

A decorative graphic of stylized, swirling white clouds with blue outlines is positioned at the top left of the slide, partially overlapping the teal background.

# Ganges Basinwide Assessment Early Findings

**IGC Bihar Growth Conference**  
Patna, India  
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The World Bank



# 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
<b>Water Systems</b>	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
<b>Economic S</b>	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
<b>Social</b>	Literature review, focus group discussions, survey	To understand the social impacts of & responses to water variability



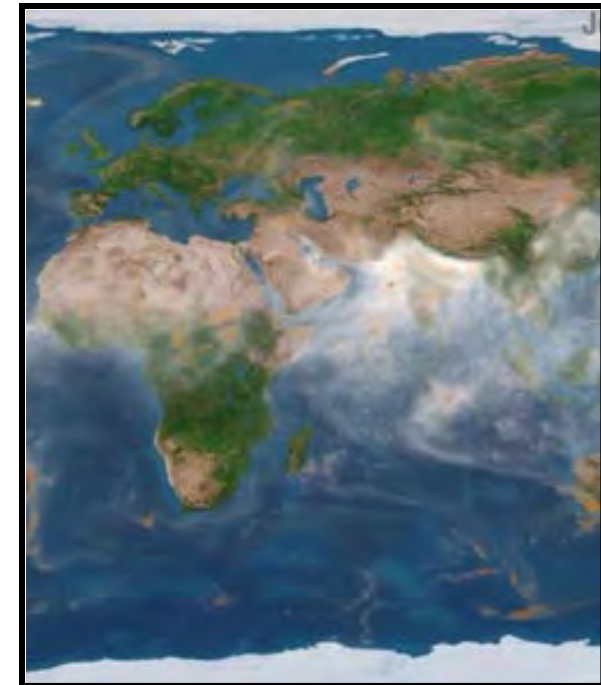
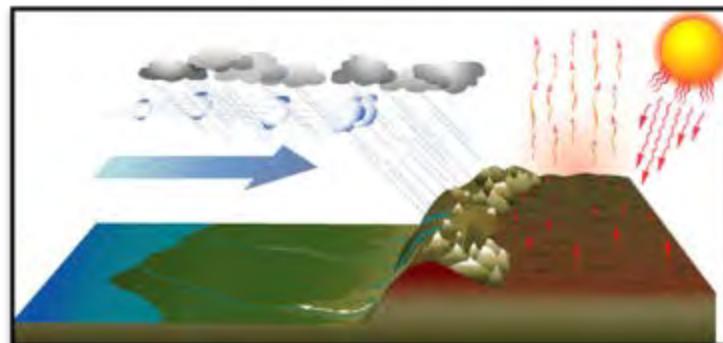
# The Ganges Basin

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?

