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Integrating sediment dynamics and connectivity in flood risk assessment of the Himalayan rivers

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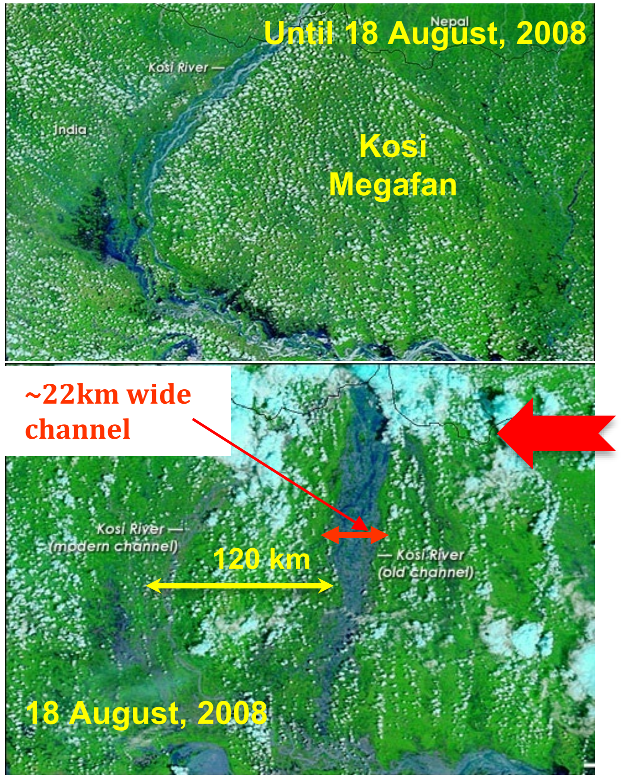
River disasters: Natural or human-induced?



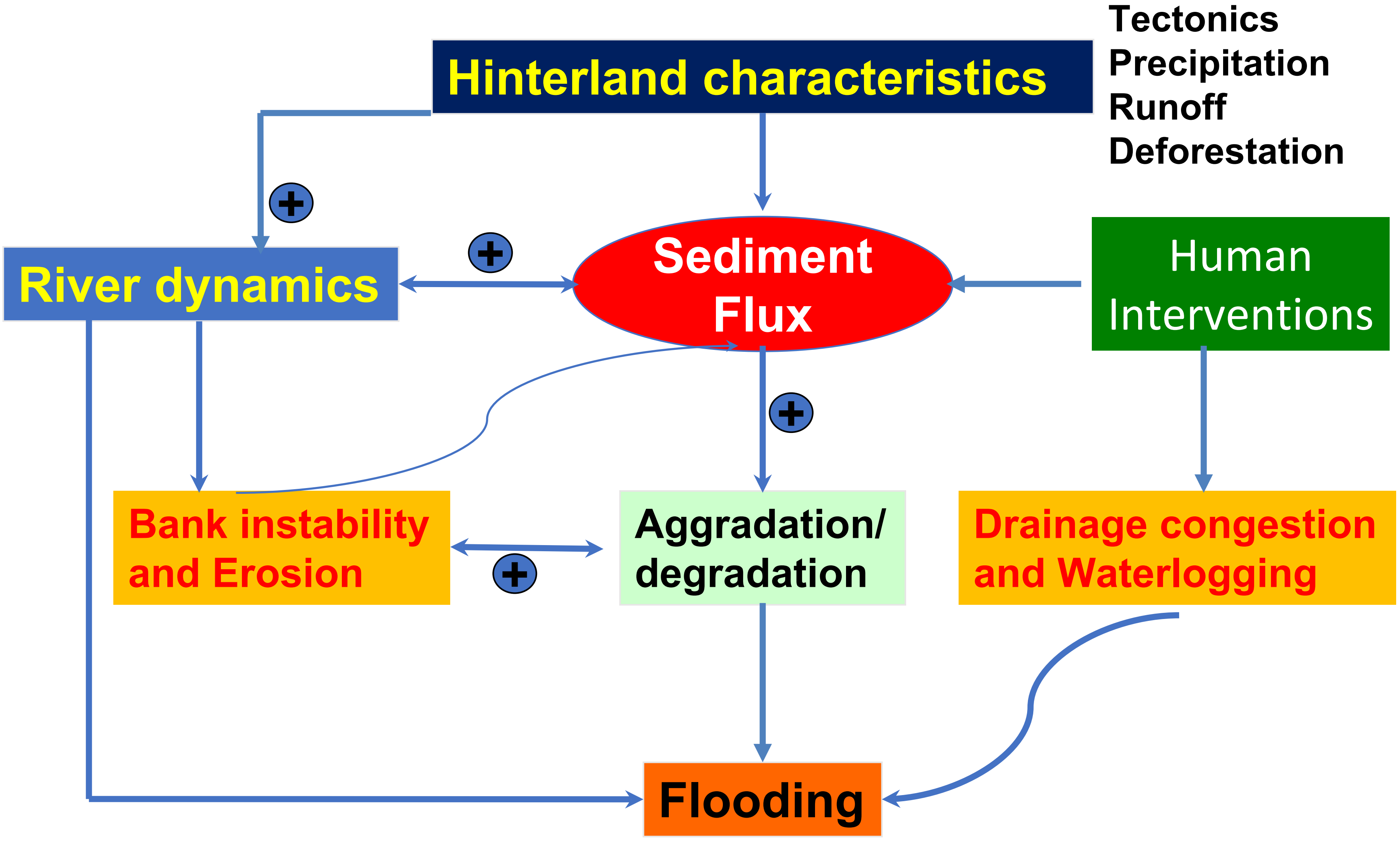
Excessive sediment flux and embankments caused excessive aggradation of river bed, breaching and extensive flooding

