Round Table on Building Climate Resilience in the Hydropower Sector through Early Warning Systems: ICDRI 2024

Date: 24-Apr-24 Time: 1600-1730 IST

Session Abstract

The Community of Practice (CoP) on Resilient Infrastructure for Energy Transition through its focus on Early Warning Systems (EWS) for Building Climate Resilience in the Hydropower Sector aims to promote medium to long-term climate change adaptation and strengthen the resilience of hydropower in flood-prone or drought-prone regions through robust EWS mechanisms.

This round table session focusing on the impacts of climate change on hydropower sector, was the first in a series of planned knowledge exchange products to potentially inform policies and practices on the existing gaps/needs. This round table has focused on facilitating the assessment on the topic of data for risk assessment.

Panelists

The panellists who participated in the session are listed below for reference.

S No	Panellist Name Designation & Organization	In-Person/ Virtual
1	Kamal Kishore, Head of Department, National Disaster Management Authority (NDMA) & Co-Chair, Coalition for Disaster Resilient Infrastructure (CDRI)	In-Person
2	Ramraj Narsimhan, Senior Director – Programmes, CDRI	In-Person
3	Roberta Boscolo, Climate and Energy Lead, World Meteorological Organization (WMO)	Virtual
4	Jinsun Lim, Energy and Environmental Policy Analyst, International Energy Agency (IEA)	In-Person
5	Marie L'Hostis, Water Resources Specialist, Asian Development Bank (ADB)	Virtual
6	Dario Liguti, Director – Sustainable Energy, United Nations Economic Commission for Europe (UNECE)	Virtual
7	Isabella Villanueva-García, Climate Change Analyst, Ministry of Energy, Government of Chile	In-Person
8	Manjusha Mishra, General Manager, National Hydroelectric Power Corporation (NHPC), India	In-Person
9	Giriraj Amarnath, Principal Researcher – Disaster Risk Management and Climate Resilience, International Water Management Institute (IWMI)	In-Person
10	Daniel Broman, Research Scientist, Pacific Northwest National Laboratory (PNNL)	Virtual

S No	Panellist Name Designation & Organization	In-Person/ Virtual
11	Dr. Mark Christian, Technical Leader, Hydropower Modernization, Electric Power Research Institute (EPRI)	Virtual
12	Hemlata Bharwani, Scientist, India Meteorological Department (IMD)	In-Person
13	Erica Udas, Ecosystem Specialist, International Centre for Integrated Mountain Development (ICIMOD)	In-Person
14	Belinda Hewitt, Senior Disaster Risk Management Specialist, Asian Development Bank (ADB)	In-Person (Observer)
15	Astha Gupta, Lead India Consultant, International Energy Agency (IEA)	In-Person (Observer)
16	Dr Bhaskar Singh Karky, Consultant, Asian Development Bank (ADB)	Virtual (Observer)

Keynote Address

The workshop commenced with a keynote speech by Kamal Kishore, the Head of Department at the National Disaster Management Authority (NDMA) and Co-Chair of the Coalition for Disaster Resilient Infrastructure (CDRI). The keynote underscored the importance of evaluating climate-related risks and augmenting resilience in the hydropower sector, while also outlining the associated challenges. The potential for leveraging pertinent data to bolster resilience was also underscored.

1. **Physical Risks to Hydropower Generation Assets** - The Glacial Lake Outburst Flood (GLOF) event in the Teesta Valley was cited as an instance where 1200 MW of generation capacity was lost within an hour. This event calls into question our conventional methods of assessing physical disaster and climate risks to projects arising from extreme hydrometeorological events. Given the high degree of uncertainty in the system, it is imperative to consider design aspects. There is a need to revisit and revise the codes and standards that were established around two decades ago. The key questions are: What should be the design considerations for the future? How should risk assessments be conducted in the context of these extreme events?
2. **Operational Risks in the Hydropower Sector in the Future** - Significant changes are being observed in hydrological flows across certain river basins. This raises questions about meeting generation targets and the associated variability. It is crucial to incorporate economic risk assessment of power generation considering future variability. The risk to project outputs also needs to be factored in.
3. **Hydrometeorological and Geophysical Events** - Many of these events occur in areas of high seismic activity. The Dam Rehabilitation and Improvement Project (DRIP) is focused on making a large asset base resilient to seismic risks. The asset base likely requires upgrades due to ageing and obsolete technology. A multi-year plan for the next two to three decades is needed, prioritizing upgrades and potentially decommissioning some assets while balancing social and economic considerations. This process must be guided by policy and regulatory instruments such as the Dam Safety Act. While policy is established, its implementation in the Indian context, and its replicability in other contexts, is crucial.

