Ganges Basinwide Assessment
Early Findings

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South Asia Water Initiative (SAWI)

- Ganges Assessment is a **regional research** study supported by **SAWI**
- The **Objective of SAWI** is to facilitate regional cooperation in the sustainable use and management of the water resources of the Himalayan Rivers in addressing development challenges and the impacts from climate change

A partnership of Australia, Norway, the U.K. and the World Bank supporting efforts in the countries sharing the rivers that rise in the Greater Himalayas:

- Afghanistan
- Bangladesh
- Bhutan
- China
- India
- Nepal
- Pakistan

The Ganges Basinwide Assessment

Background

Context

- No comprehensive model of the world's most populous basin
- Identified gap in knowledge
- World Bank regional research (OP 7.50)

Objective

- Understand risks/opportunities in the Basin & possible futures
- Create a tool for information-based dialogue within & between countries

Components

- Nested suite of models
- Water systems simulation models
- Economic optimization model
- Social analysis

The Ganges Basinwide Assessment

Methodology

- Multiple models
- Across disciplines
- Public data
- Converging picture of basin dynamics

Disciplines	Model	Objective
Water Systems	MikeBasin (&Mike11) Model	To model the surface water system in the Ganges
	Groundwater, SWAT water balance & water quality, flood modeling	To understand the dynamics of groundwater, water balance, water quality & floods
Economics	GAMS/economic optimization Model	To explore economic trade-offs & the distribution of benefits from new storage projects in the basin
	Commissioned research	Flood damages, ecosystem service values
Social	Literature review, focus group discussions, survey	To understand the social impacts of & responses to water variability

The Ganges Basin

The most populous in the world (~650m)

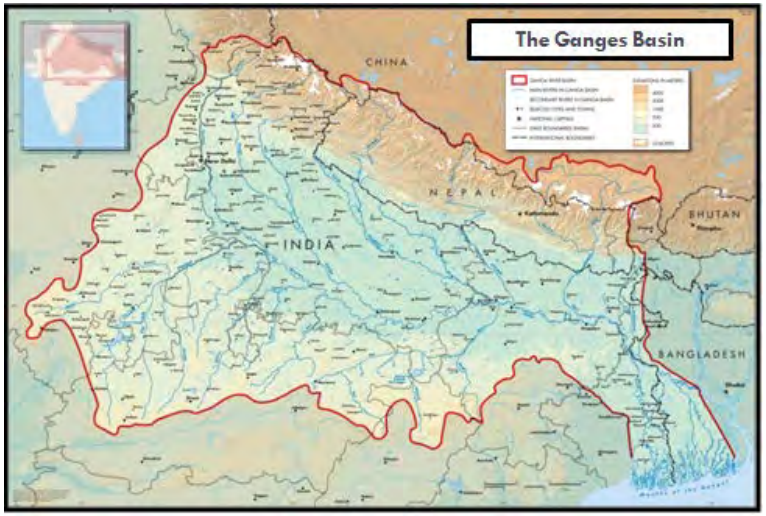
A massive, moving, varied river system

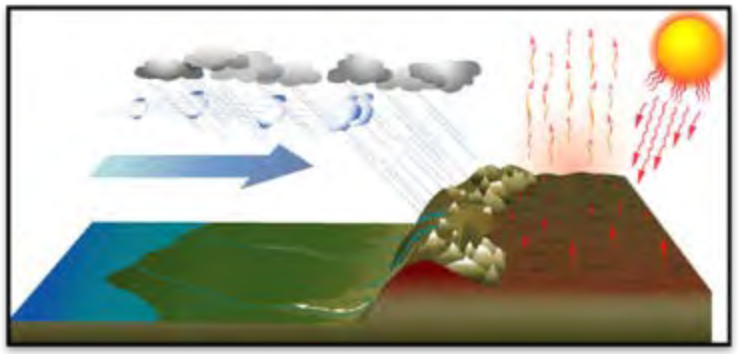
- High mountains & glaciers

- Vast plains, dominated by large irrigation systems

- The largest mangrove ecosystem in the world in the delta

Driven by the South Asia monsoon





(virtual) Fly Through the Basin

Key questions
from a basin-wide perspective

(study does not provide project specific recommendations)

Question

Is there substantial **upstream reservoir storage** in the basin?

