

# Long Term Climate Impacts on Hydro Power in Bhutan

**Tashi Dorji**  
**Senior Ecosystems Specialist**  
**ICIMOD**



**ICIMOD** : A regional intergovernmental mountain knowledge, learning and enabling centre

**Vision:** Men, women, and children of the Hindu Kush Himalayas enjoy improved wellbeing in a healthy mountain environment.

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FOR MOUNTAINS AND PEOPLE

## Regional Programmes

1. Adaptation and Resilience
2. Transboundary Landscape
3. River Basins and Cryosphere
4. Atmosphere
5. Mountain Environment Regional Information System
6. Mountain Knowledge and Action Networks

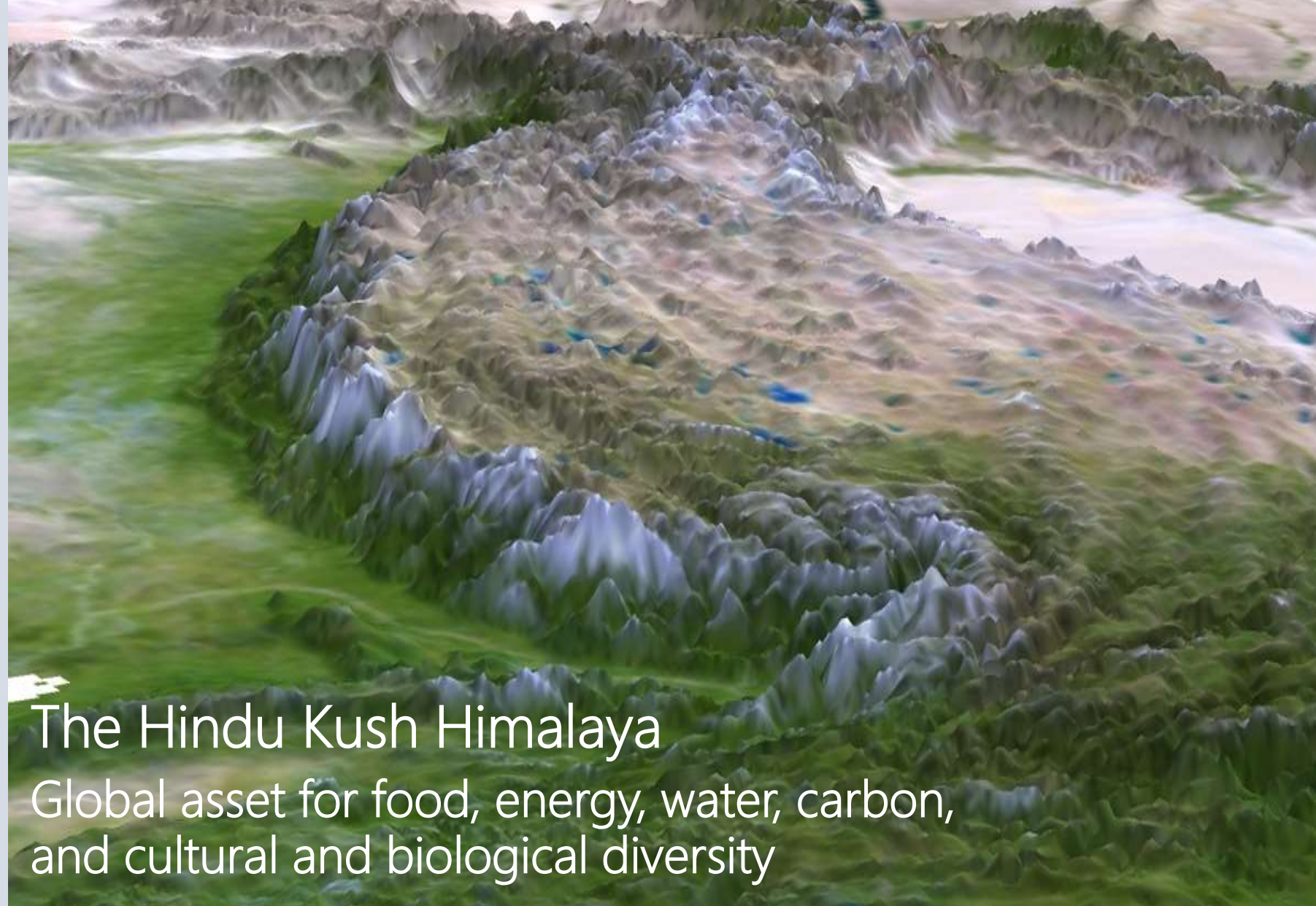


