CONSULTATIVE WORKSHOP POST-EVENT REPORT

Opportunities for strengthening sediment monitoring in Nepal

8 November 2022, Kathmandu, Nepal

SECTION 1

Background and summary

There is growing interest in developing seasonal reservoirs in new hydropower projects in Nepal as existing hydropower projects generally don't provide energy during the dry season. This requires a better understanding of sediment transport processes in all rivers, including identifying differences in sediment loads between rivers and timescales. Our research shows that that sediment transport has been increasing due to change in land use and climate. The rivers of Nepal are known for their high sediment load. This presents multiple challenges, one of which is sustainable hydropower development. Long-term data on sediment dynamics is needed to understand their impact on sustainable hydropower projects. Sediment monitoring data available today are inadequate for improved decision-making.

As part of the collaboration between ICIMOD and NVE, a preliminary report entitled 'Opportunities for strengthening sediment monitoring in large watercourses in Nepal' was published in 2022. The report identifies opportunities for better coordination for sediment monitoring in large water courses in Nepal. To highlight the conclusions in the report and to help promote initiatives for further work on sediment monitoring in Nepal, ICIMOD, ICH and NVE organised a half-day workshop on 8 November 2022 at the ICIMOD headquarters in Kathmandu. The workshop brought together various stakeholders from government, industry and academia working on sediment monitoring in Nepal.

The main ideas and opportunities for strengthening sediment monitoring are included under the following themes:

- Education and training of professionals and students in sediment-related fields
- Standardisation of methods for sediment data collection and analysis
- Creating and updating a database with adequate quality control
- Exploring the use of sediment data for broader purposes
- Collaboration between public, private sector, and universities/academia
- General comments

SECTION 2

Key messages from the workshop

Pema Gyamtsho, Director General, ICIMOD, Kirsten Winther Westgaard, Program Manager, NVE, and Tom Solberg, Project Director, ICH, welcomed the participants to the workshop.

Sedimentation processes and their impacts in river basins are not clearly understood. The impact of sediments on hydropower and other infrastructure in the catchments and the reasons why sediment transport occurs are still being studied. ICIMOD works in its member countries to help them learn and share good practices in sediment monitoring.

During the monsoon season, heavy sediment loads are generated in mountainous areas due to intense precipitation. There is also much degradation in catchments due to deforestation, construction of roads, etc., leading to increased sediment generation.

Hydropower development presents a huge opportunity for the region, and a proper understanding of sedimentation processes is important when assessing the feasibility and sustainability of hydropower. We need to develop an agenda to strengthen the sediment monitoring system and ways to collaborate in the coming years to achieve this goal.

This workshop is the culmination of the current collaboration between ICIMOD and NVE. The goal of the workshop is to bring important actors in the hydropower sector together to discuss opportunities for strengthening sediment monitoring in large rivers in Nepal.

SECTION 3

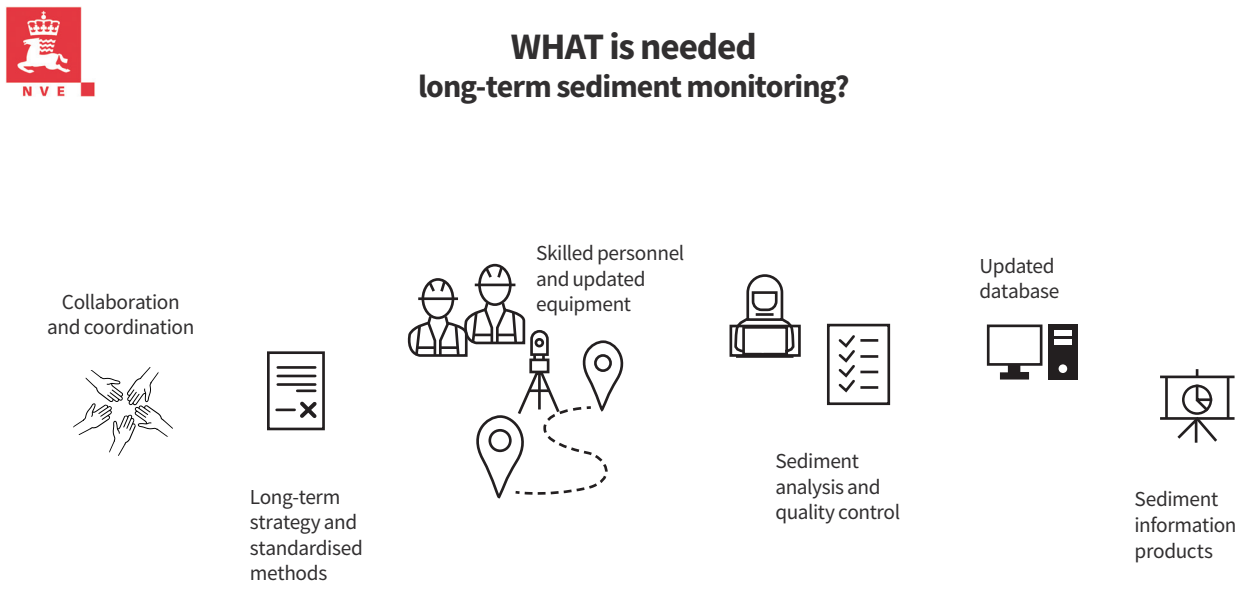
Summary of the preliminary report: Sediment load surveillance and monitoring

Mette Eltvik Henriksen, Senior Engineer, NVE, presented a summary of the main messages of the preliminary report. In the introduction, she shared the two most important lessons she has learned from her grandfather: firstly, Bernoulli's principle about how the speed of a fluid relates to the pressure of the fluid, and secondly, the fact that nothing is impossible if one tries hard enough to rise to challenges and grasp opportunities.