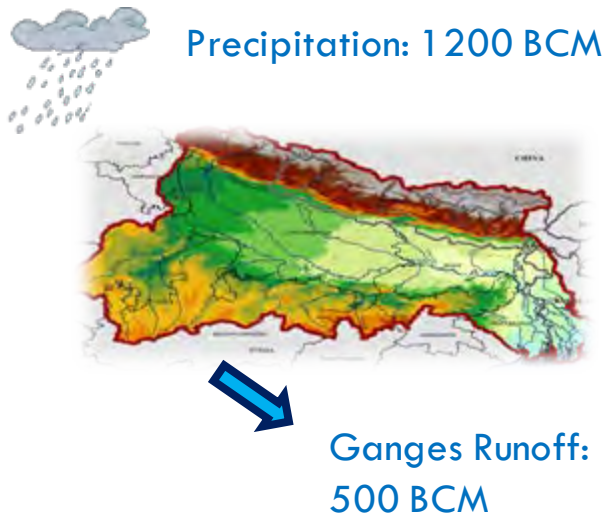
# Commonly held perceptions

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

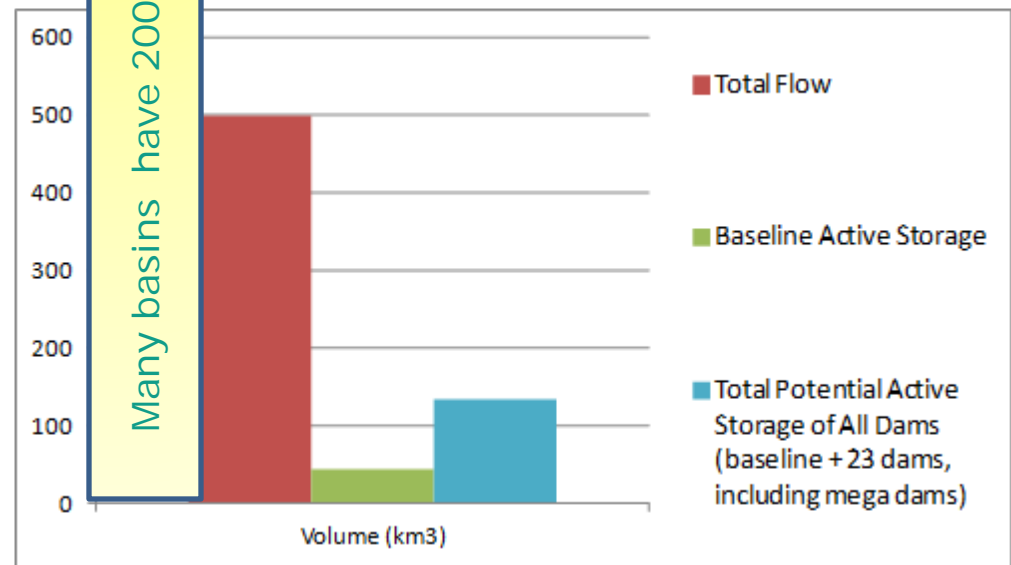
# New Insights

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

## Ganges Water Balance



## Potential volume of water storage in the Ganges



## Question

Can upstream water storage help **control basinwide flooding?**

## Commonly held perception

**Yes.** Himalayan storage reservoirs are commonly seen as the answer to Ganges floods in the plains and delta

## New Insights

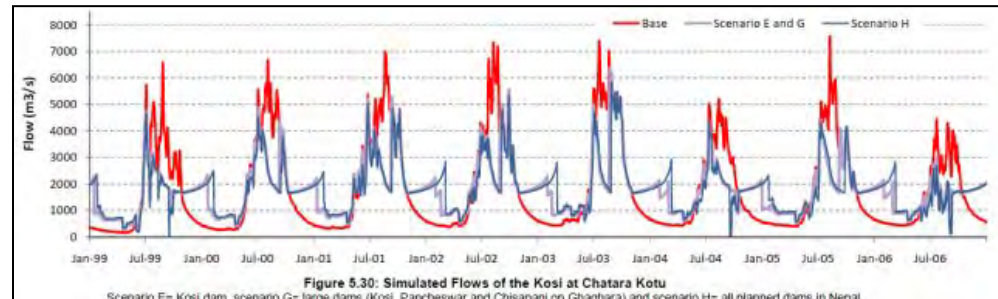
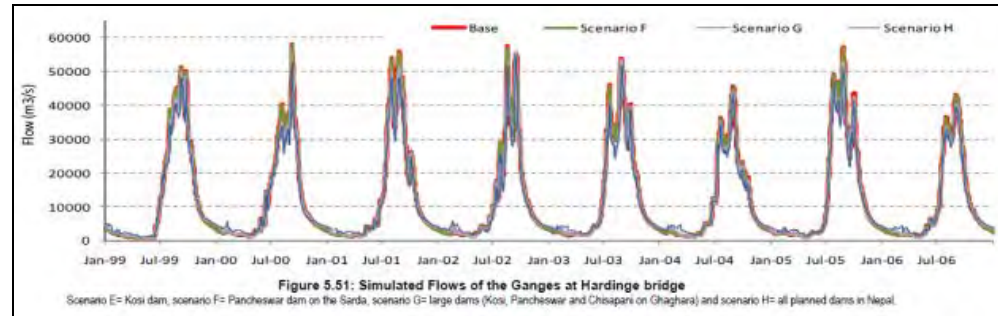
**Basinwide? No.** Too little to regulate the main stem