# OUTLINE

**Part 1: Climate change  
Key messages from  
HIMAP 1<sup>st</sup> Assessment  
Report**

**Part 2: Climate impacts  
on Hydropower in  
Bhutan**

**Part 3: Renewable Energy  
and Energy Efficiency  
Capability for the Hindu  
Kush Himalaya (REEECH)**



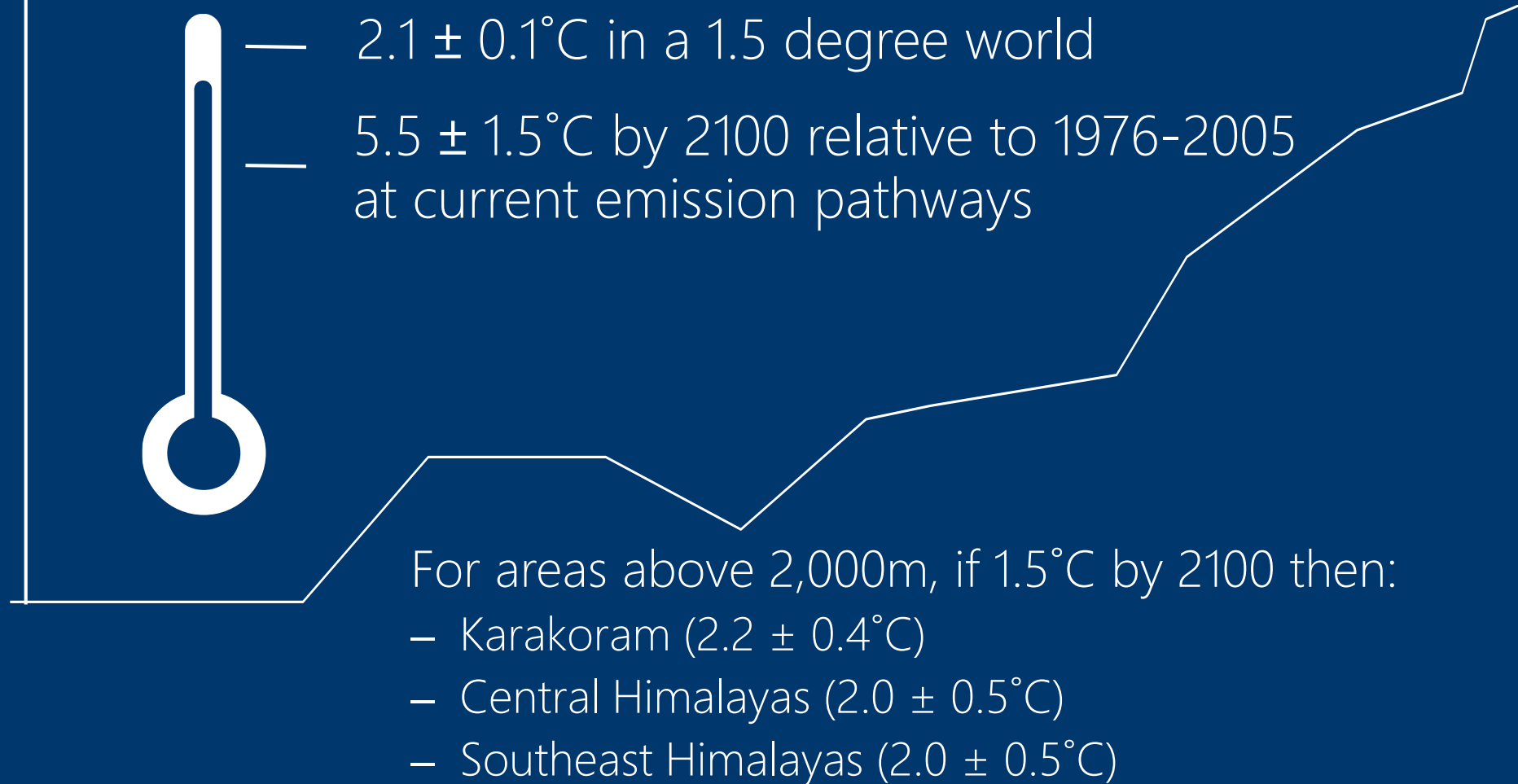
The Hindu Kush Himalaya

Global asset for food, energy, water, carbon,  
and cultural and biological diversity

# Part 1: Climate Change

Even 1.5 Degrees is Too Hot for the HKH

HKH will warm more compared to global mean and warm more rapidly at higher elevations



Source: HIMAP climate change chapter and Kraaijenbrink et al. 2017, Nature



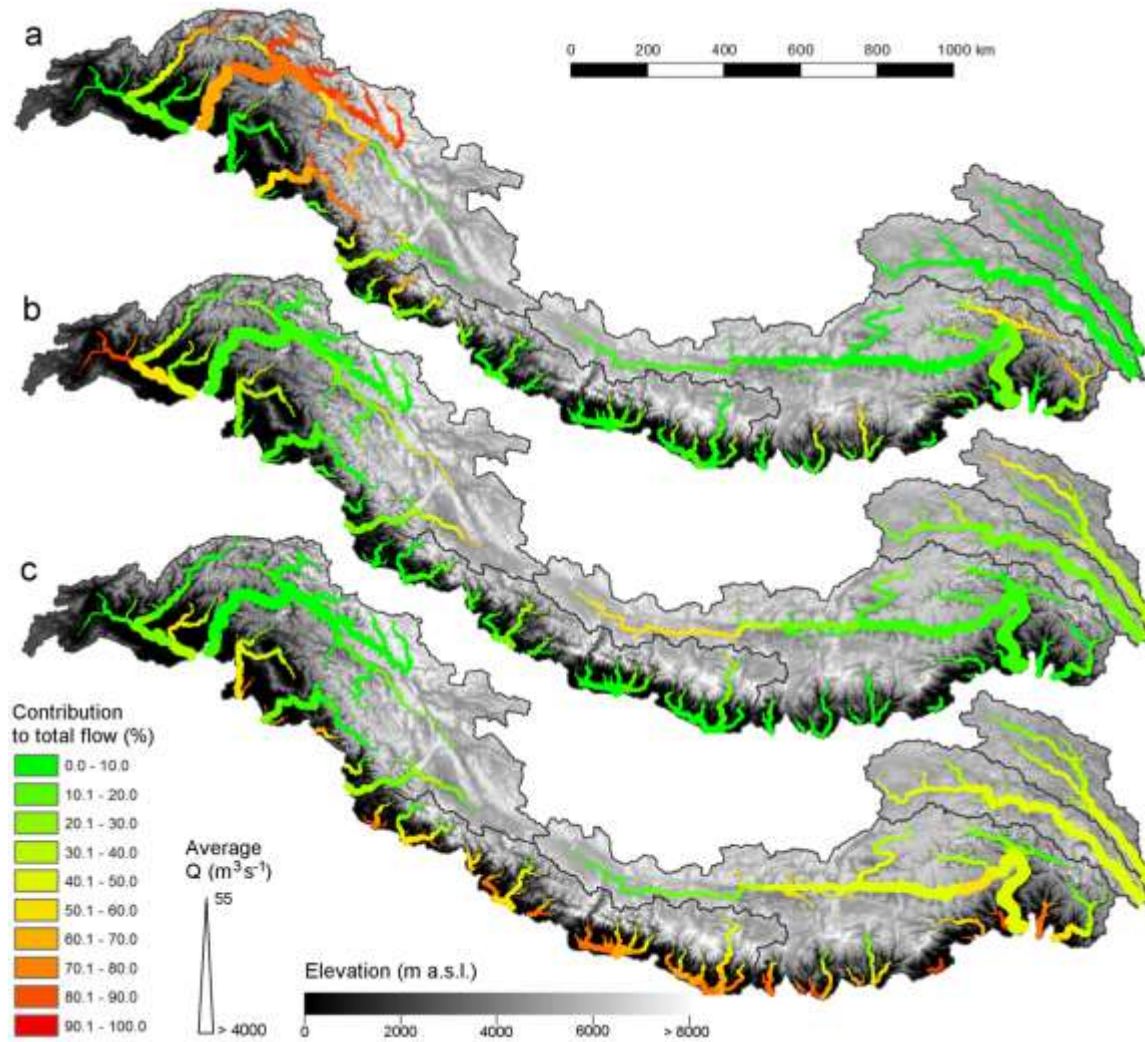
## Climate Change Impacts on Water Resources

