackling global challenges in the national interest. The fund aims to ensure that UK research takes a leading role in addressing the problems faced by developing countries through:

- Challenge-led disciplinary and interdisciplinary research
- Strengthening capacity for research and innovation within both the UK and developing countries
- Providing an agile response to emergencies where there is an urgent research need.

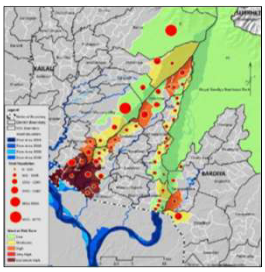
Research Councils UK invites proposals from eligible UK research organisations to establish and lead a number of challenge-led and impact-focused GCRF Interdisciplinary Research Hubs which meet the aims of Official Development Assistance. Between £8M - £20M (full economic cost) will be available for each Hub, provided over a 5 year period starting on 1st December 2018. Depending on the quality of the applications received we anticipate awarding 12-15 Hubs.

Each Hub is required to demonstrate:

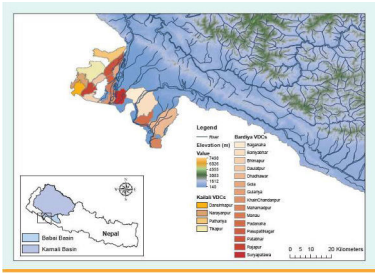
- **Challenge and Impact focus** – address a specific currently intractable development challenge(s) with realistic pathways with the potential to deliver a broad range of measurable impacts, and a clear plan for sustaining and further developing the work undertaken during the lifetime of the Hub.
- **Interdisciplinary research excellence** – anchored by well-integrated interdisciplinary approach which demonstrates both underpinning research excellence and the ability to think across, between and within the Sustainable Development Goals (SDGs), and that adds significant value to existing global research efforts.
- **Global partnerships** – a commitment to capacity building and a programme of research and supporting activities which is co-developed with international partners, through genuine and equitable partnerships with researchers and relevant development agencies; third sector and Civil Society Organisations; industry and other private sector organisations; policy makers.
- **Organisation and leadership** – strong research and operational leadership which incorporates robust financial and risk management, assurance, governance and effective monitoring and evaluation, and facilitates the ability to learn and adapt over the lifetime of the Hub.

Proposal of a hub between Edinburgh/Kings College focused on **Disaster, Risk and Resilience**

There will also be a follow-up to the 'Building Resilience' call – thought to be in the autun.



Rakhal, B., 2014, Application of remote sensing and GIS in quantification of river channel shifting in Karnali megafan of Nepal. *Masters dissertation*



Community Based Early Warning Systems (CBEWS)

- Identifying target population
- Conduct community meetings to explore and map their risks
- Fostering the development by communities of monitoring and warning systems for local hazards
- Generating public information tailored to target groups
- Developing formal mechanisms for community representatives to Monitor and oversee warning system design
- Providing training for observers, authorities and communicators who Operate the warning system
- Providing exercises and simulations to enable people to experience and practice warning interpretation and responses.

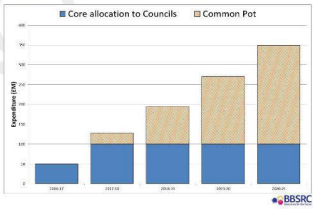
From: Community Based Early Warning Systems – A Practitioners Guide: Mercy Corps and Practical Action 2010

What is Official Development Assistance (ODA)-compliant research?

- Research that is directly and primarily relevant to the problems of developing countries.
- Research should investigate a specific problem or seek a specific outcome which will impact on developing countries in the immediate or longer-term.
- Research proposals can focus on a development topic or address an un-met capacity need in the partner country.
- Research does not need to be solely relevant to developing countries, but developing countries should be the primary beneficiaries.

BBSRC

GCRF allocation to RCUK



BBSRC

Figure 29: Sediment induced wear of Hydro-turbine (Bishwakarma MB, 2016)

Post earthquake renovations halted by follow-on debris flows off mountains.

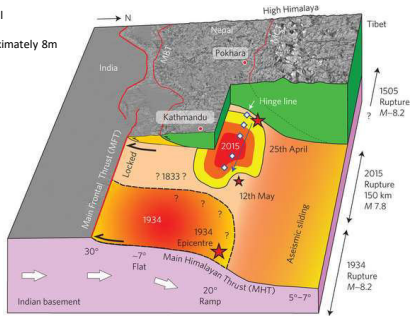
River channels raised by 10m

So do earthquakes erode more than they uplift mountains?

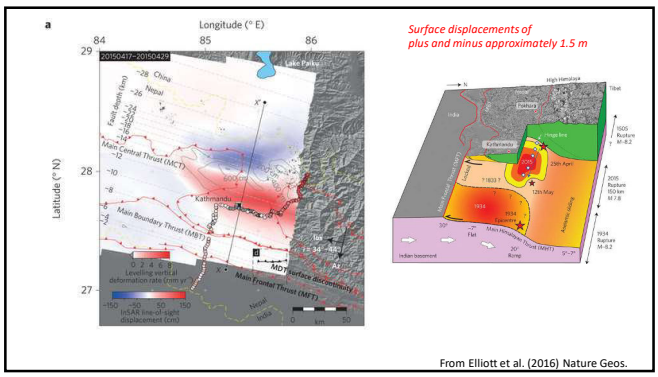
Irrelevant unless sediment is washed out of mountains.

2015 Gorkha Earthquake, Nepal

Maximum displacement approximately 8m
Rupture time 5 to 60 seconds
Did not rupture surface



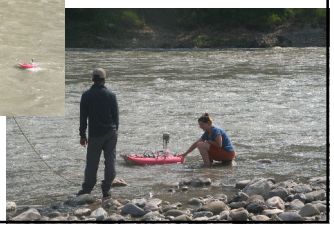
From Elliott et al. (2016) Nature Geos.



Surface displacements of plus and minus approximately 1.5 m

From Elliott et al. (2016) Nature Geos.

Measuring water and sediment discharge following the earthquake using an ADCP



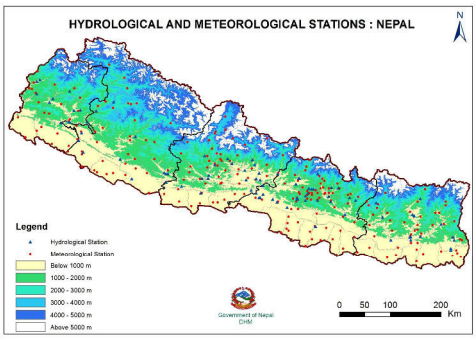
Government of Nepal
Ministry of Population and Environment
Department of Hydrology and Meteorology

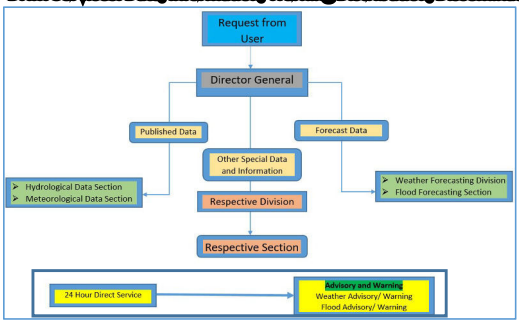
Status of Flood Forecasting and Early Warning System in Nepal

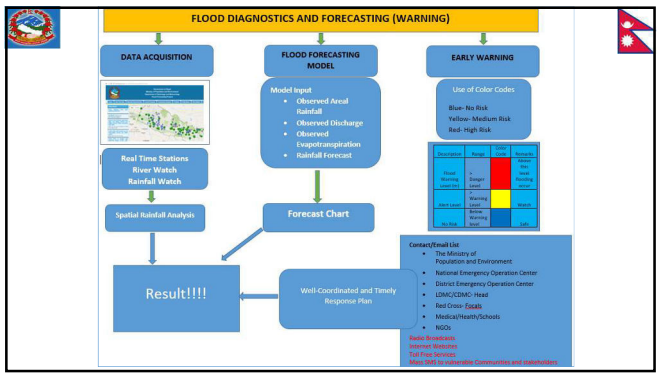
Binod Parajuli
Flood Forecasting Section

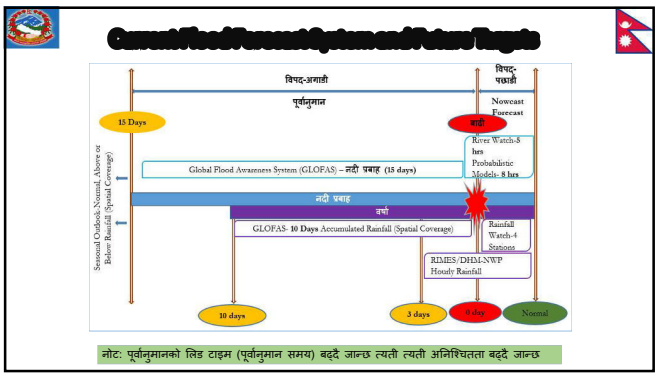
Introduction: DHM

- Department of Hydrology and meteorology has a mandate from Government of Nepal to operate the Hydrological and Metrological services in Nepal.
- To issue hydrological and Meteorological forecast /warning is one of the DHM's principal activities.

