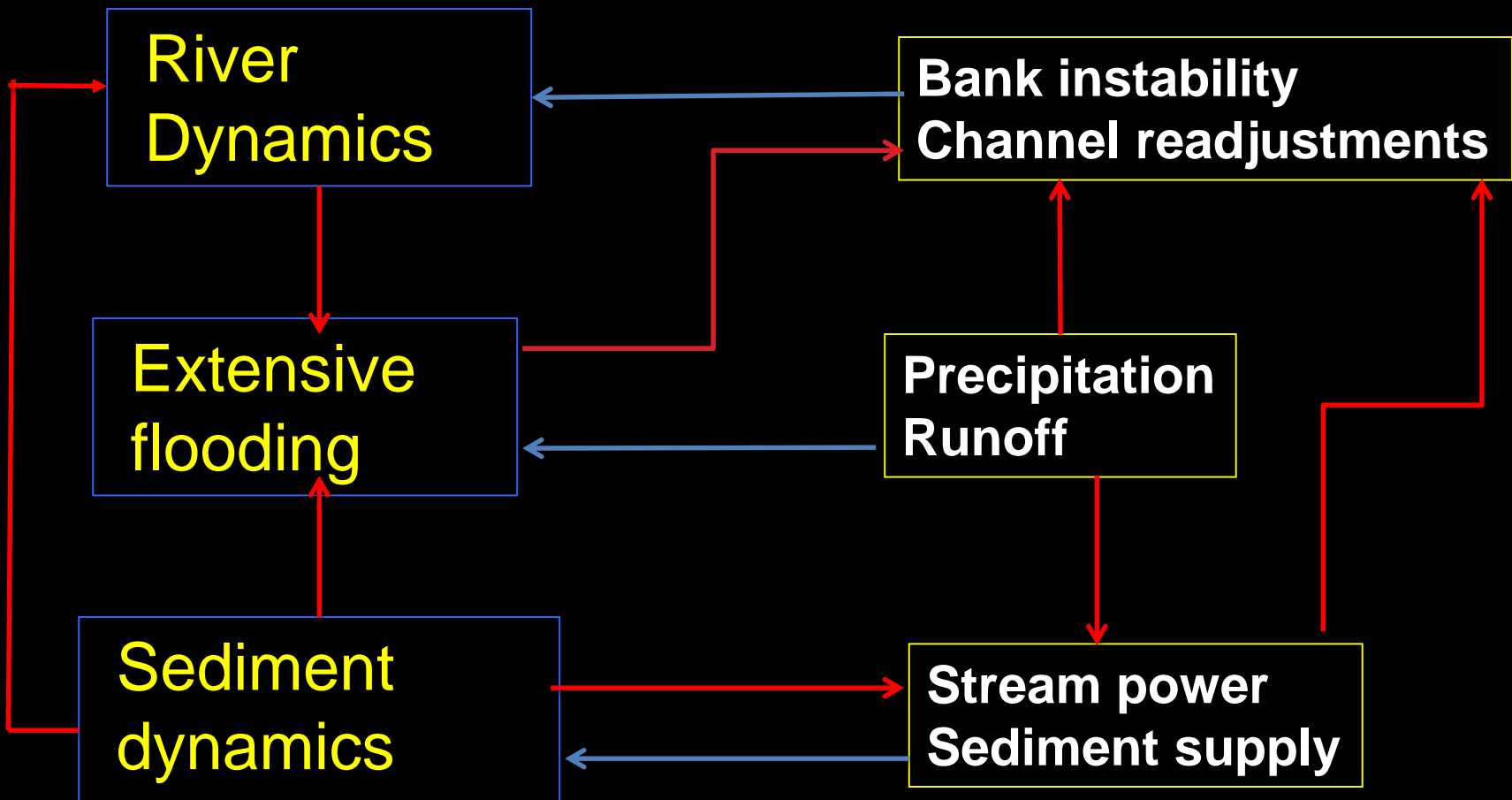


# Water and Hazards

Rajiv Sinha  
Department of Earth Sciences  
IIT Kanpur

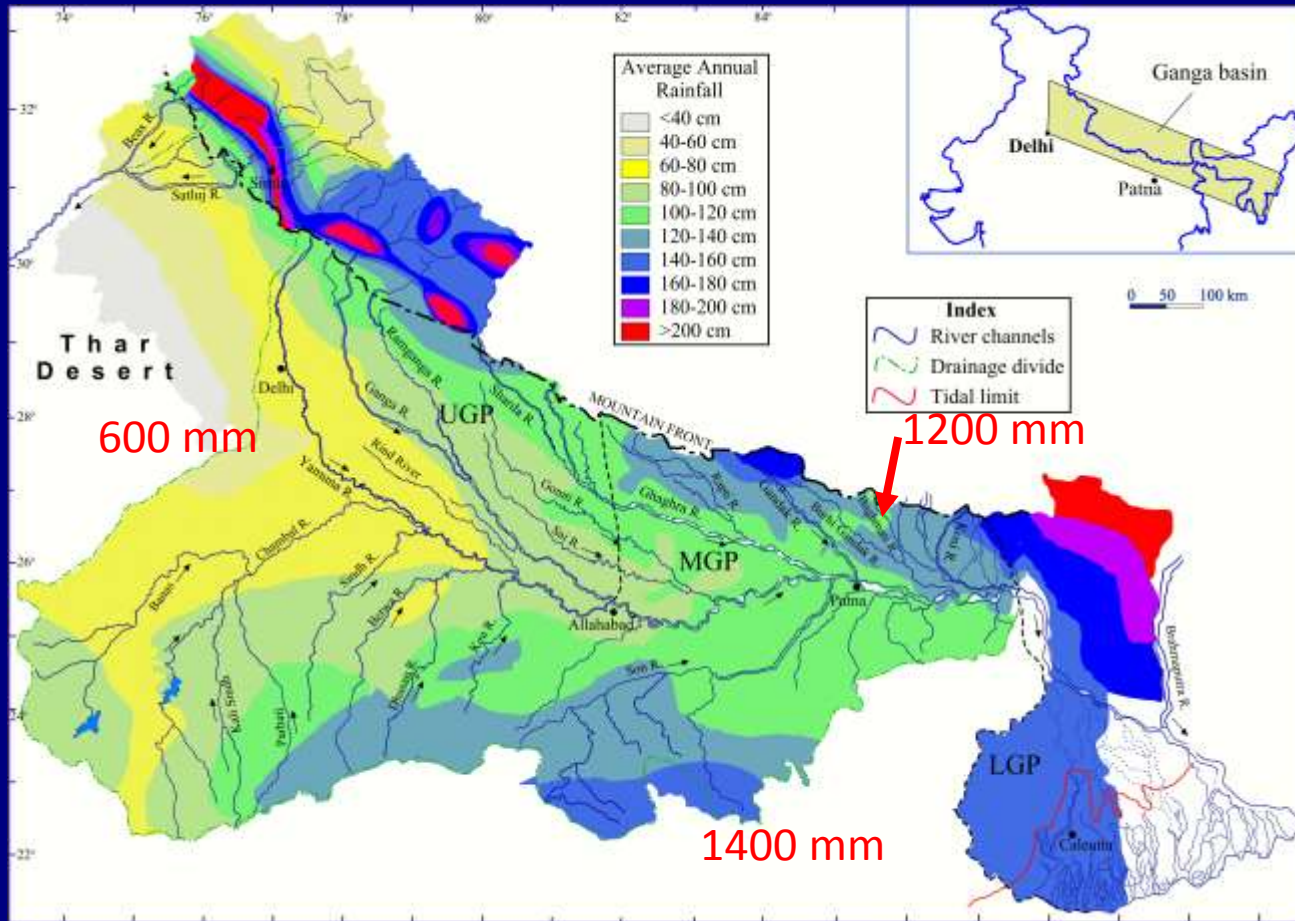
# River Hazards in the Ganga basin



- What do we know about the process and impacts?
- What has been done for their mitigation?
- What needs to be done for mitigation and prevention?