- Loss of storage in the form of ice
- Changing precipitation and flow patterns – more floods and droughts; high uncertainty
- Greater impact for those living closer to glaciers
- Predicted annual flow volume – no significant change



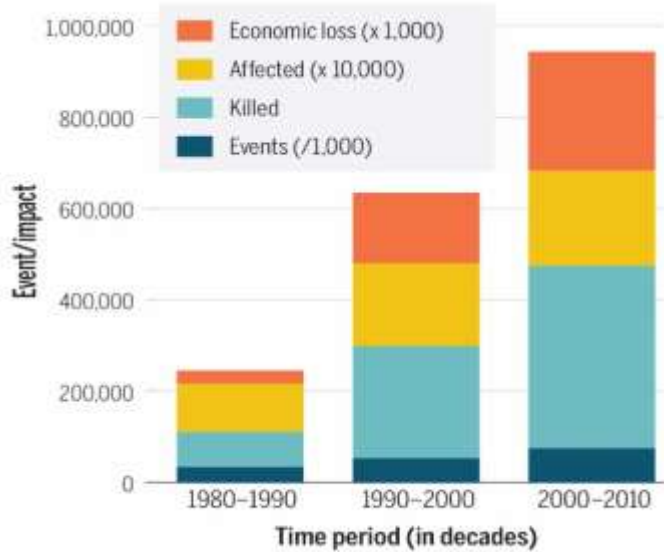


# Not running out of water, but...



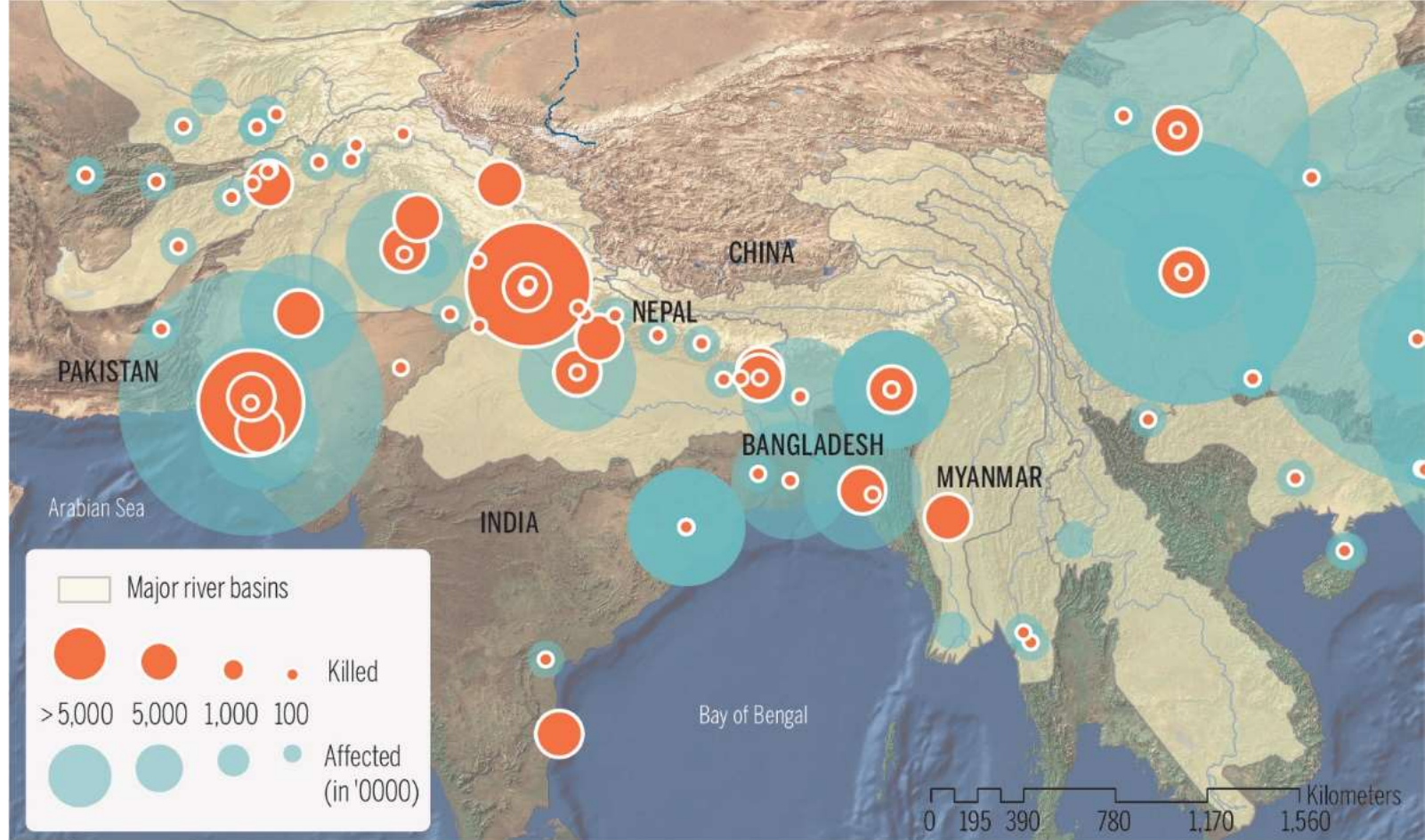
Contribution to total flow by (a) glacial melt, (b) snowmelt, and (c) rainfall-runoff for major streams during the reference period of 1998–2007. Line thickness indicates the average discharge during the reference period. Source: Lutz et al. (2014)