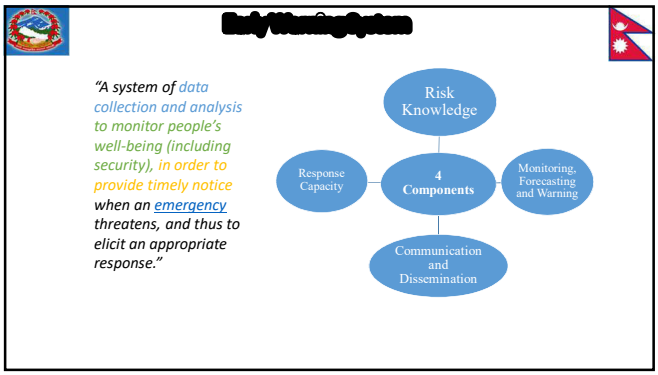




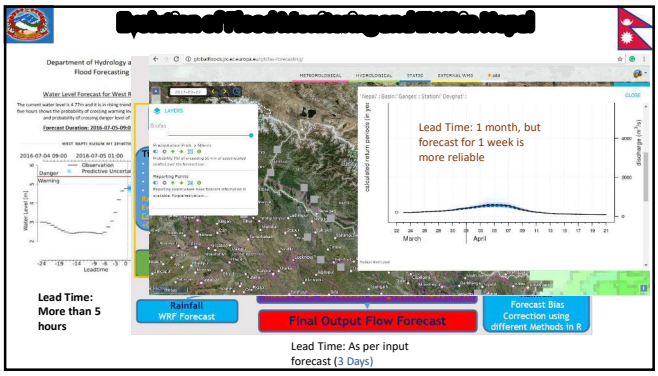

FLOOD DIAGNOSTICS AND FORECASTING (WARNING)
DATA ACQUISITION
FLOOD FORECASTING MODEL
EARLY WARNING
Model Input
Observed Areal Rainfall
Observed Discharge
Observed Evapotranspiration
Rainfall Forecast
Use of Color Codes
Blue- No Risk
Yellow- Medium Risk
Red- High Risk
Real Time Stations River Watch Rainfall Watch
Spatial Rainfall Analysis
Forecast Chart
Result!!!!
Well-Coordinated and Timely Response Plan
Contact/Email List
The Ministry of Population and Environment
National Emergency Operation Center
District Emergency Operation Center
LDMC/CDMC- Head
Red Cross- Focals
Medical/Health/Schools
NGOs

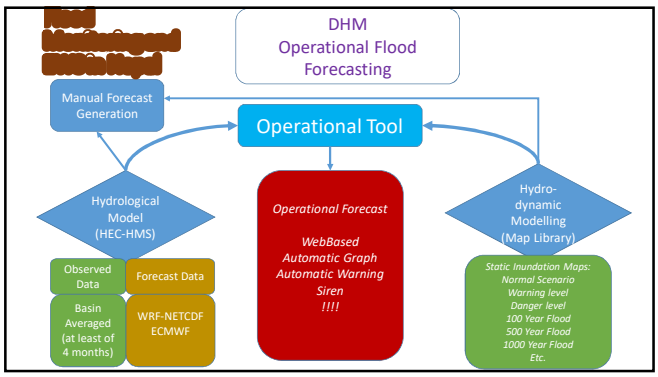

विपद्-अगाडी
पूर्वानुमान
विपद्-पछाडी
Nowcast Forecast
15 Days
नदी
River Watch-5 hrs
Probabilistic Models- 8 hrs
Global Flood Awareness System (GLOFAS) – नदी प्रवाह (15 days)
नदी प्रवाह
वर्षा
GLOFAS- 10 Days Accumulated Rainfall (Spatial Coverage)
Rainfall Watch-4 Stations
RIMES/DHM-NWP Hourly Rainfall
Seasonal Outlook-Normal, Above or Below Rainfall (Spatial Coverage)
10 days
3 days
0 day
Normal
नोट: पूर्वानुमानको लिड टाइम (पूर्वानुमान समय) बढ्दै जान्छ त्यती त्यती अनिश्चितता बढ्दै जान्छ

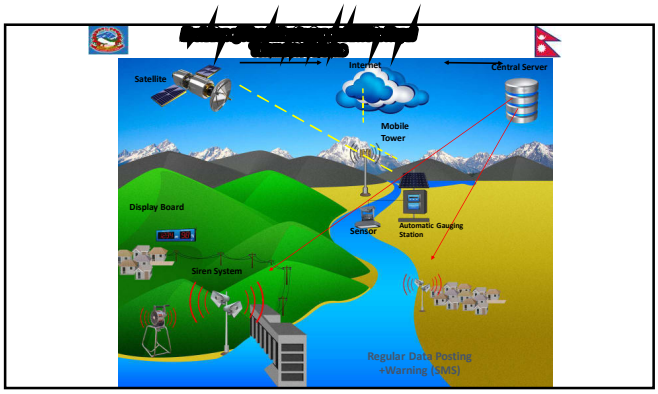
Flood Hazard Management
TWO APPROACHES
FLOOD
Take the Flood away from people
Engineering Structures
Take the People away from flood
Early warning system/ Awareness

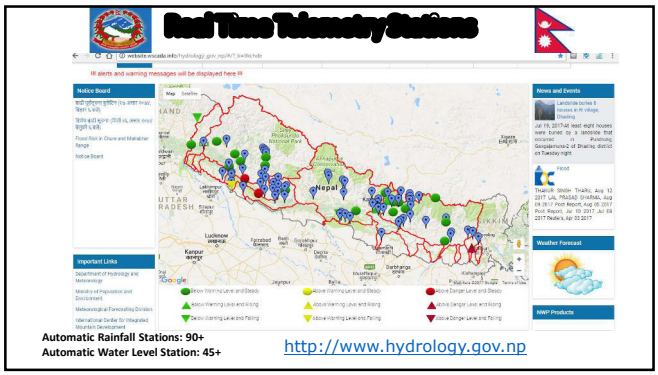

"A system of data collection and analysis to monitor people's well-being (including security), in order to provide timely notice when an emergency threatens, and thus to elicit an appropriate response."
Risk Knowledge
Response Capacity
4 Components
Monitoring, Forecasting and Warning
Communication and Dissemination

1990s
Early Days
Watch and Warn
Lead Time: a few minutes
Manual Gauge Based
2000s
Flood Station
Rainfall Stations
Lead Time: Upto 1 hrs
Preparedness
Real Time Telemetry
2010s
Lead Time: Few Hours


Lead Time: 1 month, but forecast for 1 week is more reliable
Lead Time: More than 5 hours
Rainfall WRF Forecast
Final Output Flow Forecast
Forecast Bias Correction using different Methods in R
Lead Time: As per input forecast (3 Days)