# The Ganga Basin: Modern climatic factors



- Monsoonal climate – 2000 mm in 3 mths

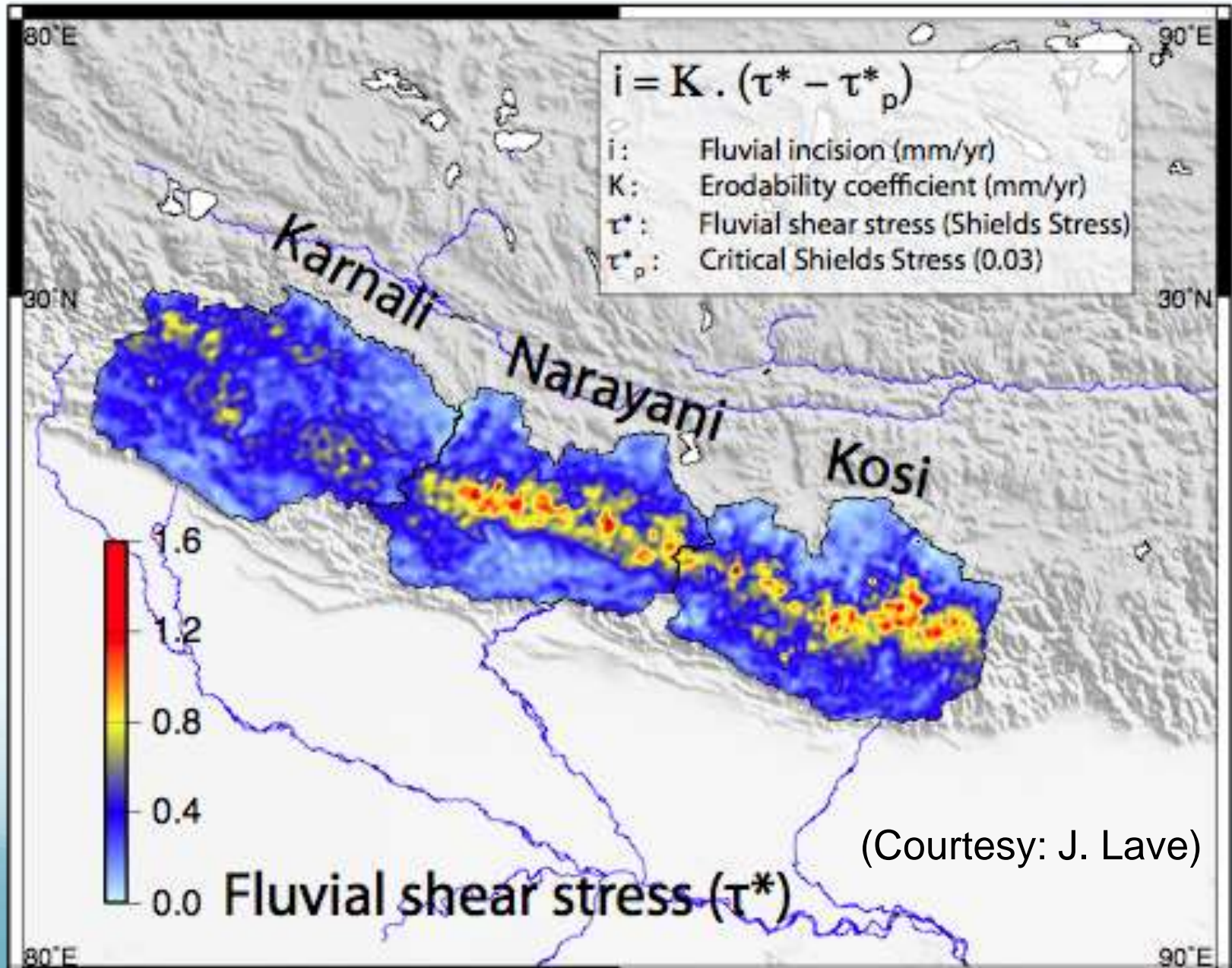
- Precipitation 2x W to E in Plains

- Slopes variable

Consequences: (Sinha et al., 2005, Himalayan Geology)

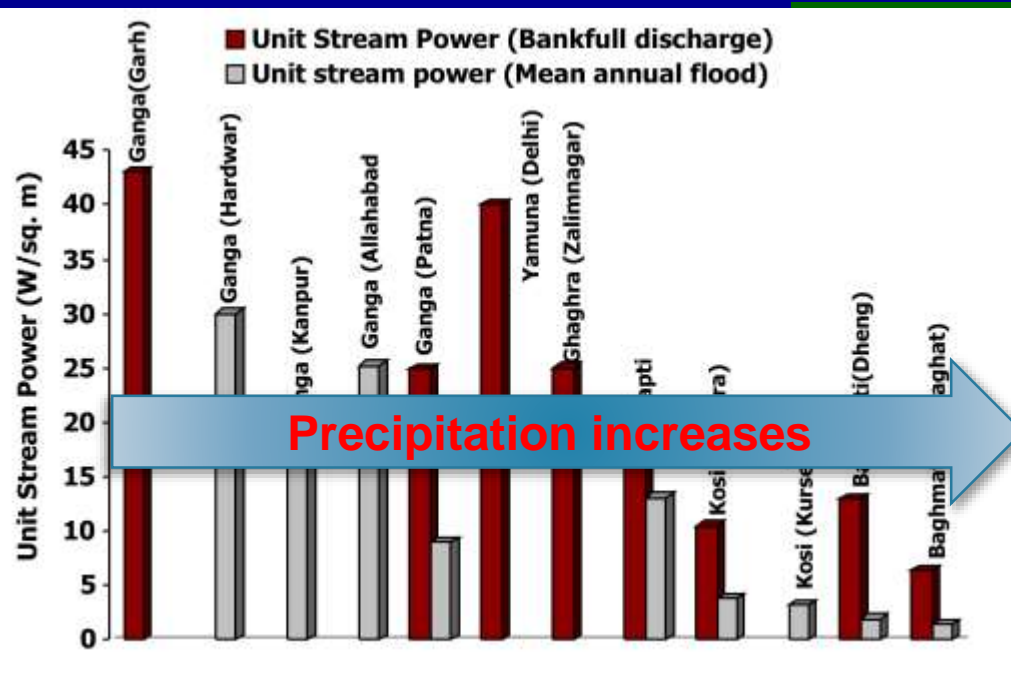
- Complex spatial response of rivers
- Stream power variable  $\Rightarrow$  water & sediment discharge, slope
- Changes river's equilibrium profile  $\Rightarrow$  Incision / Aggradation
- Geomorphic diversity across the plains