Opening Comments from Panelists

Dario Liguti	The influence of climate change on energy infrastructure, particularly in terms of geophysical dimensions, is a significant concern. The United Nations Economic Commission for Europe (UNECE) is examining the resilience of the entire energy system, adopting a comprehensive and systemic approach. This includes ensuring that the energy system is secure, affordable, and sustainable in the long run. Policymakers are required to make certain trade-offs in this process. To facilitate the understanding and full evaluation of these trade-offs, UNECE is collaborating with several organizations, including the International Energy Agency (IEA) and the World Meteorological Organization (WMO). They are launching an Artificial Intelligence (AI)-based platform for policymakers. This platform aims to aid in the construction of resilient energy systems by providing data and science-based accurate information. The ultimate goal is to minimize risk and mitigate the impacts on energy infrastructure.
Roberta Boscolo	The World Meteorological Organization (WMO) was introduced, and key findings from the 2023 State of Global Climate report were shared. The focus was on understanding potential strategies to enhance resilience across all sectors, including the energy sector. An online platform, the Climate Risk Atlas, was discussed. This platform is based on the Climate Risk Index and examines four primary hazards: mean annual precipitation, precipitation variability, and the Standardized Precipitation Index for both floods and droughts. The platform also considers future scenarios from the Intergovernmental Panel on Climate Change (IPCC) reports. The key message conveyed was the necessity of minimizing risks to assets by considering climate data and future scenarios, given the rapidly changing climate. Immediate action was strongly advocated.
Jinsun Lim	The International Energy Agency (IEA) places significant emphasis on hydropower, recognizing it as a crucial component of the clean energy transition. Hydropower provides flexibility to power systems, enabling them to accommodate variable clean energy sources. It plays a vital role in meeting the growing electricity demand in various countries. Moreover, hydropower is critical from a disaster risk reduction perspective, as dams often play a key role in mitigating flood risks. The IEA has conducted various assessments on the climate impacts of hydropower generation, considering different scenarios of low and high emissions. The IEA found that climate impacts may vary across the world, and a comprehensive and scientific assessment is essential to build resilience of hydropower plants. Given that hydropower installed capacity is expected to increase in all IEA scenarios, resilience measures, including Early Warning Systems (EWS), will be instrumental in mitigating the adverse impacts of climate change.
Marie L'Hostis	The Asian Development Bank (ADB) is now placing greater emphasis on climate resilience and adaptation in the evaluation of new projects at all stages. ADB has endorsed a new guidance note for large-scale hydropower

	plants, which recognizes global best practices and existing information. The process of building climate resilience is evolving with advancements in science and the development of new climate models, and thus requires focused attention.
Daniel Broman	The Pacific Northwest National Laboratory (PNNL) has been actively engaged in the domain of climate impacts. PNNL collaborates closely with public and private sector stakeholders in the hydropower sector to conduct climate impact assessments. There is a significant need to refine and comprehend the performance of various factors such as hydrology modeling, river routing, etc. This yields high-level and crucial information for policymakers regarding general climate impacts. The challenge lies in utilizing this information for decision-making in adaptive management, given the uncertainties associated with climate change. It is essential to incorporate this information into the design and retrofitting of infrastructure in areas impacted by climate change. On an event scale, it is important to understand specific issues that impact infrastructure, such as sedimentation and other factors that might affect infrastructure. Another critical aspect is understanding how hydropower fits into the broader context of energy security in the grid, while also ensuring that it remains secure and resilient.
Mark Christian	The Electric Power Research Institute (EPRI) launched the Climate READi initiative to better understand the intersectionality of climate change and the power sector. While multiple generation types are included in Climate READi, the longevity of hydropower assets, which often exceed 100 years, necessitates the long-term considerations. Climate READi encompasses three major workstreams: physical climate hazards, vulnerability assessments, and adaptation responses, all of which offer actionable advice. EPRI has been meticulously mapping the intersection between climate change and hydropower attributes. This includes examining the effects of various climate change mechanisms across different hydropower assets and mapping these vulnerabilities in a matrix. The initiative delves deeper by creating guidance and formalizing a methodology to assess the vulnerability of the assets. A key area of focus is the assessing the effect of changing inflows for both generation and flooding effects, utilizing data from the Oak Ridge National Laboratory.
Isabella Villanueva-García	The Ministry of Energy in Chile has been actively engaged in long-term energy planning for the past decade, as mandated by legislation. This involves forecasting energy systems up to 2060, incorporating various climate scenarios, particularly in relation to hydropower generation. Hydropower constitutes 25% of Chile's energy generation and is vital for the country's energy security. The primary challenge identified is the application of climate scenarios in the modelling process. Data plays a crucial role in processing and transforming historical data to project hydrological scenarios. These projections will aid in addressing issues related to mega droughts that