**In sub-basins? Unlikely.** Reduces peak flows, but doesn't necessarily reduce floods

**Little impact on mainstream**

**Modest impact in tributaries, but**

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



# Upstream storage is not a sufficient strategy to control Bihar floods

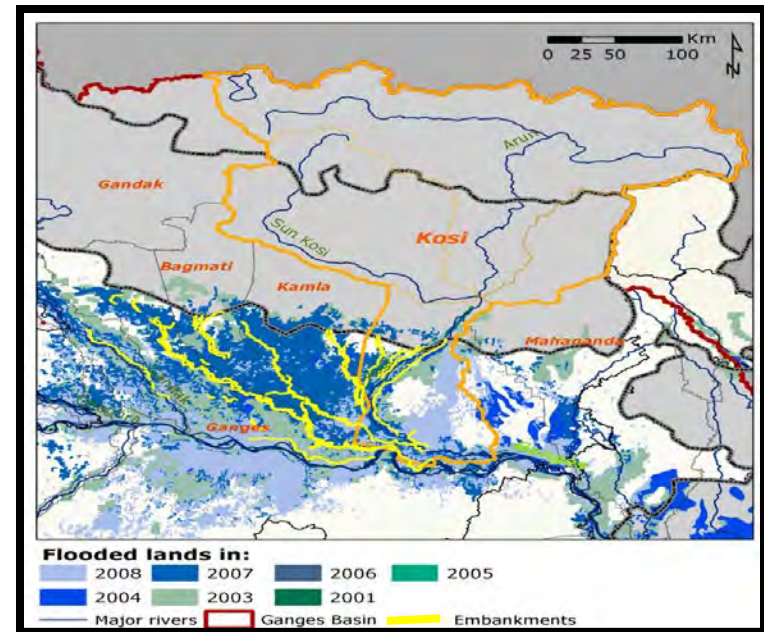


## Flooded Area



- 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

Is large infrastructure the best strategy for **protecting communities?**

## Commonly held perception

**Yes.** The most effective and reliable protection

## New Insights

**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

Can **low-flows** be **augmented** by upstream water storage?

## Commonly held perception

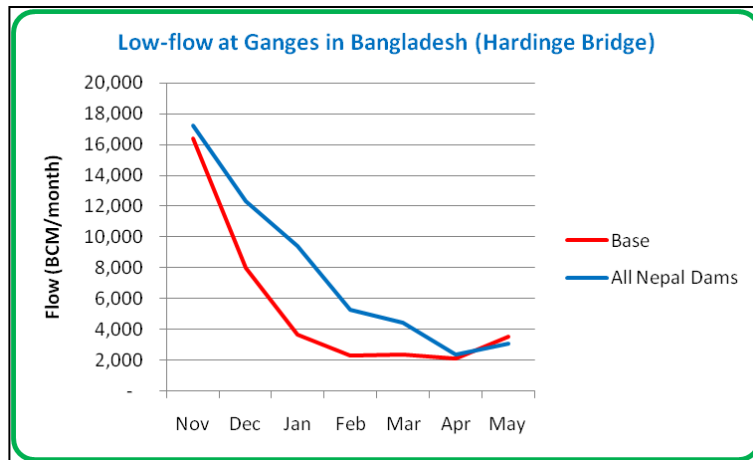
**Yes.** Monsoon waters can be held upstream and released in the dry season

## New Insights

**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

Are there good **alternatives** or complements to **reservoir storage**?

