



# Strategies and Adaptation to a Changing Climate

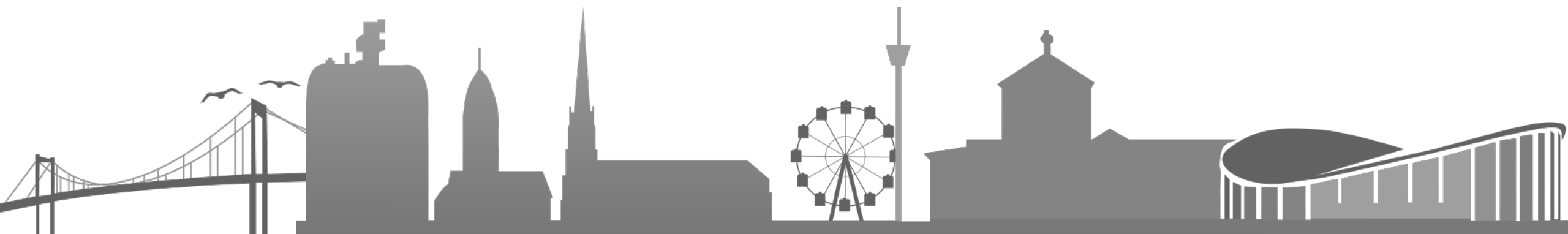
## *Perspective from the World Bank*

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**The World Bank**

SWEDCold Workshop 7

Gothenburg, June 15, 2023



# OUR PLANET FACES AN ACUTE WATER CRISIS

**2.2 billion people** lack reliable access to safely managed drinking water



**4.2 billion people** live without access to safely managed sanitation

About **60%** of the world's population lives in water-stressed basins



By **2050**, global demand for water will increase by **20-30%**

In heavily polluted areas,



declining water quality could reduce economic growth by up to

**1/3**



Drought affects about **55 million people** annually

# What the Future Has in Store

A New Paradigm for Water Storage



WORLD BANK GROUP



GWSP

GLOBAL WATER  
SECURITY & SANITATION  
PARTNERSHIP

# The 3 Core Services of Water Storage



IMPROVES  
WATER  
AVAILABILITY



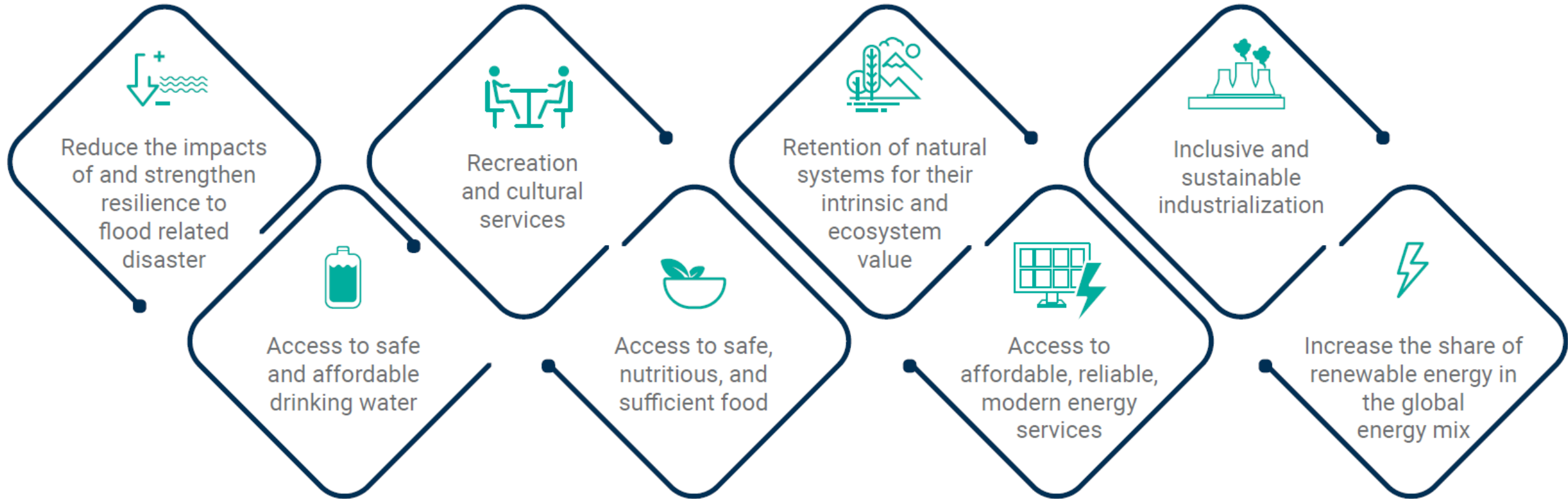
REDUCES  
FLOOD  
IMPACTS



REGULATES  
WATER  
FLOWS



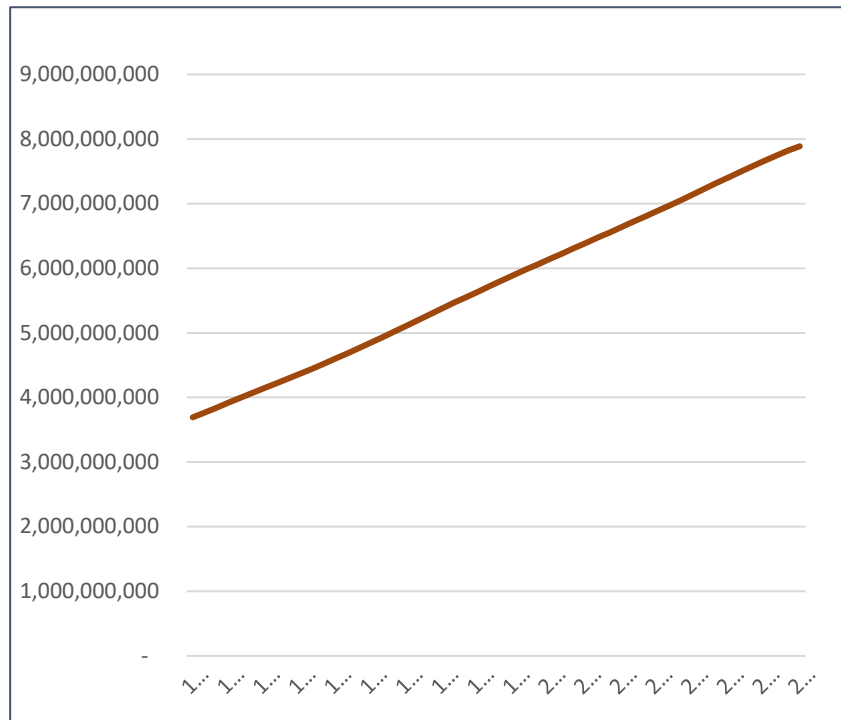
# Water storage underpins the provision of a multitude of water services