- Climate change is expected to drive **consistent increases in total runoff** of the Indus, Ganges and Brahmaputra
- **Indus**: increased glacier melt, then declines after mid-century
- **Ganges/Brahmaputra**: increased runoff due mainly to precipitation
- Climate change is likely to affect groundwater, especially springs in the mid-hills of the HKH, but limited evidence.



## Disaster risk is increasing

- Floods, droughts, landslides, glacial lake outburst floods
- One-third of disasters are floods, many crossing national borders



Data source: EMDAT OFDA Cred Database

Map prepared in Sept. 2015

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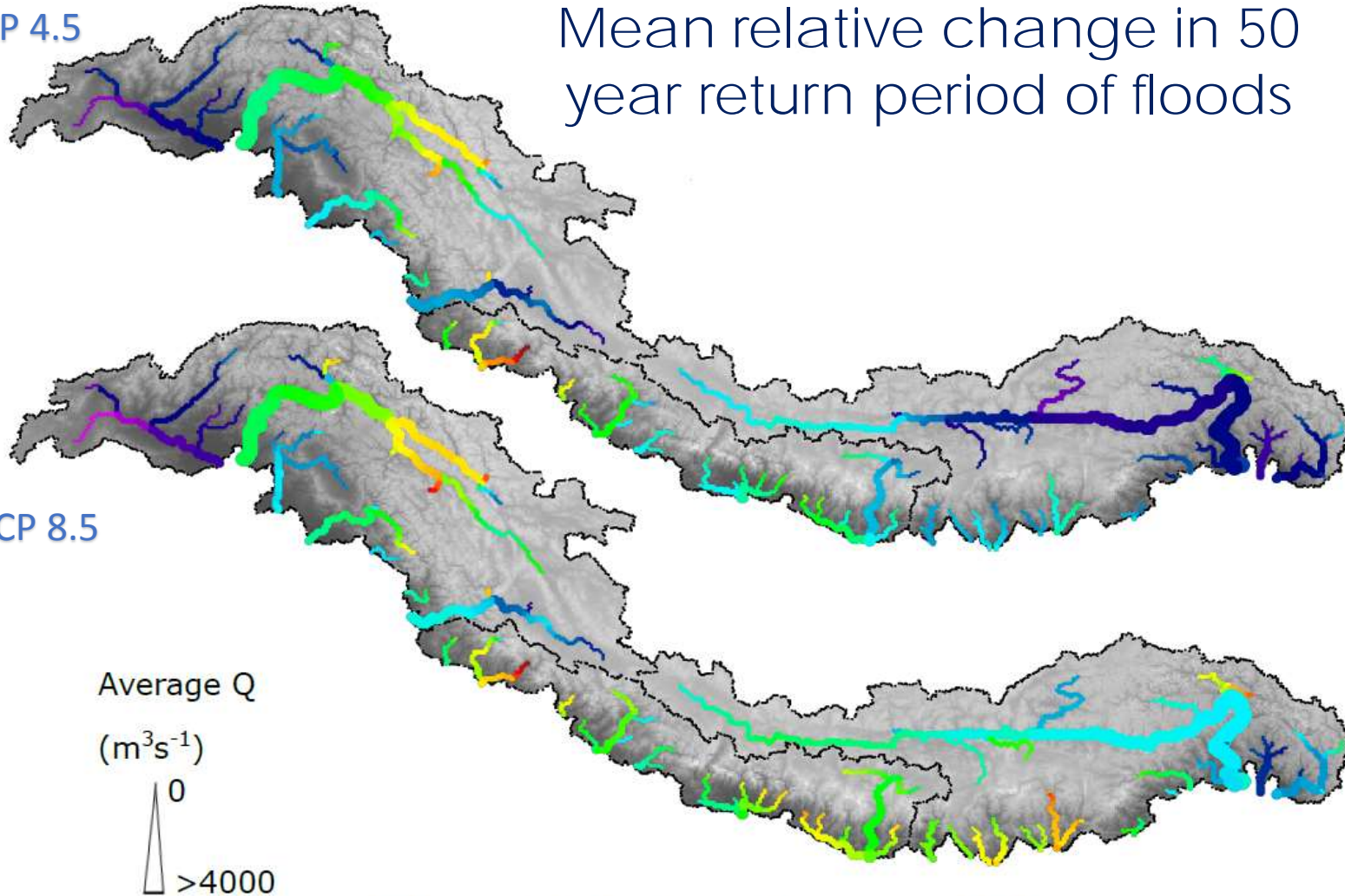
- More than 1 billion people at risk of exposure to increasing frequency and intensity of natural hazards



