Climate change, floods and sedimentation in the Koshi river basin

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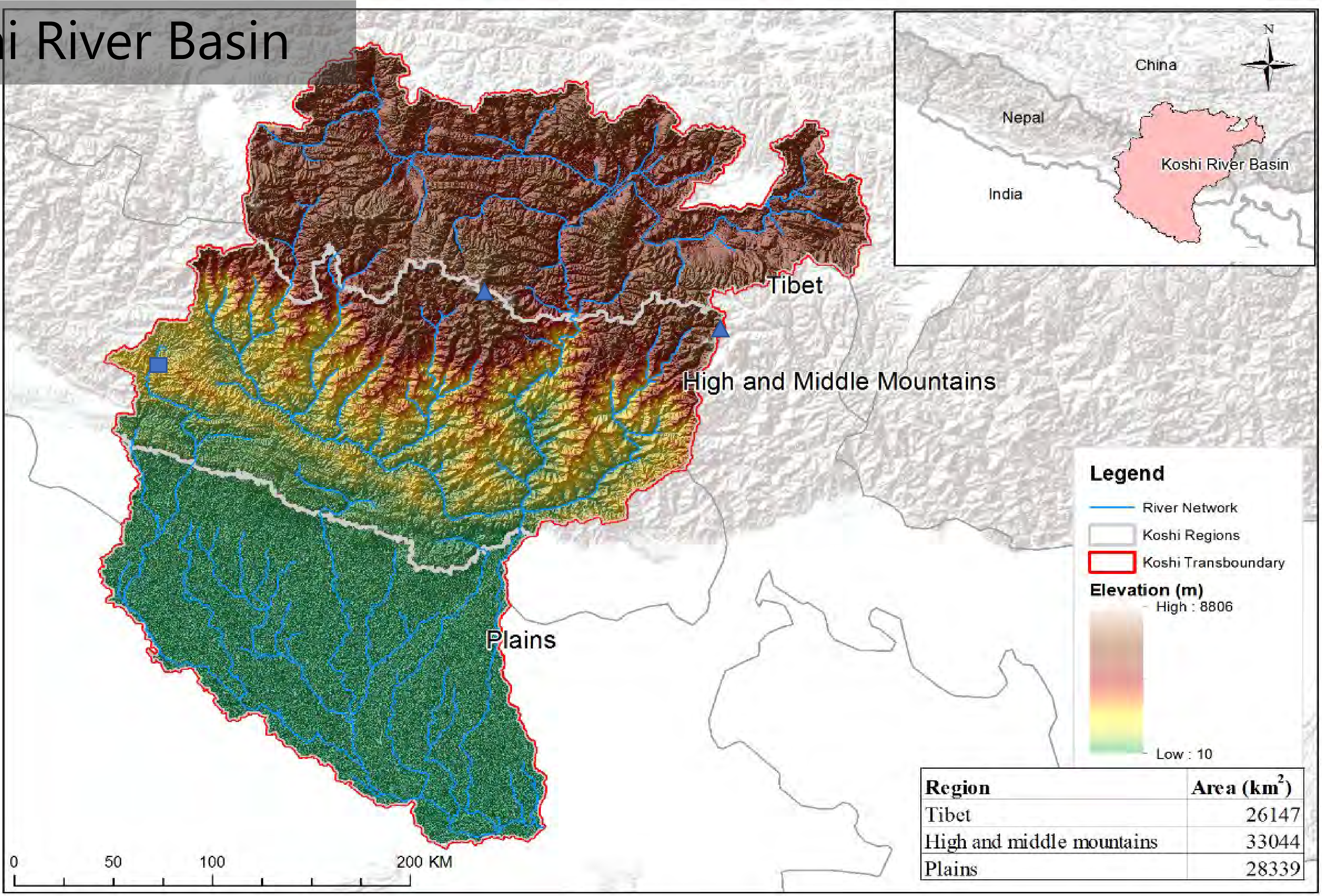
Koshi River Basin