The furious Kosi: August 2008

Unplanned management and encroachment of river space, construction of river projects and dumping of sediments

Uttarakhand Floods: 2013

Sediment Dynamics in Himalayan Rivers: a central problem!



Why has this problem remained unresolved?

Why? → Lack of process-understanding, basin-scale data on hydrology and sediment; data sharing issues in transboundary rivers

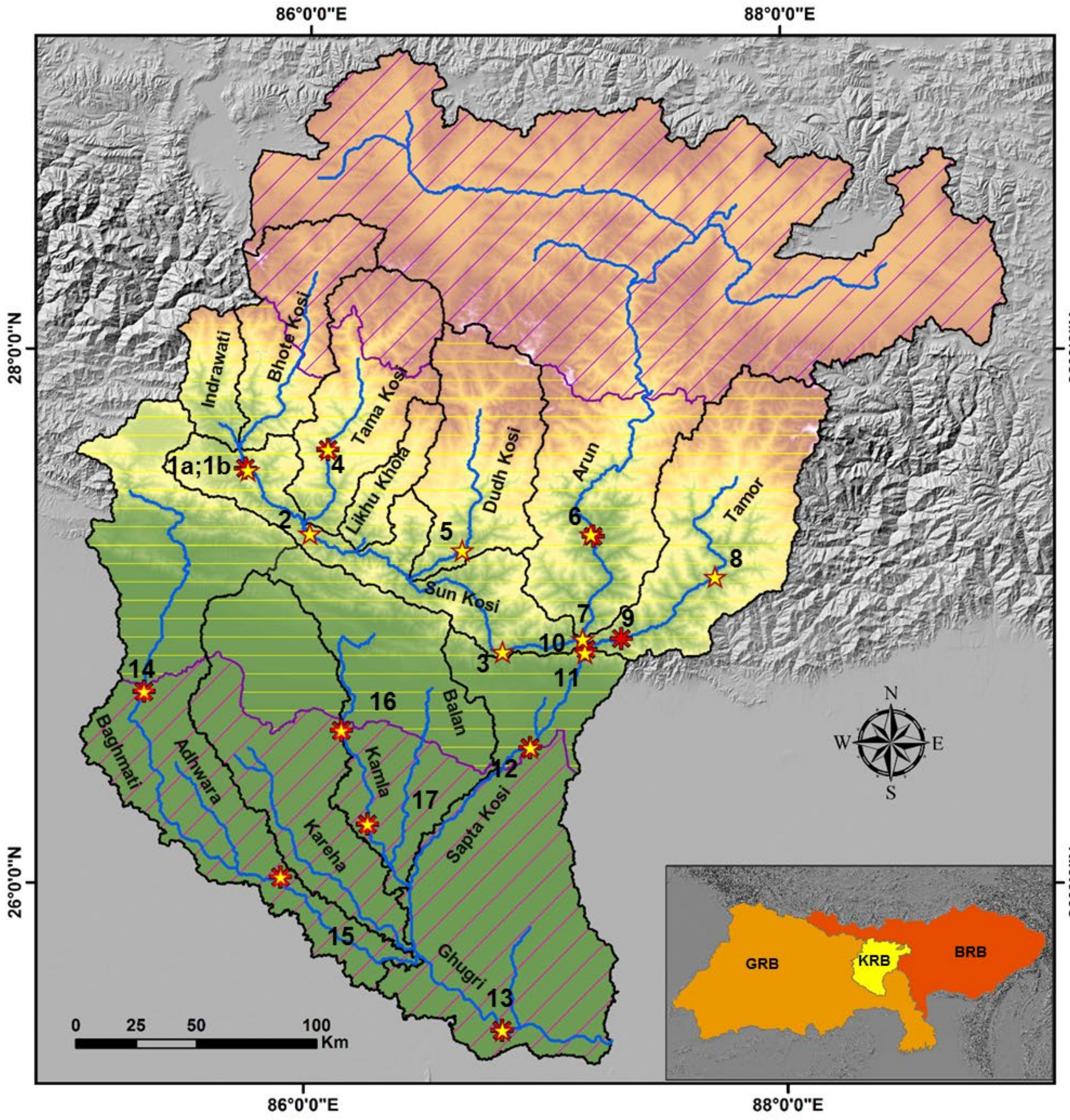
Where? → No maps of the hotspots of siltation to prioritize the action