# Problem: Declining Freshwater Storage

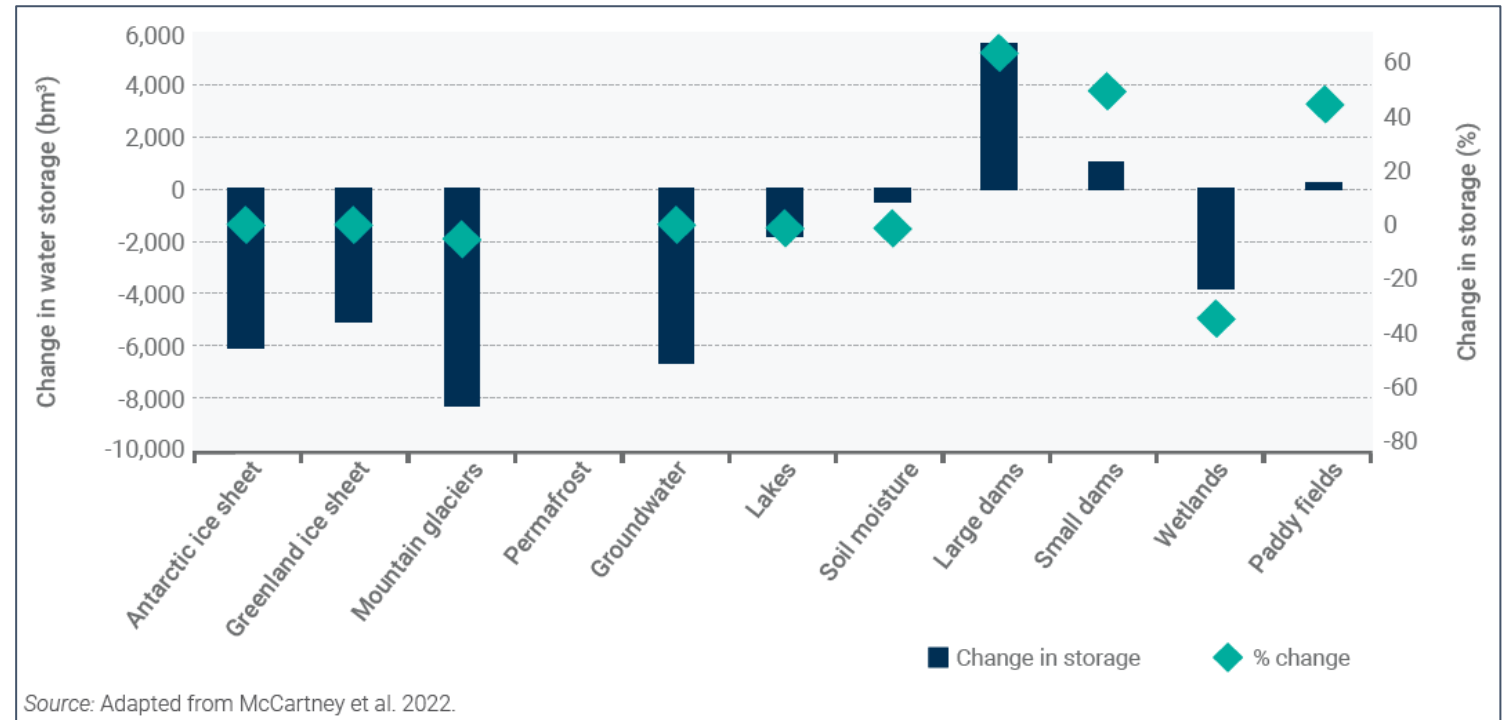
## 1 DEMAND

World Population doubled in last 50 years



## 2 SUPPLY

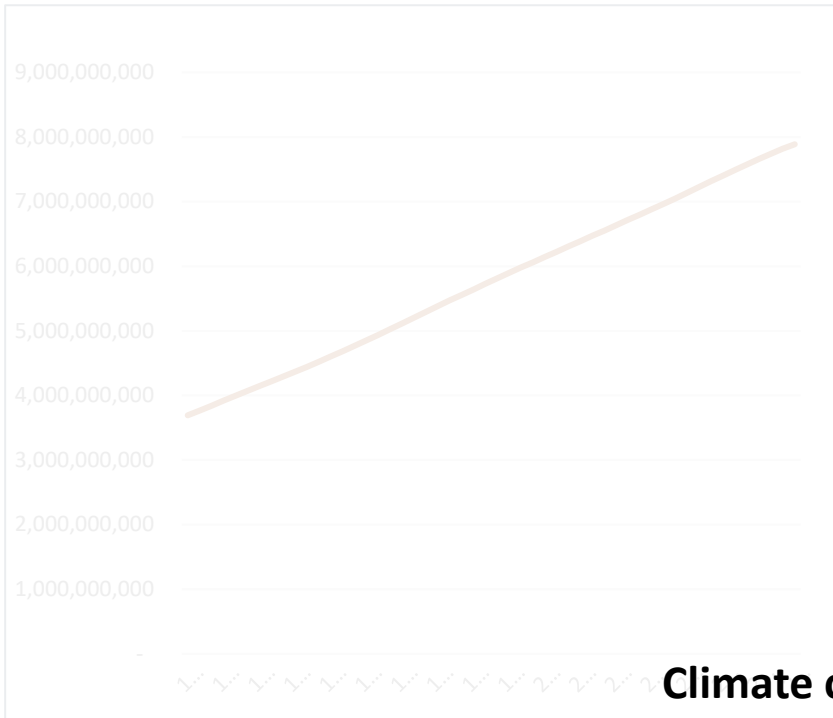
Freshwater storage declined by around 27,000 billion cubic meters