# Spatial Variability in River Energy



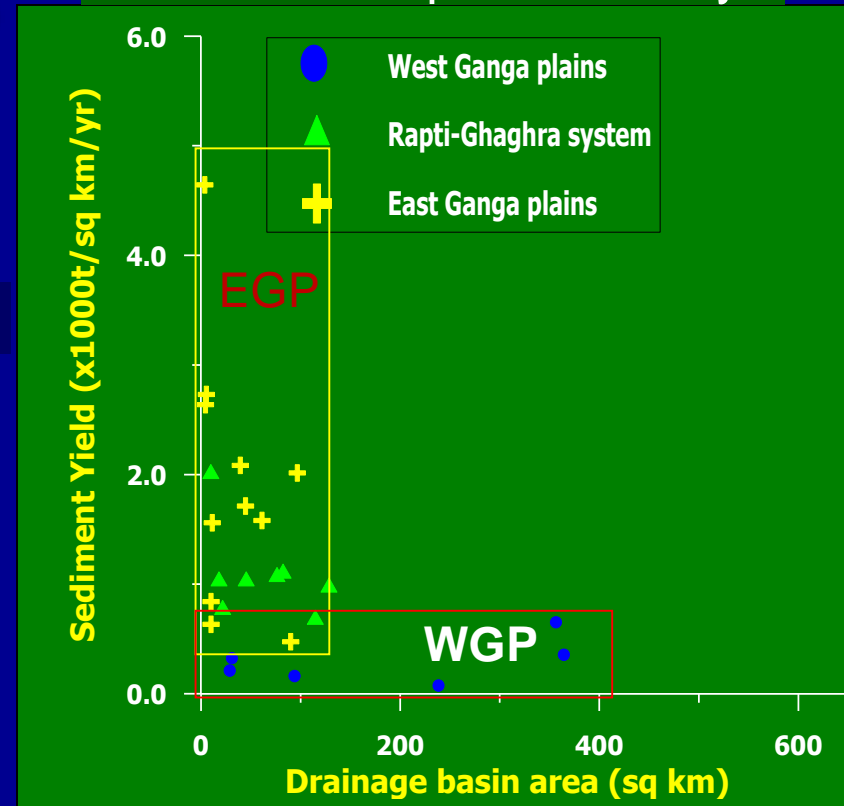
# Tectonics and Climate in the Ganga dispersal systems

Tectonic + Climate → Stream power



(Sinha et al., 2005, Geomorphology)

## Sediment Output Variability



## Consequences:

- Complex spatial response of rivers
- Changes river's equilibrium profile → Incision / Aggradation
- Differential sensitivity to external forcings such as climate change



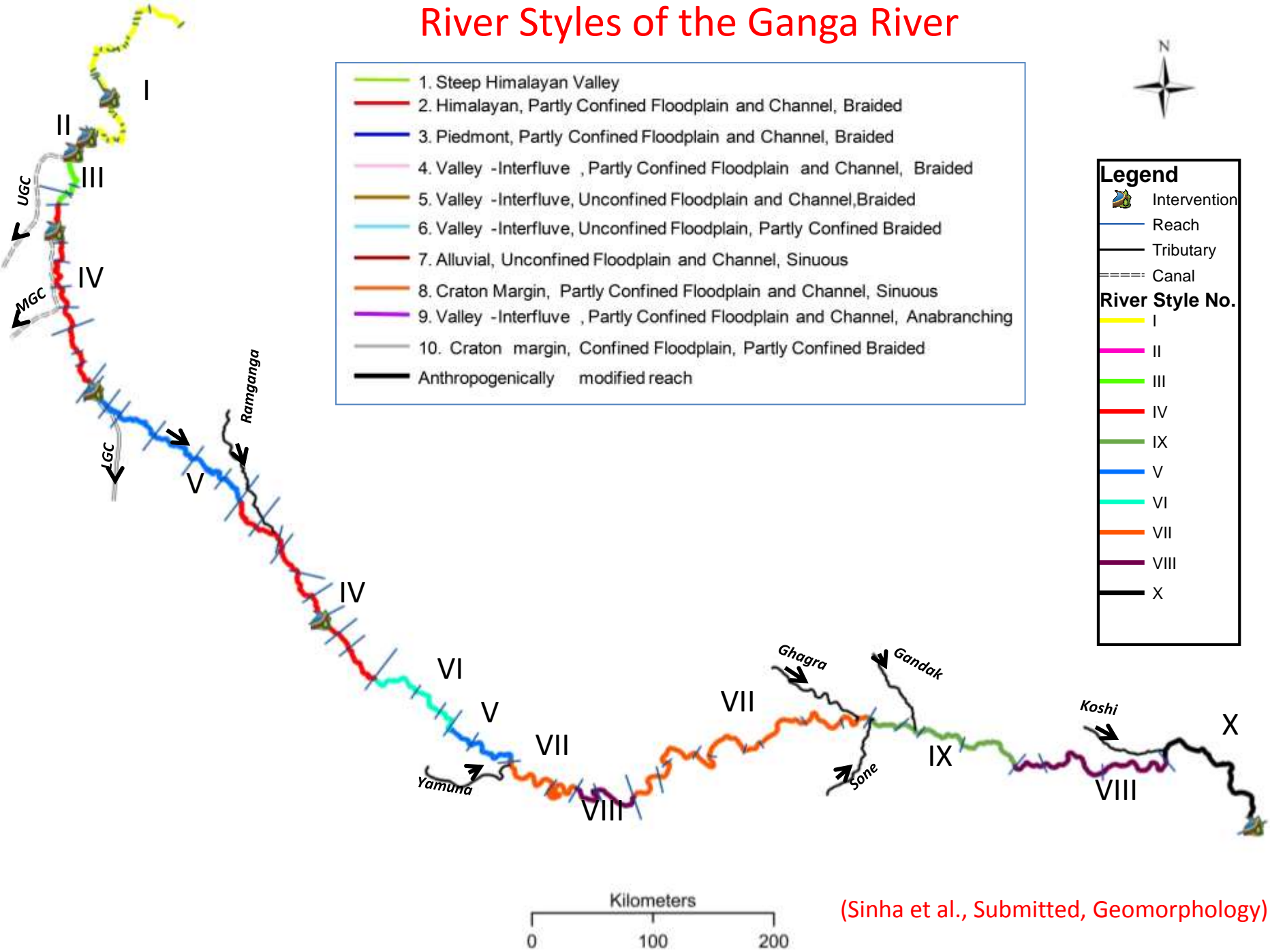
# River Styles of the Ganga River



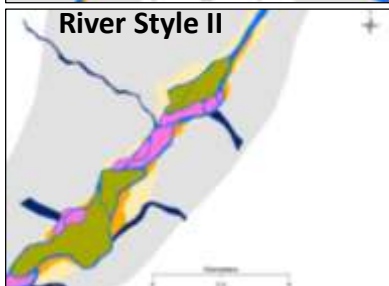
- 1. Steep Himalayan Valley
- 2. Himalayan, Partly Confined Floodplain and Channel, Braided
- 3. Piedmont, Partly Confined Floodplain and Channel, Braided
- 4. Valley - Interfluvial, Partly Confined Floodplain and Channel, Braided
- 5. Valley - Interfluvial, Unconfined Floodplain and Channel, Braided
- 6. Valley - Interfluvial, Unconfined Floodplain, Partly Confined Braided
- 7. Alluvial, Unconfined Floodplain and Channel, Sinuous
- 8. Craton Margin, Partly Confined Floodplain and Channel, Sinuous
- 9. Valley - Interfluvial, Partly Confined Floodplain and Channel, Anabranching
- 10. Craton margin, Confined Floodplain, Partly Confined Braided
- Anthropogenically modified reach