How much? → No estimates of the volume of silt accumulated in the channel

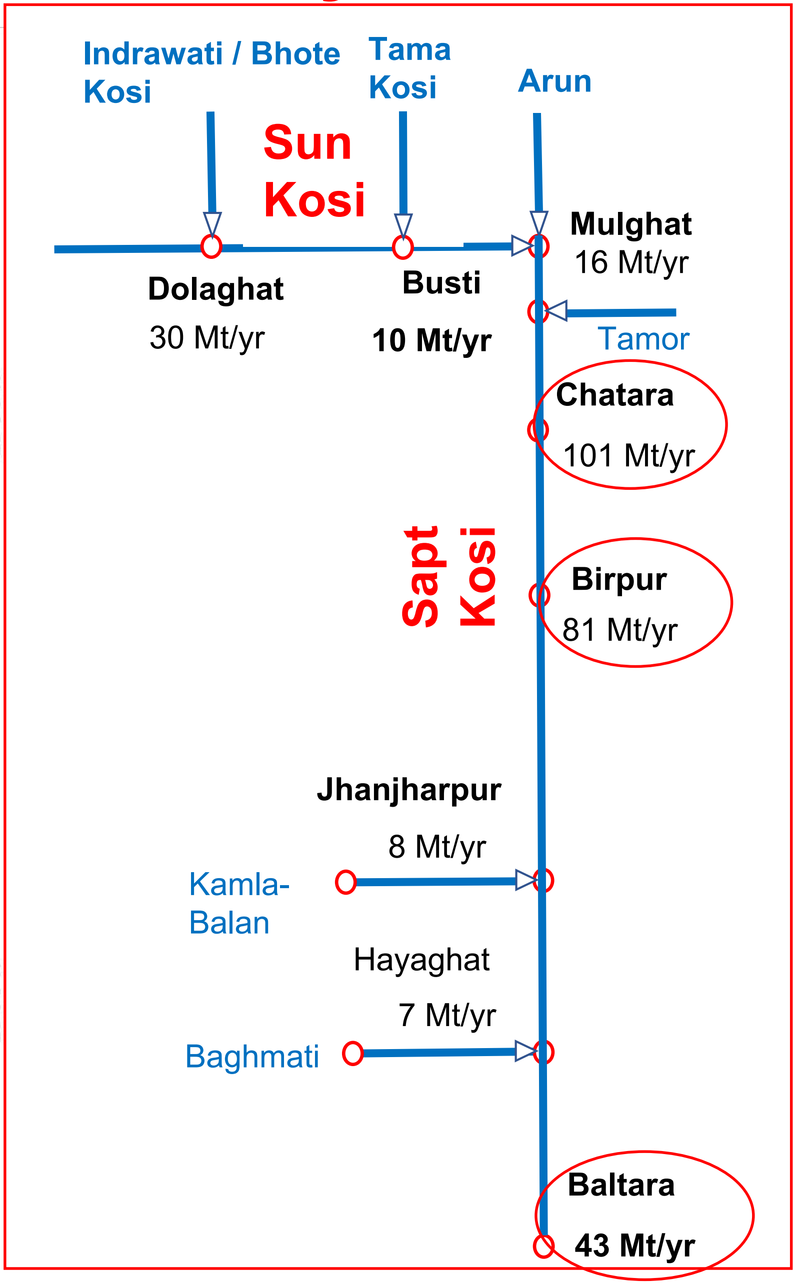
What to do? → No assessment of commercial uses of silt and no mapping of stakeholders