Region	Area (km^2)
Tibet	26147
High and middle mountains	33044
Plains	28339

Upstream-downstream Linkages

Opportunities

Snowmelt

Glacier melt

Agriculture

Hydropower

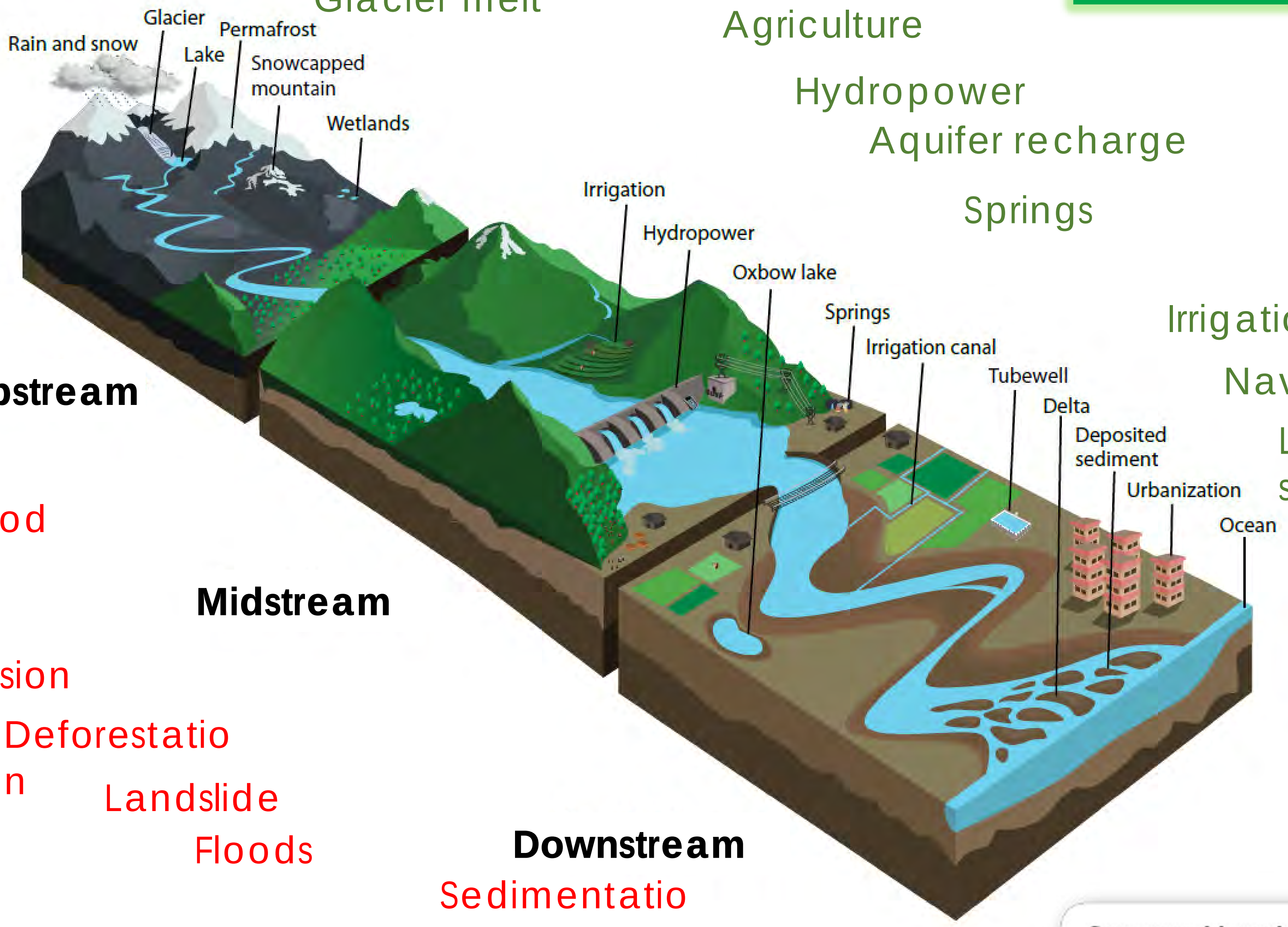
Aquifer recharge

Springs

Irrigation

Navigation

Large settlements



Upstream

Midstream

Downstream

Threats

GLOF

Landslide

Avalanche

Flash flood

Erosion

Deforestation

Landslide

Floods

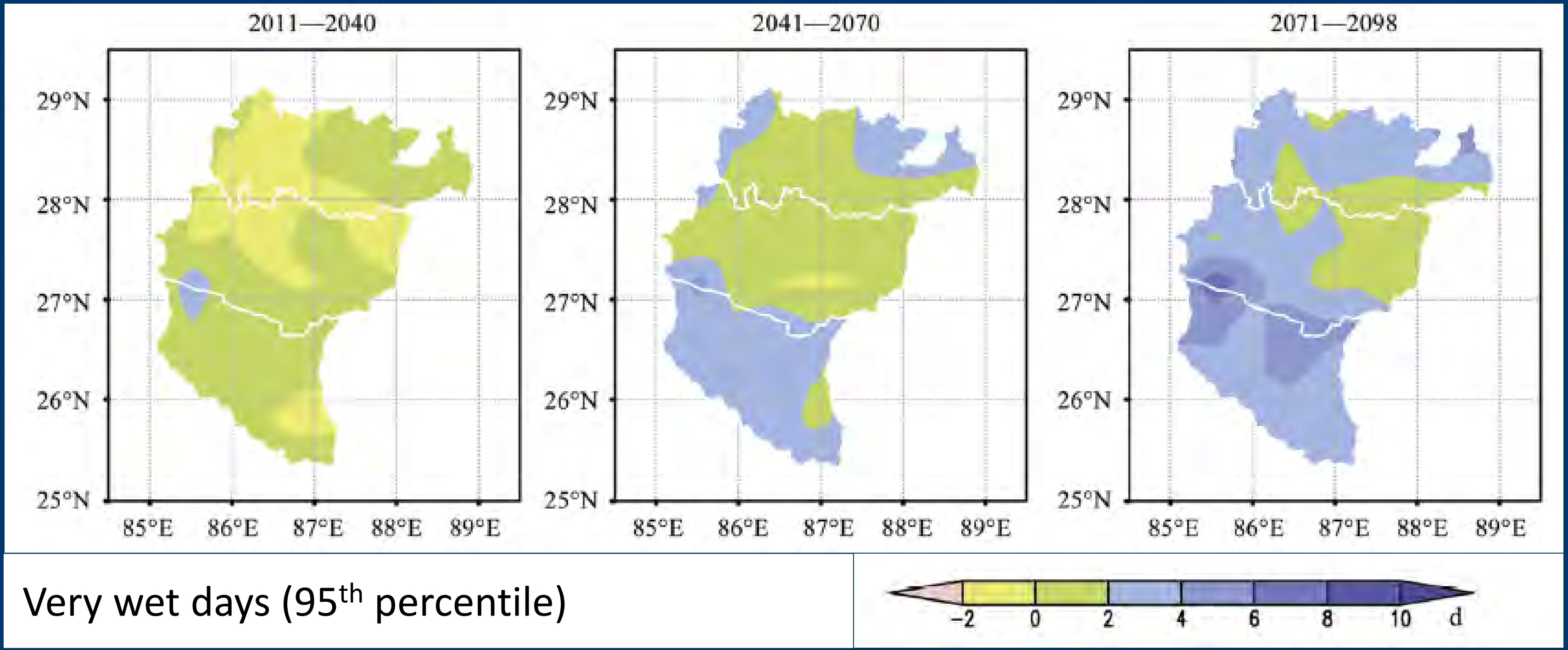
Sedimentation

Flood

GW depletion

Source: Nepal et al. 2018

Rainfall regime are likely to be changed



Very wet days (95th percentile)

Increasing trend

- Rainfall intensity
- Consecutive dry days
- Very wet days

Decreasing trend

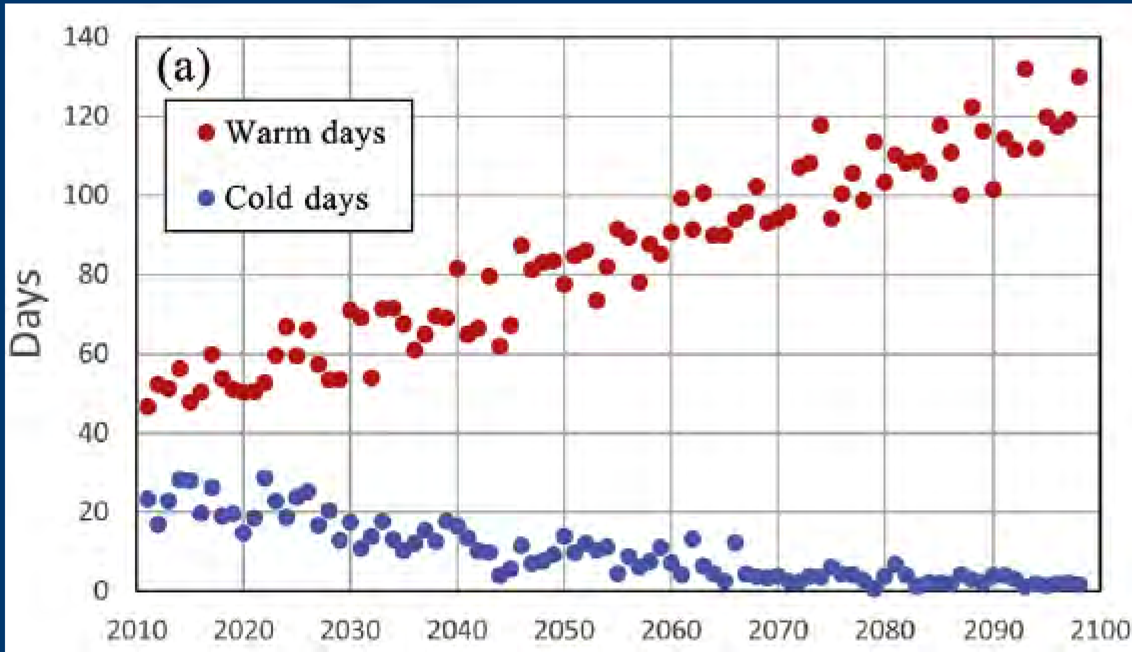
- Rainfall frequency
- Consecutive dry days
- Moderate rainfall