# Flood magnitude may double

RCP 4.5

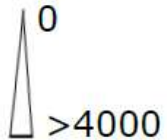
Mean relative change in 50 year return period of floods



RCP 8.5

Average Q

( $\text{m}^3\text{s}^{-1}$ )



Mean Relative Change [%]



**Average river flow will increase by 2100 in upper river basins:**  
50% in upper Indus  
30%–40% in upper Ganges  
25%–50% in upper Brahmaputra

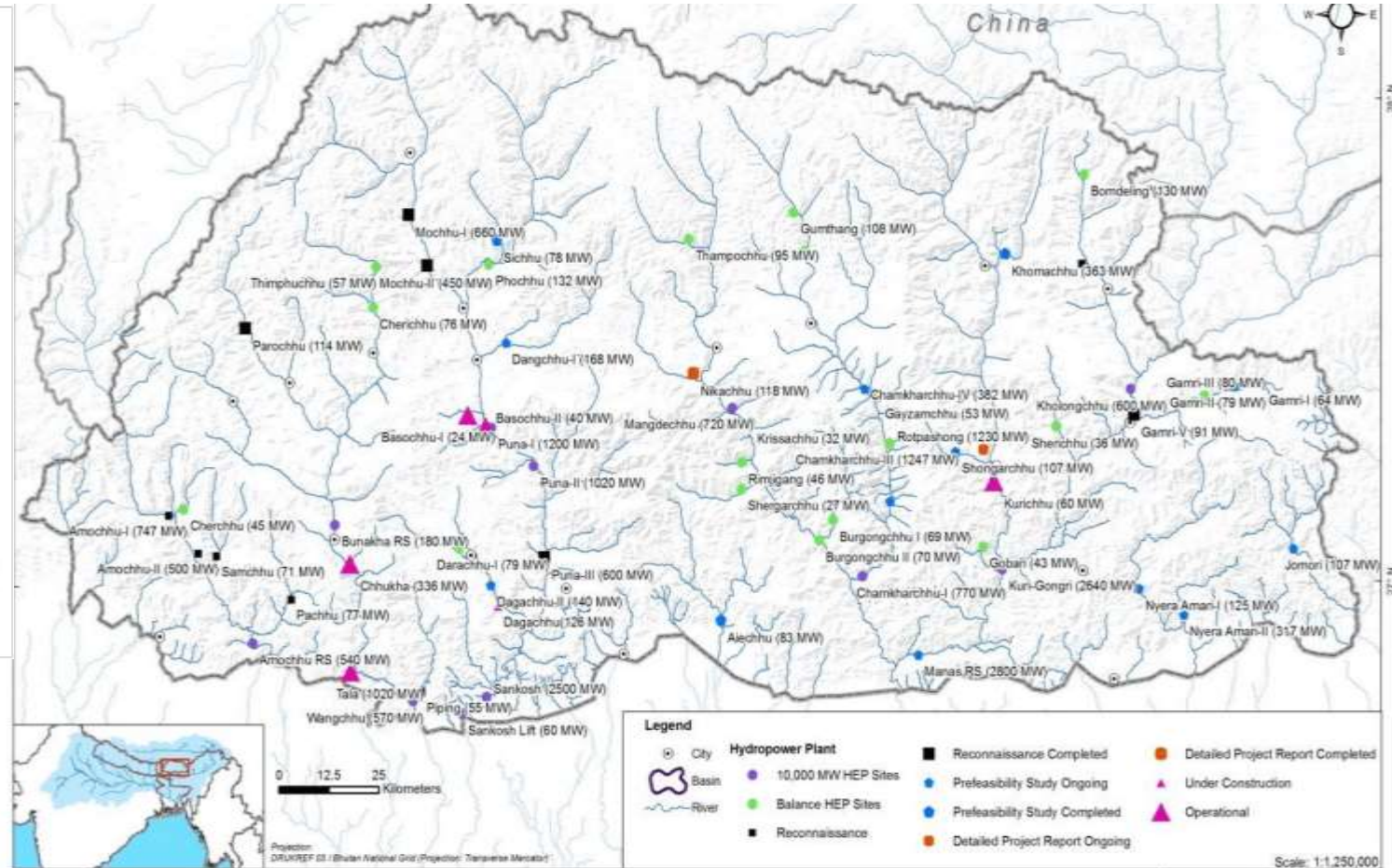
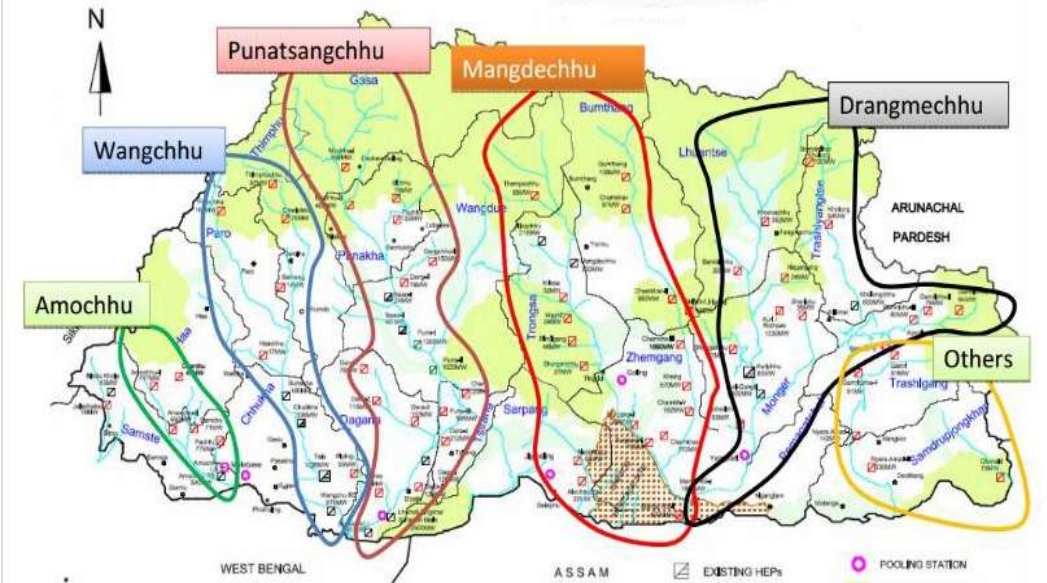
**Intensities of 'once in 50 years' flood events will increase:**  
40%–110% in upstream areas  
115%–150% in downstream areas