	impact hydropower generation in Chile. A key lesson learned from this process is the importance of diversifying energy sources.
Manjusha Mishra	Extreme rainfall events significantly impact hydropower generation. The importance of dam safety has been underscored since the introduction of the Dam Safety Act in India. The Early Warning System (EWS) for all power stations in the National Hydroelectric Power Corporation (NHPC) was a focal point of the opening remarks. The aim is to ensure EWS in upstream locations that can provide a warning at least 1-2 hours in advance, disseminated through cloud-based systems to all stakeholders. Dissemination channels include hooters, sirens, and messages, including those transmitted through social media. The Central Control Facility at the dam and the Master Control Facility in Faridabad play a crucial role in disseminating EWS messages. A software called e-AABHAS was specifically developed to enable stringent monitoring of river water levels and discharges both upstream and downstream of hydropower projects identified as 'vulnerable'. The EWS system is currently being strengthened and expanded to include Glacial Lake Outburst Flood (GLOF) events in the future, in addition to addressing structural interventions. NHPC has a Memorandum of Understanding (MoU) with the National Remote Sensing Centre (NRSC) and the Defence Geoinformatics Research Establishment (DGRE) for avalanche monitoring in GLOF events. Furthermore, NHPC has approached the Centre for Development of Advanced Computing (C-DAC) for the implementation of a comprehensive EWS system in the Teesta basin. Challenges include addressing issues related to power supply and distribution when a disaster strikes.

Deep Dive

The roundtable discussion delved in-depth into the topic of utilizing data for risk assessment, with the following questions presented to the panellists.

What initiatives or collaboration platforms will be needed to assess climate risks and impacts?	**Dario Liguti** Interoperability and data transmission across platforms are crucial for real-time communication. For instance, the World Meteorological Organization's platform for weather pattern projections integrates data collection and estimation platforms to inform policy decisions. Addressing compatibility and built-in protocol interoperability is vital for timely responses to emerging issues. Organizations are urged to consider these aspects - information transmission protocols, data compatibility, and standards, interoperability - as they are technical barriers to achieving the goal of informing policy decisions with science-based evidence. **Marie L'Hostis**

	Establishing such databases involves overcoming challenges related to scaling data from project to regional or national levels. These challenges include sensitivities around data sharing from data custodians, including governments and private entities. The data must be made accessible, adaptable to local contexts, and interoperable. A pilot initiative could be implemented to address these issues.
How can we establish a climate event database or knowledge centre to safeguard existing hydropower investments from severe climate impacts?	**Mark Christian** Establishing a database requires a collaborative and dynamic structure that can adapt based on continuous feedback. It is essential to engage with the actual hydropower asset data owners and operators, particularly when implementing changes or creating high-level guidance. Robust communication and adequate resources are necessary for effective engagement. Leveraging the experience of other organizations in the field is also key. Furthermore, it is important to ensure that the guidance provided is adaptable and accessible throughout the structure.
What data is required for modelling future climate risks to guide financial decisions?	**Roberta Boscolo** The World Meteorological Organization (WMO) exemplifies the use of data at different time scales, each serving a specific purpose and providing risk information. Historical data, such as reanalysis of climate patterns over the past 100 years, serve to understand asset exposure and vulnerability to meteorological hazards. Seasonal and sub-seasonal forecasts form the basis for Early Warning Systems (EWS), aiding to reduce the risk exposure and build resilience through preparedness. The reduced lead time to act, from 15 days to 3 months, can thereby facilitate the impact mitigation decisions. Annual to decadal prediction are crucial for planning infrastructure maintenance and enhancing the resilience of critical infrastructure assets over the changes expected in the next 30 to 50 years. WMO's open database, like the Copernicus data Store, can be used for exploring climate projections and extract information for planning infrastructure resilience in response to climate change. While the data is globally available, it is important to contextualize the information at regional or local level. **Manjusha Mishra** The increase in short-term extreme events necessitates the strengthening of data for Early Warning Systems (EWS). The goal is to extend the EWS reaction time from the current 1-2 hours to 1-2 days. This requires specific forecasting data for catchment areas. However, data gathering presents challenges due to the sensitive and classified nature of some data. These issues can be addressed through data sharing and collaboration. Additionally, there is a need to calculate flood