# Problem: Compounded by Climate Change

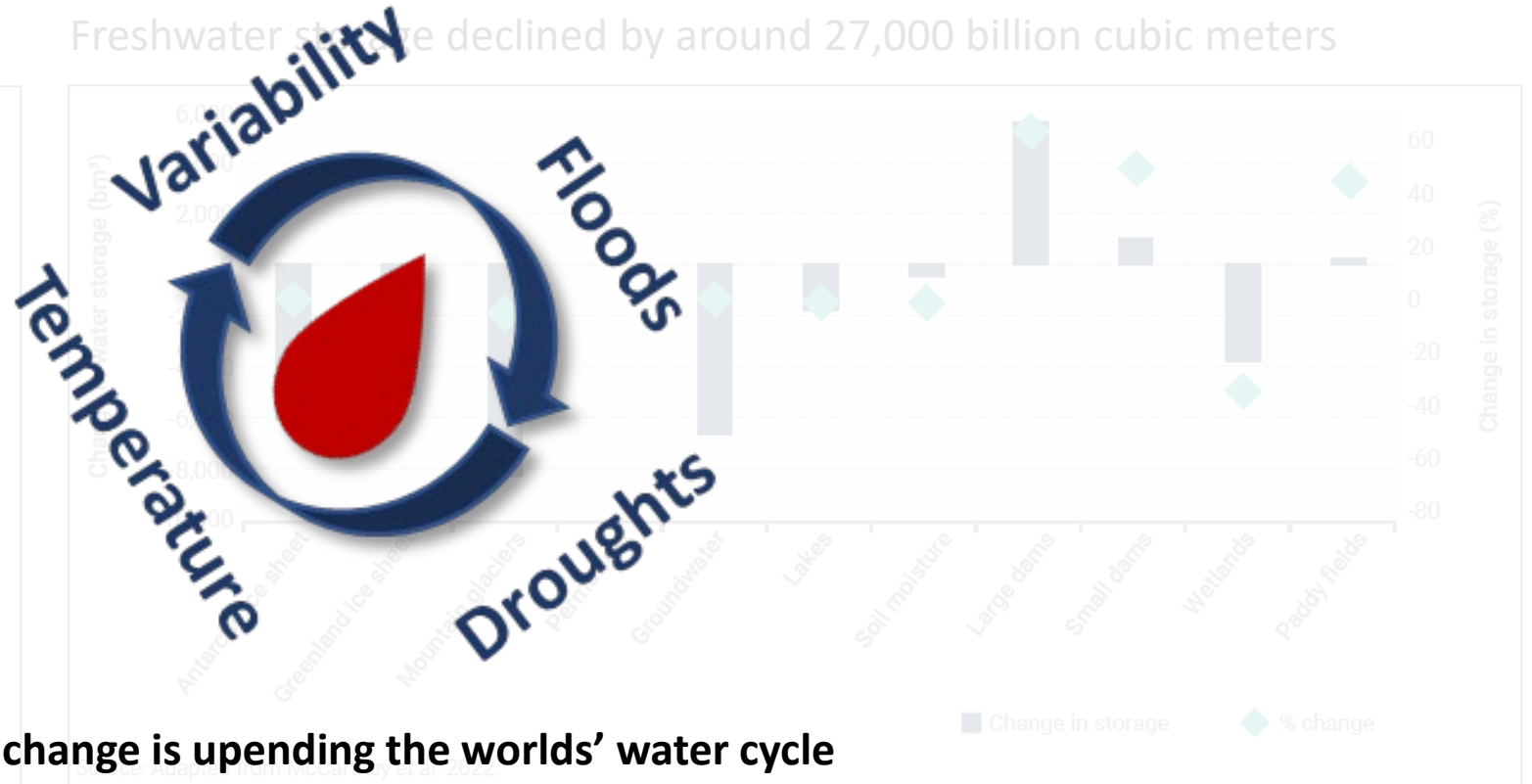
## 1 DEMAND

World Population doubled in last 50 years



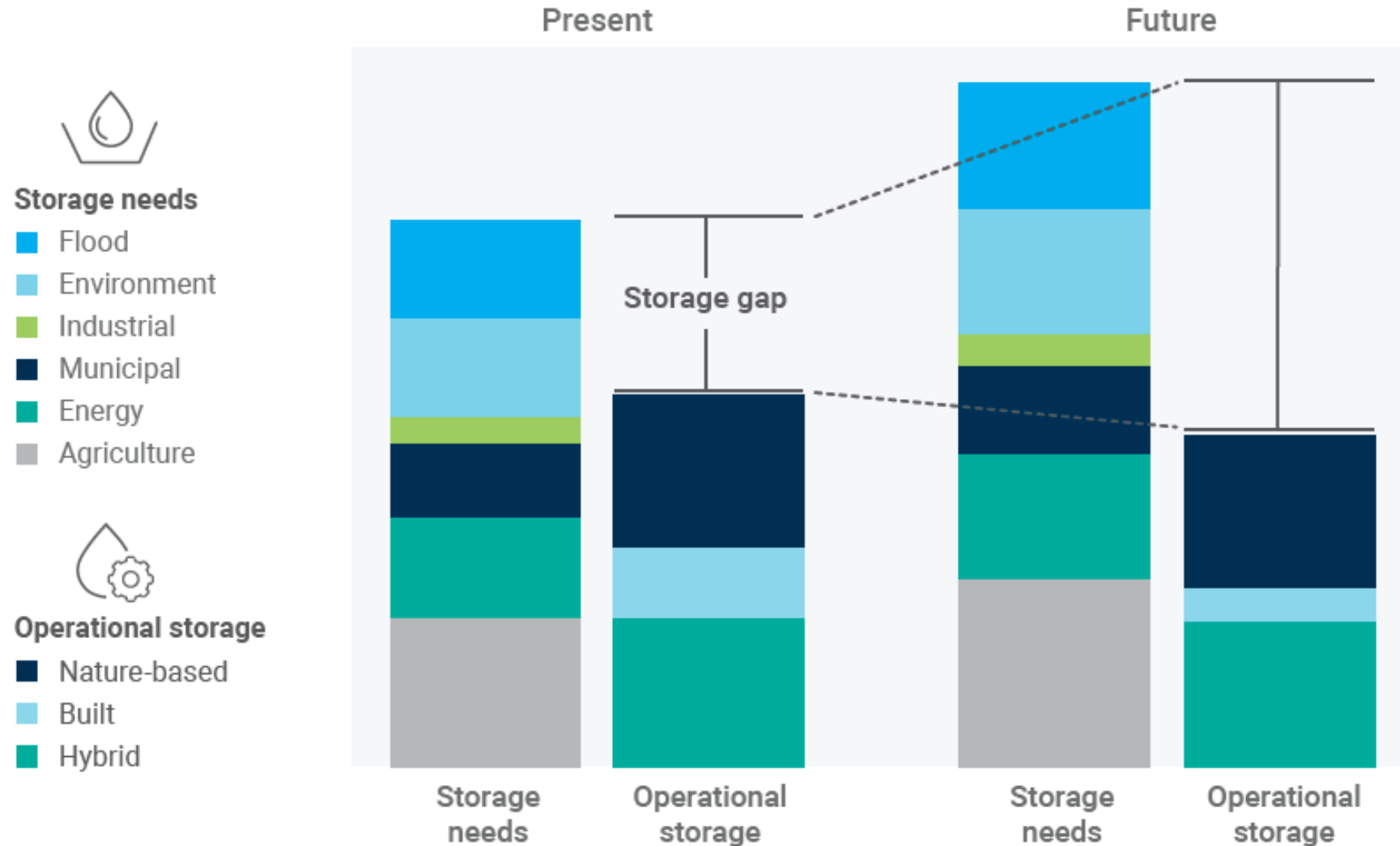
## 3 CLIMATE CHANGE

Freshwater storage declined by around 27,000 billion cubic meters



Climate change is upending the worlds' water cycle

# The Growing Storage Gap: A Whole of Economy Issue



Source: Adapted from GWP and IWMI 2021.