Source: Rajbhandari, 2017

Increasing temperature trend in the Koshi River basin

2.3 °C

Increase in maximum temp in last 40 years in Nepal

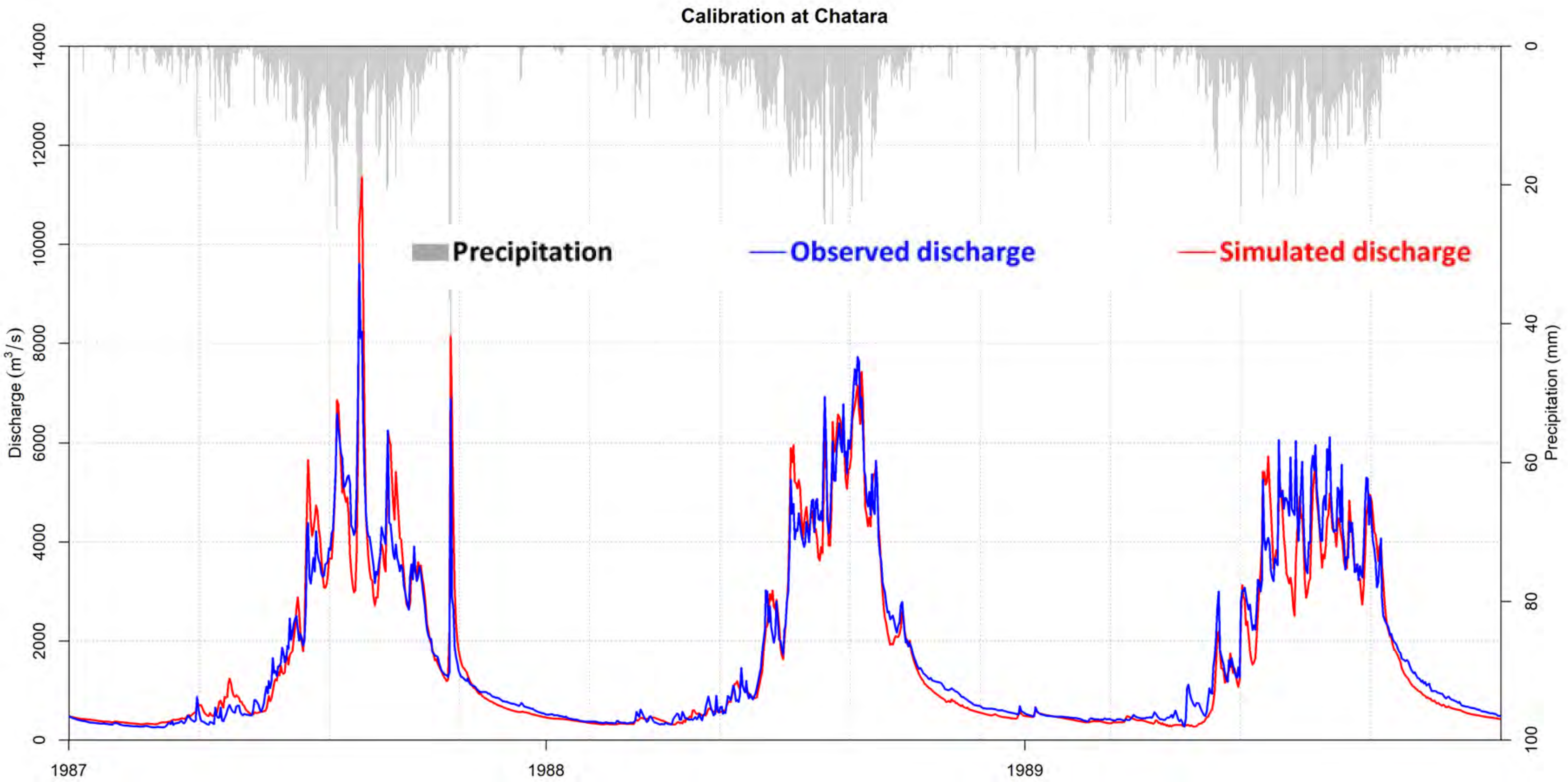


- Maximum temperature increasing at the rate of 0.58 °C/decade
- Warm days and cold days are projected to increase
- Rainfall frequency might decrease

