HydroPower Development Program 50 years

NTNU

Hydropower Development Seminar

50 year anniversary for the Hydropower Development Program

12. June 2023

Pravin Karki

Global Lead for Hydropower

World Bank

Europe 1985-1991

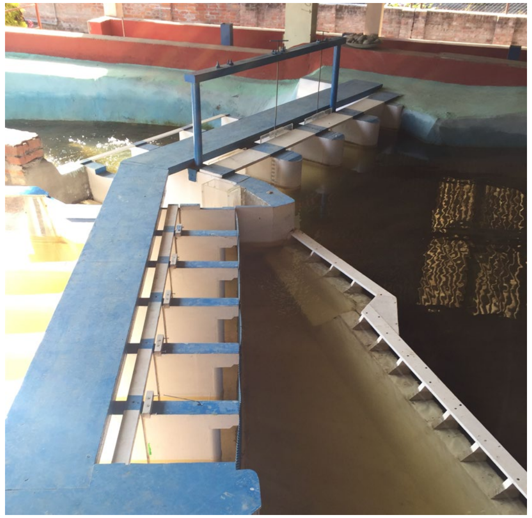
Nepal 1991-1996

Norway 1996-1998

NTNU

Nepal 1998-2000

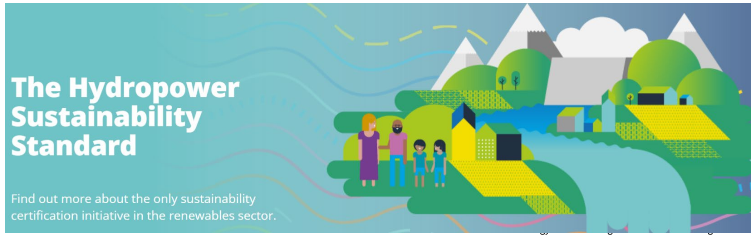
Hydro Lab



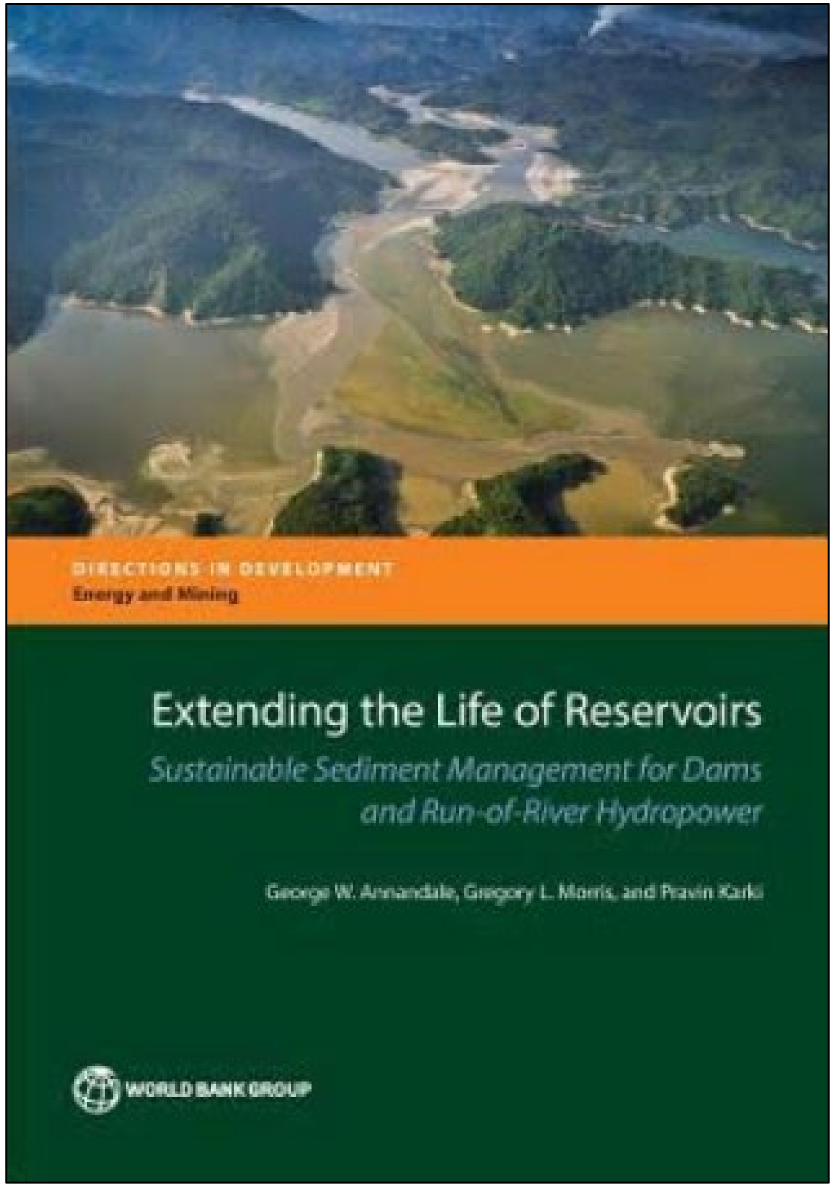
England 2000-2008

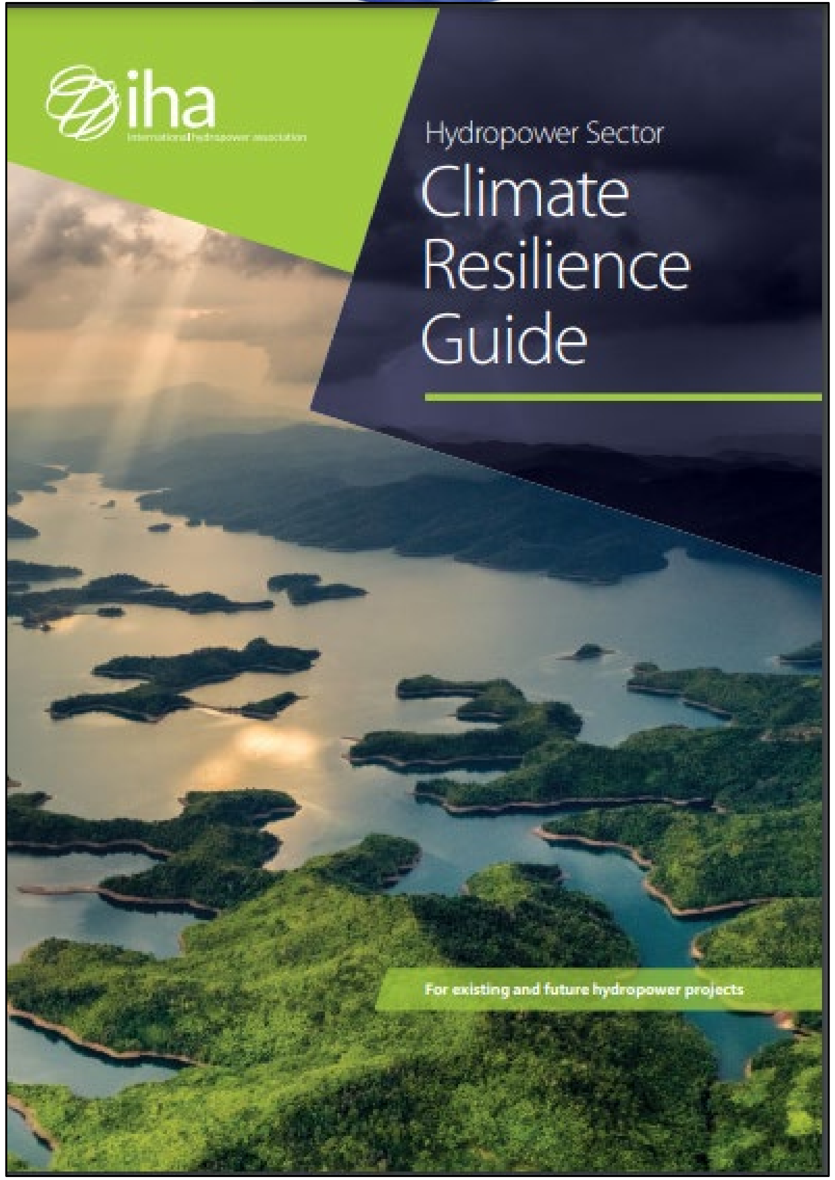
iha

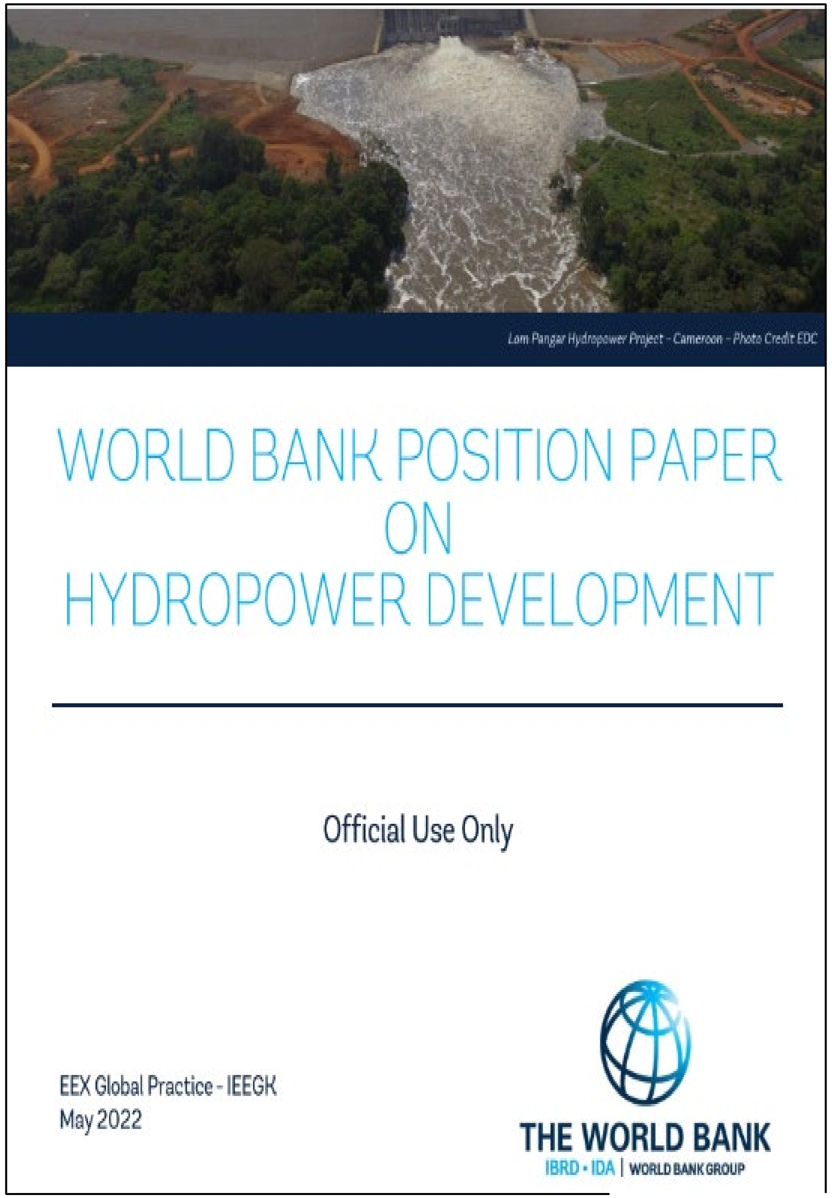