Note: Amounts of storage needed and operational storage are stylized estimates.

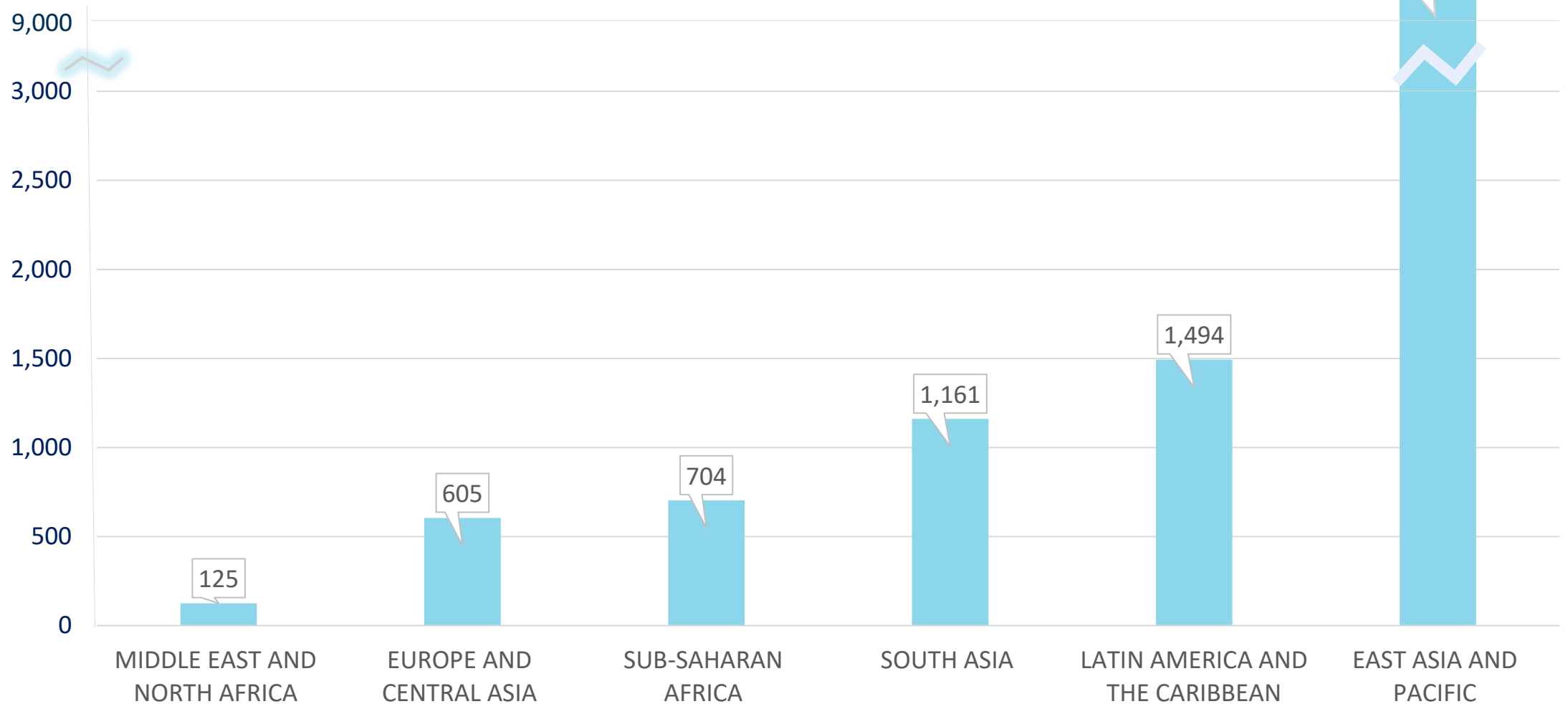


# From Storage Facilities to Storage Systems...



# Going beyond life extension

Number of Large Dams over 50 Years Old in WBG Client Countries

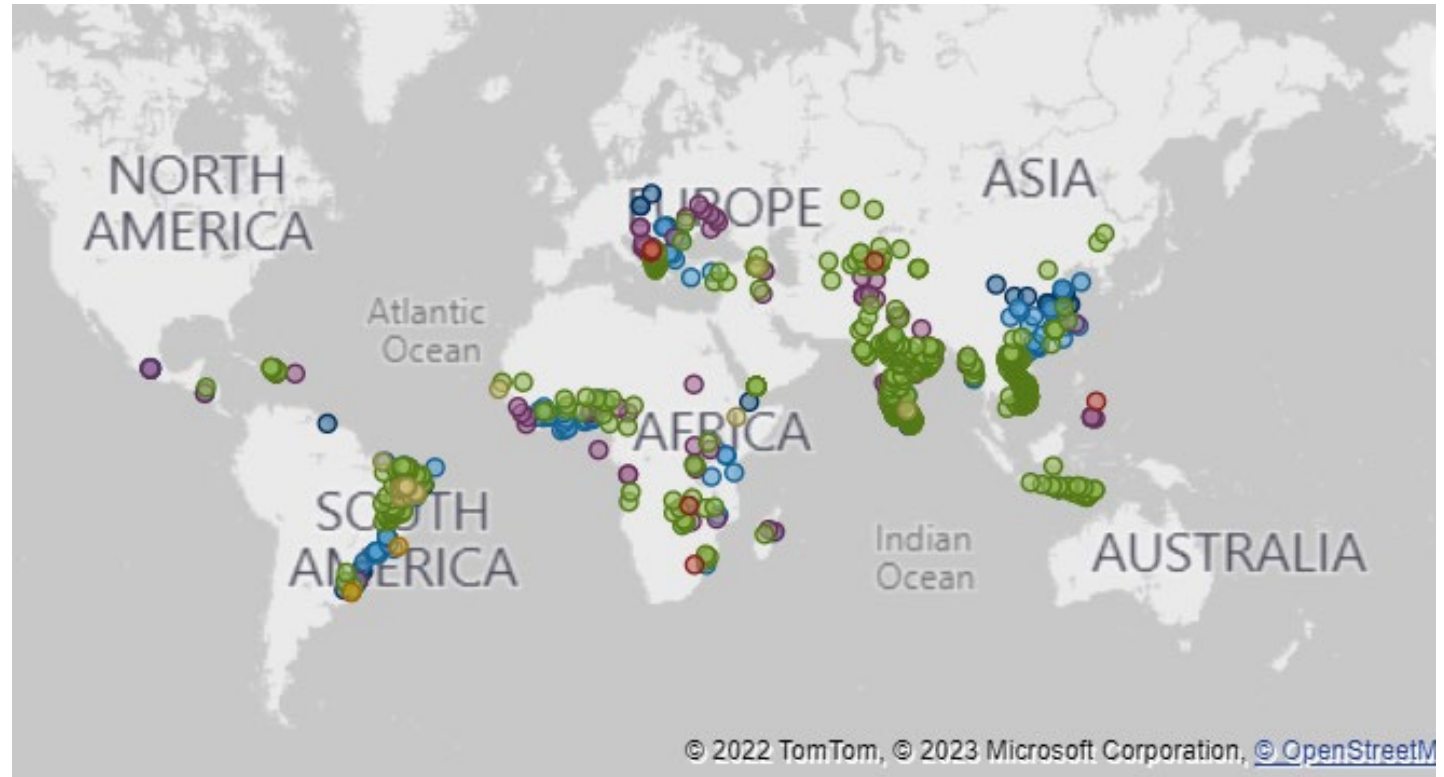
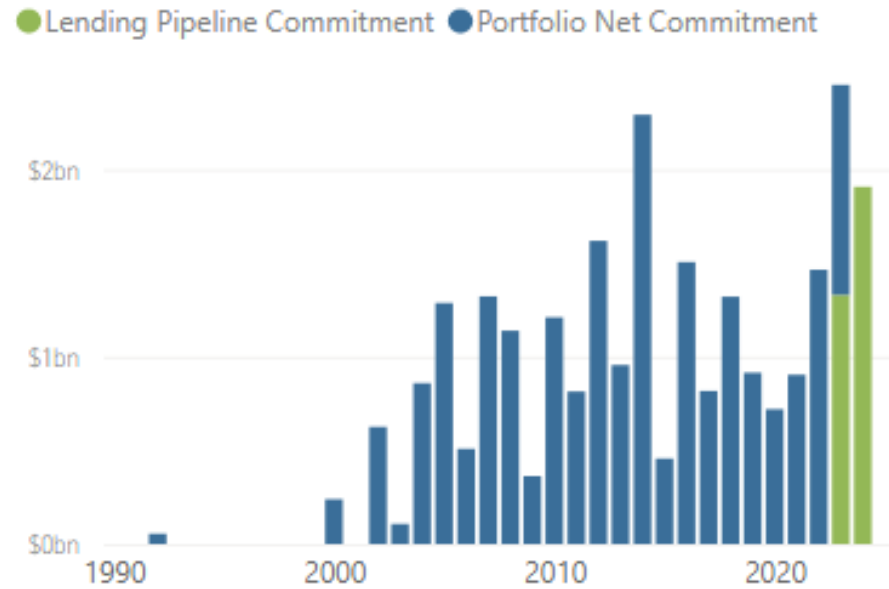


Source: ICOLD WRD

# Portfolio of Bank-funded Projects Involving Dams

## Projects for Rehab and Upgrading Existing Dams

World Bank Commitments (USD)



# Challenge & Opportunity #1

## **Challenge:**

- The need to retrofit and reoperate existing dams and reservoirs, owing to climate change and other socioeconomic pressures, comes as the world also grapples with the aging of its stock of dams.

## **Opportunity:**

- Retrofitting, reoperation and modernization of existing presents is a chance to increase benefits, improve safety and performance, and revisit environmental and social dimensions to improve sustainability

# Challenge & Opportunity #2

## **Challenge:**

- As the past is no longer a reliable roadmap for the future, changing hydrology presents a risk to safety, asset performance, and economic and financial viability.

## **Opportunity:**

- Stress-testing and robust decision-making techniques provide an opportunity to create projects not only more resilient to climate change but other shocks as well.