**Legend**

- Intervention
- Reach
- Tributary
- Canal
- River Style No.**
- I
- II
- III
- IV
- IX
- V
- VI
- VII
- VIII
- X



(Sinha et al., Submitted, Geomorphology)



**Legend**

- Main channel
- Tributary
- Active floodplain
- Inactive floodplain
- Valley Margin
- Channel Belt Features**
- Mid channel bar
- Transverse bar
- Point bar
- Confluence bar
- Alluvial island
- Side bar
- Abandoned braid bar
- Chute channel
- Secondary channel

**Flood Plain Features**

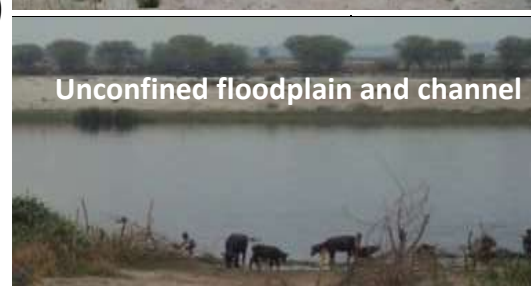
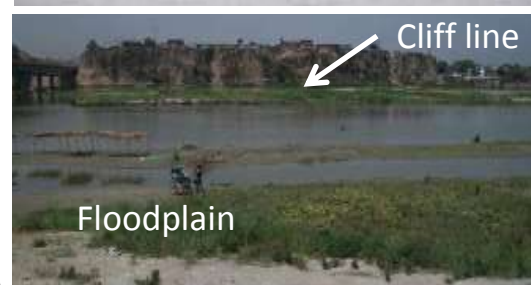
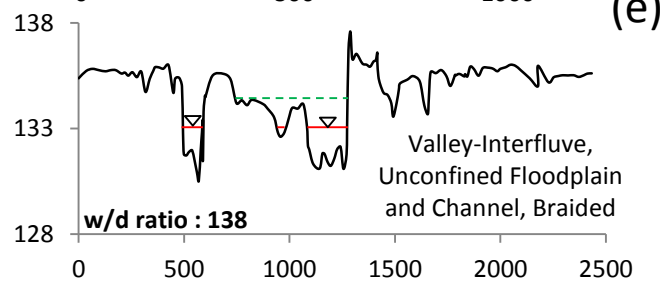
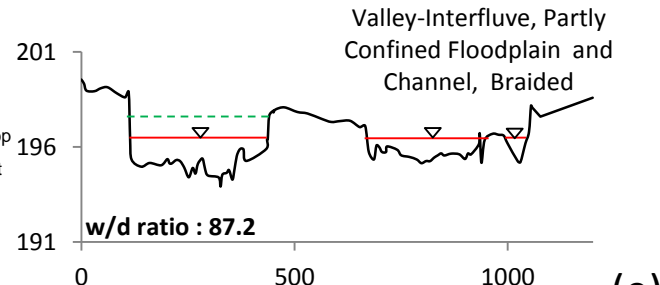
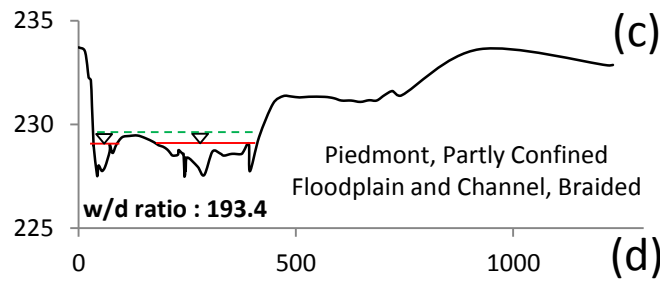
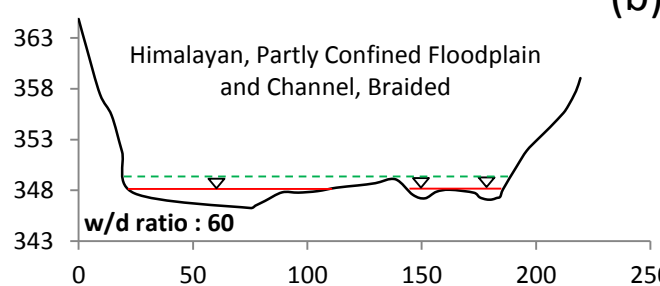
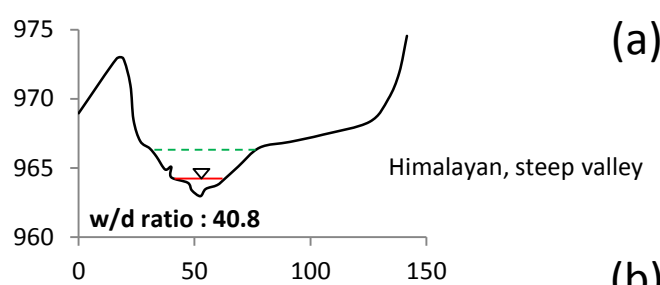
- Ox bow lake
- Flood channel
- Marshy/Wetland
- Bar accretionary surface
- Meander cutoff
- Meander Scrolls
- Abandoned/dry channel
- Abandoned meander loop
- Abandoned meander belt
- Abandoned point bar
- Sand patches

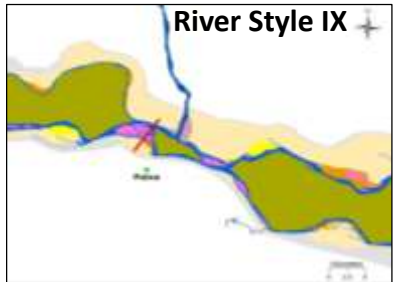
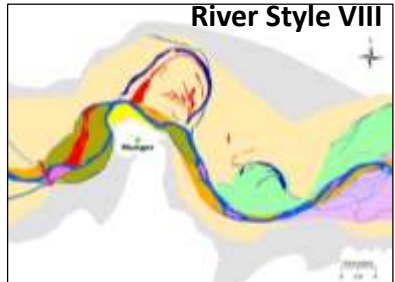
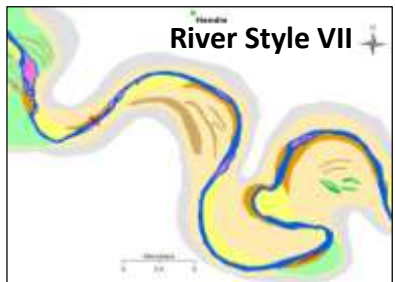
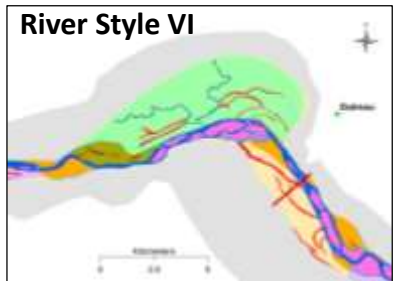
Bankfull level