UNIVERSITY OF CAMBRIDGE



World Bank 2008-present

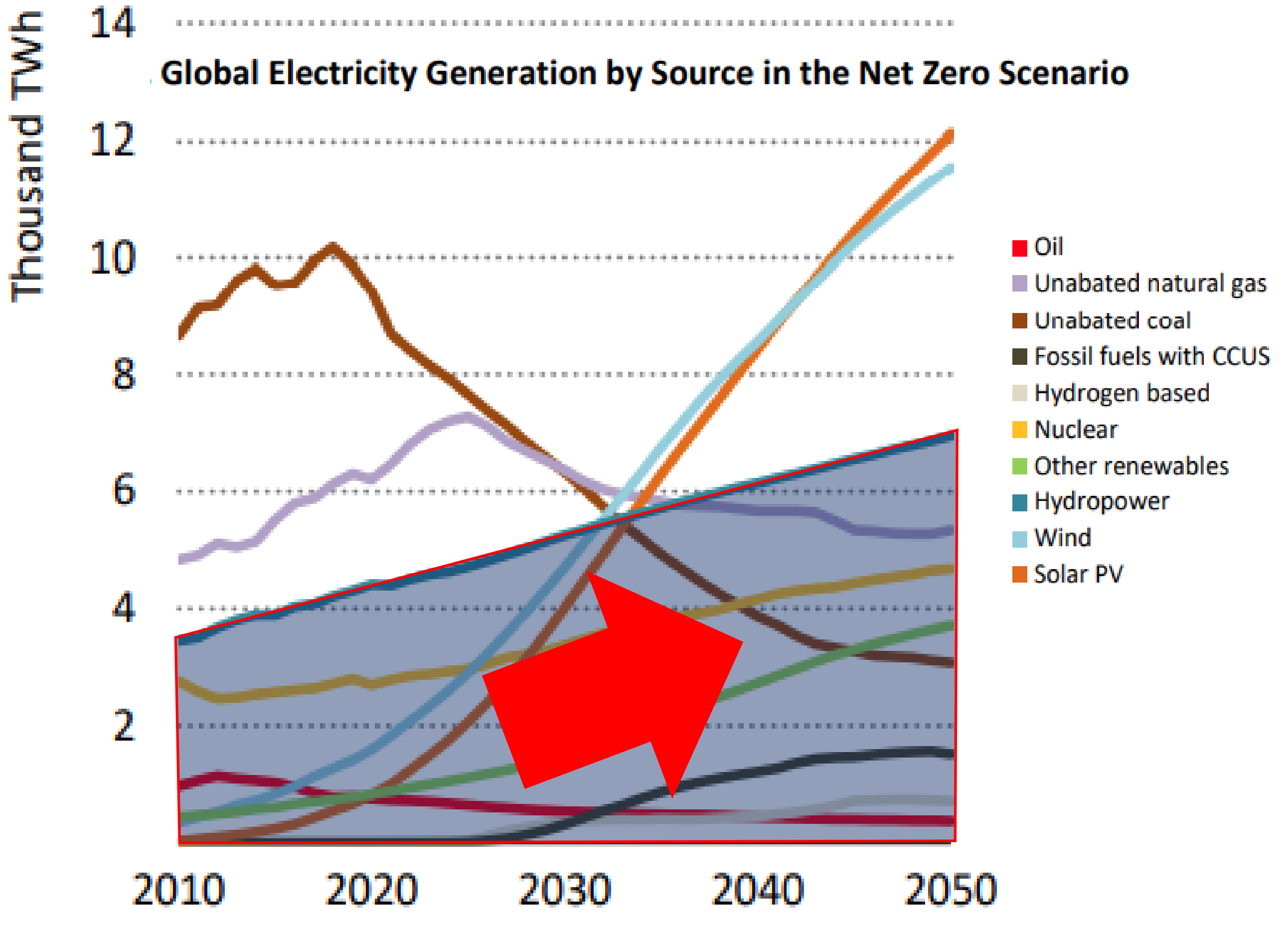






Hydropower is back

- Backbone of the energy transition
- Low-carbon
- Dispatchable and flexible to integrate variable renewable energy (wind, solar…)
- IEA Net zero calls for doubling the existing installed capacity by 2050
- Third largest energy source in the electricity mix by 2050

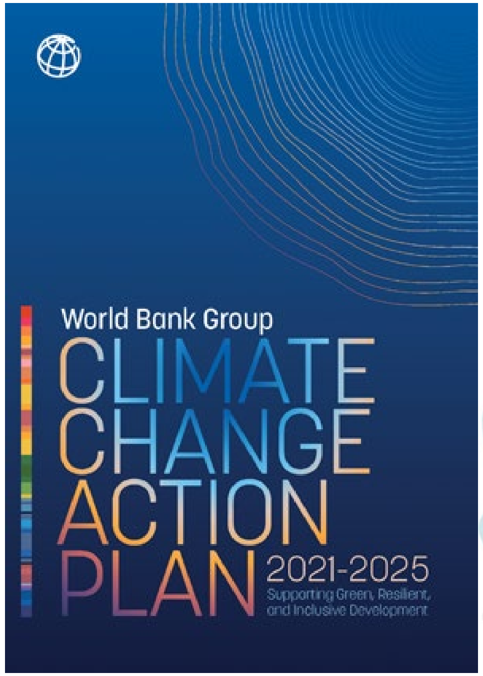


Source: International Energy Agency 2021. *Net Zero by 2050*. Paris: IEA.

GLOBAL CONTEXT

- With a critical target for affordable, reliable, sustainable and modern energy for all, all RE technologies will be needed
- The International Renewable Energy Agency (IRENA) has estimated that 850 GW of additional hydropower capacity, including pumped storage hydropower, would be required by 2050 in order to meet the Paris Agreement temperature goals;
- The International Energy Agency (IEA) has estimated that at least 1300 GW of new hydropower capacity would need to be added in order to achieve Net Zero by 2050

Corporate commitments



IDA
International Development Association
WORLD BANK GROUP

A strong business line at the Bank: Since 2002, 131 hydropower projects, for a total investment of $17 billion in 68 countries. Currently Upper Cisokan PS in Indonesia

Future challenges and opportunities in hydropower where NTNU research can help

- Benefit sharing
- Understanding the new role of hydropower
- Delivering projects on time and under budget
- Climate Change and Disaster Risk Management