# Forthcoming Work from the World Bank

# *Getting More from Existing Dams: A Catalogue*

*(collaboration with DamWatch Engineering)*

- 5Rs typology covering built and nature reservoirs – Bank’s new report on global storage\* (see next slide)
- Driving force: Dam safety as well as green growth agenda and climate mitigation and adaptation agenda
- A catalogue including 21 Fact Sheets covering technical, institutional, economic & financial, and environmental & social aspects
- Lower “hanging fruits” covered by ongoing and future operations compared to construction of new dams

Source of 5Rs: What the Future Has in Store: A New Paradigm for Water Storage (WB 2023)

# Getting More from Existing Dams: A Catalogue

(collaboration with DamWatch Engineering)

5 Rs	Type of Project	Sector
Retrofitting	Sustaining or enhancing performance of existing asset	Renewable energy
		Water supply and irrigation
		Flood control and climate change resilience
		Environmental improvements
	Add functionality to existing asset	Renewable energy
		Water supply and irrigation
Rehabilitation	Sustaining or enhancing performance of existing asset	Renewable energy
		Water supply and irrigation
		Flood control and climate change resilience
		Safety
	Add functionality to existing asset	Environmental improvements
	Reoperation	Sustaining or enhancing performance of existing asset
Water supply and irrigation		
Flood control and climate change resilience		
Environmental improvements		
Add functionality to existing asset		Flood control and climate change resilience
		Social improvements
Reform	Sustaining or enhancing performance of existing asset	Policy and institutional support

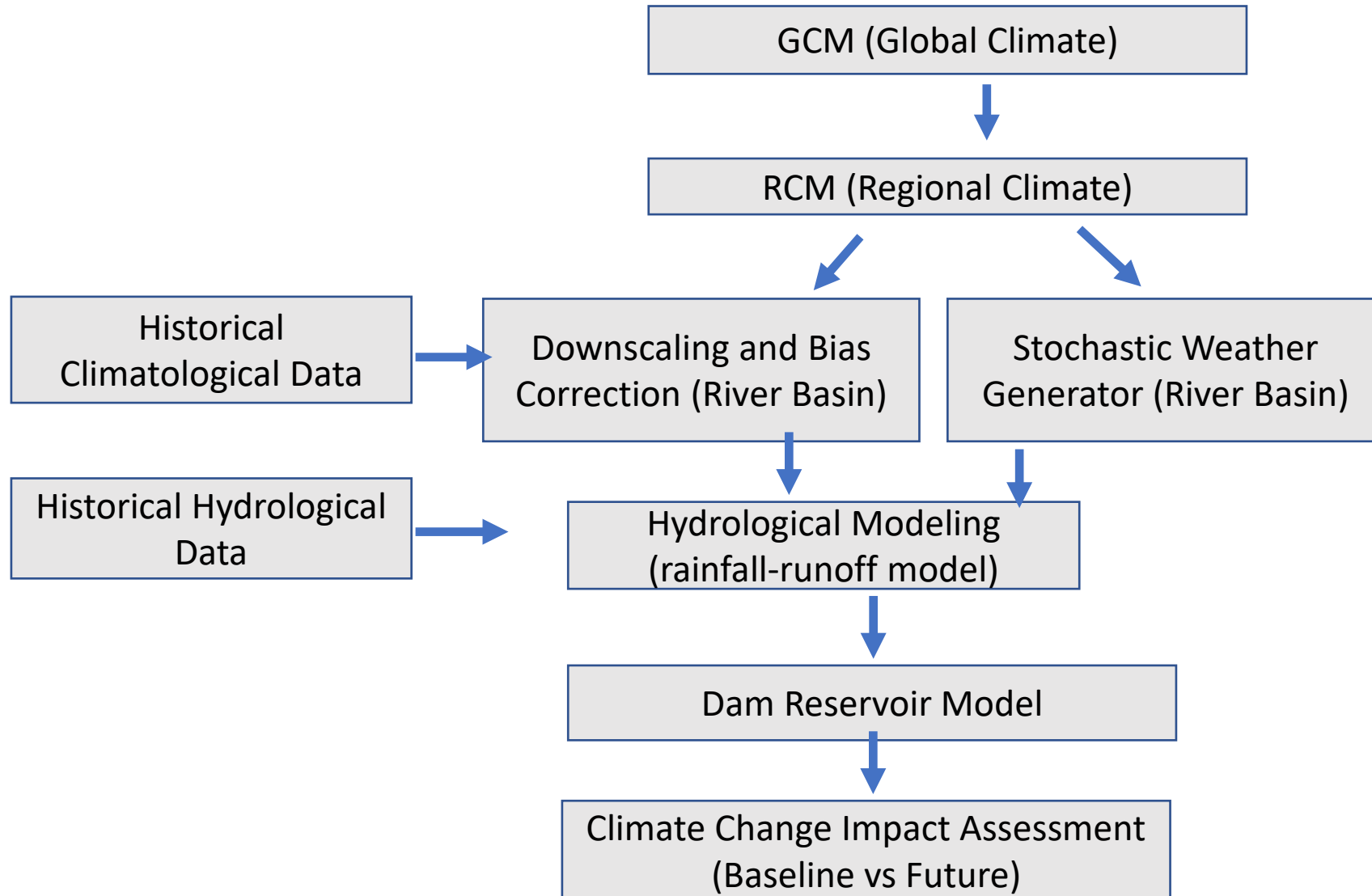
Note: Raising new dams is not covered in the context of existing dams