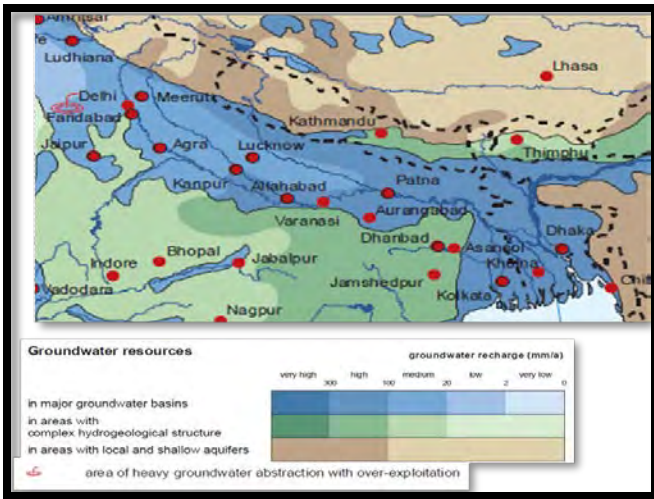
# Commonly held perception

**No.** Large man-made storage is the only option adequate for the scale of the challenge

# New Insights

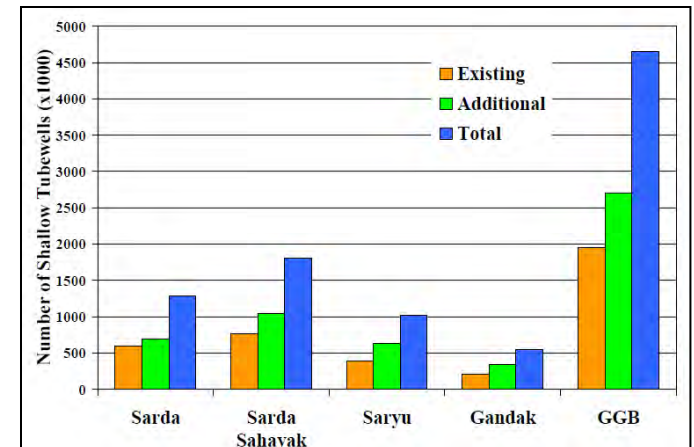
**Yes.** Natural underground water storage, strategically & sustainably managed, could be used in the basin on a scale comparable to the full suite of dams considered in our models

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

Is there substantial **untapped hydropower**?

# Commonly held perception

**Yes.** A lot. Enough for domestic energy as well as significant exports

# New Insights

**Yes.** The 23 largest dams have an installed capacity of ~25,000MW (65-70 TWh) & a value of some \$5bn/yr

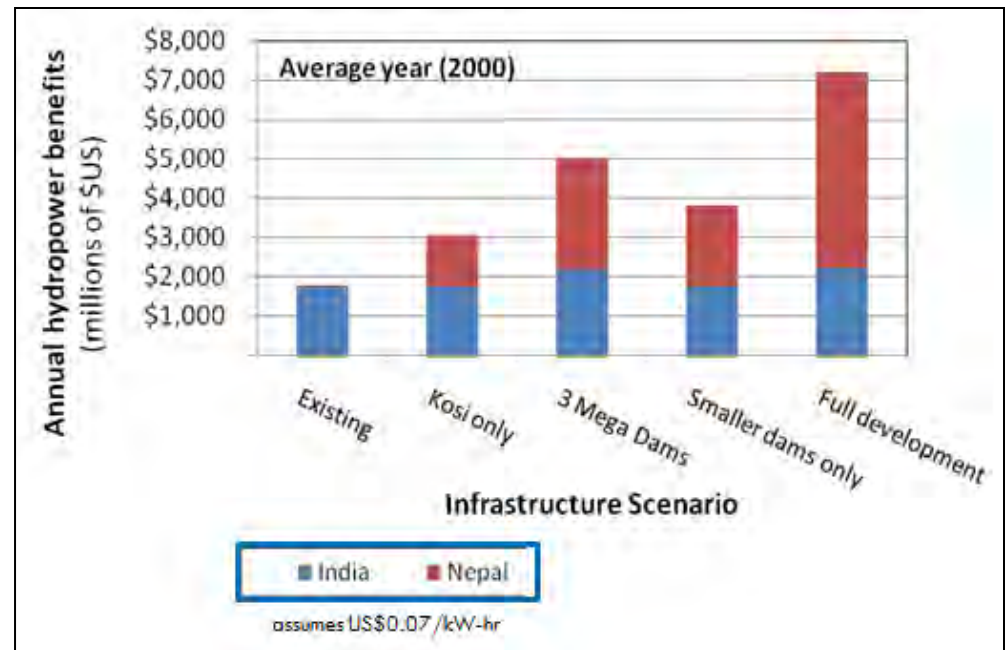
## 3 largest dams

- 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)