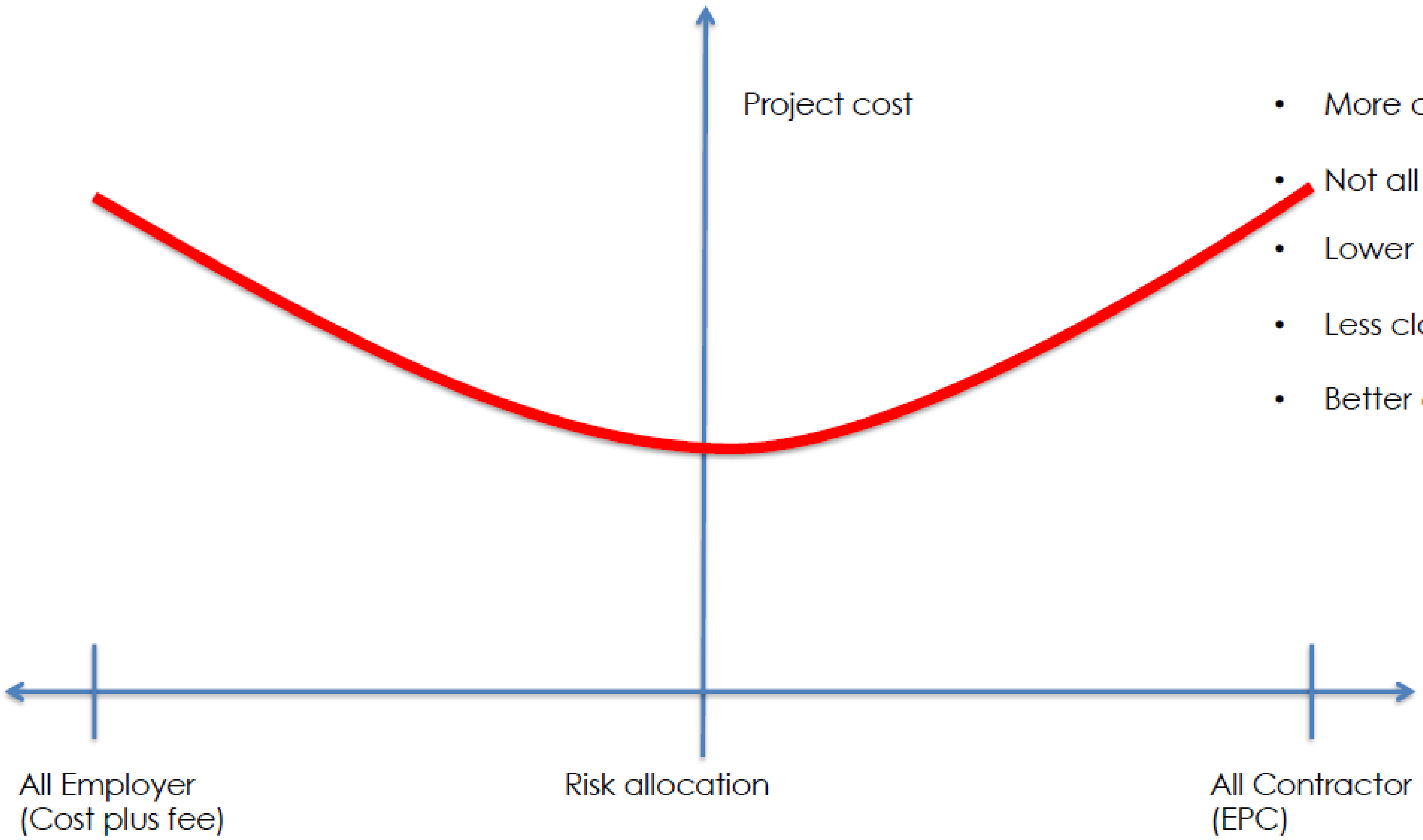
Upper Arun Hydropower Project (UAHEP)

Benefit Sharing to Prioritize Development for Local Communities

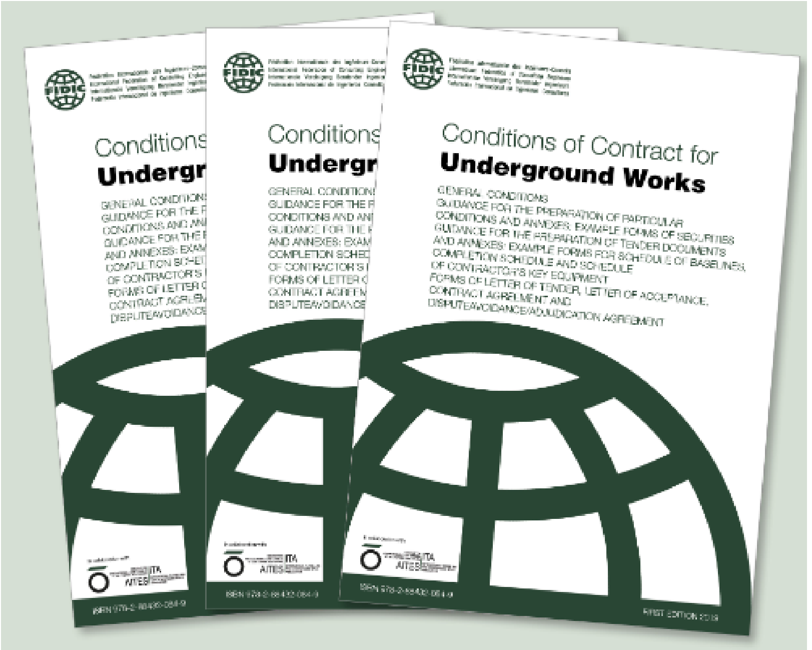
Hydropower's role is changing ...