Commonly held perceptions

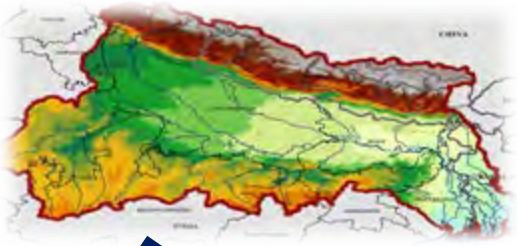
Yes. Large multi-purpose dams could regulate the extreme flows of the Ganges River

New Insights

Not really. The largest 23 dams would only hold an additional 18% of the annual flow

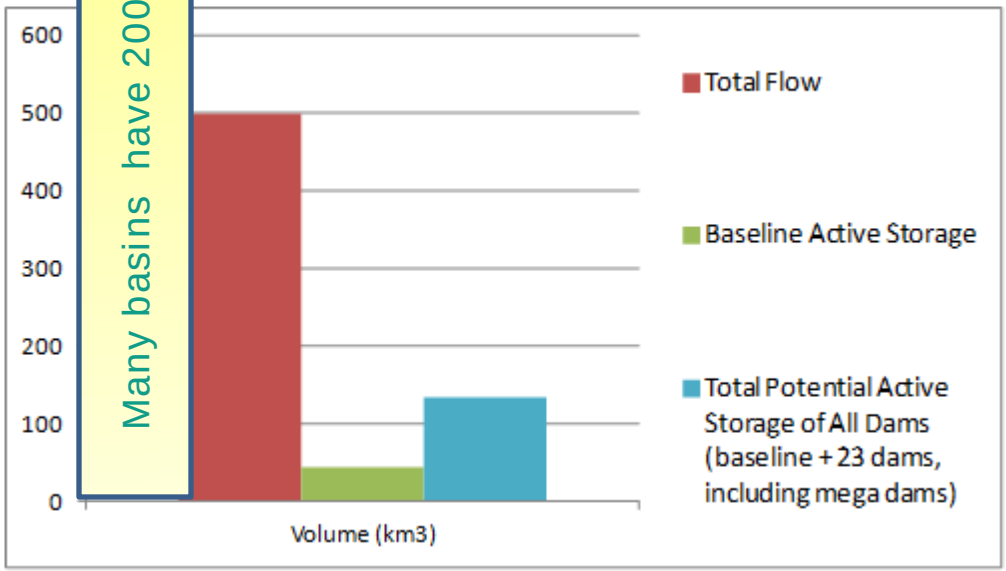
Ganges Water Balance

Precipitation: 1200 BCM



Ganges Runoff: 500 BCM

Poter olume of water storage in the Ganges



Question	Commonly held perception	New Insights
Can upstream water storage help **control basinwide flooding?**	**Yes.** Himalayan storage reservoirs are commonly seen as the answer to Ganges floods in the plains and delta	**Basinwide? No.** Too little to regulate the main stem **In sub-basins? Unlikely.** Reduces peak flows, but doesn't necessarily reduce floods