# ***Climate Change Impact Assessment on Extreme Hydrological Events and Resilience Enhancement for Dam Safety*** ***(Collaboration with ICHARM under the auspices of UNESCO)***

- Building on main guidelines (ICOLD, IHA, WMO, WB, etc.) and country specific diagnosis (e.g. Country Climate and Development Reports)
- A bottom-up approach from risk screening, risk analysis, climate stress test, risk management, to monitoring & evaluation according to IHA Climate Resilience Guide and WB decision tree framework.
- High risk cases involving unacceptable outcomes and plausibility may be further evaluated through modeling using downscaled GCM outputs in a proportionate manner to potential risks.
- A comprehensive review and application of adaptation and resilience enhancement measures against climate change impacts on extreme events

# Climate Change Impact Assessment for Critical Cases



- Assessment should be fit for purpose considering potential risk of dams, data availability, required expertise and cost)
- Coping with uncertainties (GCM large ensembles, bias correction, etc.)
- Climate change impact on PMP and other critical events, such as GLOF

# Climate Change Adaptation & Resilience Enhancement

- Review options covering both structural and non-structural measures in a comprehensive manner, considering technical, economic, environmental and social aspects
- Staged approach with due consideration to uncertainties in climate projections
- The evaluation of “tolerable” risk of dams and downstream communities vs utilities performance for hydropower, water supply, irrigation, etc. in consultation with regulator, owner, and other key stakeholders
- Cost effectiveness is an important element in particular for safety & resilience enhancement of existing dams vs new dams
- Regular monitoring, evaluation, and review is crucial.

# Climate Change Adaptation & Resilience Enhancement - Structural Measures

Planning	Selection of dam types: easy to raise, resistant to overtopping
	Emergency off-stream diversion or storage
Design	Structural design to allow future dam raising, if and when necessary
	Structural design to allow for easy and cost-effective addition of discharge capacity in the future, if and when hydrological loads increase
	Emergency spillway, including fuse plugs, fuse gates, and so on under extreme high floods
	Low-level outlets to for pre-flood reservoir drawdown and emergency drawdown
Construction	Build and maintain river diversion structures to allow future use in sediment flushing
Operation and maintenance	Test gates' operation regularly to ensure their reliability in emergency conditions
	Consider adding controllable gates to free spillways
	Increase reservoir freeboard during flood seasons
Retrofitting and reoperation	Retrofit dams to provide more resistance to overtopping, in particular for small earthfill dams, using cement soil materials, roller compacted concrete, etc.
	Increase spillway capacity or provide additional spillways using piano-key weir, fuse gate, fuse plug, etc.

# Climate Change Adaptation & Resilience Enhancement Non-Structural Measures

Planning	Catchment/watershed conservation and management to prevent peak flood increase, landslides or debris flow, and sediment yields
	Sediment assessment and management plan using most suitable techniques
	Enhanced hydro-meteorological monitoring/gauging involving communities, as appropriate
	Assessment and monitoring of upstream geohazards, such as landslides, slope failure, and glaciers which could cause GLOFs
	Initiate and maintain risk register throughout all phases of a dam's life cycle
Design	Risk analysis and assessment, including climate change impact assessment covering impacts on geo-hazards and glaciers in the catchment to assess potential risks, mitigation measures, and design adaptation for all phases of dam life cycle
Construction	Quality control, EPP, and first reservoir filling plan, including flood monitoring / forecasting (incl. snow /glacier melting depending on watersheds) and warning procedures
Operation and maintenance	Hydro-meteorological monitoring of rainfall, snowpack, temperature, river flow, etc. including upstream geohazards and glaciers
	Review and update reservoir operation rules; Introduction of enhanced reservoir operation and decision support system linked with flood forecasting system
	Emergency preparedness—identification, classification, notification/warning, and response
	Training dam operators and downstream communities for EPP
Retrofitting and reoperation	Periodic reevaluation of mitigation and resilience enhancement measures against intensified floods under climate change
	Establishment of adaptation fund with periodic replenishment

# Advanced inflow forecasting and reservoir operation is one of key adaptation measures to intensified floods

1. Technological advancement for enhanced rainfall & inflow forecasting
  - Allowing for more dynamic operation, balancing conflicting interests between water use benefits, flood management and dam safety
  - Dealing with uncertainties using Ensemble rainfall and runoff prediction with decision-support tools and downstream warning system
2. Institutional setup and coordination (dam owner/operator, regulator, climate & hydrometeorological agency, science group, and other key stakeholders)
3. Needs for gradual introduction & piloting with capacity building for establishing a system with due consideration to the causes and patterns of intensive rainfall, basin characteristics (size, topography), etc.
4. Introduction of useful cases with advanced flood forecasting and decision support system (US, Italy, Japan, etc.)



# Tack så mycket & Many thanks!

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