	TRADITIONAL ENERGY MARKET - YESTERDAY	ENERGY TRANSITION - TODAY	NET-ZERO EMISSIONS - TOMORROW
Hydropower role	• Generate energy - baseload and hourly peaking	• Enable integration of VRE (i.e., wind and solar) and facilitate energy transition/grid decarbonization	• Support VRE generation which will determine operation patterns of the power system
Grid services	• Balance energy supply	• Ensure grid stability and reliability through ancillary services such as frequency regulation, voltage support, active power-loss compensation, black start	• Store surplus VRE generation and provide increased grid resiliency (e.g., enhanced energy balancing and frequency regulation) through pumped storage hydropower and other storage technologies
Multipurpose benefits	• Flood protection, irrigation support, water supply and recreation		
Sustainability	• No defined/ unique industry standard	• Hydropower Sustainability Guidelines are voluntary	• Sustainable hydropower development is the norm • Renewable energy projects contribute to biodiversity protection and conservation

Balanced risk allocation



- More contractors will tender
- Not all foreseen risks materialize
- Lower prices for the works
- Less claims, less disputes
- Better cost stability



Balanced risk allocation

The ground and groundwater related risks should be assigned to the Employer, as the Party who will most benefit from the completed project and as the party that can best control these risks.

- **If ground is "worse" than anticipated: Employer bears the cost**
- **If ground is "better" than anticipated: Employer gets the profit**

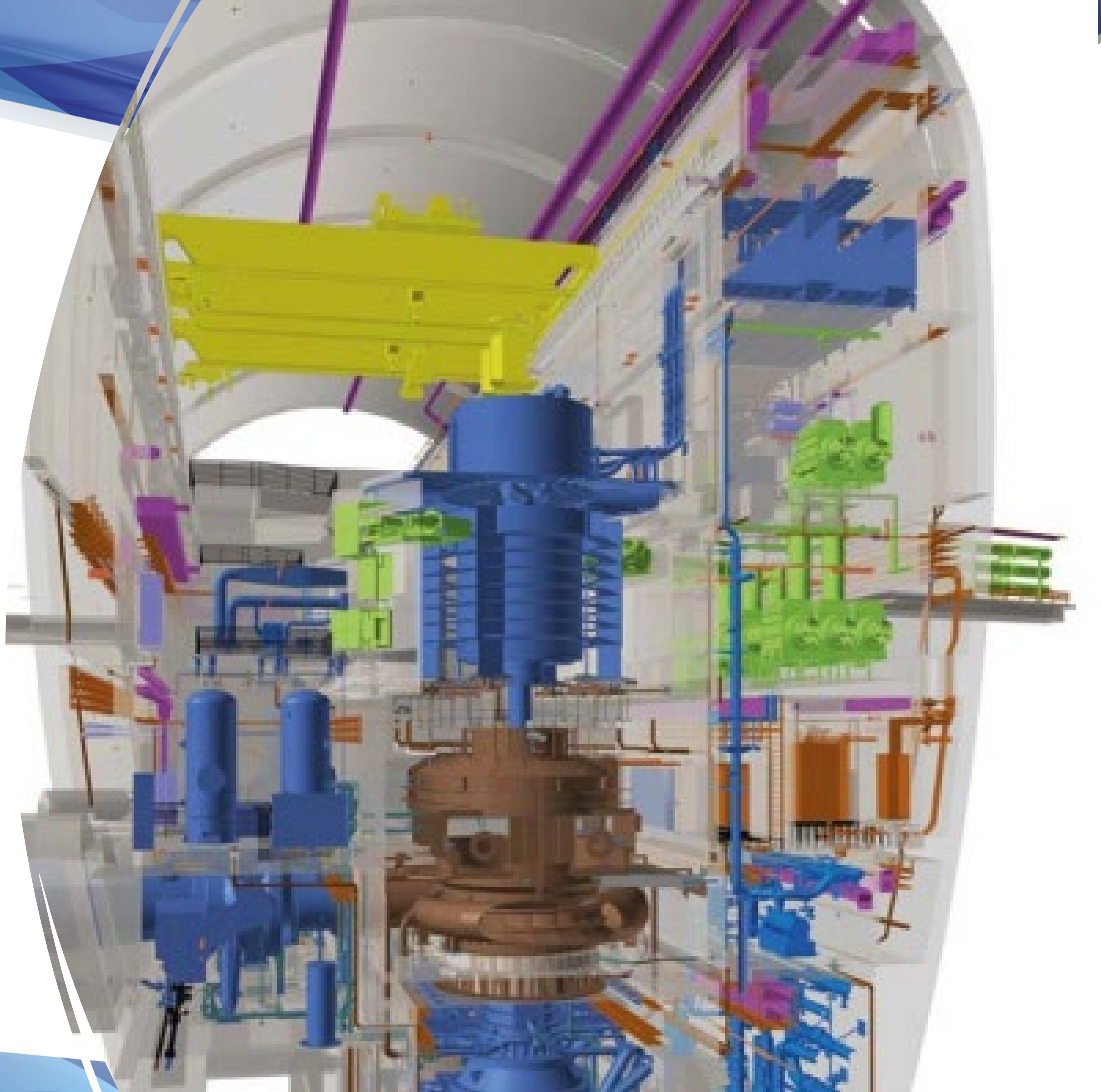
The risks related to productivity and cost in any expected ground should be assigned to the Contractor, as the party who knows its methods and equipment best, and as the party that can best control these risks.