Water level

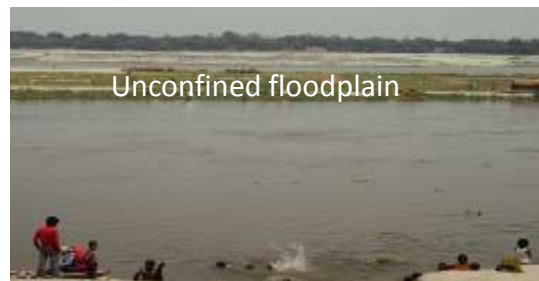
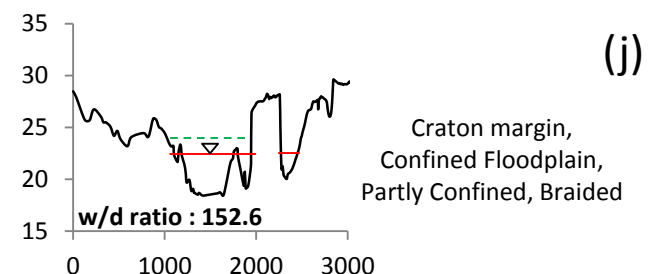
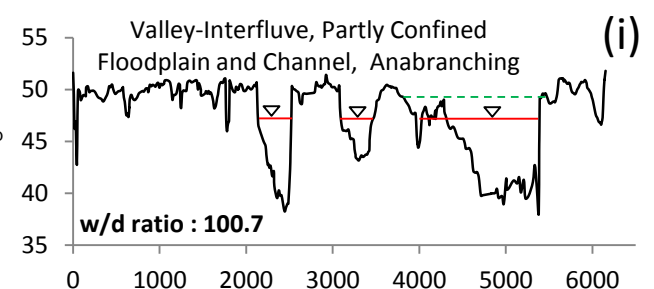
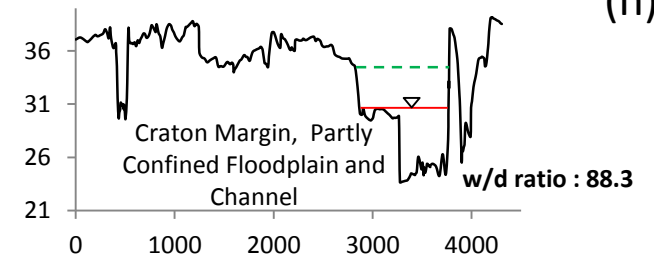
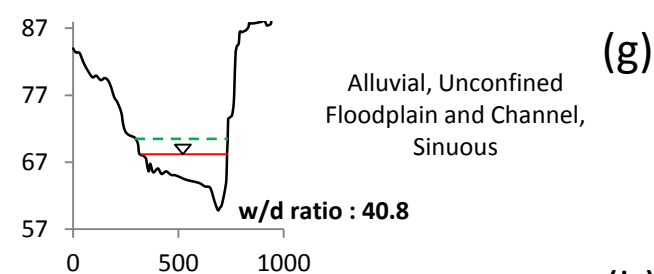
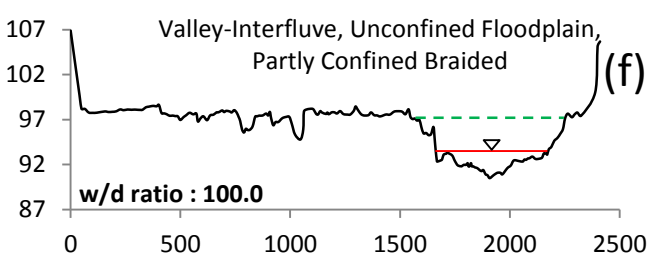
**X-axis**-Distance from left bank in meter.