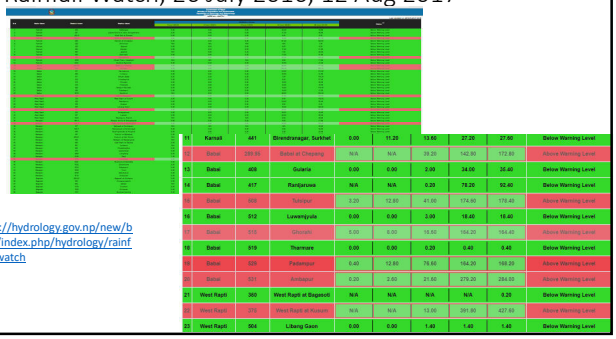




Automatic Rainfall Stations: 90+
Automatic Water Level Station: 45+

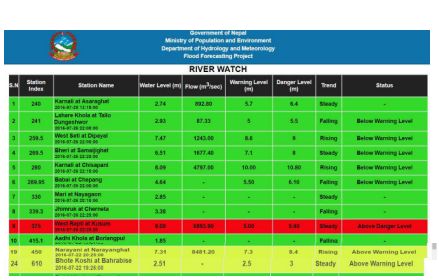
http://www.hydrology.gov.np

Rainfall Watch, 26 July 2016, 12 Aug 2017



http://hydrology.gov.np/new/bull3/index.php/hydrology/rainfall_watch

River Watch 26 July 2016



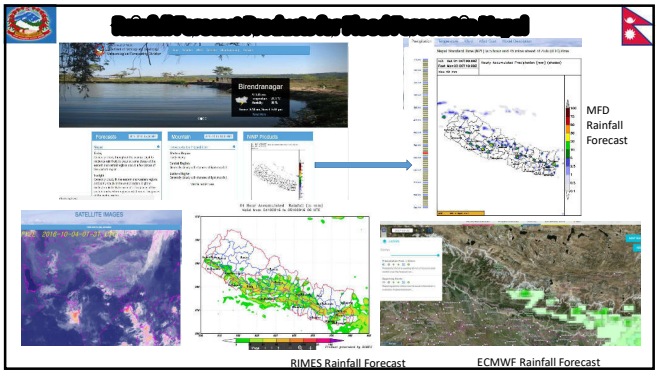
Government of Nepal
Ministry of Population and Environment
Department of Hydrology and Meteorology
Flood Forecasting Project

RIVER WATCH

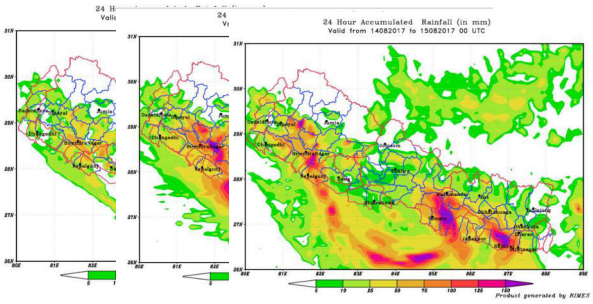
S.N	Station Index	Station Name	Water Level (m)	Flow (m³/sec)	Warning Level (m)	Danger Level (m)	Trend	Status
1	240	Karnali at Asaraghat 2016-07-26 12:15:00	2.74	692.00	5.7	6.4	Steady	-
2	241	Lahare Khola at Tallo Dungeshwor 2016-07-26 12:00:00	2.93	87.33	5	5.5	Falling	Below Warning Level
3	259.5	West Seti at Dipayal 2016-07-26 12:00:00	7.47	1243.00	8.6	9	Rising	Below Warning Level
4	269.5	Bheri at Samajighat 2016-07-26 12:00:00	6.51	1677.40	7.1	8	Steady	Below Warning Level
5	280	Karnali at Chisapani 2016-07-26 12:15:00	8.09	4797.00	10.00	10.80	Rising	Below Warning Level
6	280.95	Babai at Chisapani 2016-07-26 12:00:00	4.64	-	5.50	6.10	Falling	Below Warning Level
7	330	Mari at Nayagaon 2016-07-26 12:15:00	2.85	-	-	-	Steady	-
8	339.3	Jhimruk at Chemeta 2016-07-26 12:00:00	3.38	-	-	-	Falling	-
9	275	West Rapti at Kusum 2016-07-26 12:15:00	5.00	6890.90	5.00	5.50	Steady	Above Danger Level
10	455.1	Andhi Khola at Boriengpul 2016-07-26 12:00:00	1.85	-	-	-	Falling	-
19	450	Narayani at Narayanghat 2016-07-22 20:25:00	7.31	8481.20	7.3	8.4	Rising	Above Warning Level
24	610	Bhote Koshi at Bahrabise 2016-07-22 19:25:00	2.51	-	2.5	3	Steady	Above Warning Level

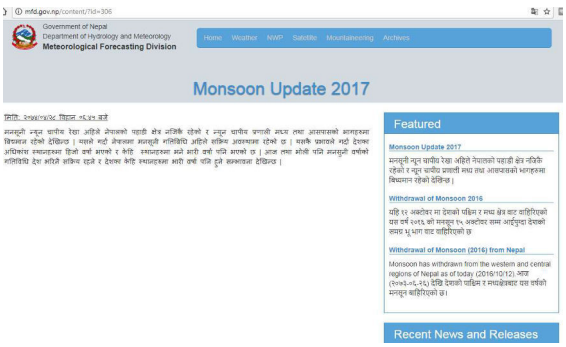
Bagmati, Kankai, Narayani and West Rapti crossed danger level

Babai and Bheri crossed warning level

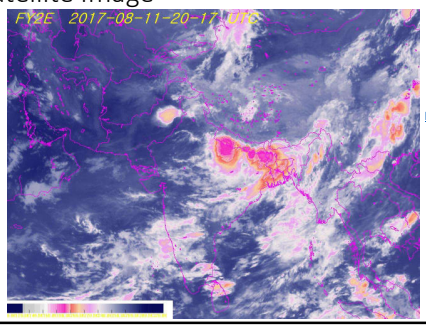


आज, भोली र पर्सीको वर्षा पूर्वानुमान



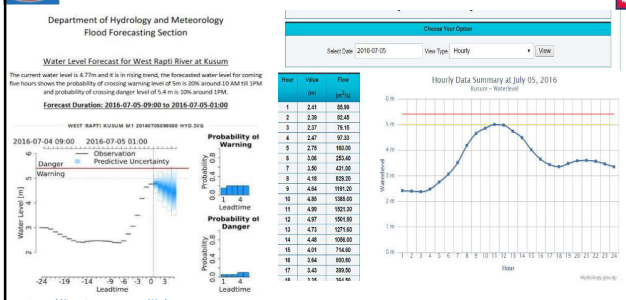


Satellite Image



http://mfd.gov.np/satellite/

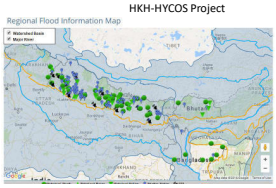
Flood Modelling using Mechanistic Model

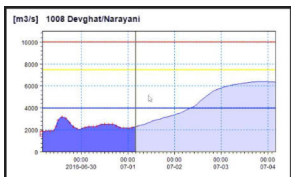


http://flood.rts.com.np/fft/

Flood Forecasting using Computer Models

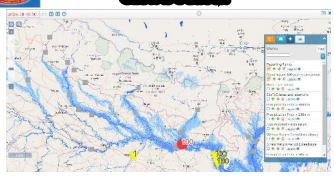
HKH-HYCOS Project



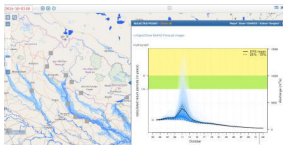


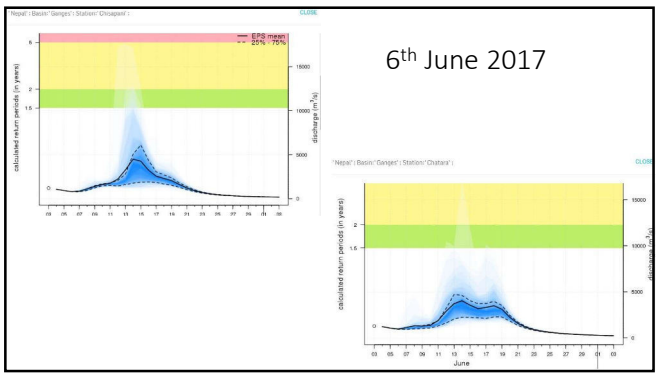
- Mike 11 model is being run in 5 river basins using GFS rainfall forecast and WRF Rainfall forecast
- Data Assimilation part is also included in the model