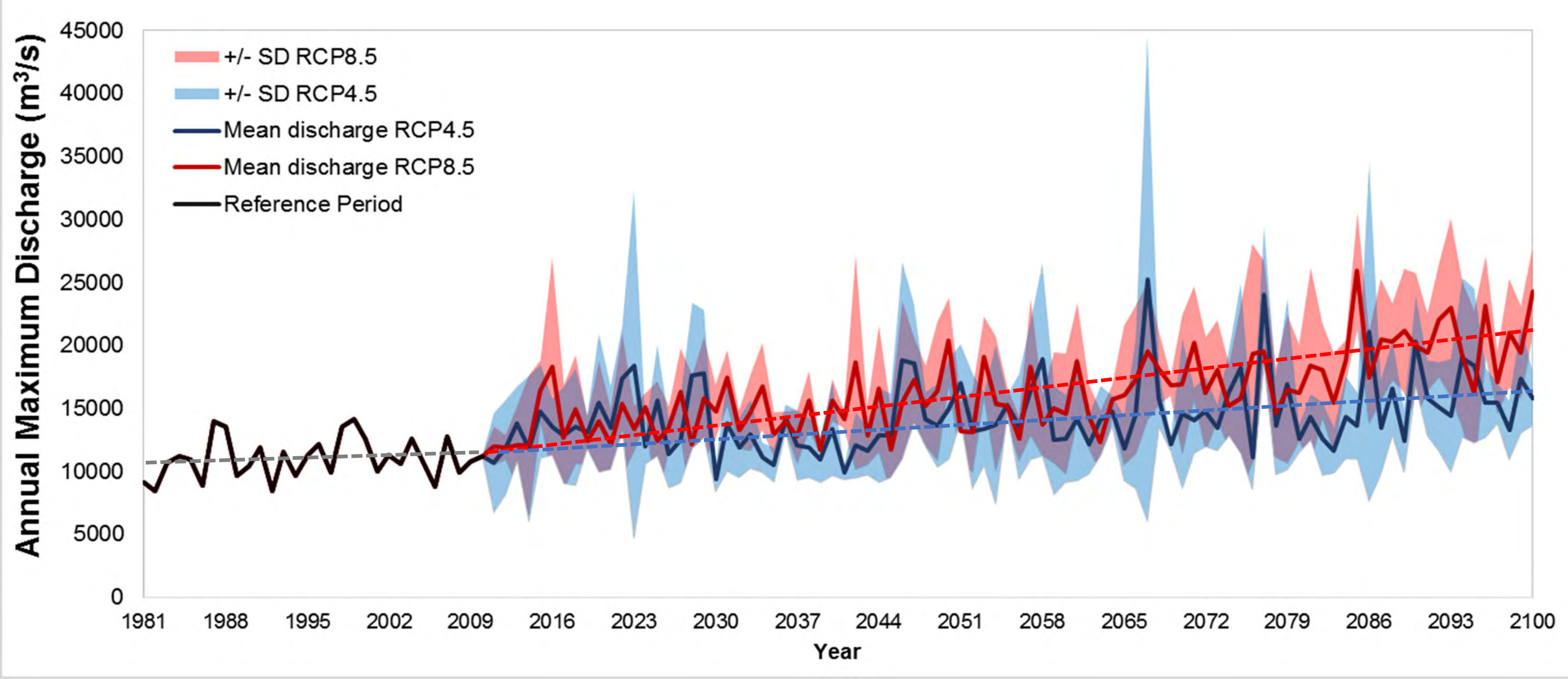
Source: Nepal, 2016

Source: Rajbhandari, 2017

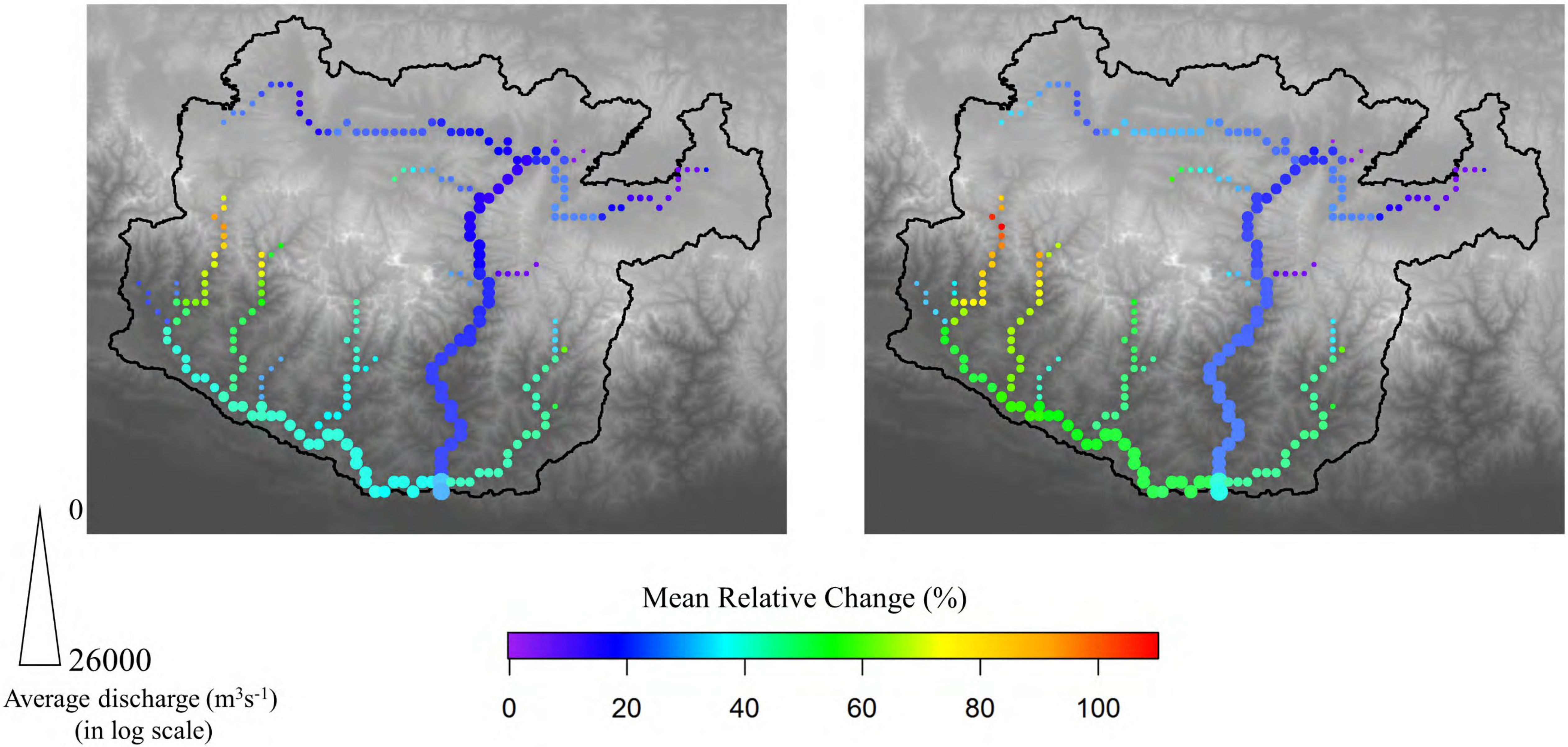
Understanding behavior of Koshi River



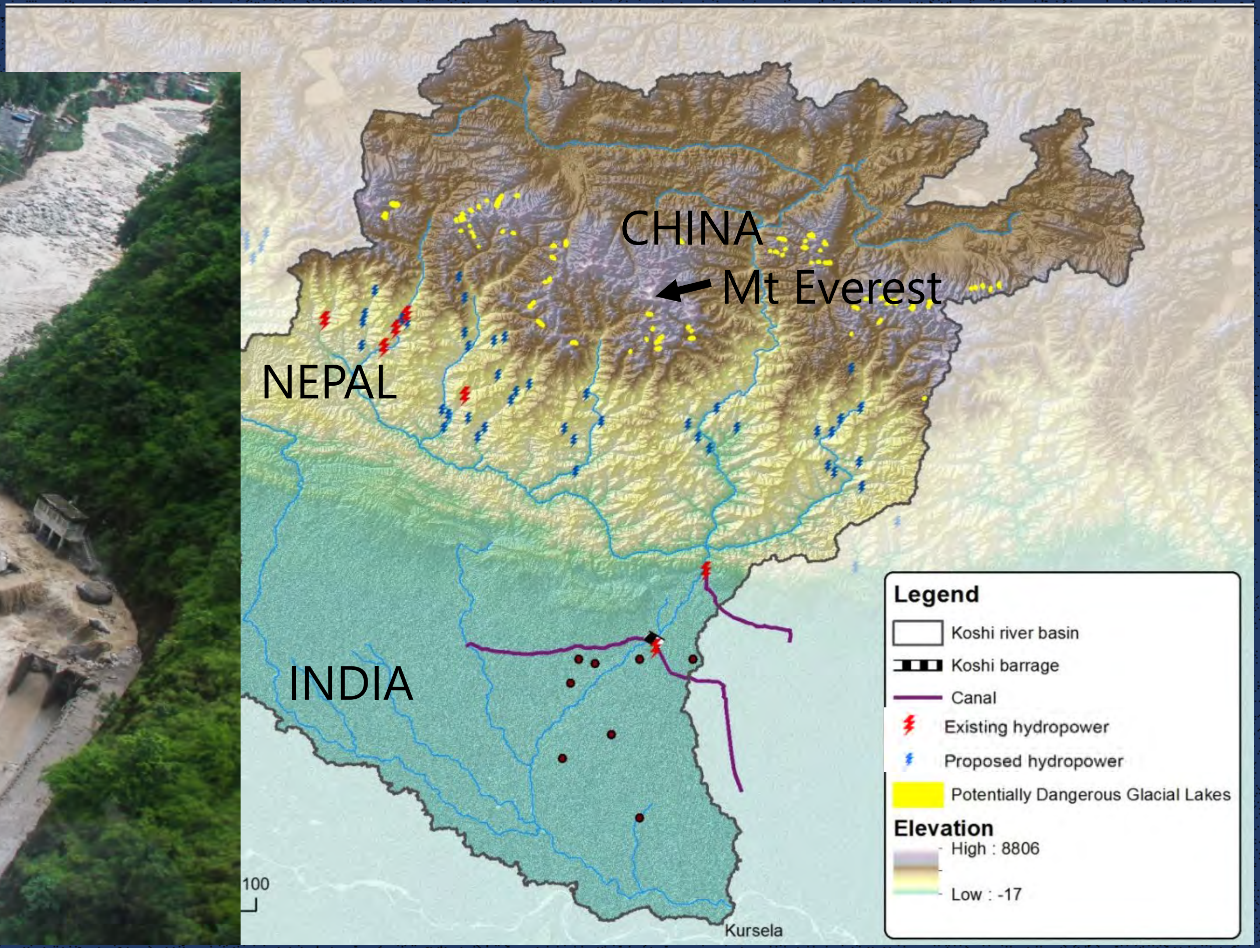
Koshi Floods: Annual Maximum by 2100



Flood discharge of 50-year return period by 2100



Infrastructure and extreme events

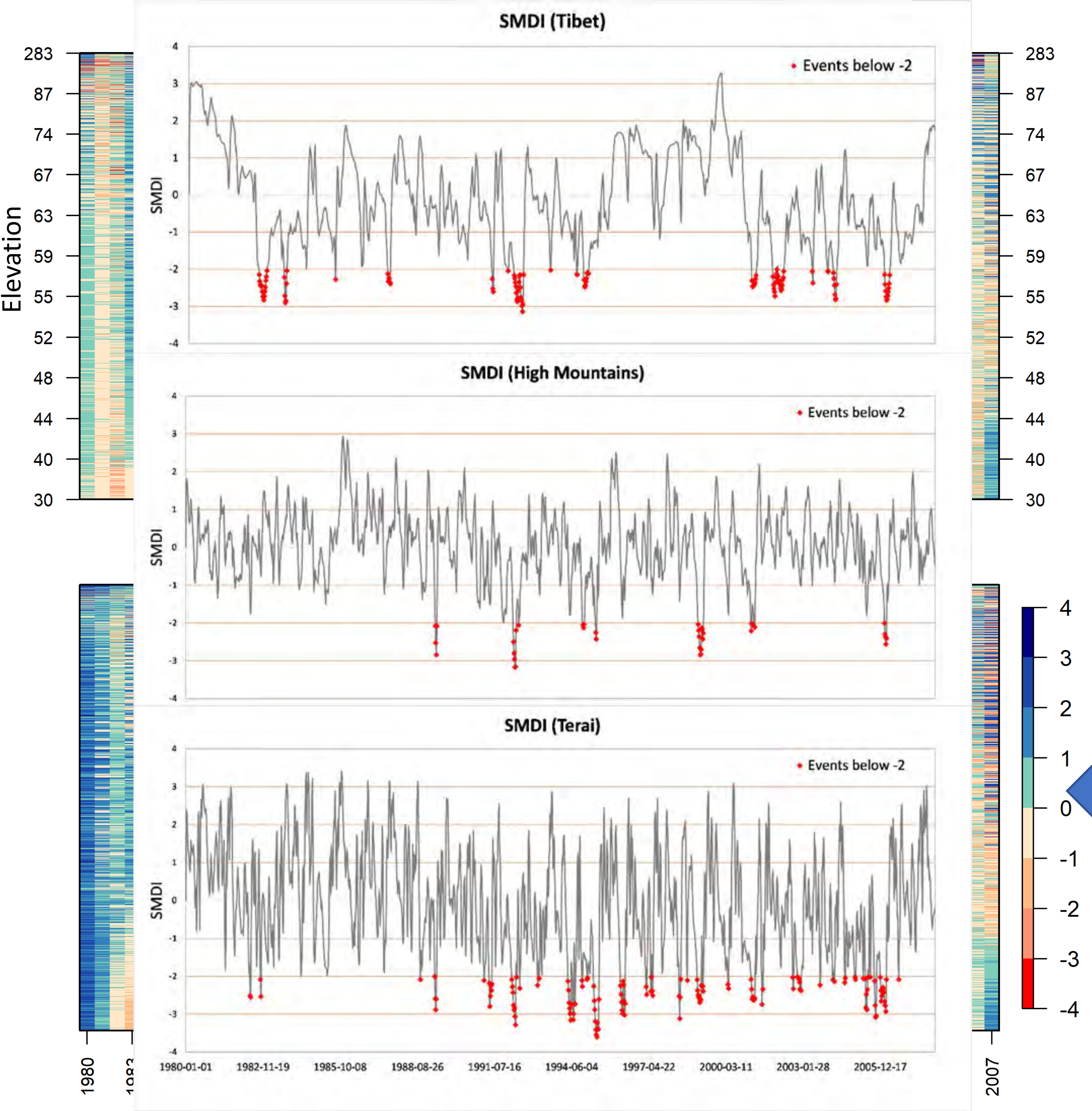


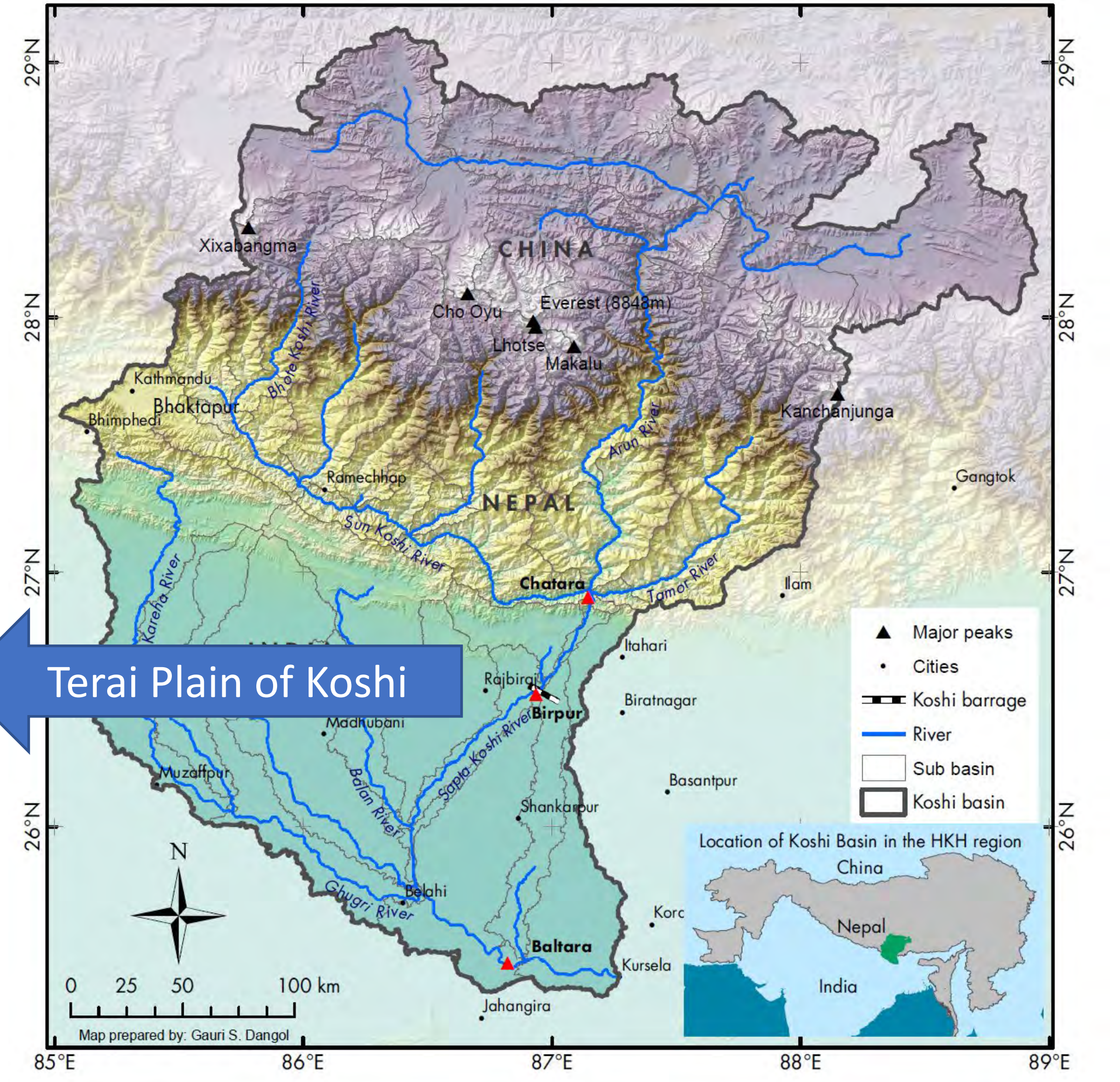
ICIMOD, 2011

Data Source:
Koshi Basin Information System, ICIMOD

ICIMOD

Soil moisture deficient index in Terai of Koshi





Soil erosion risk map

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RESEARCH ARTICLE

Estimation of Soil Erosion Dynamics in the Koshi Basin Using GIS and Remote Sensing to Assess Priority Areas for Conservation

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Abstract

High levels of water-induced erosion in the transboundary Himalayan river basins are contributing to substantial changes in basin hydrology and inundation. Basin-wide information on erosion dynamics is needed for conservation planning, but field-based studies are limited. This study used remote sensing (RS) data and a geographic information system (GIS) to estimate the spatial distribution of soil erosion across the entire Koshi basin, to identify changes between 1990 and 2010, and to develop a conservation priority map. The revised universal soil loss equation (RUSLE) was used in an ArcGIS environment with rainfall erosivity, soil erodibility, slope length and steepness, cover-management, and support practice factors as primary parameters. The estimated annual erosion from the basin was around 40 million tonnes (40 million tonnes in 1990 and 42 million tonnes in 2010). The results were within the range of reported levels derived from isolated plot measurements and model estimates. Erosion risk was divided into eight classes from very low to extremely high and mapped to show the spatial pattern of soil erosion risk in the basin in 1990 and 2010. The erosion risk class remained unchanged between 1990 and 2010 in close to 87% of the study area, but increased over 9.0% of the area and decreased over 3.8%, indicating an overall worsening of the situation. Areas with a high and increasing risk of erosion were identified as priority areas for conservation. The study provides the first assessment of erosion dynamics at the basin level and provides a basis for identifying conservation priorities across the Koshi basin. The model has a good potential for application in similar river basins in the Himalayan region.