- **If Contractor is faster in a ground as expected, he may increase his profit**
- **If Contractor is slower in a ground as expected, he may incur a loss**

Balanced risk allocation

Building Information Modelling (BIM) in Hydropower Projects

- \- Ultimate collaboration: Model-based design enhances efficient information sharing between all stakeholders through the entire project life cycle.
- – Minimizing project risks: Reviewing of 3D models leads to transparency and early identification of potential conflicts and reduces project risks in terms of costs and time.
- – Better communication: Visualization and simulation of critical issues supports communication and leads to better decisions.
- – Improved quality: Information and construction documents derived from a digital building model are consistent and automatically updated to meet stringent project schedules.
- – Centralized, intelligent database for project and operation: The database created during the project development can be used optimally for plant operation and maintenance



Hydropower Sector Climate Resilience Guide

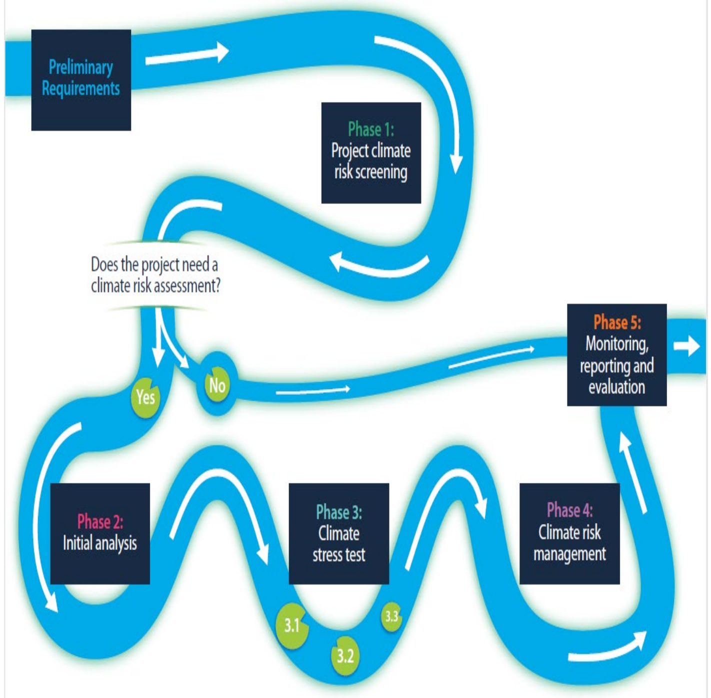
Decision Tree Framework

The ‘Guide’ was followed to assess the climate change impact on the hydropower system. The methodology in the Guide is adapted from the Decision Tree Framework (Ray and Brown 2015) which is a process for evaluating climate and non-climate risks to water development investments. The Guide responds to the need for clarity on good international industry practice for project owners, financial institutions, governments and private developers to consider climate risks in hydropower development and operations.

The Five Phrase Approach

The Guide is designed to take users through a 5 phase approach to incorporate climate resilience into hydropower project appraisal, design, construction and/or operation, to ensure that the project is resilient. The phases are:

- Phase 1: Project climate risk screening
- Phase 2: Initial analysis
- Phase 3: Climate stress test
- Phase 4: Climate risk management
- Phase 5: Monitoring, reporting and evaluation.



Process Understanding

Hazard Types & Triggers

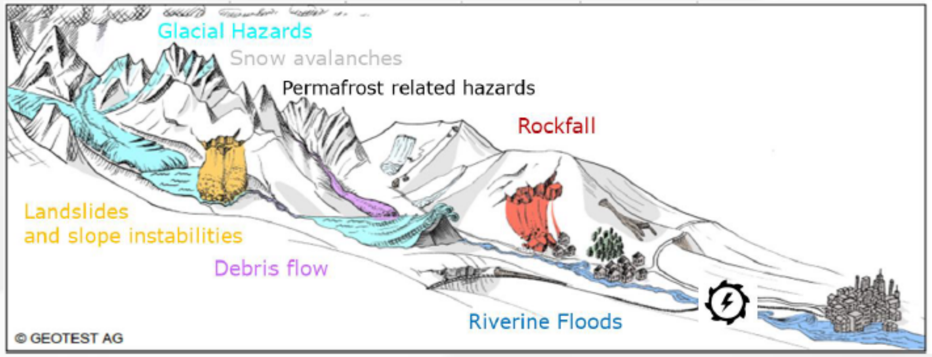
Single-type & muti-type (cascading) events