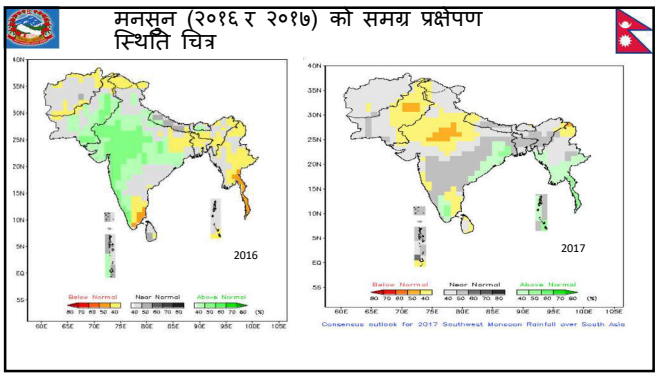
[redacted]

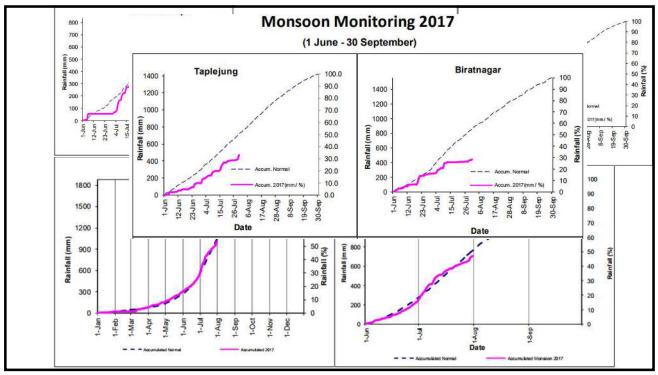


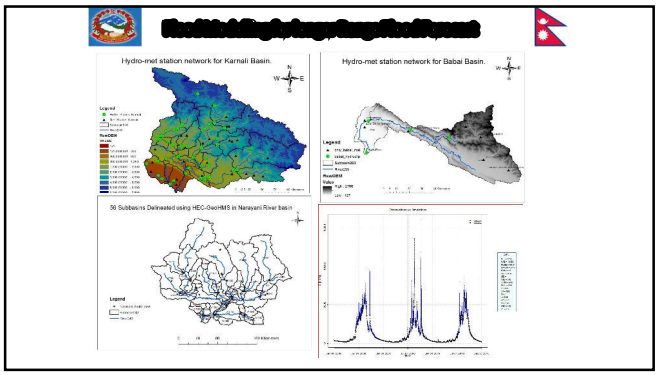
8 Reporting points in Nepal





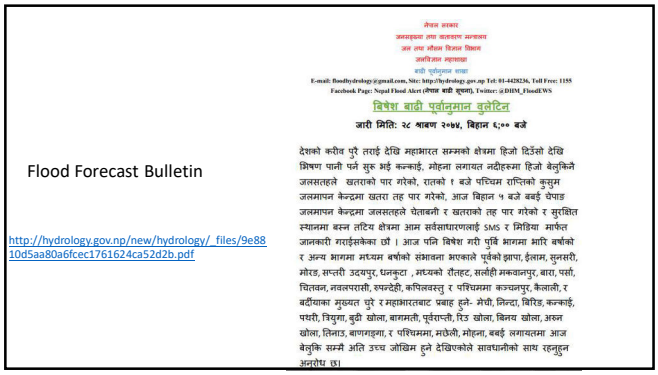






Flood Forecast Bulletin

http://hydrology.gov.np/new/hydrology/_files/9e8810d5aa80a6fcec1761624ca52d2b.pdf



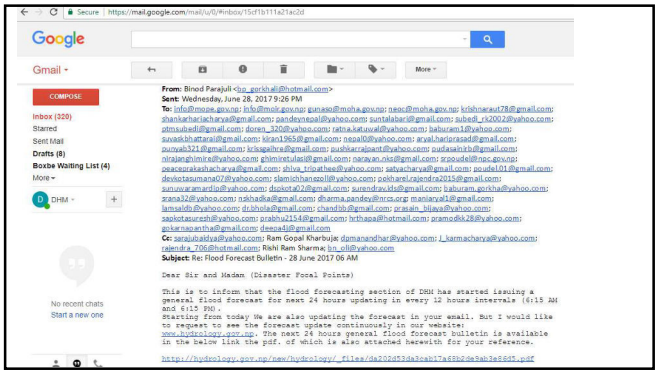
नेपाल सरकार
जलस्रोत तथा सदाचार्यन मन्त्रालय
जल तथा भौतिक विज्ञान विभाग
जलविज्ञान महाशाखा
बाढी पूर्वानुमान शाखा

E-mail: floodhydrology@gmail.com, Site: http://hydrology.gov.np Tel: 01-4428236, Toll Free: 1155
Facebook Page: Nepal Flood Alert (नेपाल बाढी सूचना), Twitter: @DHM_FloodEWS

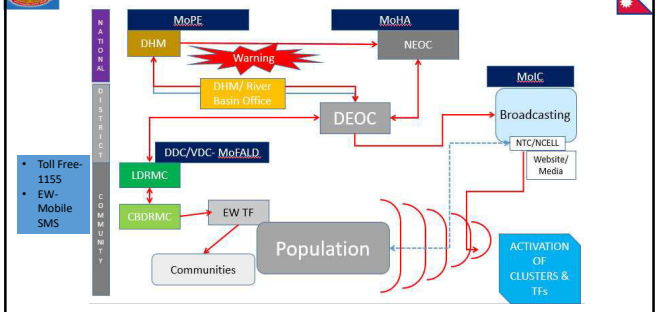
विशेष बाढी पूर्वानुमान बुलेटिन

जारी मिति: २८ श्रावण २०७४, बिहान ६:०० बजे

देशको करीब पुरै तराई देखि महाभारत सम्मको क्षेत्रमा हिजो दिउँसो देखि झिषण पानी परे सुरू भई कन्काई, मोहना लगायत नदीहरूमा हिजो बेलुकिने जलसतहले खतराको पार गरेको, रातको १ बजे पश्चिम राप्तिको कुसुम जलमापन केन्द्रमा खतरा तह पार गरेको, आज बिहान ५ बजे बबई पेपाड जलमापन केन्द्रमा जलसतहले चेतावनी र खतराको तह पार गरेको र सुरक्षित स्थानमा बस्न तटिय क्षेत्रमा आम सर्वसाधारणलाई SMS र मिडिया मार्फत जानकारी गराईसकेका छौं । आज पनि विशेश गरी पुर्वि भागमा भारि बर्षाको र अन्य भागमा मध्यम बर्षाको संभावना भएकाले पूर्वको झापा, ईलाम, सुनसरी, मोरङ, सप्तरी उदयपुर, धनकुटा , मध्यमेरी तेहाट, सर्लाही मकवानपुर, बारा, पर्सा, चितवन, नवलपरासी, रुपन्देही, कपिलवस्तु र पश्चिममा कञ्चनपुर, कैलाली, र बर्दीयाका मुख्यत पुरे र महाभारतबाट प्रवाह हुने- मेची, निन्दा, बिरिङ, कन्काई, पथरी, चियुगा, बुढी खोला, बागमती, पूर्वराप्ती, रिउ खोला, बिनय खोला, अरुन खोला, तिनाउ, बाणगाइगा, र पश्चिममा, मछेली, मोहना, बबई लगायतमा आज बेलुकि सम्मै अति उच्च जोखिम हुने देखिएकोले सावधानीको साथ रहनुहुन अनुरोध छ।