Little impact on mainstream

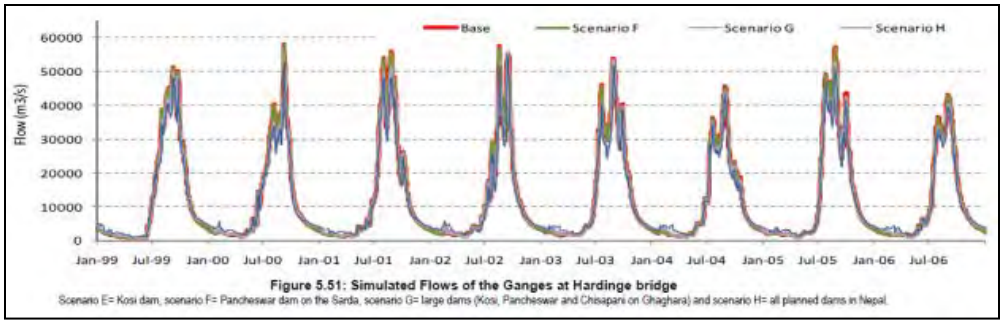


Figure 5.51: Simulated Flows of the Ganges at Hardinge bridge

Scenario E= Kosi dam, scenario F= Pancheswar dam on the Sarda, scenario G= large dams (Kosi, Pancheswar and Chisapani on Ghaghara) and scenario H= all planned dams in Nepal

Modest impact in tributaries, but

- most rivers are fully embanked
- local rainfall & embankment failures cause most flooding

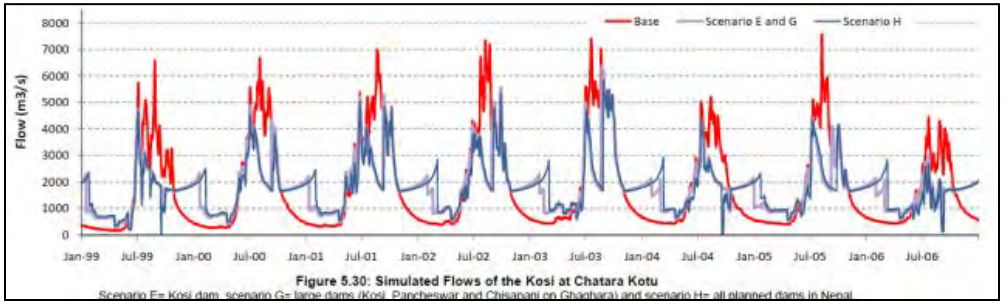


Figure 5.30: Simulated Flows of the Kosi at Chatara Kotu

Scenario F= Kosi dam, scenario G= large dams (Kosi, Pancheswar and Chisapani on Ghaghara) and scenario H= all planned dams in Nepal

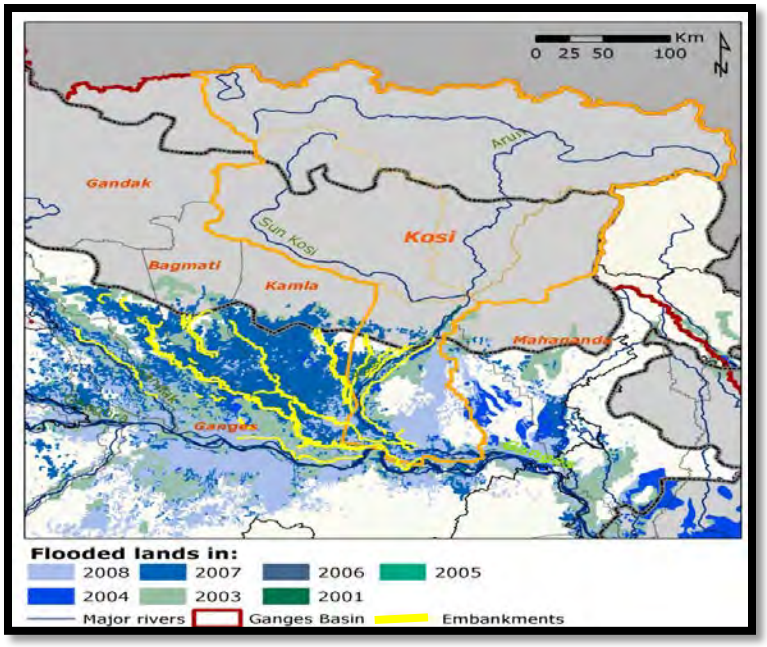
Upstream storage is not a sufficient strategy to control Bihar floods