	inundation areas, which may require data from the Copernicus system. Localised data are also necessary, requiring collaboration with local NRSC centres. Therefore, interagency collaboration is essential to address these requirements. **Mark Christian** In addition to the previously mentioned points, two more aspects are crucial. First, the classification of hydropower system attributes is important due to the site-specific nature of hydropower projects, which results from the diversity of standards and locations. Categorising these attributes in a meaningful and actionable way and using them to drive identify which climatological characteristics are most impactful to hydropower operation and safety of interest (such as flood control, dam composition, etc.) is essential. Second, a comprehensive spectrum of data, along with data classification characterization, can help identify the starting point for further expansion. Collaboration plays a key role in enabling this process.
How can localized factors be integrated into projections to enhance understanding of hydropower generation risks and impacts across various geographical locations?	**Jinsun Lim** A plant-by-plant analysis is crucial to understand geographical variability in climate impacts. Furthermore, a more careful approach is needed for some locations such as high mountain regions and small island states, where models show significant discrepancies. Localised data, including rainfall, soil moisture, temperature, land use, vegetation, glacier melting, and others are still needed although substantial progress has been made in this area. Understanding the social and economic impacts is also necessary, requiring various types of data. Collaboration is key to obtaining localised data, benefiting both local agencies and the international community. **Roberta Boscolo** From the WMO's perspective, it is crucial to collaborate with local agencies, such as national hydrometeorological agencies. Involving these agencies in the project and the analysis of hydropower assets in their respective countries can aid in extracting local-level information. Therefore, a national mandate in this direction is important as it will facilitate the integration of more information specific to each geography. **Hemlata Bharwani** The Chamoli incident serves as a pertinent example. The focus is on leveraging both locally available data and atmospheric science data. A wide array of models and data are available for issuing forecasts, including Numerical Weather Prediction (NWP) models and high-resolution models. Specialised

	projects, such as the South Asia Flash Flood Guidance project, provide specific metrics like snowmelt ratios. The India Meteorological Department (IMD) is open to collaborating with agencies on data sharing for these projects. This multi-faceted approach ensures comprehensive and accurate forecasting. **Isabella Villanueva-García** A fundamental aspect of climate change, particularly from an adaptation perspective, is to concentrate on localized impacts. The challenge lies in managing the disaggregation of data with a focus on climate change and risks and linking this with the impacts on people and communities. For instance, the effects of hydropower on local and indigenous communities in Chile can be addressed by adopting a participatory process and involving them in the planning process. This approach ensures that the specific needs and concerns of these communities are considered, promoting sustainable and inclusive development. **Giriraj Amarnath** The emphasis on built infrastructure needs to be balanced with the impacts of hydropower on local communities. Nature-based Solutions (NbS) could be a potential solution. The International Water Management Institute (IWMI) has been implementing a project in Africa, "Water Wise", advocating for assessments of natural infrastructure and eco-hydrological solutions. It also highlights the return on investment when combining nature-based infrastructure with hard infrastructure. The discourse needs to incorporate a social dimension, focusing on the role of the hydropower sector in poverty alleviation, water-energy security, and livelihood security. It is also crucial to consider environmental aspects such as forest and biodiversity conservation. Trade-off analysis is important to allow decision-makers to view the situation from an ecosystem perspective. Hydropower is a complex system, and localized factors need to be considered. This includes translating data into a localized context, focusing on smaller catchments or watersheds. IWMI is developing a catchment risk and resilience index, working with basin indicators, to understand the potential impact of hydropower. While water demand is increasing, the role of climate change in the hydropower sector, from the viewpoint of sustainable water resource management, is often overlooked. Emphasis on environmental flows and understanding future water flows is important. Simulations of hydropower impacts at the local

	scale and local level scenario analysis are needed, as problems in one watershed may differ from another. The focus should be on water availability, water demand, and livelihoods. An integrated localized factor approach can improve risk assessment at a local scale in a more granular level. This can also help answer questions about optimizing infrastructure and whether it will improve water allocation. A multi-sectoral view is needed to tailor a local perspective of the challenges that hydropower would bring. Enhancing the resilience of communities is also needed from an implementation viewpoint. Overall, stakeholder buy-in is required as ecosystems are becoming more fragile. Trade-off analysis can help answer these complex questions.