**Y-axis**-Elevation from MSL in meter.



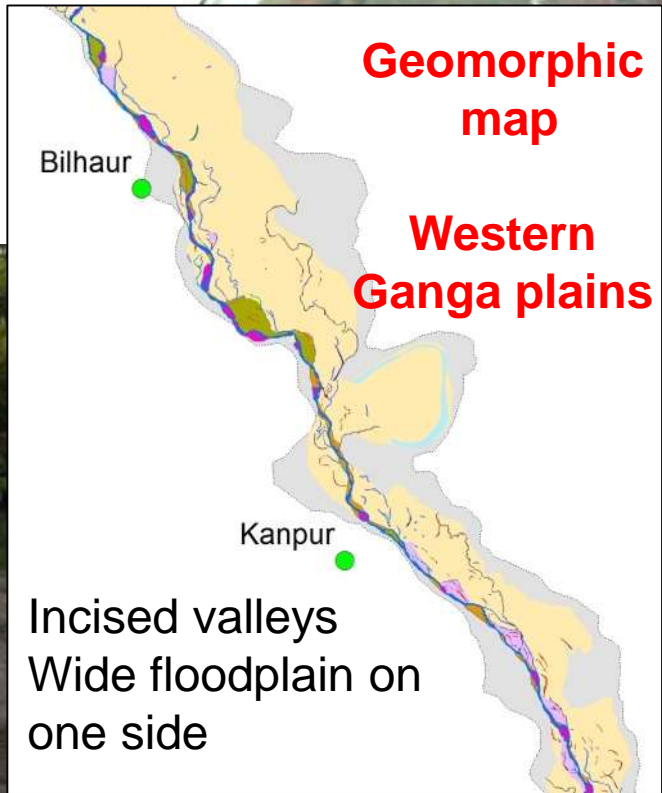
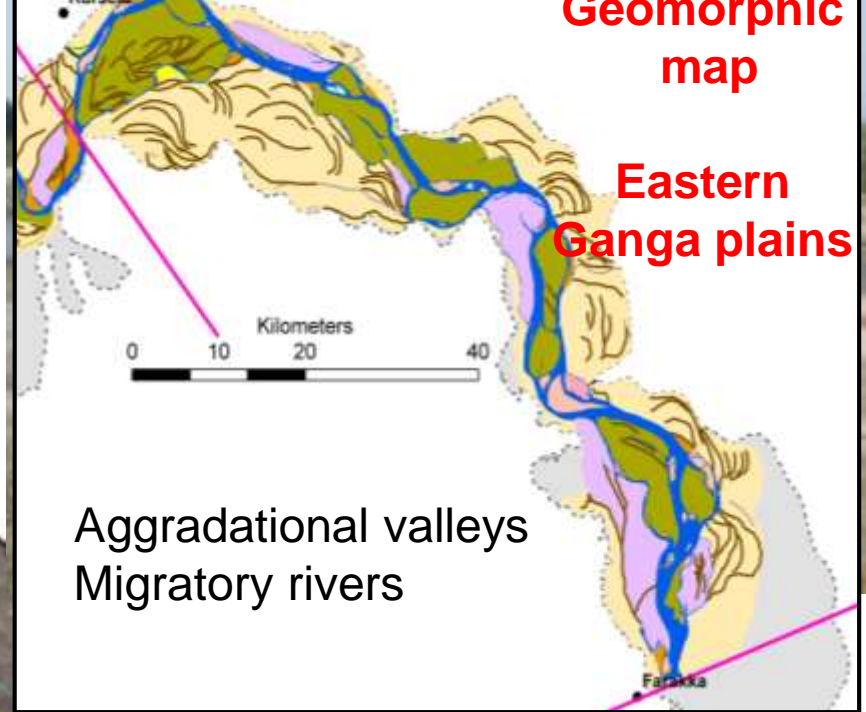
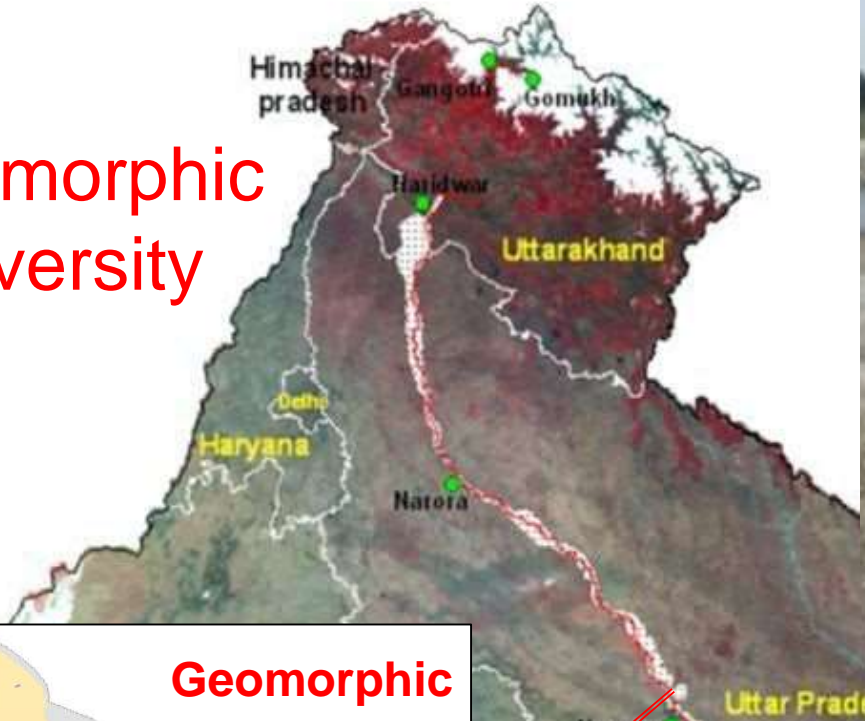


- Legend**
- Main channel
  - Tributary
  - Active floodplain
  - Inactive floodplain
  - Valley Margin
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  - Abandoned point bar
  - Sand patches
- Bankfull level**
- Water level**
- X-axis**-Distance from left bank in meter.
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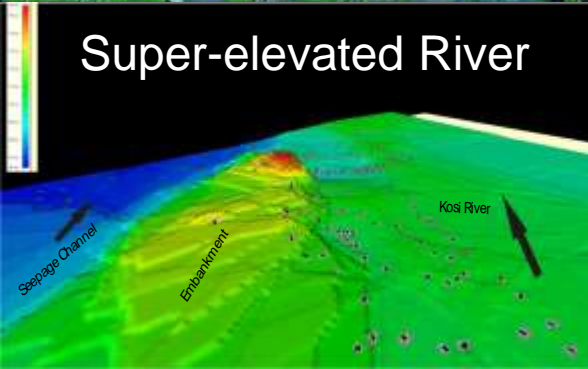
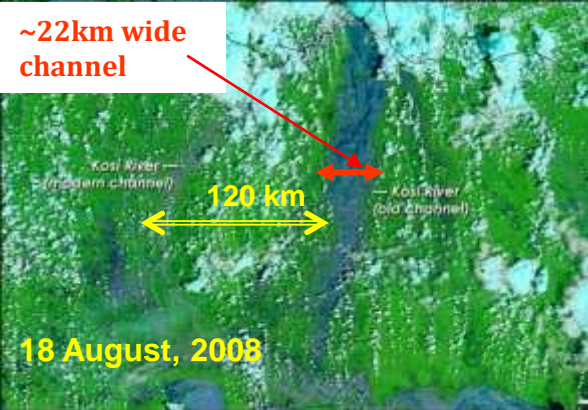
# Geomorphic Diversity



### Why is this diversity important?

- Implications for flood management
- Morphological control on river dynamics
- Defines specific habitat conditions and stresses the need of their maintenance
- Differential response to external forcings e.g. climate change
- Important for knowledge-based design and purposeful interventions

This map shows the Ganga basin in Bihar and West Bengal, with cities like Allahabad, Varanasi, Buxar, Patna, and Farakka marked. A scale bar indicates 50 Km.