SAWI SOUTH ASIA WATER INITIATIVE

Flooded Area

- Most of the flooded area in Bihar is outside the Kosi Basin

Embankments



- Most major tributaries are embanked
- Most floods (outside embankments) from direct rainfall & embankment breaches

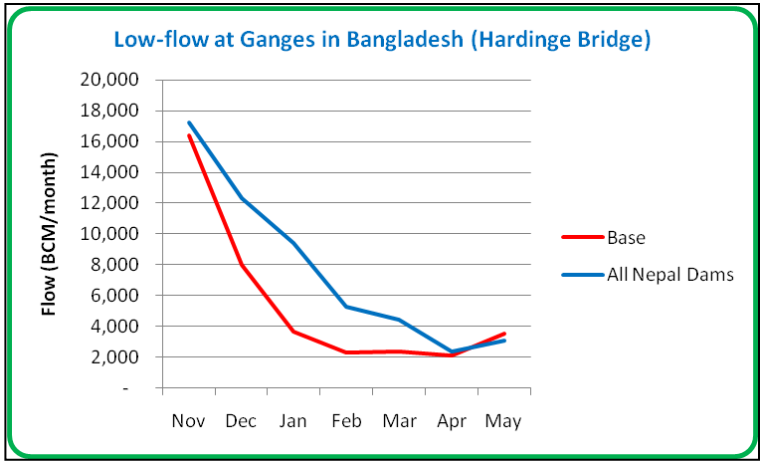
Question	Commonly held perception	New Insights
Is large infrastructure the best strategy for **protecting communities?**	**Yes**. The most effective and reliable protection	**Not everywhere & not exclusively.** Hard and soft, transboundary and local interventions are needed

A shift from 'flood control' to 'flood management'

- Regional forecast and warning systems
- National/localized:
  - Embankment asset management
  - Drainage
  - Land zoning
  - Safe havens
  - Insurance
  - Communications

Question	Commonly held perception	New Insights
Can **low-flows** be **augmented** by upstream water storage?	**Yes**. Monsoon waters can be held upstream and released in the dry season	**Yes, but.** A small portion of the flood, makes a big difference to low flows But the best use and economic value of this water is unclear

Max. increase of 20-45 BCM

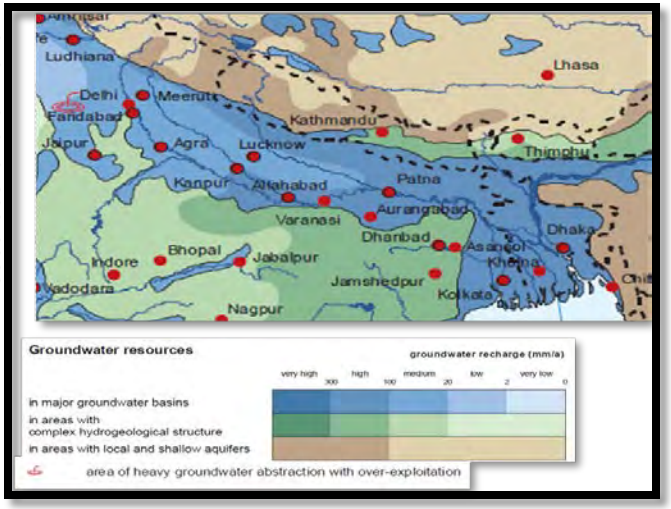


Volumes are still small relative to peak flows, so the integrity of the hydrological system is unlikely to be threatened

