Climate information for the hydropower sector in Nepal

Developments in identifying plausible changes in extreme rainfall

Key messages

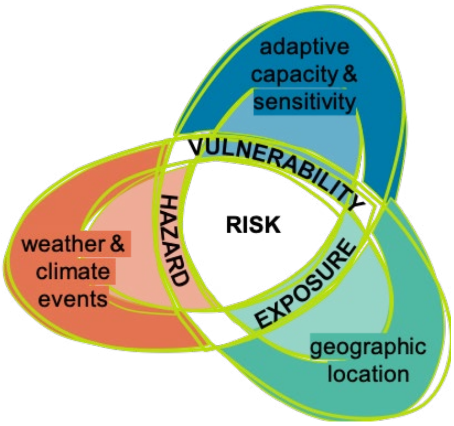
1. The hydropower sector in Nepal is vulnerable to flooding linked to extreme rainfall, and the risks are changing.
2. To better understand current and future risks in a changing climate, the climatic drivers of extreme rainfall events have been identified and a subset of available climate models which best represent these drivers has been created.
3. The work contributes to the co-development of relevant, useful and accessible climate information to guide adaptation planning and investment decisions in the hydropower sector to help achieve climate resilience.

Background information

Hydropower is crucial to Nepal's energy system, generating 90% of power, with further expansion planned for the future[1]. The hydropower sector in Nepal is at risk from high flow events, caused by extreme rainfall events or glacial lake outburst floods (GLOFs). The risk of these events occurring under current climate conditions is not well understood, making it difficult to calculate future changes in risk.

Understanding how high flow events linked to extreme rainfall may change in the future is challenging as climate models are unable to capture the details of these events. A new report identifies the large-scale conditions that drive extreme rainfall and evaluates which climate models most accurately capture these conditions. This work aims to address the need for relevant and reliable climate information to guide long-term planning for the hydropower sector.

Construction of the Upper Marsyangdi Hydroelectric Station.



Risk of flooding events caused by extreme rainfall

The magnitude of climate risk depends on:

- the **hazard** – the nature, timing and location of extreme rainfall;
- **exposure** to the hazard – the location of hydropower infrastructure in relation to the hazard and subsequent impacts, such as flooding, landslides and GLOFs;
- and **vulnerability** of the infrastructure to the impacts of extreme rainfall, such as the ability of turbines to cope with high amounts of sediment and debris.

To reduce climate risks, reliable information is needed to help understand the hazards and manage exposure and vulnerability.

Case study: flooding in Nepal in 2014

In most years, the area of lowest pressure, or "monsoon trough", is south of the Himalayas but in some years this shifts north to the foothills of the Himalayas. Low-pressure systems from the Bay of Bengal move moist air northwards. When this air is uplifted over the mountains, it enhances the amount of precipitation, focusing the heaviest rainfall in northeast India and Nepal.

In August 2014, heavy rain conditions triggered a landslide in Jure, damming the Sunkoshi River at Jure. The water that built up behind the temporary dam submerged the powerhouse of the Sanima Hydropower project and washed away two gates at the Sunkoshi Hydroelectric project[2]. Overall five hydropower stations and several transmission lines were damaged which reduced Nepal's power generation by 66 MW[3].

The Sunkoshi Hydropower station was damaged by the rain-triggered landslides in 2014.

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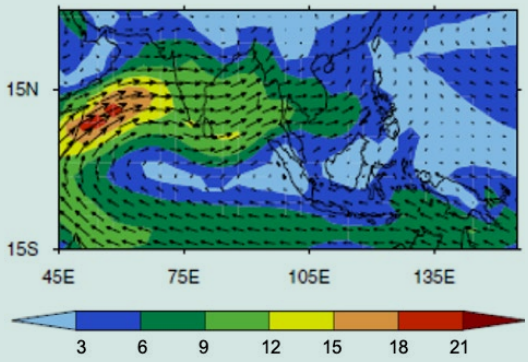
Large-scale drivers of extreme rainfall events in Nepal

Studying past extreme rainfall events in South Asia has highlighted the importance of the timing and location of monsoon rainfall. Extreme events often occur during years with high variability in monsoon rains, and not necessarily years with above average seasonal rainfall.

Extreme rainfall events in South Asia are driven by three large-scale climatic processes:

1. **Monsoon flow characteristics** – monsoon winds are strongest in the core of the Somali Jet. Winds are westerly across India, south-westerly across the Bay of Bengal, and westerly across continental southeast Asia (see figure on right).
2. **Interannual variability** - El Niño Southern Oscillation (ENSO), a natural climate fluctuation over the equatorial Pacific, and other large-scale patterns of variability, affect rainfall from year to year. Heavier rainfall is typical in La Niña years (the negative phase of ENSO).
3. **Intra-seasonal variability** – weekly or monthly natural fluctuations, such as the boreal summer intra-seasonal oscillation, affect when and where rain falls within a season.