=> Need a comprehensive understanding of sediment dynamics

Sediment Budget of transboundary the Kosi River



(Sinha et al., 2019, Jour. of



Total sediment accumulated since the embankment construction:

Chatara-Birpur:

= 1080 MT

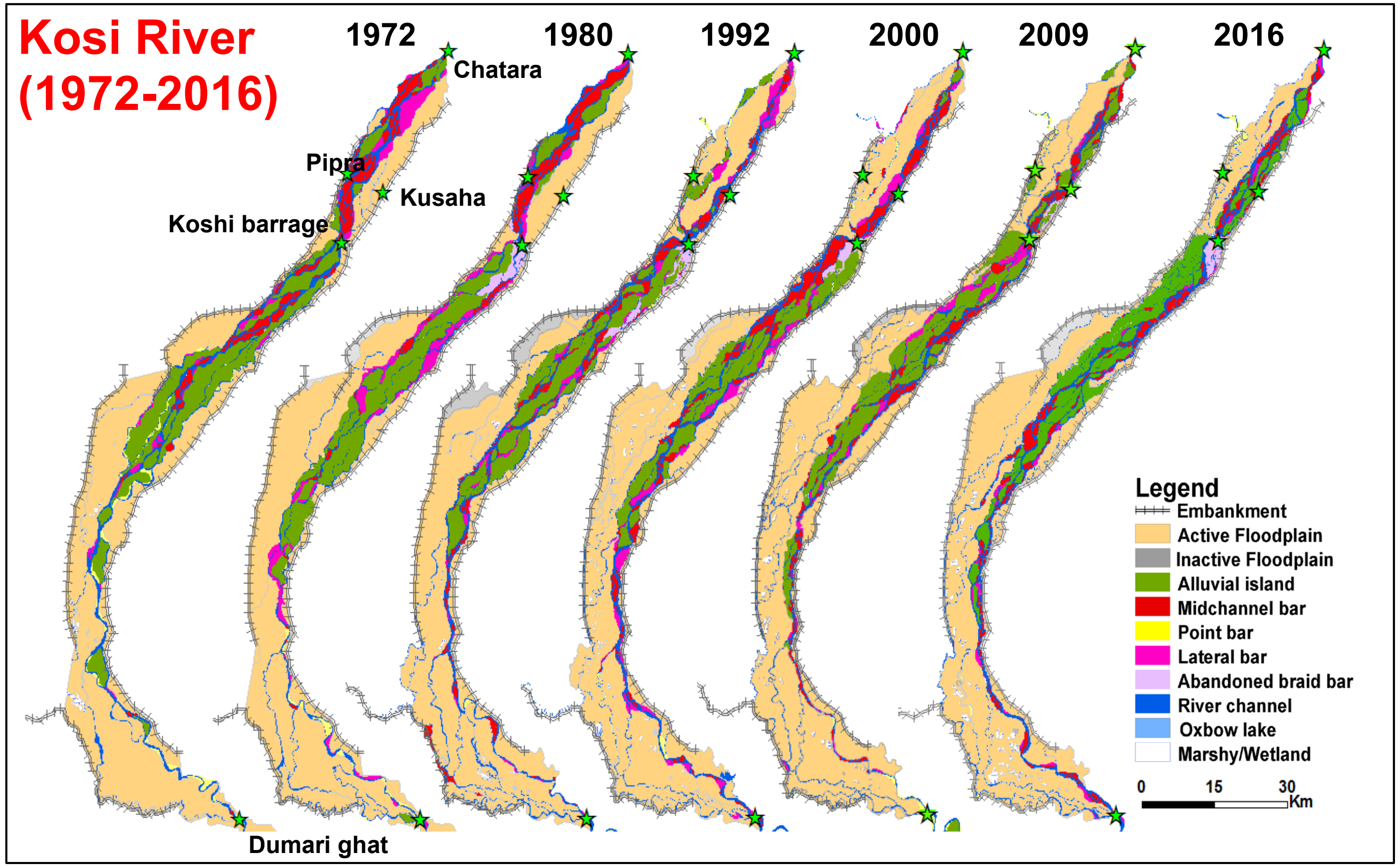
= **408×10^6** m^3

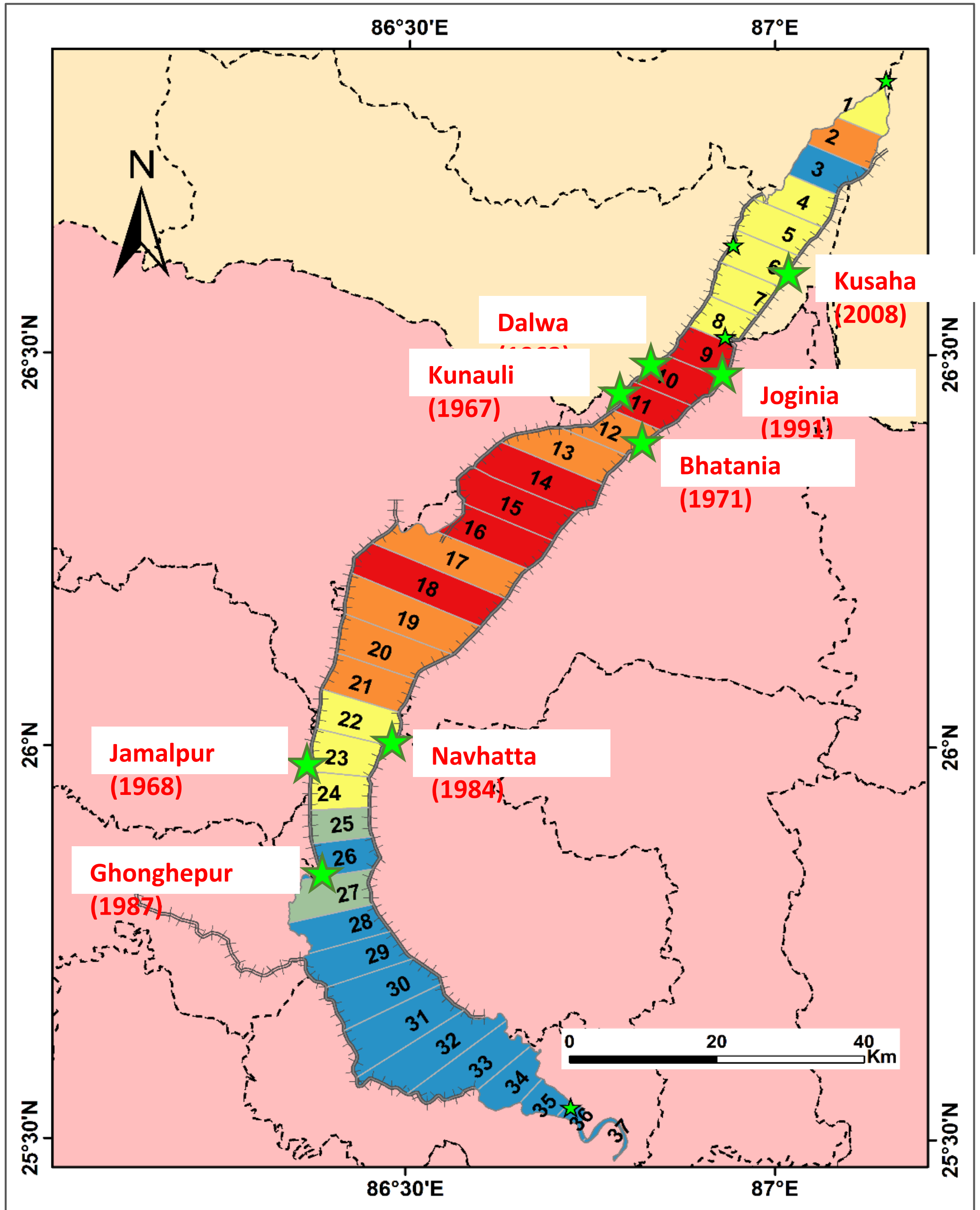
Birpur-Baltara:

= 2862 MT

= **1080×10^6** m^3

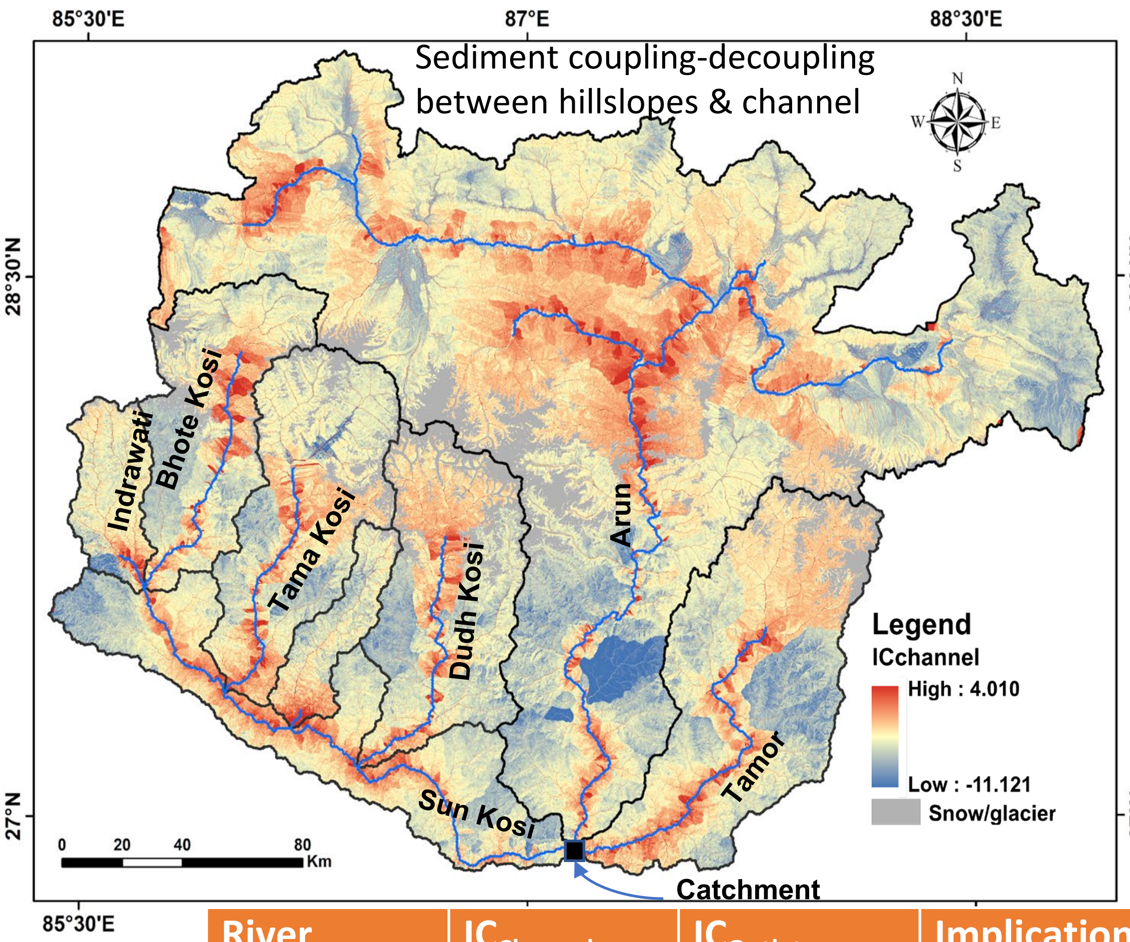
Hotspots of siltation mapped by computing the ratio of Bar area to channel area (BA/CA) in each reach