Summing up

The panellists were requested to summarize the discussion by identifying existing challenges for cross-sectoral and multi-country data collaboration in this area, along with providing potential opportunities.

Daniel Broman	Leveraging earth system data presents opportunities and challenges, including the need for validation of meteorological data and the sensitive use of data for evaluation purposes.
Mark Christian	Leveraging existing data, particularly hydrological forecasts, presents a significant opportunity. Translating this high-level data to asset-specific activities and identifying impactful next steps is crucial. However, using this data to drive meaningful change in investments is complex and requires multi-stakeholder engagement. Such discussions are key to addressing these challenges.
Marie L'Hostis	Legal and regulatory frameworks pose challenges, particularly in terms of data privacy and security. However, by addressing these issues and engaging in multi-country, multi-stakeholder data creation, we can unlock the full potential of enhancing the climate resilience of this sector.
Giriraj Amarnath	Data reliability is a global challenge in hydropower analysis, hydrology, and flood forecasting. Improving Early Warning Systems (EWS) infrastructure is crucial, but capabilities are limited. Developing a catalogue of hydropower disasters and best practices through initiatives like CDRI can fill information gaps. Opportunities lie in multi-stakeholder coordination to enhance hydropower efficiency and grid stability using AI. EWS can foster collaboration and knowledge sharing. Despite its cost, EWS can be optimized by focusing on maintenance and stakeholder coordination. It should integrate climate change protection for long-term adaptation strategies, bringing co-benefits to sectors impacted by hydropower.
Erica Udas	The International Centre for Integrated Mountain Development (ICIMOD) is enhancing flood forecasting by making community-based Early Warning Systems (EWS) more reliable and linking them with local governments for financial sustainability. They are monitoring

	permafrost and the cryosphere, particularly during winter when rivers are primarily snow-fed. ICIMOD is mapping potential Glacial Lake Outburst Flood (GLOF) lakes and developing risk models using machine learning and AI techniques. They are also collaborating with the Government of Nepal to establish guidelines for climate-resilient hydropower development. Considering the mountainous context, ICIMOD is exploring the potential of small and micro hydropower producers for productive use in the irrigation sector. A mapping process of these projects is underway to aid investment decision-making.
Jinsun Lim	The biggest challenge lies in obtaining comprehensive datasets. While the International Energy Agency (IEA) has made significant progress in gathering meteorological data, there is a need to acquire hydrological, social, economic, and energy sector data. A key opportunity exists in the CDRI led Community of Practice (CoP) on Hydropower Sector resilience, which can spearhead initiatives to compile comprehensive data for Early Warning Systems (EWS).
Hemlata Bharwani	The challenge lies in the uncertainty and quality control of data. However, this also presents an opportunity for rigorous verification and validation of the data to ensure its accuracy and reliability.
Isabella Villanueva-García	The primary challenge lies in intersectoral and interinstitutional coordination due to the involvement of numerous stakeholders in data collection and analysis. However, this also presents an opportunity to learn about the data and enhance coordination, leading to improved decision-making processes.
Manjusha Mishra	While empirical methods are currently used for estimating block volumes, the need for real-time information for glacier lakes is evident. This presents an opportunity to leverage technological advancements. Additionally, there is a willingness at the project level to implement Early Warning Systems (EWS), further enhancing the potential for improved data analysis and decision-making.

Conclusion

The moderator, Ramraj Narsimhan, encapsulated the discussion as follows: Several salient points were emphasized which included the significance of data spanning various time scales; the necessity for data that is customized to the local context; the resolution of the data matrix; the priority of providing extended lead times during extreme events; the importance of societal engagement and collaboration with a broad spectrum of stakeholders; and the merit of capitalizing on past experiences. These components are vital in the context of enhancing hydropower resilience and adapting to climate change. They underscore the complexity of the issue and the requirement for a comprehensive, multi-dimensional strategy.

In conclusion, Aishwarya Pillai from CDRI set out the future focus and a call to action following this insightful discussion, which served as a foundational platform for subsequent dialogues within the Community of Practice on Hydropower Sector Resilience: We extend our gratitude to the entire team and CDRI for facilitating this multi-stakeholder dialogue. This is a pivotal activity, and there are numerous more to follow, including in-depth explorations and sustained engagements with all partners, which will also involve collaborations with

ICIMOD, IWMI, EPRI, PNNL, among others. We anticipate the creation of knowledge products and tangible outcomes from this Community of Practice.