OPEN ACCESS

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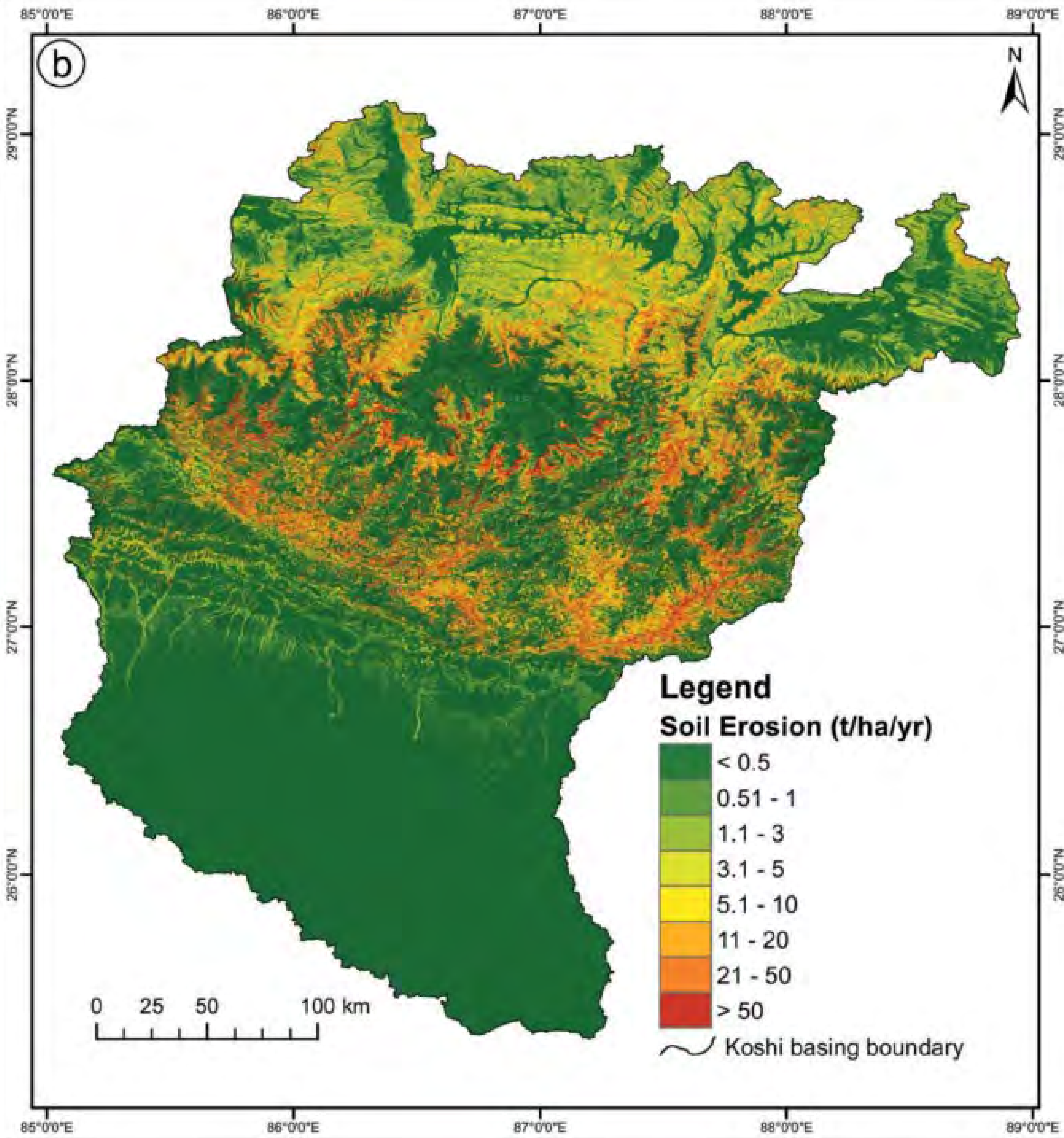
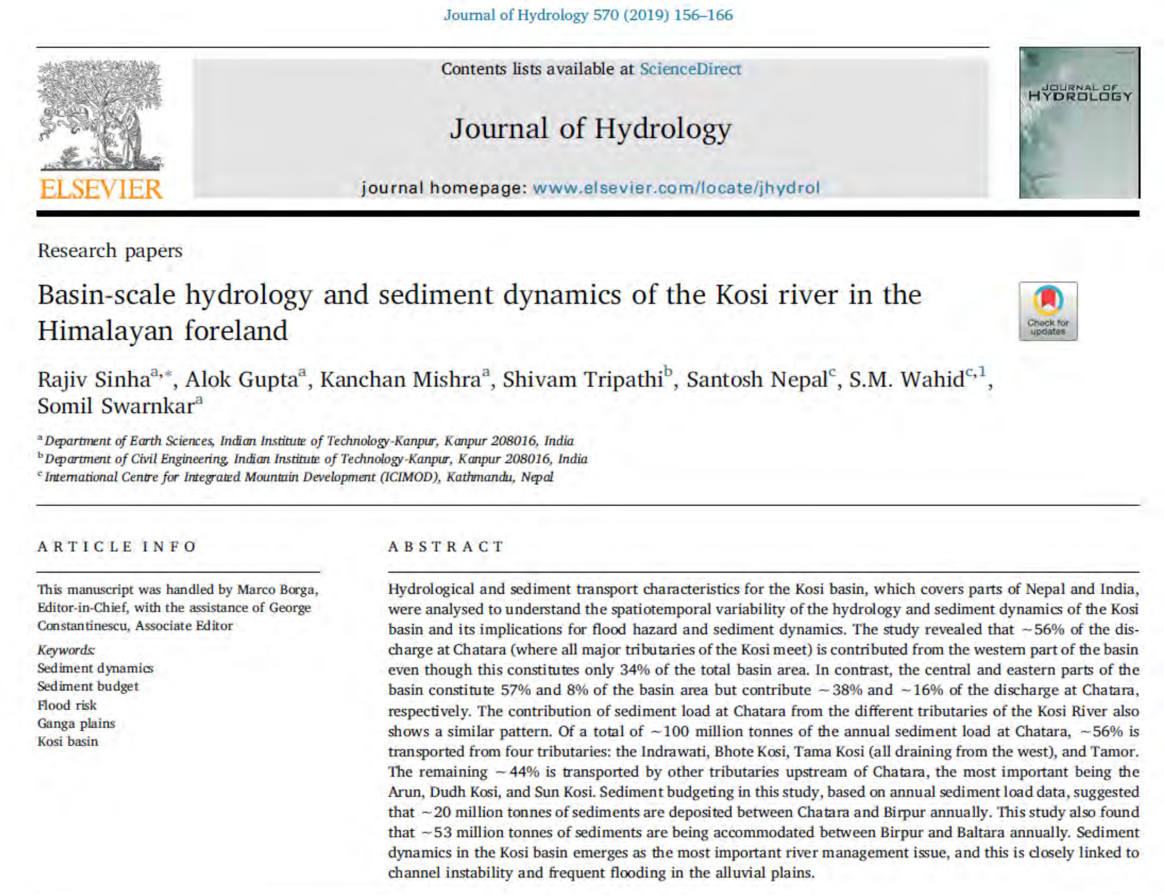


Sediment dynamics

1st study to highlights the basin scale hydrology and sedimentation



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Research papers

Basin-scale hydrology and sediment dynamics of the Kosi river in the Himalayan foreland