**The furious Kosi: August 2008**

# River disasters: Natural or human-induced?

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

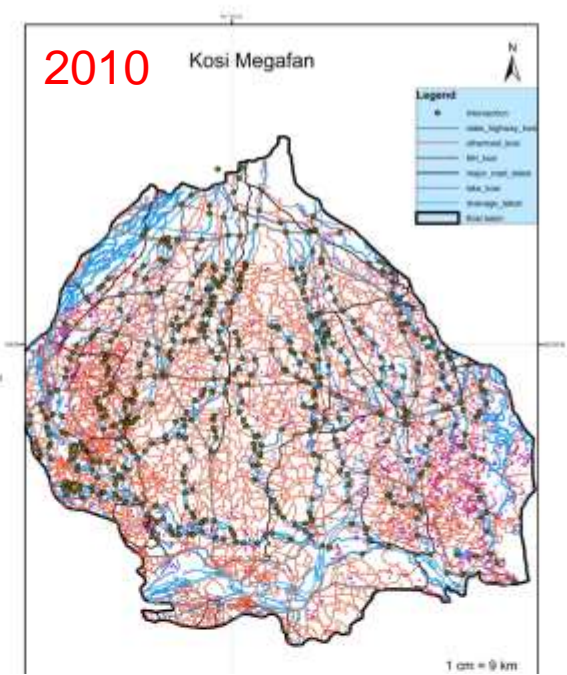
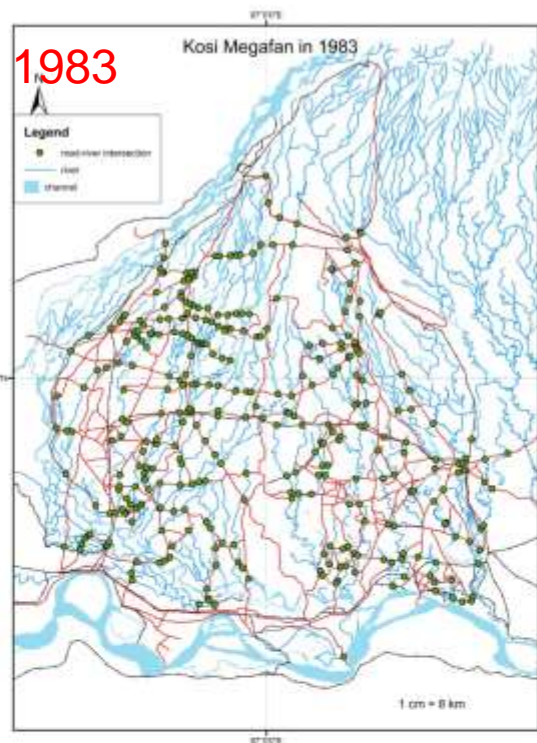
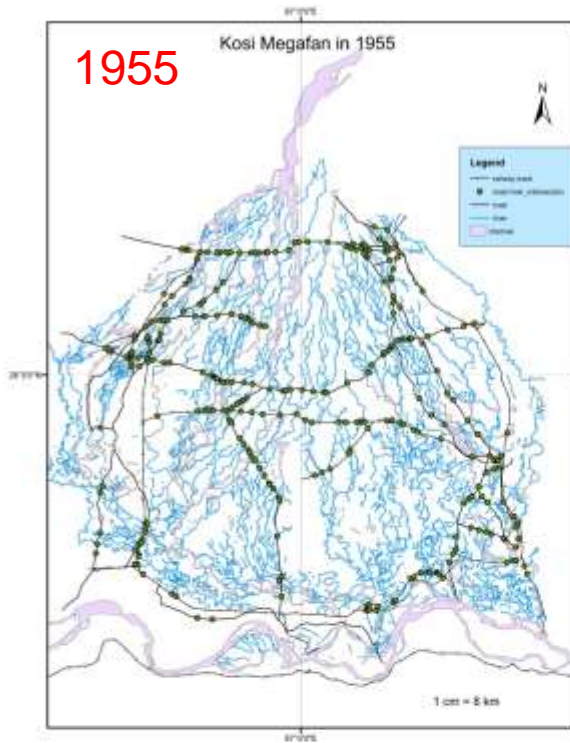
Unplanned management and encroachment of river space, construction of river projects and dumping of sediments



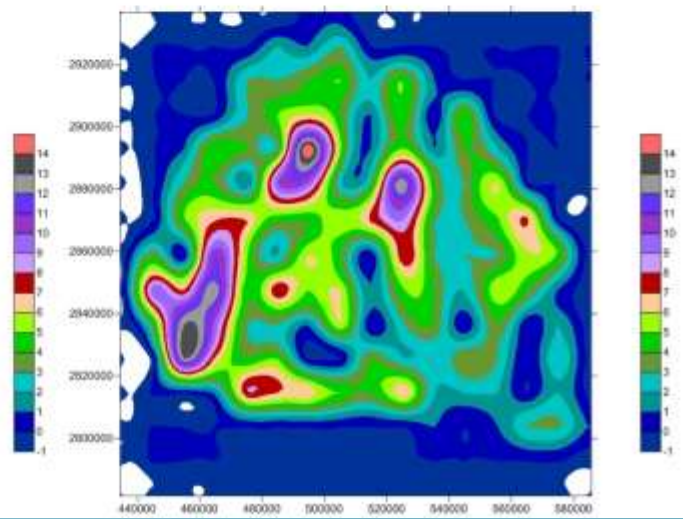
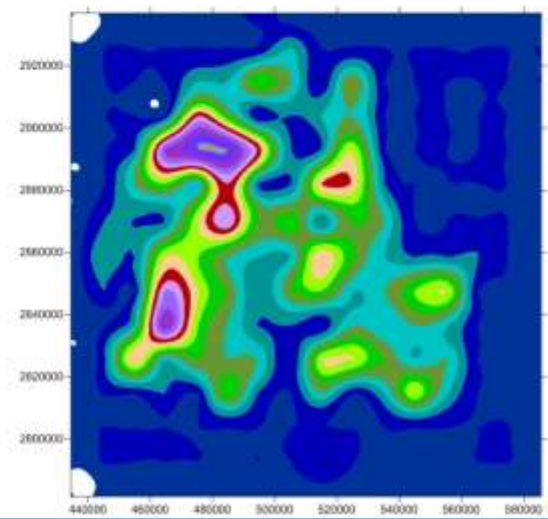
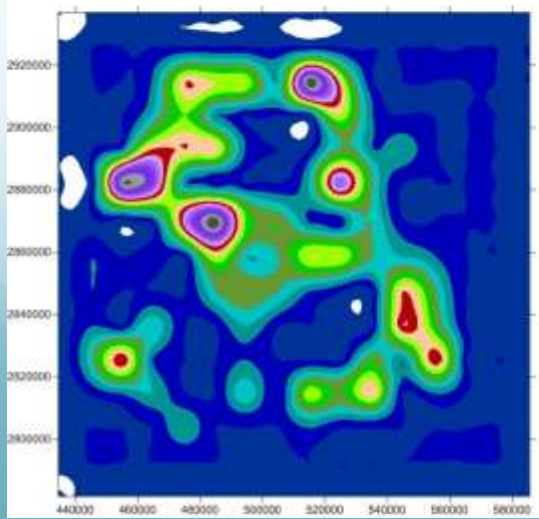
**Uttrakhand, 2013**