Best use & value of these increased flows **is unclear**

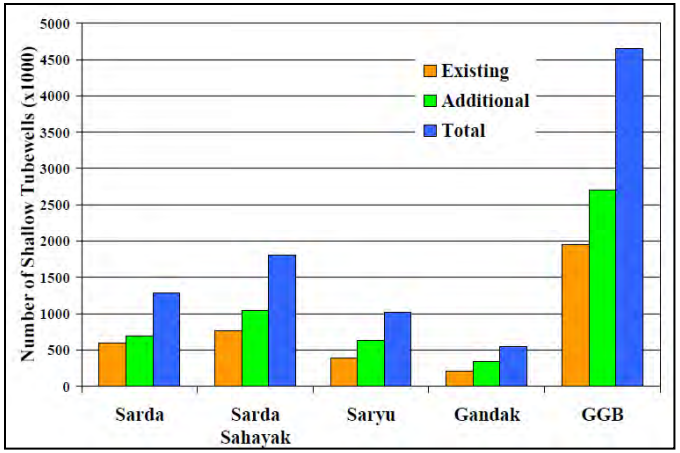
- Water does not appear to be the key factor limiting productivity
- In waterlogged areas additional low season water could harm
- Other values, i.e., ecosystems, navigation, municipal could be high but need study

Question	Commonly held perception	New Insights
Are there good **alternatives** or complements **to reservoir storage**?	**No**. Large man-made storage is the only option adequate for the scale of the challenge	**Yes.** Natural underground water storage, strategically & sustainably managed, could be used in the basin on a scale comparable to the full suite of dams considered in our models



BGR & UNESCO, Map "Groundwater Resources of the World

Additional, sustainable groundwater resources available in the Ganges plains
In contrast to elsewhere in India



In the Ghaghra-Gomti Basin **2.5m new tubewells could be sustainably utilized** providing **groundwater storage** of over **20 BCM**

Question	Commonly held perception	New Insights
Is there substantial **untapped hydropower**?	**Yes**. A lot. Enough for domestic energy as well as significant exports	**Yes.** The 23 largest dams have an installed capacity of ~25,000MW (65-70 TWh) & a value of some $5bn/yr

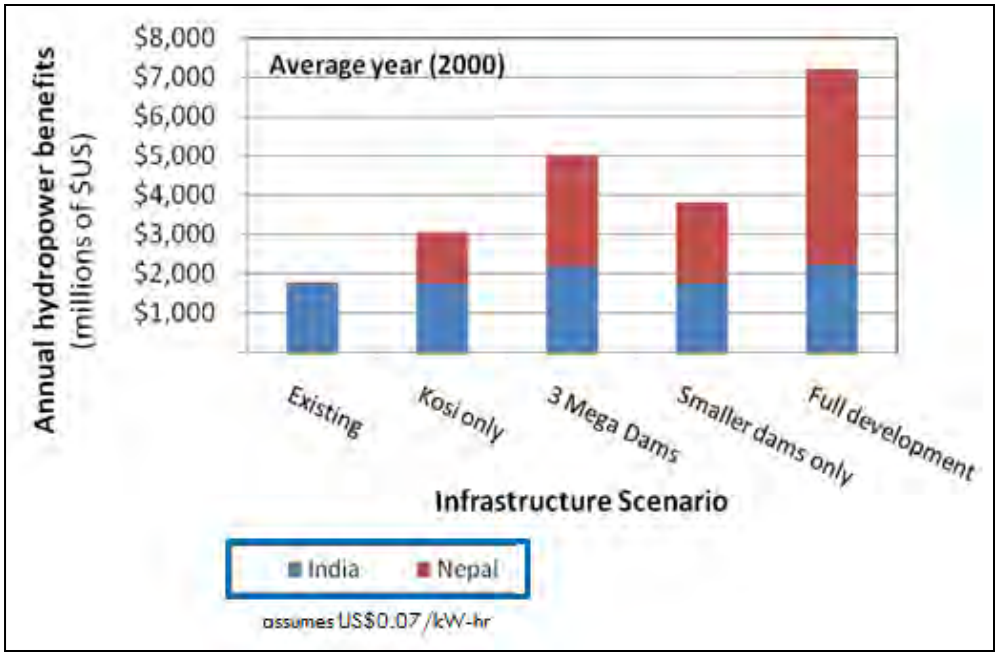
Annual Hydropower Benefits

3 largest dams

- 19,000 MW installed capacity
- 35-45 TW-hr/yr power generated

11 smaller dams

- 4,600 MW installed capacity
- 18 TW-hr/yr power generated (26-30 TWh/yr with 20 smaller dams)



Question

What are the **cost & benefit sharing dynamics;** do downstream benefits justify compensation to upstream countries?