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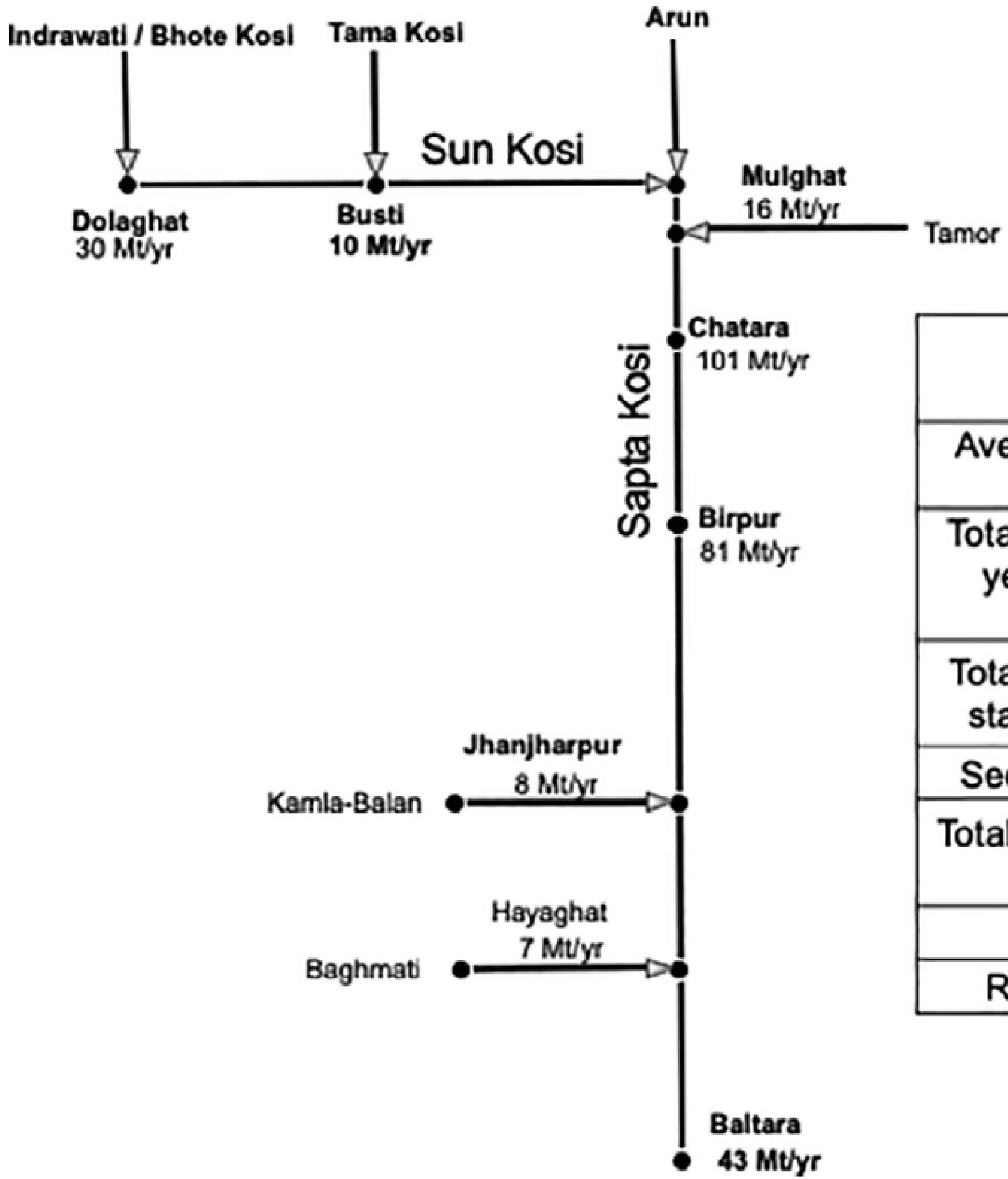
Kosi basin

ABSTRACT

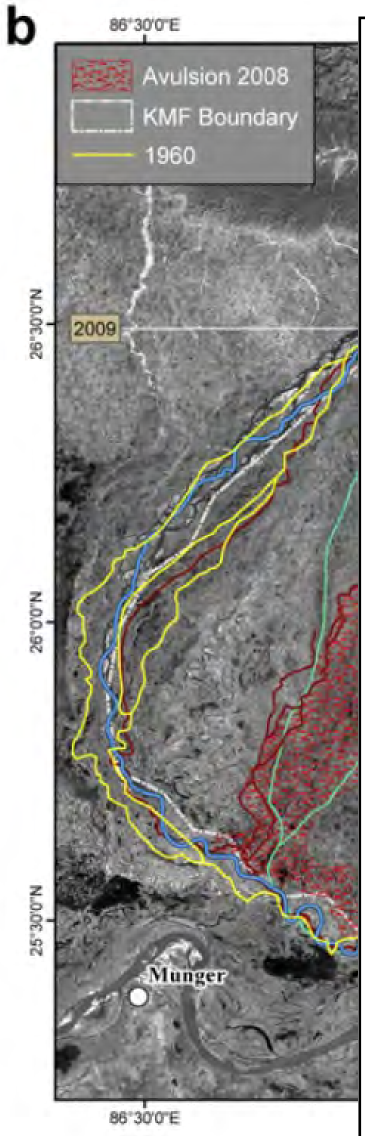
Hydrological and sediment transport characteristics for the Kosi basin, which covers parts of Nepal and India, were analysed to understand the spatiotemporal variability of the hydrology and sediment dynamics of the Kosi basin and its implications for flood hazard and sediment dynamics. The study revealed that ~56% of the discharge at Chatara (where all major tributaries of the Kosi meet) is contributed from the western part of the basin even though this constitutes only 34% of the total basin area. In contrast, the central and eastern parts of the basin constitute 57% and 8% of the basin area but contribute ~38% and ~16% of the discharge at Chatara, respectively. The contribution of sediment load at Chatara from the different tributaries of the Kosi River also shows a similar pattern. Of a total of ~100 million tonnes of the annual sediment load at Chatara, ~56% is transported from four tributaries: the Indrawati, Bhote Kosi, Tama Kosi (all draining from the west), and Tamor. The remaining ~44% is transported by other tributaries upstream of Chatara, the most important being the Arun, Dudh Kosi, and Sun Kosi. Sediment budgeting in this study, based on annual sediment load data, suggested that ~20 million tonnes of sediments are deposited between Chatara and Birpur annually. This study also found that ~53 million tonnes of sediments are being accommodated between Birpur and Baltara annually. Sediment dynamics in the Kosi basin emerges as the most important river management issue, and this is closely linked to channel instability and frequent flooding in the alluvial plains.

Sediment budgeting



Parameters	Chatara-Birpur	Birpur-Baltara
Average sediment load between the stretch (Mt/yr)	(101-81) =20	(81+8+7-43) = 53
Total sediment mass deposition in 54 years (post embankment period) (million tonnes)	1080	2862
Total area of deposition between the stations (channel belt area) (km^2)	142	507
Sediment Density (fine sand) kg/m^3	2650	2650
Total sediment volume accumulated in 54 years m^3	408×10^6	1080×10^6
Sediment thickness (m)	2.87	2.13
Rate of sedimentation (cm/year)	5.31	3.94