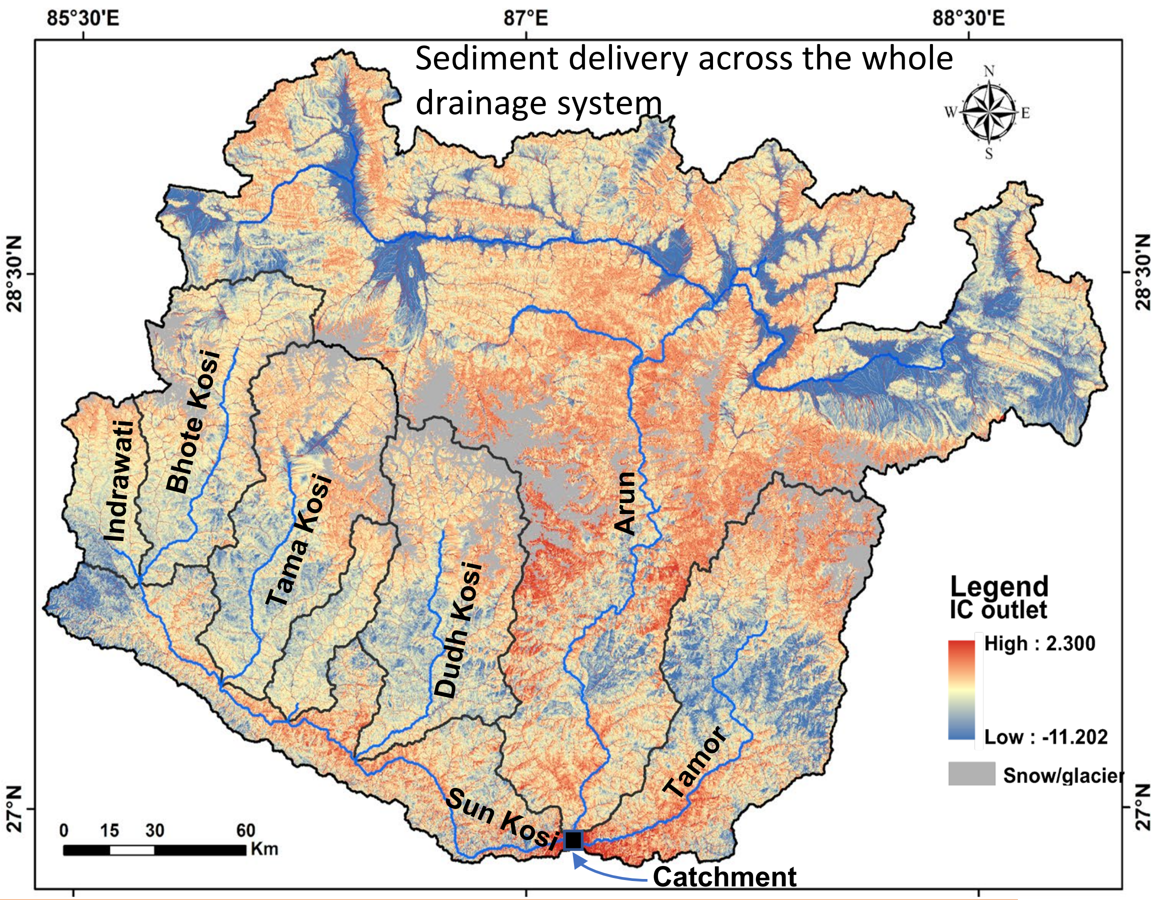


- Past breaches along the Kosi coincide with the hotspots of siltation.
- Validates the hypothesis that siltation has resulted in 'superelevation' of riverbed and hence increase in lateral slope leading to breaches.
- All breaches resulted in large floods and therefore these hotspots of siltation are also high flood risk zones.

Hillslope to Channel connectivity ($IC_{channel}$)