Various trigger mechanisms

Climate change & human activity as drivers

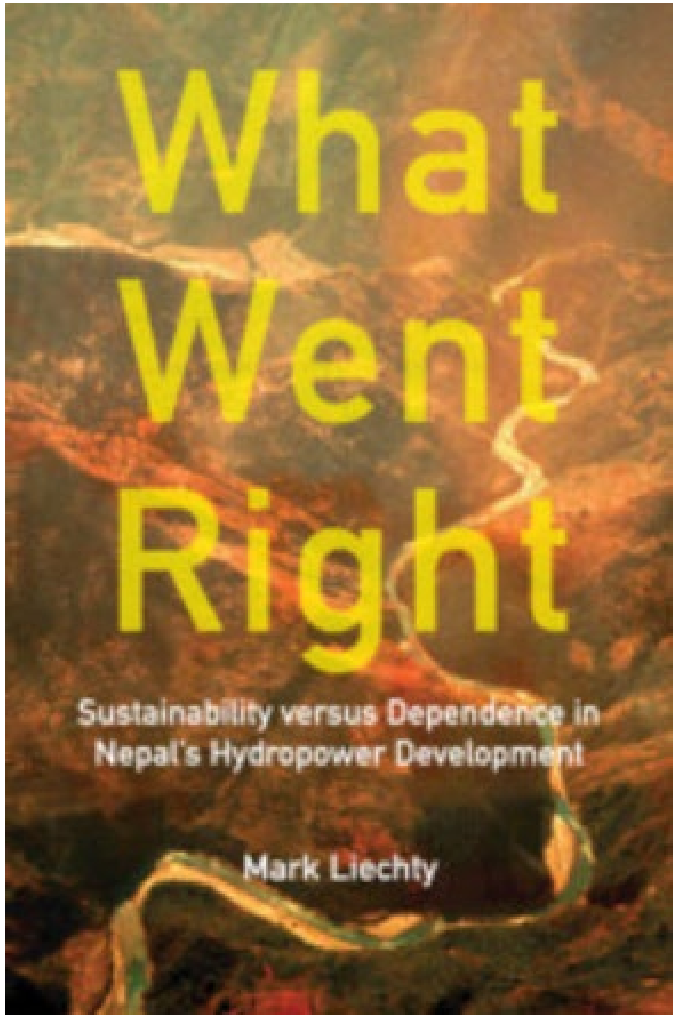
Of particular importance for Arun valley are

- Landslides and LDOF events, but also
- GLOFs & cascading events, with permafrost degradation being an important driver



Hazard Types	Triggers (Drivers)					
	Seismic & tectonic activity	Other (hydro-) geolog. processes	Weather & Climate	Climate Change: Permafrost Degradation Glacier retr.	Climate Change: Changes in Atmospheric variables	Human activity
Single-type and primary events						
- Earthquakes	● (red)					
- Rock-/Ice-avalanches	● (red)	●	●	● (red)	● (red)	
- GLOF	● (grey)	● (red)	●	● (red)	●	
- Landslides	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)
- Debris Flow	● (grey)	●	●	●	●	●
- Riverine Floods			●		● (red)	
Multi-type & cascading events						
- Rock/Ice-avalanche → GLOF	●	●	●	● (red)	●	
- Landslide → LDOF	● (red)	● (red)	● (red)	●	● (red)	● (red)
- Riverine Flood → Landslides		●	●		●	
- GLOF → Landslides	● (grey)	● (red)	●	● (red)	●	
- Dam break Flood	●	●	●		●	●
- Complex cascading events	● (red)	● (red)	● (red)	● (red)	● (red)	

Legend	Relevance for Arun hydropower projects:
	not existing / not relevant
● (grey)	minor relevance
●	relevant
● (red)	important



Nepal’s hydropower sector is one of the country’s few development success stories. Unlike almost every other “developing” country, in Nepal local firms design and build complex hydropower facilities using Nepali engineers, contractors, components, and labor.

Mark Liechty, What Went Right
Sustainability Versus Dependence in Nepal's Hydropower Development

In 2007 less than 30% of Nepal’s population had access to electricity. Today in 2023, the access rate is close to 98%.

In 1984, I sat for my school leaving certificate examinations studying under a candle. Today people are riding electric vehicles charged by electricity from hydropower.

THANK YOU

- Prof Dagfinn Lysne
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