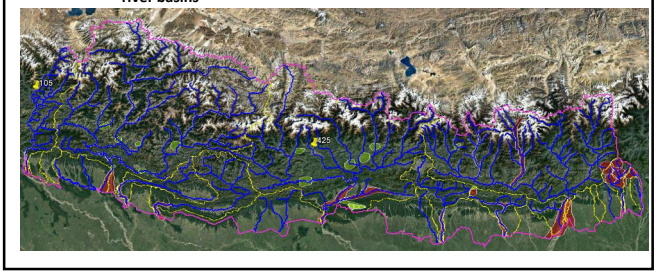
Flood Early Warning Dissemination

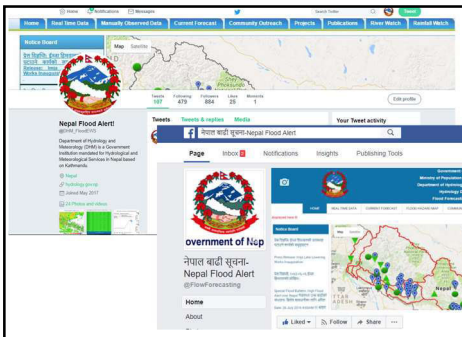


Mass SMS to vulnerable communities

42 polygons in 8 river basins

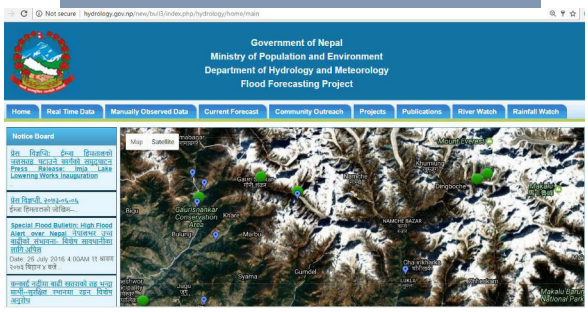
Targeted particularly for flood and landslide





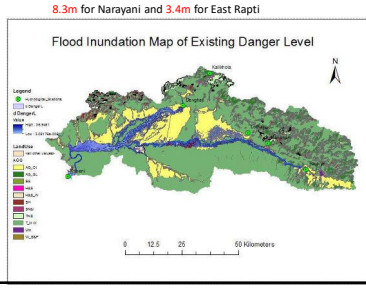
Social Media for Wider Dissemination

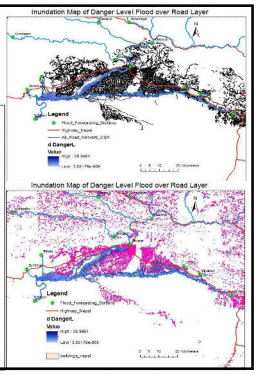
Current EWS for Tsho Rolpa and Imja Glacial Lake Possible Outburst:



Inundation Map for Danger Level

8.3m for Narayani and 3.4m for East Rapti





Way Forward

- Identification of flood zones and development of flood risk maps
- Identifying/Establishing Monitoring Stations in Transboundary Rivers
- Re-evaluation of danger and warning levels
- Development of real-time data management system
- Development of flood forecasting models
- Development of decision support systems for various application
- Strengthening bilateral cooperation with China and India to reduce the impact of flood and inundation

Thank You!

Geomorphological control for Flooding in Nepal

Dr. Basanta Raj Adhikari, Institute of Engineering
Email: bradhikari@ioe.edu.np
Web-page: http://bradhikari.com.np/

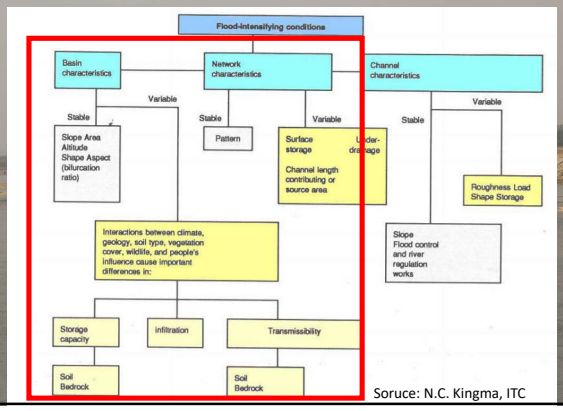
Basic Sciences involved in flood hazard

- Geomorphology
- Hydrology
- Meteorology
- Soil Science
- Vegetation Science

Geomorphic Impacts of Floods

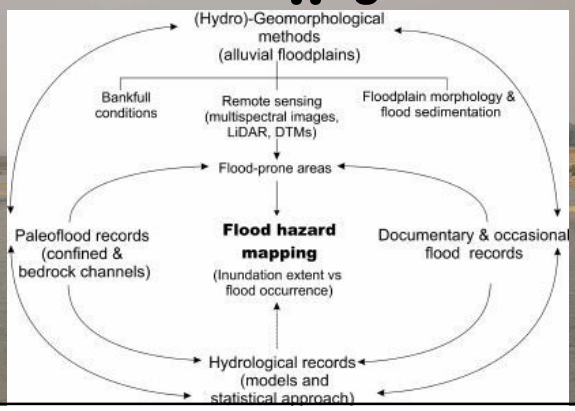
- The passage of a flood wave through a river system constitutes a geomorphological as well as a hydrological event
  - Erosion
  - Transport
  - Deposition

Flood intensifying factors



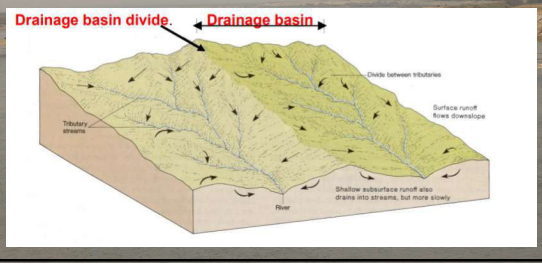
Soruce: N.C. Kingma, ITC

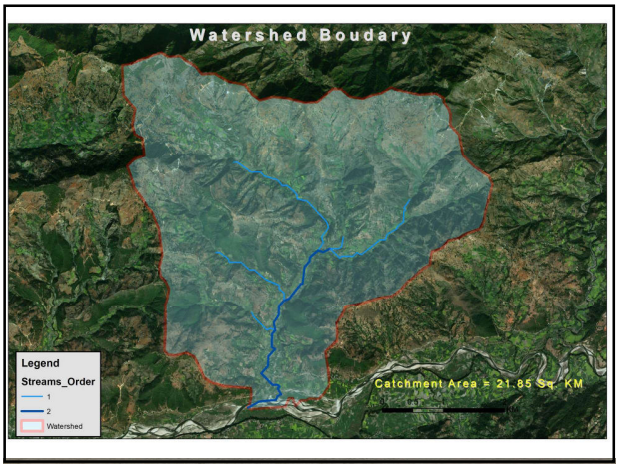
Flood Hazard Mapping



Geomorphic impacts of Floods

- Riverine flooding occurs within the drainage basin

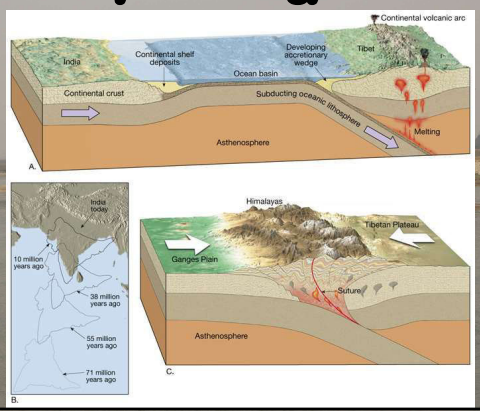




Seismicity and Geology

- Seismo-tectonic movement
- Extreme rainfall event triggers
  - landslides (including slope failure, slumps, creeps, wedge failures),
  - Pluvial processes (including debris flows, debris slides, debris torrents, mud flows, mud slides, debris torrents with mud), and
  - Erosional processes including bank cutting, sheet erosion etc.