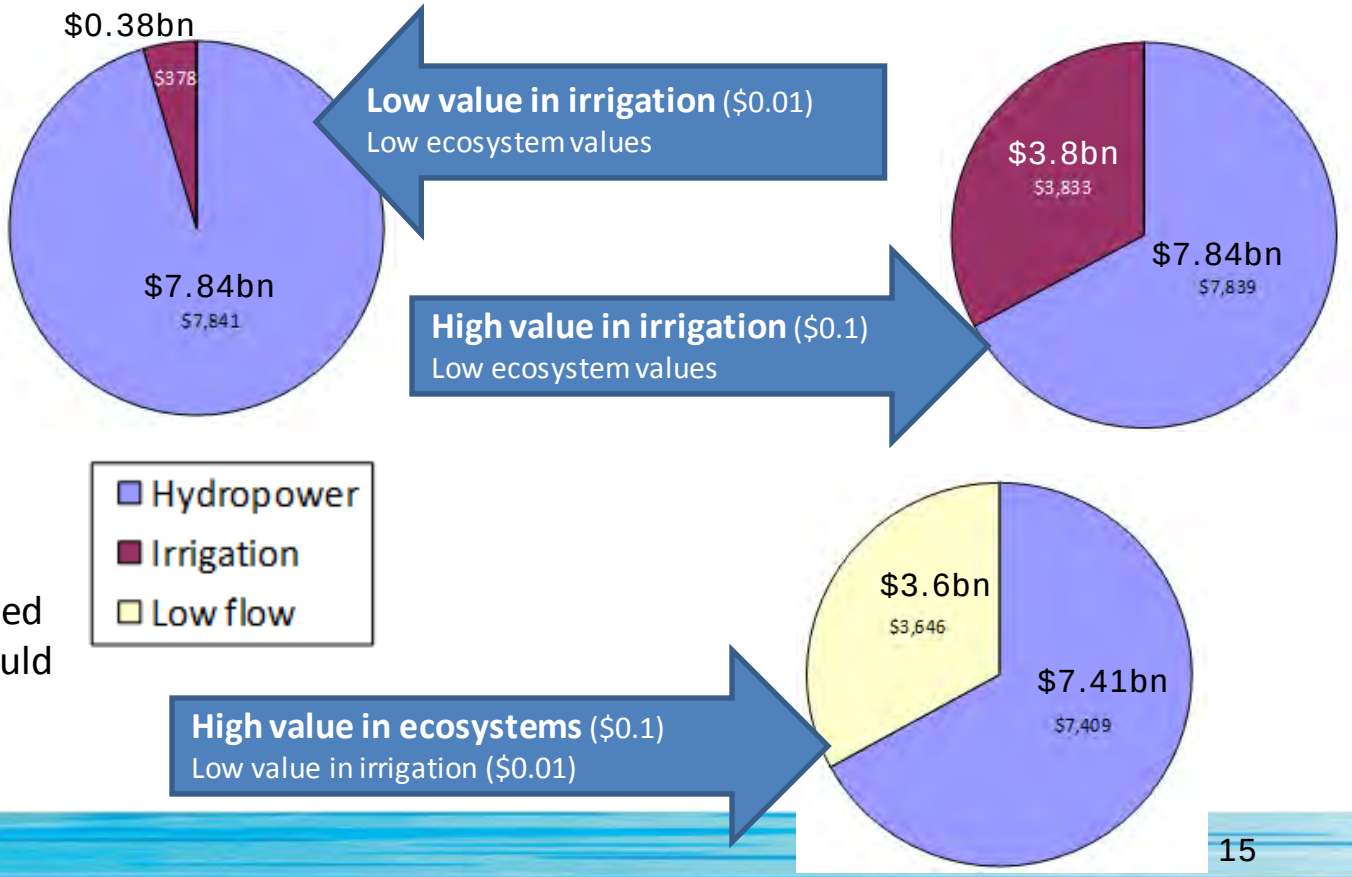
Commonly held perception

Big benefits upstream & downstream. Views vary widely about the upstream/downstream distribution of benefits

New Insights

Big benefits, mostly in hydropower. Hydropower (upstream) would provide the overwhelming share of benefits from dams today

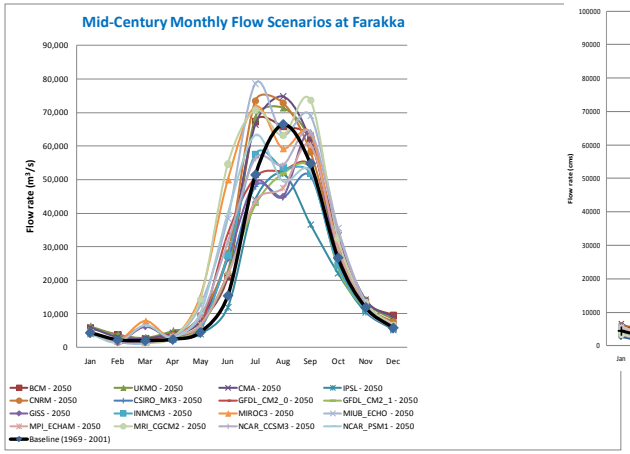
- Hydropower benefits are greatest
- Current agricultural productivity is low
- In the future if agricultural productivity rises dramatica then the distribution of benefits will change
- Ecosystem values of enhanced low flows are uncertain, could be significant

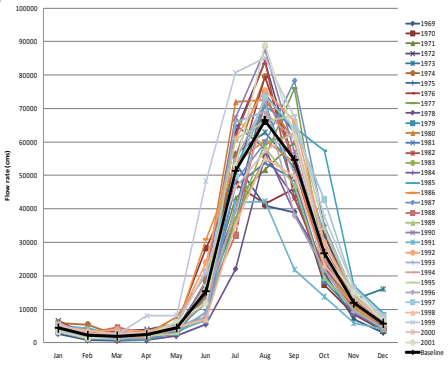


Question	Commonly held perception	New Insights
How will **climate change** impact the basin?	**Enormously**. Sea level rise, glacier melt and monsoon changes will be unprecedented	**Great uncertainty, but opportunities to act now**. A focus on managing current variability is a 'no regrets' strategy

- **Temperatures will increase** (snow accumulation/melt, evaporation, crop water needs)
- **Glaciers will melt faster** (but just 4% of basin flow)
- **Sea-levels will rise** (but needs to be considered with erosion/sedimentation)
- **Precipitation scenarios vary widely**
- **Study recommendations are generally robust to climate change**

Estimates of Runoff at the India-Bangladesh Border





Model predictions
2050

Historical data
1970-2000

Take Away Messages from the Ganges Assessment

1. **For regional floods:**
   focus on information & institutions, not just infrastructure
   Upstream storage infrastructure cannot control flooding in the basin – real, immediate benefits can, however, come from cooperative regional monitoring & warning systems, coupled with localized flood responses

2. **For water storage to enhance low flows:**
   look underground, not just upstream
   Upstream storage can provide significant additional low season flows. Groundwater storage (i.e., in UP) can provide similar benefits, possibly more immediately & at lower costs

3. **Hydropower development & trade in the basin remain very promising**
   Significant potential to deliver clean peaking power & improve trade imbalances, and the benefit sharing calculus may be simpler if flood & agricultural water benefits are smaller

Thank you