*Wijngaard et al. 2017, PLOS One*



# Part 2: Climate impacts on Hydropower in Bhutan

Basin Maps of Bhutan



- Economically feasible hydropower potential 24,000 MW
- Installed capacity about 1,500 MW
- Envisages about 74 dams across river basins

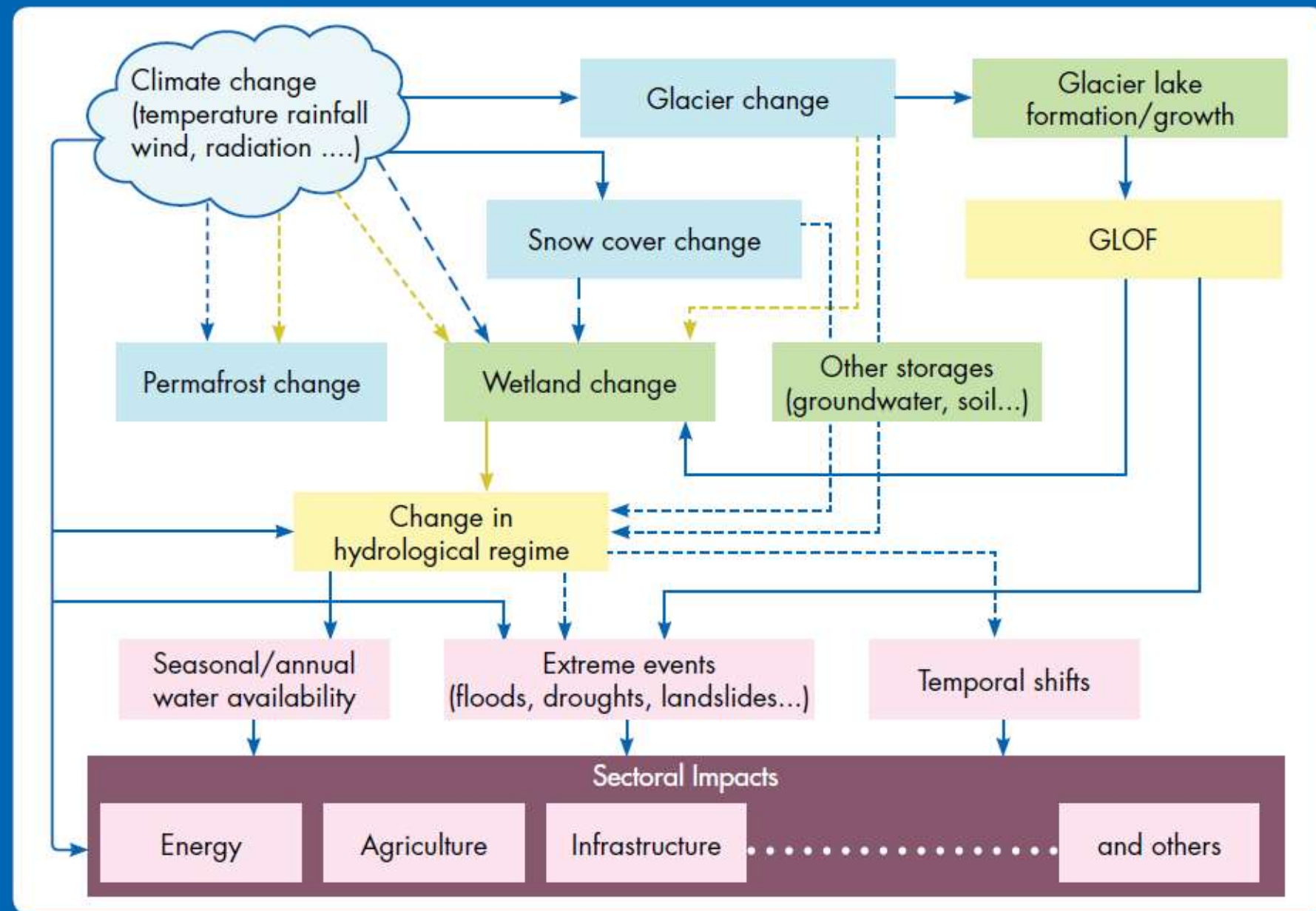
Bhutan: Adapting to Climate Change through IWRM

Hydropower plants



# Changes in Climate, hydrology and impacts on different sectors

- Climate variability (spatial and seasonal)
- Changes in Cryosphere (snow and ice reserve)
- Cryosphere dynamics and hydrological regimes
- Climate change impacts on Glacial lakes





# Climate variability, water and hydropower

## Threats/Variabilities

- Prediction of an increase in summer flows in the rivers in the short run, decrease in the long-run
- Under a warmer and more variable climate, the onset of monsoons will be more erratic which will cause disruptions in natural cycles
- Bhutan is already experiencing increase in frequency of intense monsoon rains causing flash floods and landslides