Seismicity and Geology



BangaBagar, Baitadi

Baisaha Khola, Morang

Source: Saroj Karki

Source: Saroj Karki

Source: Saroj Karki

Source: Saroj Karki

Source: Saroj Karki

Lizzie Dingle & Mikaël Attal

Edinburgh Land Surface Dynamics Group

Sediment export from the Himalaya and flood risk in the Terai

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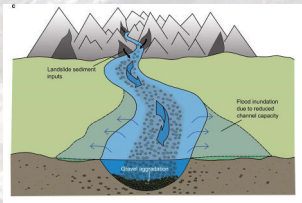
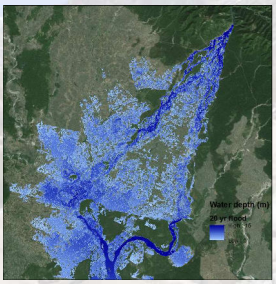
River-related hazards are related to two mechanisms:

Overbank flooding → modelled (role of sediment?)

Channel migration and avulsion → not so easy!



Flooding – not just about water



Existing HEC-RAS output based on 20 yr flood discharge (Credit: Dr Dilip Gautam and the Department of Hydrology and Meteorology, Nepal)

Existing modelling - HECRAS

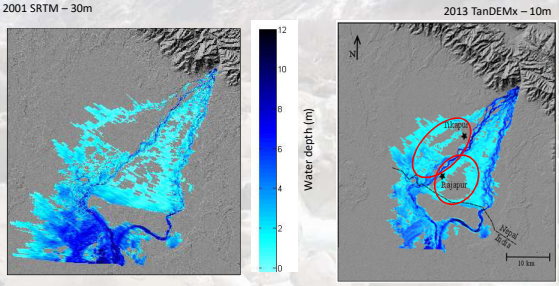
- **30 m SRTM DEM from 2001 with +/- 10 m vertical error**
- **VERY LOW RELIEF LANDSCAPE – within error of DEM**
- **How sensitive are model outputs to slight changes in topography / DEM resolution / boundary conditions?**

Flooding – not just about water

Sensitivity of the tools

2001 SRTM – 30m

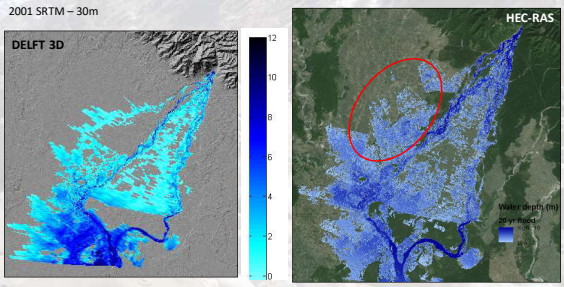
2013 TanDEMx – 10m



Flooding – not just about water

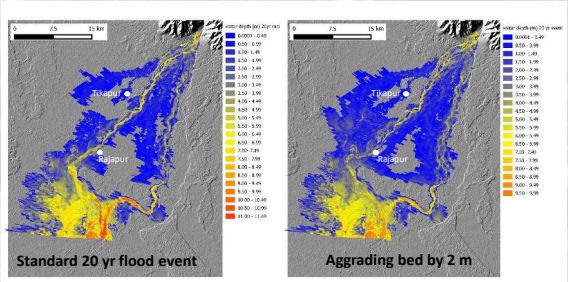
Sensitivity of the tools

2001 SRTM – 30m



Flooding – not just about water

Effect of sediment deposition

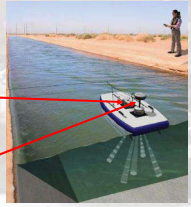


Acoustic Doppler Current Profiler (ADCP)

ADCP unit

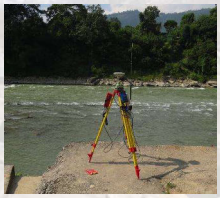
Power pack (& radio)

GPS rover and antenna



Floodplain and channel elevation

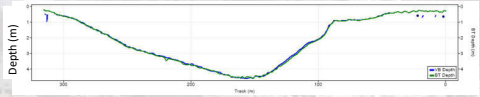
Real Time Kinematic (RTK) GPS



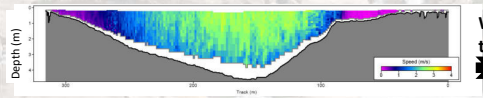
Base station

Rover – can be used on ADCP or on land

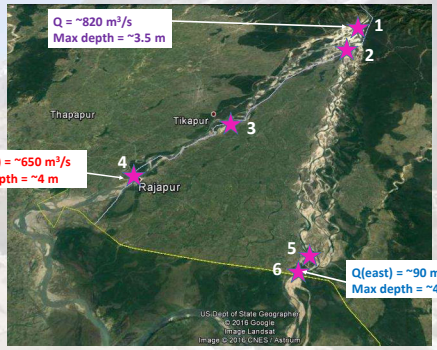
ADCP outputs



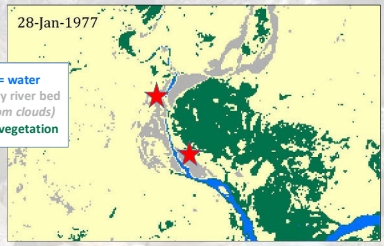
Channel geometry



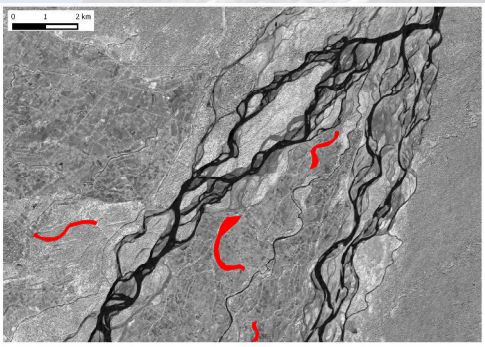
Water velocity through full column
discharge



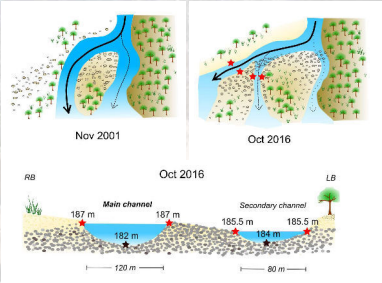
Channel migration: 1977 - 2016



3 km



Karnali bifurcation stability



Cross-section looking upstream

IN SUMMARY…

FLOODING:

- Flooding maps are informative tools but they are very sensitive to DEM resolution and age, water depth at the time of acquisition, sediment deposition / erosion and river engineering.
- New ways of improving DEM preparation (e.g., TanDEM-X) and assessing the influence of sediment (data + modelling, see Maggie's presentation).

CHANNEL MIGRATION:

- OSL dating will give estimate of timescales over which channels migrate but still some work to do to understand processes involved and forecast future evolution.

Maggie Creed

Edinburgh Land Surface Dynamics Group

Hydraulic modelling of dynamic fluvial system using Delft 3D

Presentation Layout

- Introducing Delft 3D
- Setting up the numerical model
  - Inputs
  - Selecting outputs
- Post-processing the data
- Advantages and challenges of modelling

Delft 3D

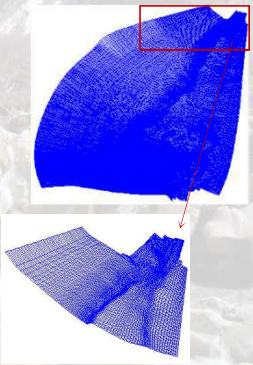
- 2D depth averaged equations
  - No vertical velocity component
  - Flow in horizontal plane
  - Fast, approximate
- 3D model – several 2D layers
- Hydraulic Model
  - Hydrodynamics (water)
  - Morphology (sediment)

What do we want to achieve?

- How does bed aggradation/degradation affect flood extent?
- Bed changes at bifurcation
  - Impact on flood extent?
  - Flow in East & West branch?
- Simple, 2D approximation
  - No sediment transport
  - Vary bed elevation

Setting up the model – Physical domain

- Grid generation
  - Structured grid
  - Compromise runtime/resolution
- Delft 3D
  - 40 000 to 60 000 cells per domain
  - Sub domains in parallel
- Karnali floodplain
  - 50 000 cells
  - Smallest 30 m x 30 m approx.