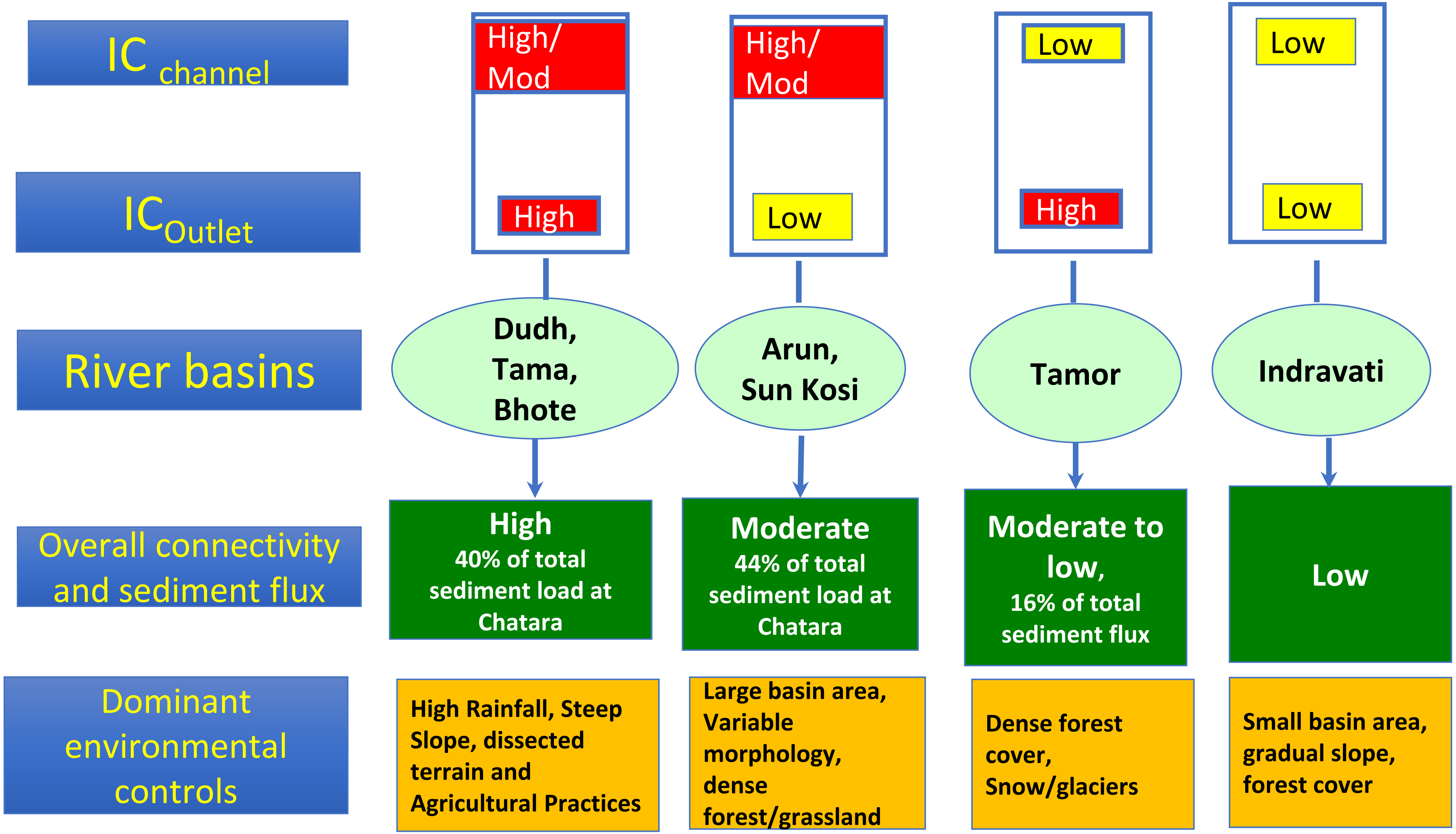


Catchment Connectivity (IC_{outlet})



River	$IC_{Channel}$	IC_{Outlet}	Implication
Indravati	Low	Low	Very low potential for sediment dynamics
Bhote K.	Moderate	Moderate	Moderate potential for sediments reaching the channel and the outlet
Tama K.	Moderate	Moderate	
Dudh K.	High	High	Very high potential for sediments reaching the channel and the outlet
Sun K	Moderate	Low	Sediments can reach the channel but the potential to reach the outlet is low
Arun	High	Low	
Tamor	Low	High	Sediments cannot reach the channel and overall sediment dynamics is low

Overall Response to Sediment Connectivity



Major Learnings

- Strong linkages between sediment dynamics and flood risk and **river avulsion**
- Apart from rainfall and geological factors, sediment connectivity in the upper catchment drives the sediment flux at the outlets in a major way.
- Apart from slope, LULC also governs the sediment connectivity, and therefor, the impact of changing LULC on connectivity is crucial to understand.
- Channel aggradation due to high sediment flux leads to 'superelevated' rivers which in turn leads to breach of embankment and extensive flooding.
- Several 'hotspots' of siltation coincide with the past breaching sites followed by flooding – this underscores the role of siltation on flood risk.
- Long terms solutions to such problems in transboundary rivers require basin scale understanding of river processes and effective sediment management strategies.

Integrating Sediment Management in flood risk assessment

How Much Silt? → First order estimates of silt accumulated over the last 3-4 decades

Where to de-silt? → Identification of hotspots of aggradation and degradation

How to de-silt? → Mechanisms and techniques of desilting

What to do with silt? → Commercial utilization of silt

Key Policy Recommendations

1. Strong need to bridge the gap between science and policy for flood management of transboundary rivers

2. Joint monitoring and assessment of sediment data across borders, including data sharing, for flood management and planning

3. Urgently need additional and modern hydrological stations in the Kosi basin for continuous sediment measurements.

4. Harmonise data gathering and sharing between all concerned states/countries.

5. Sediment management should become an essential part of flood risk assessment and management at the national as well as transboundary scale.

Key Policy Recommendations

1. Effectively manage flooding on the Kosi River by moving from a policy of 'river control' to a policy of 'river management'.

2. Take measures to address sediment dynamics and improve drainage in low-lying areas.

3. Prepare basin scale GIS interactive flood risk maps based on scientific data and reasoning, historical data analysis and modelling approaches, and link them to an online database and flood warning system.

4. Preparation of local flood management plans, using a combination of scientific and local knowledge of Kosi River hazards.

5. Develop and involve communities in flood and sediment management strategies.

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