## Annual Hydropower Benefits



# Question

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

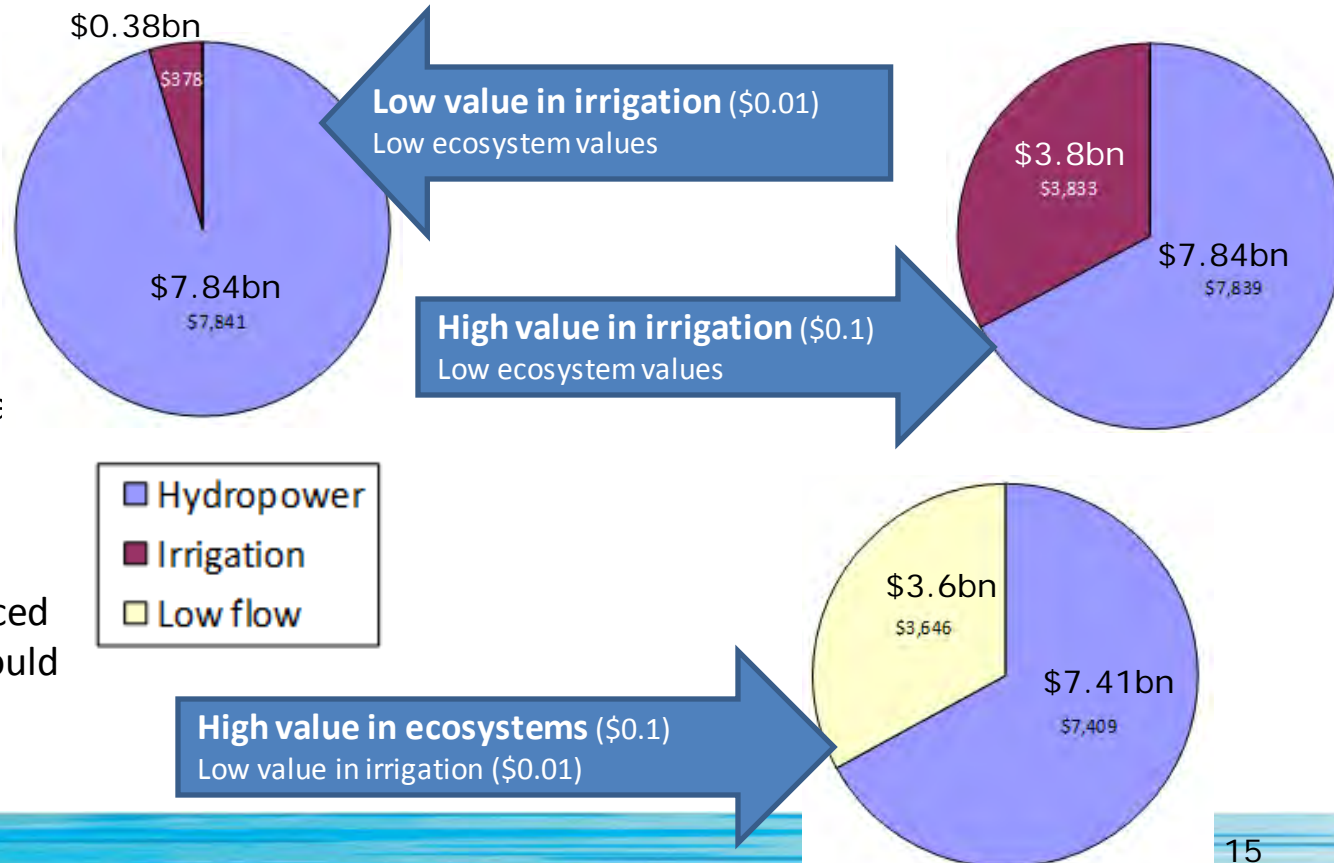
# Commonly held perception

**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 dramatically then the distribution of benefits will change
- Ecosystem values of enhanced low flows are uncertain, could be significant



# Question

How will **climate change** impact the basin?

# Commonly held perception

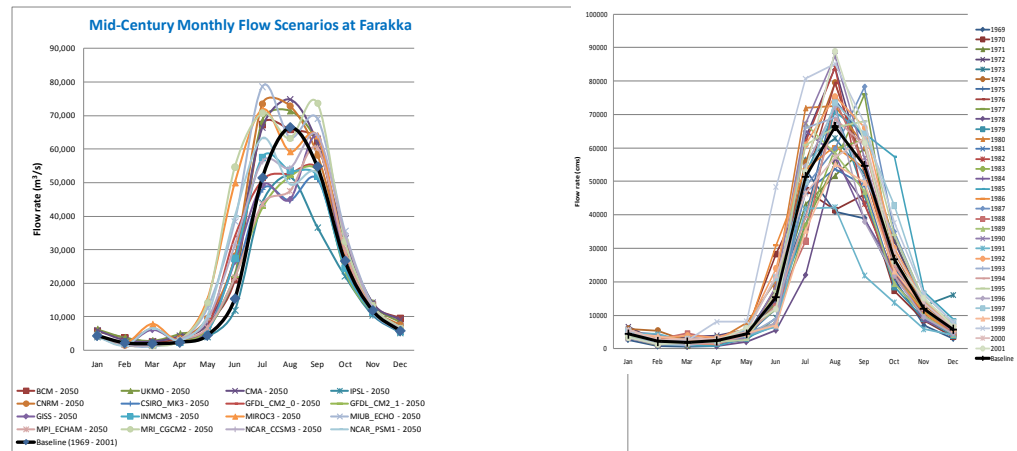
**Enormously.** Sea level rise, glacier melt and monsoon changes will be unprecedented

# New Insights

**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

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## 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