Setting up the model – bathymetry/flow

- Assign value to each cell
- Bathymetry – SRTM 30m, TanDEMx
- Water level
  - Water only in river
  - Bathymetry + main channel water depth
- Velocity – initially zero everywhere
- Roughness
  - Constant value
  - Polygons to assign different roughness
    - E.g. sand bed, gravel bed, dense trees, argiculture

Bifurcation bathymetry

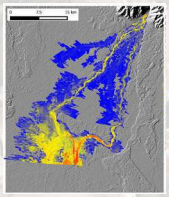
Roughness distribution

Selecting outputs

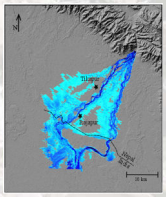
- Boundary conditions
  - Inflow: Discharge at gauge station
  - Outflow: discharge – water depth relationship
- Recording data – select cross sections
  - Inflow/Outflow
  - Bifurcation
  - East/West branch
  - Choose output time step
- Run model – 2 steps

Post-processing

- Delft 3D couple with Matlab
  - Produce flood map at given time
  - Graph time-varying discharge/water depth/flow velocity at cross section



Export shp file – GIS

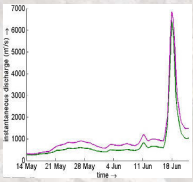


Export Matlab array/figures

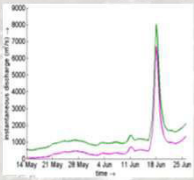
Changing bifurcation bed elevation

- 3 scenarios
  1. No change to SRTM elevation
     - West branch main channel
  2. SRTM – 2m
     - Channel elevation Oct 2016 except bifurcation
     - Man channel east branch
     - East branch is main channel
  3. Bathymetry modified to match Oct 2016 field trip
     - Bifurcation -5 m in west branch, -0.5 m in east branch
     - - 2 m in channel
     - West branch is main channel

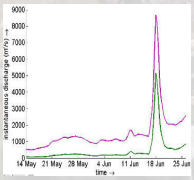
Discharge East (green) & West (purple)



SRTM unmodified
Aggradation 2-5 m
Main channel West branch

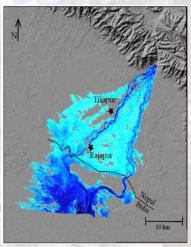


SRTM – 2 m
Channel elevation 2016
except at bifurcation
Main channel East branch

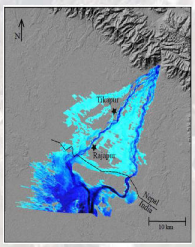


SRTM adjusted to
represent 2016 fieldwork.
-0.5 to -5 m at bifurcation
-2 m in channels
Main channel West branch

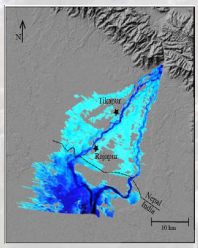
Flood maps



SRTM unmodified
Aggradation 2-5 m
Main channel West branch



SRTM – 2 m
Channel elevation 2016
except at bifurcation
Main channel East branch



SRTM adjusted to
represent 2016 fieldwork.
-0.5 to -5 m at bifurcation
-2 m in channels
Main channel West branch

Modelling outcomes

- Short time
  - Good approximate results
  - Highlights sensitivity of numerical models
- Delft 3d
  - Easy to use: 6 weeks to working model
  - Easy to change bathymetry/roughness locally
  - Easily change bifurcation
  - Sediment can be included
  - Resolution can be increased with parallel programming
  - Complex setting up initial grid

Questions?

Social Context of flooding
Initial observations

Remo Pedreschi and Jeevan Sharma

School Architecture
University of Edinburgh

School of Social and Political Science

Vernacular and modern construction, what knowledge have we lost?

View after the 1999 Duzce, arthquakee,Turkey, showing collapsed reinforced concrete building immediately adjacent to a traditional hımıs¸ residence with only one panel of brick infill missing.
Langenbach

Systems already exist in Nepal

Flood resilient vernacular housing technology in Nepal, D Gautam et al

New construction in reinforced concrete next to a traditional earthen house near Thimphu, Bhutan, 2010., Langenbach alien in scale and language

Refuge Fata, secure water supply
Adjacent to embankment
Village below level of river

Rather rough construction

Fata refuge

Some key points for discussion

- Location of refuge platform on site
- Direct access to platform stairs to village rather than from embankment?
- Use of refuge between floods
- Key factors in design of refuge, shape, openings, accessibility
- Access to bridge as additional refuge
- Re-focus building as community, for didactic purposes, exemplar construction

Larger refuge clear access to village

More ordered village, larger plots, better construction

Refuge under
Construction

Effectively engineered
Lack of skills in shuttering

Local construction using Reinforced concrete, similar to Practical Action but key differences
Raised platform, less well engineered reinforcement

makeshift shuttering

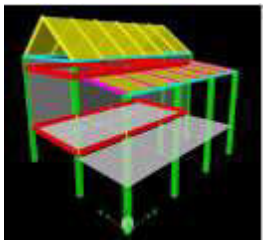
A rather beautiful house, well constructed , flood resilient using traditional techniques and skills

'I saw clearly , once again, that in order for something to truly reach modest people, it must have a lightness, a mysterious ease, a concise simplicity ' Eladio Dieste

a vernacular language is a language that is not only local in its origins,
but fluid and ever-changing. Langenbach

a vernacular language is a language that is not only local in its origins,
but fluid and ever-changing. Langenbach

Interesting example from Bangladesh, flood resilience



Concrete and timber Hybrid,
Concrete columns with stepped earth plinth
Timber beams for roof and floor, attic to provide protection for valuables

From local building practices to vulnerability reduction: building resilience through existing resources, knowledge and know-how

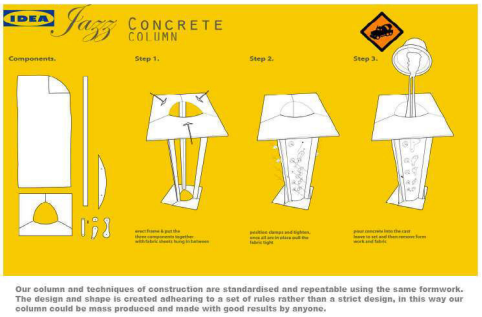
Link tradition and modernity

- Avoid low quality imitations
- Gap exists between technical knowledge in the universities and building practices implemented by the majority of the people.
- Put local populations at the centre of development project: support the bearers of local knowledge and know-how, strengthen social ties, thus enable a return of individual dignity
- Implement through an iterative approach, pilot projects, consolidation phase, dissemination. Adjust methodological approach, strategies and architectural design at all steps of the project
- Use prototype as demonstrations, apply solutions at small scale, in order to achieve local and national awareness regarding the potential of local materials for building quality housing
- Pay attention to economic accessibility issues, so that duplication is possible for a great number

Replace conventional formwork with flexible formwork

A disruptive technology that require considerably less skill and can be easily learned

Non Prismatic columns using fabric formwork much simpler to construct yet geometry more complex
Simplified construction and improved appearance
Proprietary flexible tube



A simple kit of parts with no stitching needed that produces 'Jazz' concrete in a range of designs

Rural house in Canada built using flexible formwork

Architecture and construction

- Vernacular systems are effective. need encouragement, support and dissemination
- RC systems are developing to reflect particular local systems , but lack of formwork skills
- Opportunity new, disruptive solutions to formwork
- Innovative development projects initiated in incremental stages to embed local knowledge, traditions and needs
- Hybrid vernacular processes of development- match funding with ambitions

Political economy of the area: commodification of land, labor and money

- Major transformation in political economy of livelihoods (labor, land and agricultural /practices)
- Major transformation in development activities, such as roads, bridges, development programmes etc
- Market as a major force
- Changes in the nature of the State (extraction to more democratic due to expansion of public sphere and civil society)

What do we know about floods?