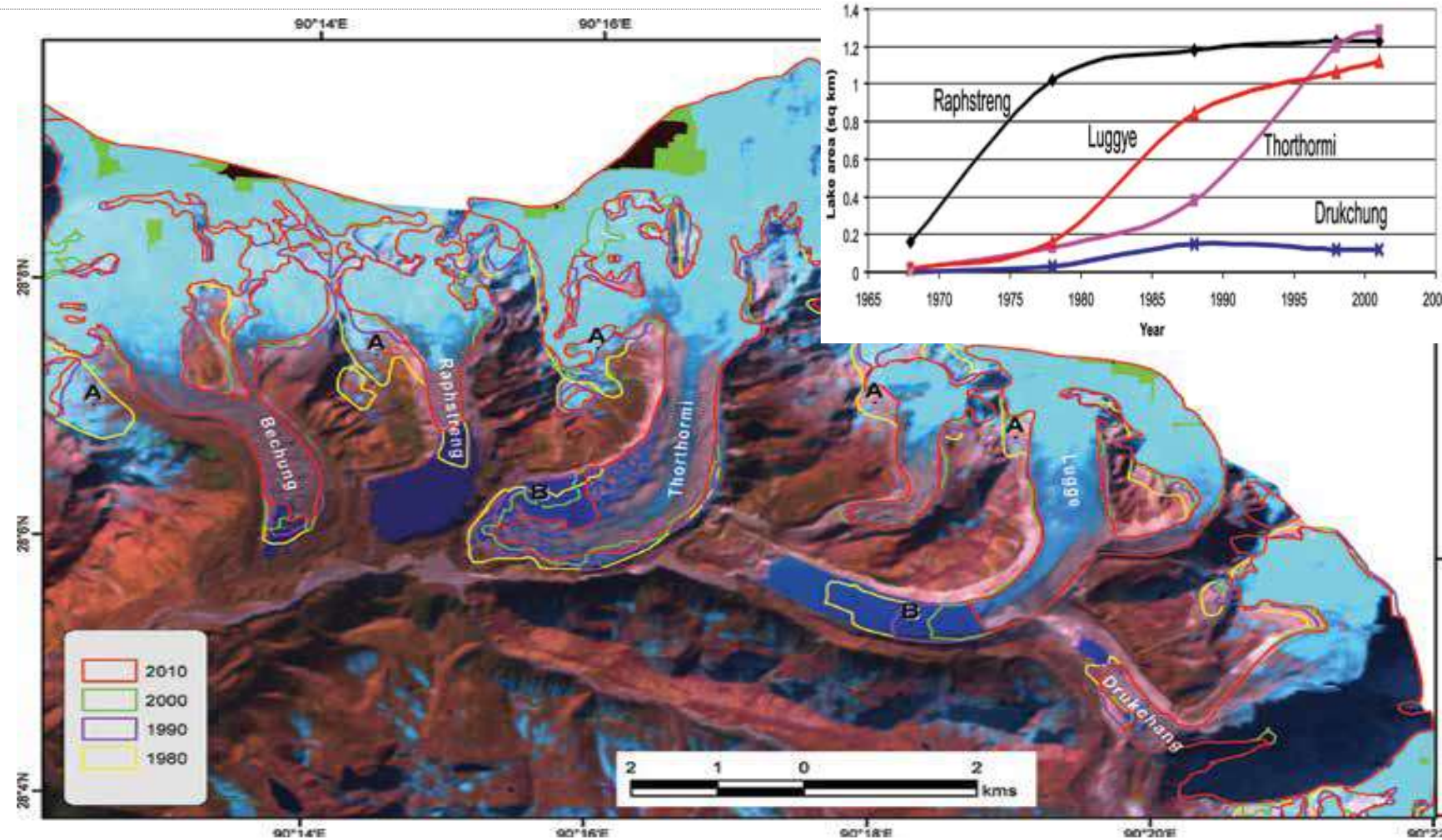


## Impacts on Hydropower

- Disruption of average flows affect optimum hydropower generation
- Uncertainty in the magnitude of flow increase affect hydropower generation
- Damage to infrastructure, transmission pipelines and power distribution
- Increased Sediments affect the optimal performance

# Climate Change and State of Cryosphere

- Bhutan has lost over 20% of its glaciers since 1980. Growing in size- increasing the risk of GLOF
- Total ice volume measurements vary considerably
- No strong trends have been observed in snow cover
- Little is known about the distribution of permafrost