# (Dis) connectivity over the Kosi Megafan

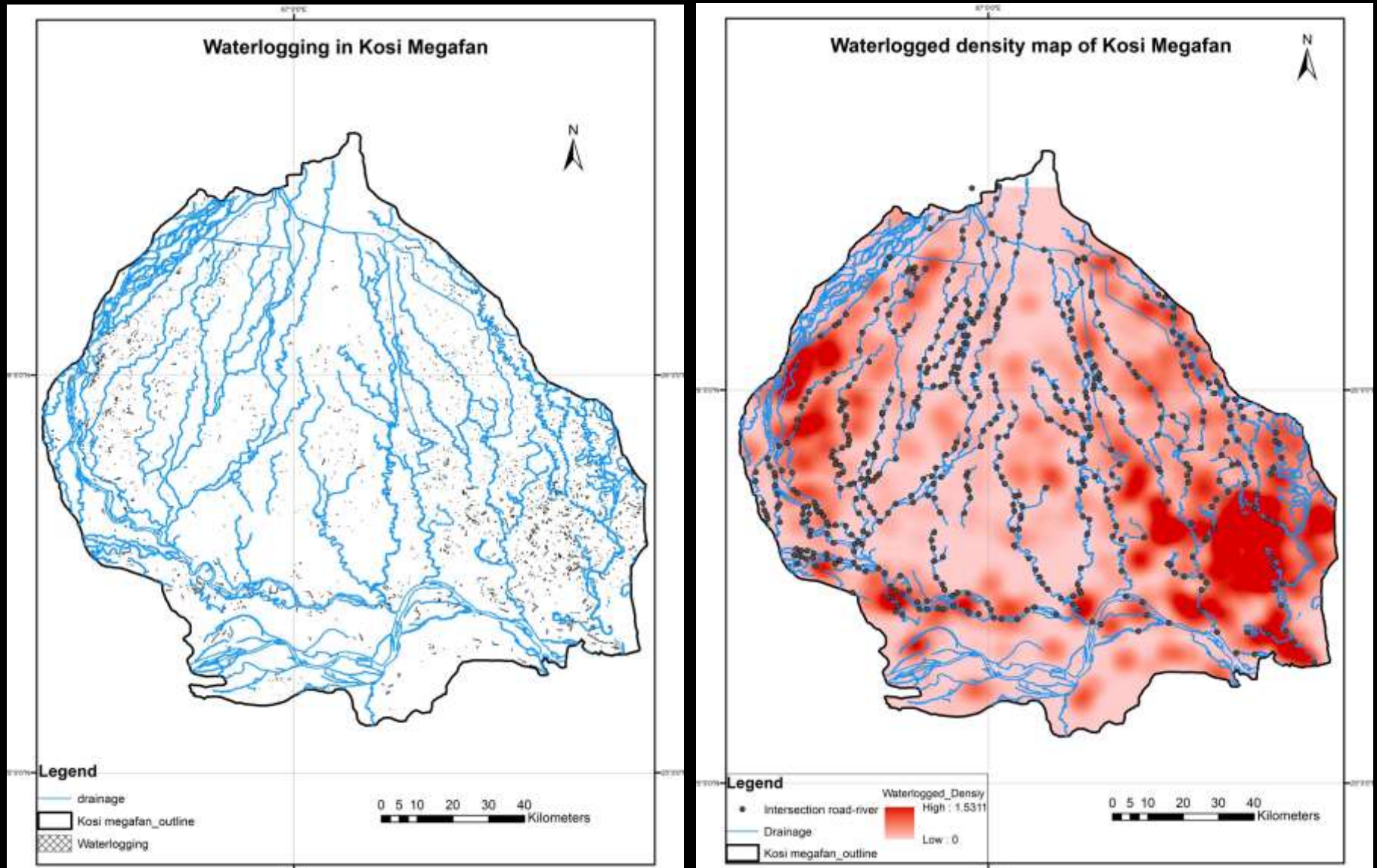


(Kumar et al., 2014, Geomorphology)



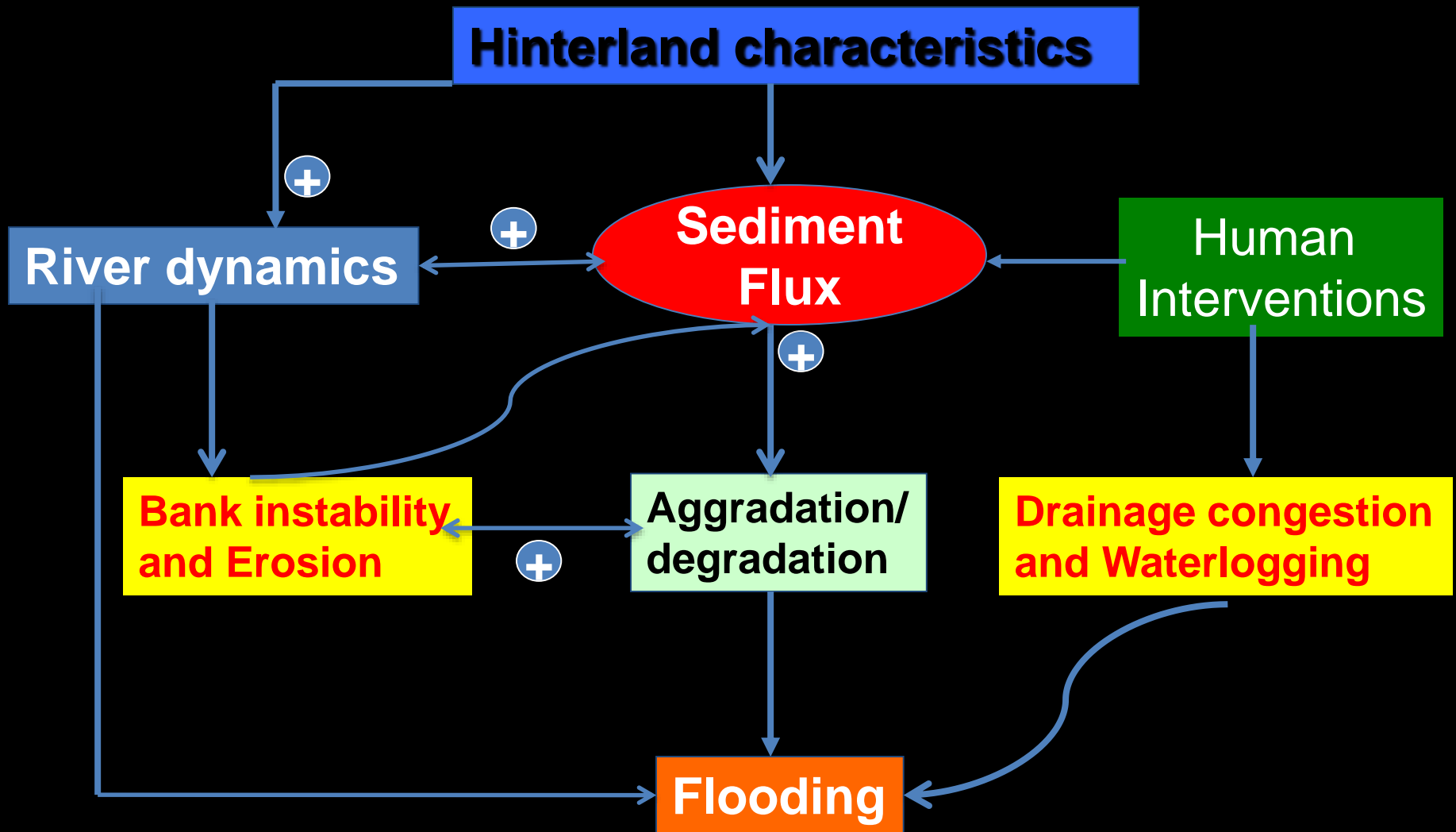


# Waterlogging and Drainage Congestion



Waterlogged area is positively correlated to the density of intersection point – results in major drainage congestion and longer periods of inundation (Kumar et al., 2014, Geomorphology)

# Sediment Management: a central problem!



# Major Research Questions

- How to define the **resilience and threshold** of geomorphic system to floods and its relationship to other river processes such as river dynamics and bank erosion?
- How do we develop the **best engineering practices** for flood management in **sediment-charged** Himalayan rivers?
- How to quantify **sediment dynamics** in high and middle mountains and its linkage with basin properties? Impact on infrastructures?
- How to assess the impact of floods on **ecological services**?
- How do we develop effective **floodplain zoning** and policy options for the Ganga basin taking into account biophysical as well as socio-economic factors?
- How can we develop an efficient **flood warning system** and building codes against flood resistant buildings?
- How can we map **vulnerability and resilience** to flooding and standardize the methodology to help the policy managers?