Observed monsoon flow characteristics (see point 1) averaged over June to August (JJA) from ERA40 reanalysis data from 1979-1998. The colours indicate the strength of low level winds (m/s) and the arrows indicate the direction[4].

Simulating climate processes that drive extreme rainfall

Climate models can be useful tools but they have limitations. Often they do not reliably simulate the amounts and timings of observed monsoon rainfall. This makes it challenging to accurately forecast future changes in extreme events. We can improve confidence in model outputs if they can be shown to accurately capture the large-scale climate processes that drive extreme rainfall.

Process-based evaluation assesses how well climate models capture large-scale drivers of extreme rainfall. This helps in identifying models to exclude from further analysis.

Consider all available climate model simulations → Assess how well models capture key driving processes of extreme rainfall → **Exclude** poorly performing models, use intermediate models with **caution**

Model A | Model B | Model C | Model D

	Model A	Model B	Model C	Model D
Monsoon flow	✔	✔	✘	✔
Interannual variability	✔	✘	✘	✔
Intra-seasonal variability	✔	✔	✘	✘

Model A | Model B | ~~Model C~~ | Model D

Result: A subset of climate model projections for South Asia that most accurately represent the large-scale climatic processes which drive extreme rainfall events in Nepal. These models can be used to address climate-related questions from the hydropower sector.

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Quantifying risk of current and future extreme rainfall events

Current climate risk

Observed precipitation extremes do not paint a full picture of what could plausibly happen in our current climate[5, 6, 7]. Combing the observational record with new weather and climate forecast models enables us to explore a greater range of unseen possibilities.

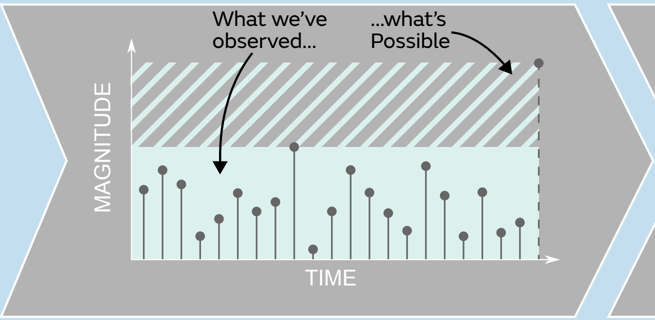
In the current climate, there is a higher risk of unprecedented extreme rainfall than we would expect from looking at observation records on their own. This is especially true where observations records are incomplete or only extend a few decades into the past.

Future climate risk

Temperatures are increasing and rainfall patterns are changing as a result of climate change. Climate model projections indicate that precipitation extremes could become more intense and may be more frequent[8].

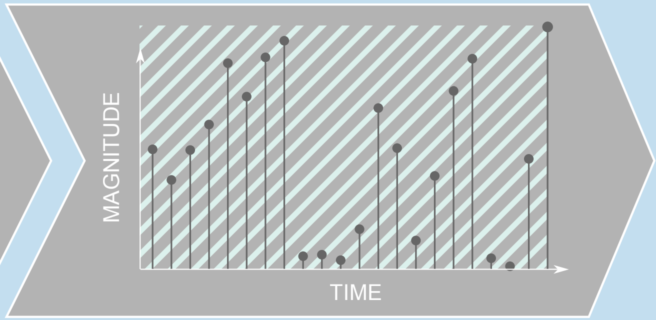
This would mean that a precipitation event that is considered extreme in the current climate is likely to be more common in the future, and extreme events in the future will likely be more extreme than those we experience now.

CURRENT CLIMATE (1981 – 2010)



Combining observations with climate models simulates extreme rainfall events that haven't been recorded yet but could plausibly occur.

FUTURE CLIMATE (2041 – 2070)



Future precipitation extremes may be more frequent and more intense compared to the current climate.

We are quantifying the risk of extreme rainfall events in Nepal, both in the current and future climate. We can only understand the potential impacts of these extreme events by **working with industry and policy makers to understand the vulnerability of the hydropower infrastructure** to hazards associated with extreme rainfall.

What action can the hydropower sector take?

The hydropower sector needs to be prepared for extreme high flow events to ensure it is resilient to current and future climate.

Consider how climate affects your business:

- What weather and climate hazards are you vulnerable to?
- What would be the worst-case scenario if there was an extreme rainfall event which caused high river flow?
- How are weather and climate data currently incorporated into your decision-making process?

Sunkoshi Small Hydropower Plant, Nepal.

Next steps:

We would like to work with you to understand what weather and climate information could be provided to make the hydropower sector in Nepal able to withstand variation in the current and future climate. Please get in touch with us for more information: ARRCC@metoffice.gov.uk

References:

1. bit.ly/USAIDNepal; 2. bit.ly/2PfLtEa; 3. bit.ly/3xfQk9u; 4. bit.ly/McSweeney14; 5. bit.ly/Thompson17; 6. bit.ly/Thompson19a; 7. bit.ly/Kay20ERL; 8. bit.ly/3sLEv7m.

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