# Key Messages

NOV – APRIL SKY

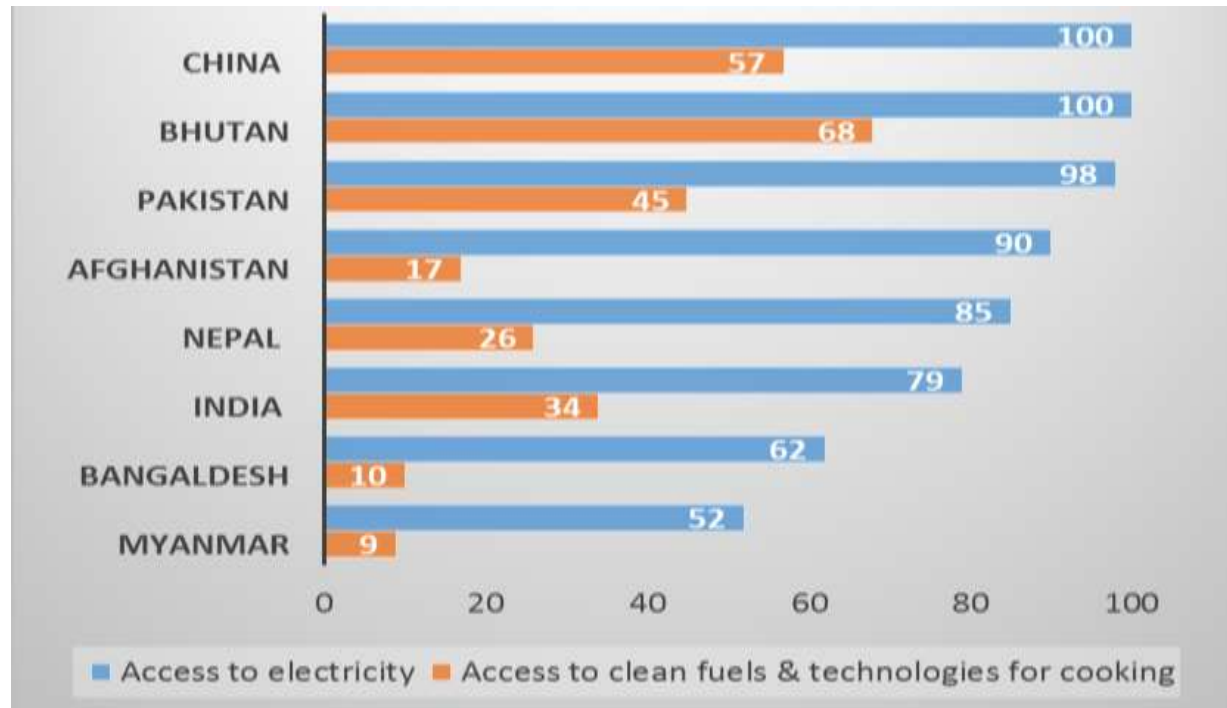
- Black carbon

1. The atmospheric concentration of greenhouse gases and short-lived climate pollutants has increased, snow and ice have diminished and the trend is likely to continue
2. Hydropower generation will get more and more uncertain in future due to climate impacts:
  - ✓ Changes in Hydrological regime
  - ✓ The magnitudes of extreme events
  - ✓ Hazards associated with shrinking glaciers, glacial lake outburst floods



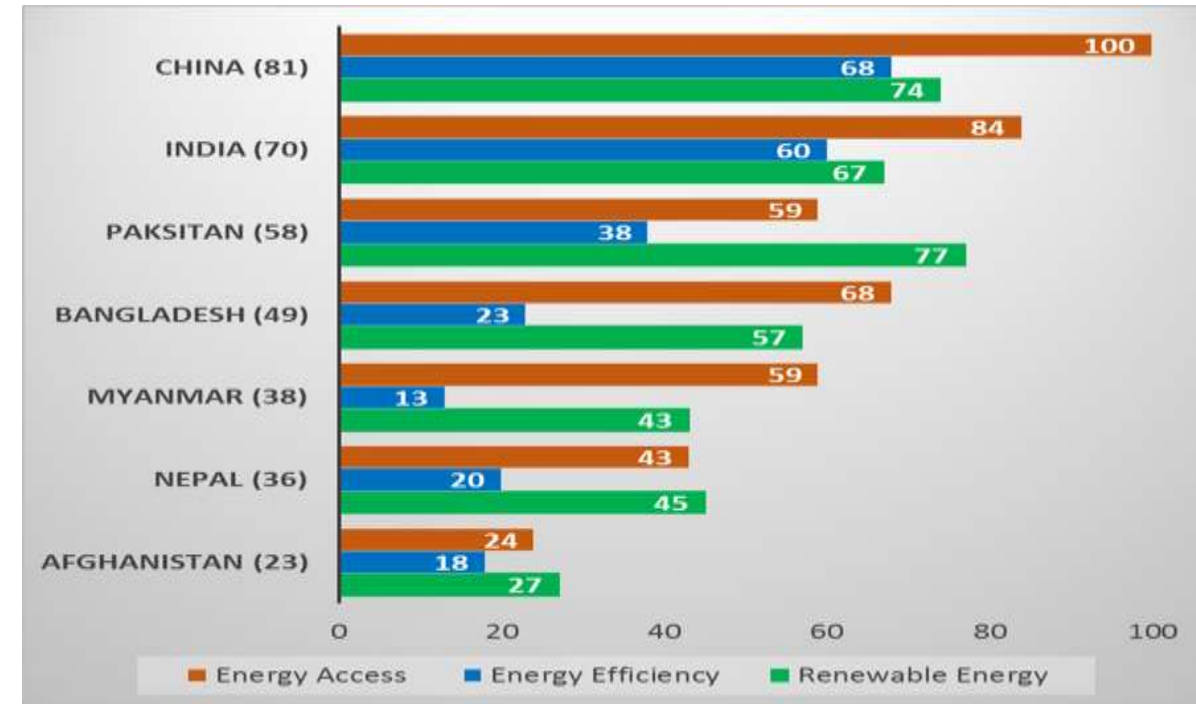
# Part 3: REEECH-Renewable Energy and Energy Efficiency Capability for the Hindu Kush Himalaya

Access to Electricity & Clean Cooking in 2014 (% of population)



➤ **Over 80% of rural population in HKH countries rely on traditional solid fuel for cooking & heating**

Performance on Regulatory Indicators of Sustainable Energy (RISE)



➤ **Persistence of manifold barriers on 3 pillar of SE4ALL**



# REEECH strategic thrusts-operational phase (2018-2022)

## Long-Term Development Goal

- Improved access to appropriate, modern, affordable, and reliable energy services in the HKH region, as well as enhanced safeguarding of essential mountain ecosystem services

## Key Outcome

- innovative mountain specific sustainable energy solutions in the context of climate change mitigation and adaptation

## Core Components

1. Knowledge, data management and awareness raising
2. Policy development and implementation
3. Capacity development
4. Promotion of investment, entrepreneurship and innovation

*Up-Coming Event (Department of Renewable Energy+ ICIMOD + ADB)*  
**SUSTAINABLE ACCESS TO CLEAN ENERGY FOR HINDU KUSH  
HIMALAYA**

**Thimphu, Bhutan, 25-26 February 2019**

***Thank you***