Koshi channel shifting



- 113 Km shifting to westward in last 200 years
- Koshi embankment breach in 2008
  - 235 people dies
  - 2500 village affected
  - >300,000 houses damaged

rty et al., 2010

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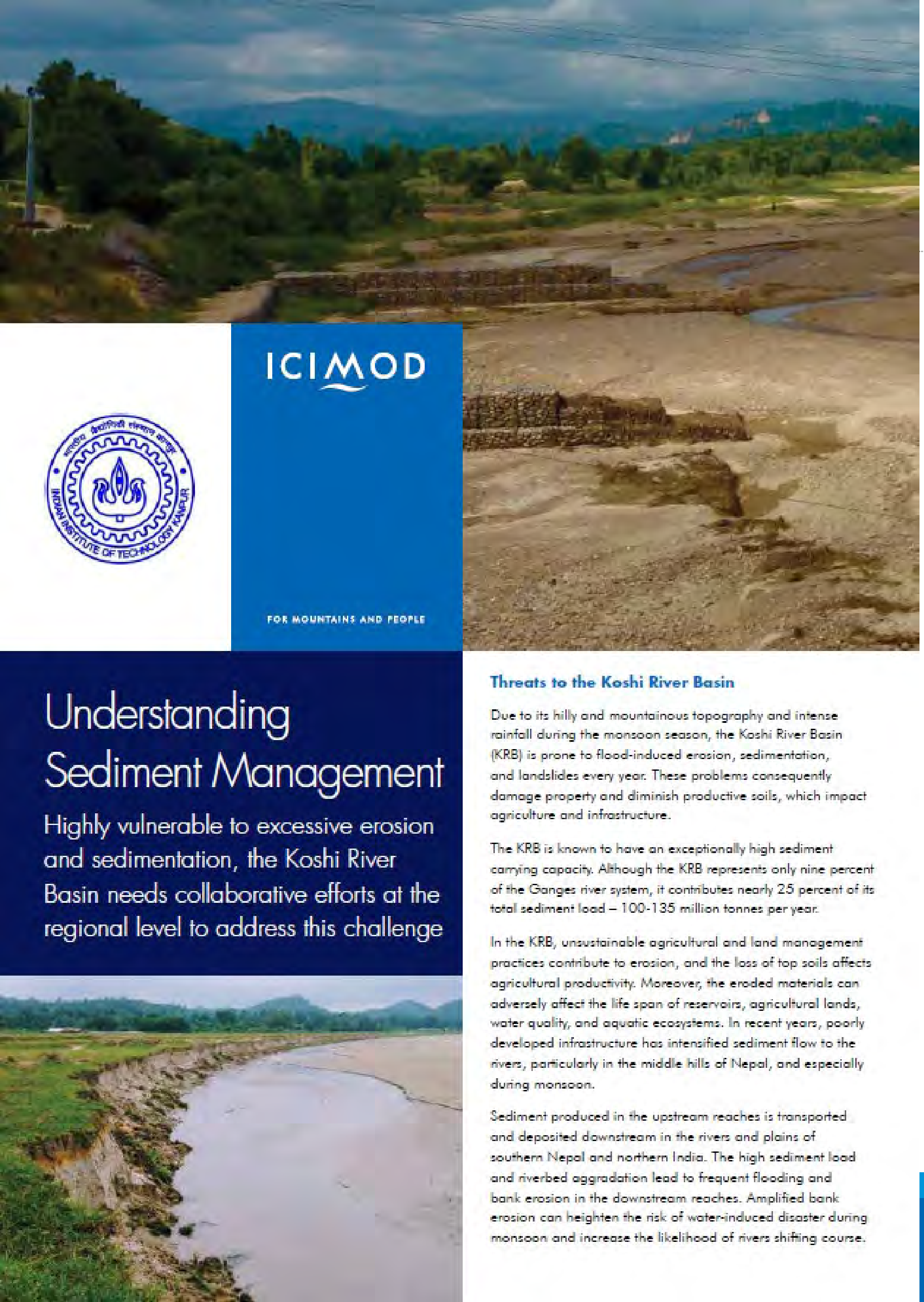
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Understanding Sediment Management

Highly vulnerable to excessive erosion and sedimentation, the Koshi River Basin needs collaborative efforts at the regional level to address this challenge

Threats to the Koshi River Basin

Due to its hilly and mountainous topography and intense rainfall during the monsoon season, the Koshi River Basin (KRB) is prone to flood-induced erosion, sedimentation, and landslides every year. These problems consequently damage property and diminish productive soils, which impact agriculture and infrastructure.

The KRB is known to have an exceptionally high sediment carrying capacity. Although the KRB represents only nine percent of the Ganges river system, it contributes nearly 25 percent of its total sediment load – 100-135 million tonnes per year.

In the KRB, unsustainable agricultural and land management practices contribute to erosion, and the loss of top soils affects agricultural productivity. Moreover, the eroded materials can adversely affect the life span of reservoirs, agricultural lands, water quality, and aquatic ecosystems. In recent years, poorly developed infrastructure has intensified sediment flow to the rivers, particularly in the middle hills of Nepal, and especially during monsoon.

Sediment produced in the upstream reaches is transported and deposited downstream in the rivers and plains of southern Nepal and northern India. The high sediment load and riverbed aggradation lead to frequent flooding and bank erosion in the downstream reaches. Amplified bank erosion can heighten the risk of water-induced disaster during monsoon and increase the likelihood of rivers shifting course.

Recommendations for improved sediment management

1. Identify areas of excessive erosion in the upstream and manage land and vegetation as appropriate.

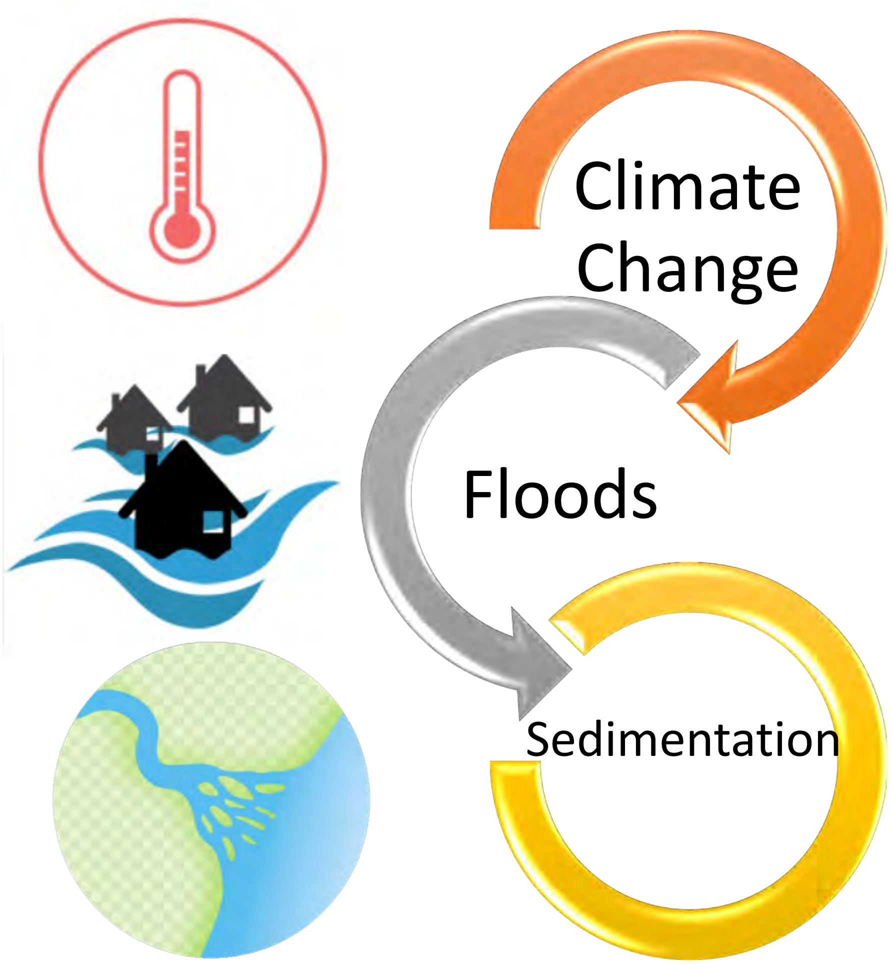
2. Establish more stations for measuring sediment load

3. Conduct integrated assessments of land cover changes, erosion, and sedimentation at the transboundary level.

4. Conduct strategic dredging of downstream stretches and consider innovative approaches for using dredged silt

5. Encourage greater transboundary cooperation

Integrated assessment of climate change, floods and sedimentation



- Climate change, floods and sedimentation need to be studied together
  - Change in rainfall regime
  - Change in extreme precipitation events
  - How the sediment dynamics will change under the future climate change?
  - How the vulnerability and risk changes?

Thank you

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