- People see the river more than floods (interaction with the river and its use is far greater)
- Floods as valuable, floods as destructive (flood as risk is not necessarily shared by the people)
- Floods act as rupture in a few households' lives (not for all)
- History of destructive floods but floods don't occur every year (major destructive flood)
- People use bullock carts, mobile phones, radio, roads, boats, bridges and higher buildings to their advantage to deal with floods

A few points: 'parachute visit'

- Going through a major social transformation (commodification of land, labor and money) and ideas of modernity
- Reflective engagement with human intervention (market, state and society/community) incl. irrigation canal, extraction of stone
- Perception and use of the river (more than floods)
- Disaggregation of 'community'
- What does scientific knowledge/information mean?

Implications for programming

- Foreground livelihoods (and not just flood risks) within the dynamic political economy of the region
- How to empower local community to build their resilience? (increase their bargaining power, improve their livelihoods, offer them more choices) e.g. use of 'shelter'
- How to make scientific findings available to the local community, and how can science learn from community?

Connecting Pixel to people

(Making use of flood inundation maps: Research into use)

Dynamic Flood Topographies in the Terai Nepal: Community Perceptions and Resilience (DISTAL)

Madhab Uprety and Sanchita Neupane

PRACTICAL ACTION Consulting

Research Outputs

Inundation Maps under different Flood Scenarios

- HEC-RAS Model (SRTM-30m)
- Delft 3D Model (TanDEM-X 10m)

Limitation for research uptake

- Models do not capture the embankments and river training works (Inundation solely based on the natural flow of the river)
- Just a hazard map, requires exposure data for risk assessment and analysis

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Do we have the exposure data?

- Open Street Mapping (OSM)
- Mapping key utilities such as residential houses, roads, safe shelters, schools etc. for Lower Karnali Region
- Just the exposure details, No socio-economic data for now, future work!

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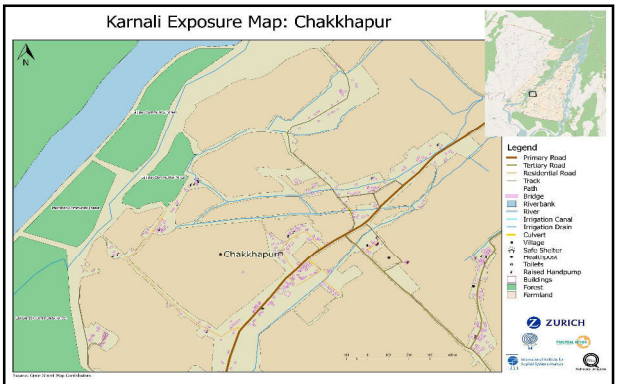
Karnali Exposure Map: Chakkhapur



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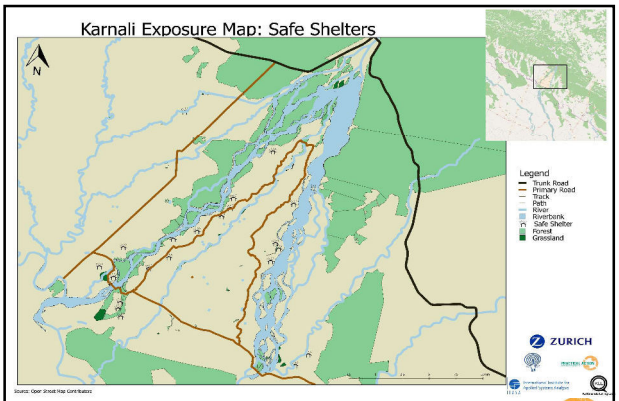
Karnali Exposure Map: Safe Shelters



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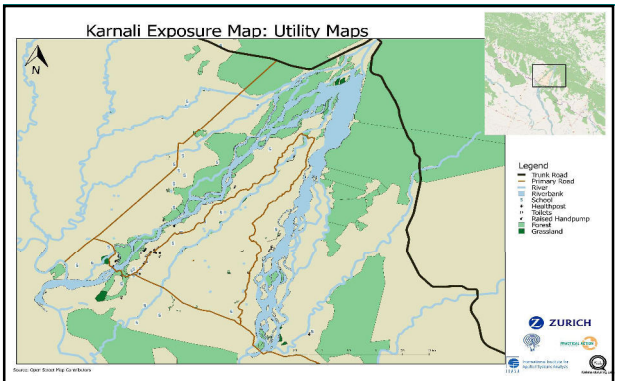
Karnali Exposure Map: Utility Maps



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What we are doing ?

- Overlaying the available flood inundation maps over Open Street Map layers for Lower Karnali Region
- Making comparison between the model outputs from HECRAS and Delft 3D Modelling for 20 Year and 100 Year Flood Scenarios
- Also looking how the inundation map for modified river section (way to incorporate sediment dynamics) differs in extent and exposure

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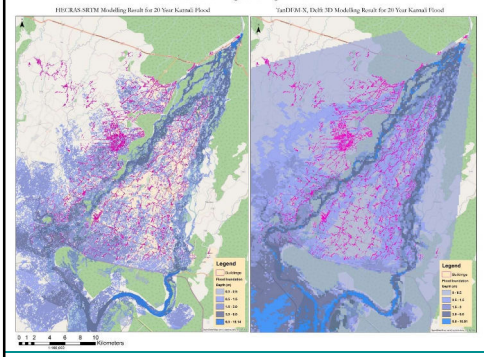

Extent:
Delft 3D modelling captures larger extent of lower depth inundation

Hot spot zones:
Northernmost delta region-Delft 3D Model

Southernmost delta region-HECRAS

Southern border region of Tikapur for both models

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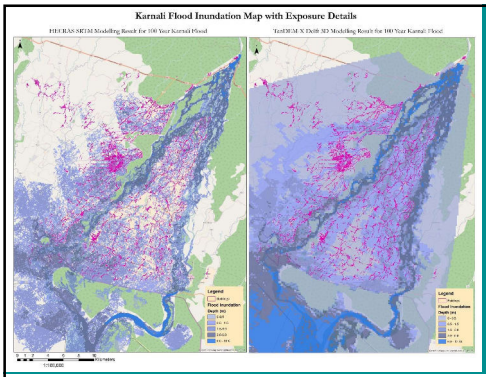

- *Similar differences across the model results as observed for 20 year flood scenarios*
- *Level of flooding increased in the hotspot zones*
- *Delft 3D Modelling captured more prominent flooding beyond the Nepal border*

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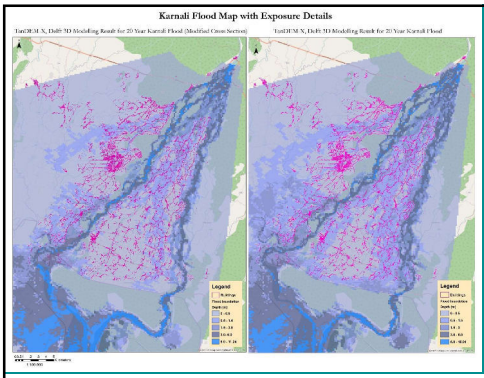

Extent of flooding is significantly reduced when river cross section is modified (sediment dynamics in the picture)

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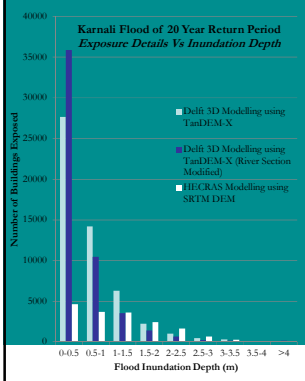
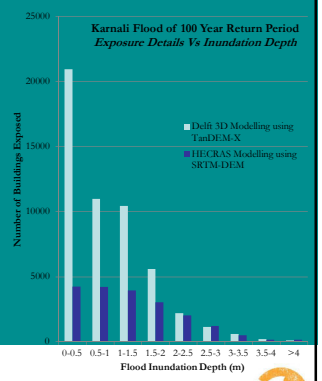
Karnali Flood Risk Analysis (Inundation Depth Vs Exposure Building Details)





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Conclusions

- *Use of Open street maps could be way to test the sensitivity of the flood maps with respect to exposure data*
- *Over laying flood model maps over OSM and incorporating local knowledge and perception can help to generate flood risk maps*
- *The warning and danger levels identified for existing early warning system can be validated on the ground (Risk based approach for issuing warnings)*

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