The preliminary report is an outcome of the SnowAMP Phase 2 (snow accumulation and melt process) part of the ICIMOD-NVE collaborative project 2019–2022. The report is based on a fact-finding workshop held in May 2019, during which it became apparent there is a need for long-term data to understand how sediment dynamics can affect the sustainability of hydropower projects in Nepal. 2022 is the end of the ICIMOD-NVE project period, and we, unfortunately, do not have the mandate to work further on this topic. It is hoped that this workshop will stimulate actors to pursue the opportunities and challenges highlighted in the report.

Long-term sediment monitoring is important for hydropower projects. It helps generate information that project developers need to convince investors and decision-makers of the feasibility and long-term sustainability of their projects. Good historical data and expert knowledge of sediment transport

FIGURE 1 **POSSIBLE STEPS TOWARD A SUSTAINABLE SEDIMENT MONITORING SYSTEM**



is necessary for developing a robust strategy for managing sediment risks. Such a strategy should guide the planning, design, and operation of hydropower projects. Other sectors such as agriculture, navigation, flood alleviation, road and bridge construction, land use planning, etc. could also benefit from such data.

Workshop participants were divided into groups to deliberate on the following topics:

- Education and training of professionals in sediment-related fields
- Standardisation of methods for sediment data collection and analysis
- Creating and updating a database with adequate quality control
- Explore the use of sediment data for broader purposes
- Collaboration between public, private sector, and universities/academia

Henriksen opened the group work on the above topics, the results from which are included in this post-event report.

SECTION 4

Cost-effective sediment monitoring on hydropower projects

Umesh Singh of Hydrolab explained that run-of-river hydropower projects are often designed based only on water availability. It is, however, often the sediment content in the flow that limits the production during operation in the monsoon period. Experiences from the Karnali corridor: Connecting India and China

Optimum sediment management can be achieved by reduced exposure through improved sediment exclusion capacity; increased resistance against erosion by sediment-friendly turbine design; reduced losses with an efficient operation and maintenance programme; and reduced exposure through a sediment management orientated operation regime.

We need to know the sediment load in the river to design the optimum size of settling basins, to estimate guaranteed lifetimes for turbines and turbine repair and maintenance frequency and costs, to assess the value of available water during the monsoon, and the cost per tonne of sediments passing through turbines. Sediment monitoring is essential for determining these important parameters.

Sediment sampling includes a sampling of both suspended sediments and bedload. There are a number of technologies for suspended sediment sampling, including depth-integrated sampling, iso-kinetic sampling, and hand-held point sampling. Automatic methods such as ADPC measurements are also available, but these require careful understanding, planning, and calibration. The sampling frequency is important and is defined in the Hydropower Development Guidelines (DOED, 2018). Typically, at least one sample per day during the monsoon period (preferably 2–3 or more) and less frequently outside the monsoon season is recommended. Ongoing research and development of sediment surrogate technology looks promising for the automatic measurement of sediments using different techniques; however, none of the technologies have been fully successful in covering the required range of concentration and particle sizes present in rivers.

Sediment Particle Size Distribution (PSD) can be measured in a number of ways including sieve analysis, sedimentation methods (pipette tube, hydrometer, VA Tube), and by laser diffraction methods.

Mineral content can be analysed by physical examination under a binocular microscope, by chemical examination using acid wash techniques, by optical examination under a petrographic microscope, and by using X-ray diffraction methods.

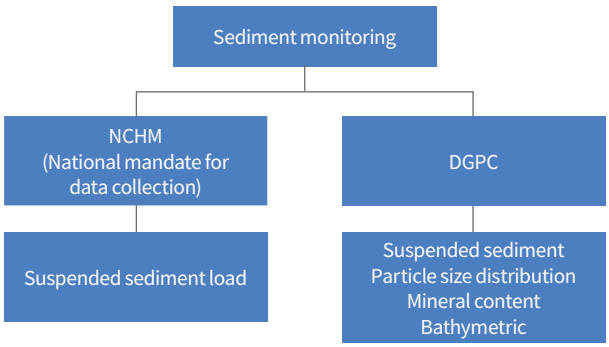
SECTION 5

Experience from sediment monitoring in Bhutan

Pratigya Pradhan, Chief Engineer (Civil), Druk Green Power Corporation, shared experiences related to sediment monitoring in Bhutan. Hydropower development in Bhutan began with assistance from Norway. In 1992 the government came up with the Power System Master Plan (PSMP), which included 76 sites of >10 MW and 23,760 MW of technically and economically viable capacity. The installed generation capacity in Bhutan is currently 2335 MW, and projects that will generate an additional 1243 MW are under construction.

Figure 2 shows the division of sediment monitoring tasks between two organisations in Bhutan. In 1992 the National Centre for Hydrology and Meteorology (NCHM), formerly the Department of Hydromet Services, began sediment monitoring in Bhutan as part of the preparation of the Power System Master Plan under NORAD funding. It was initiated in the Punatsangchhu basin and has since been extended to 27 monitoring stations, mostly in the four main rivers of Bhutan, as shown in Figure 3. Hydropower plants in Bhutan are required to conduct sediment monitoring.

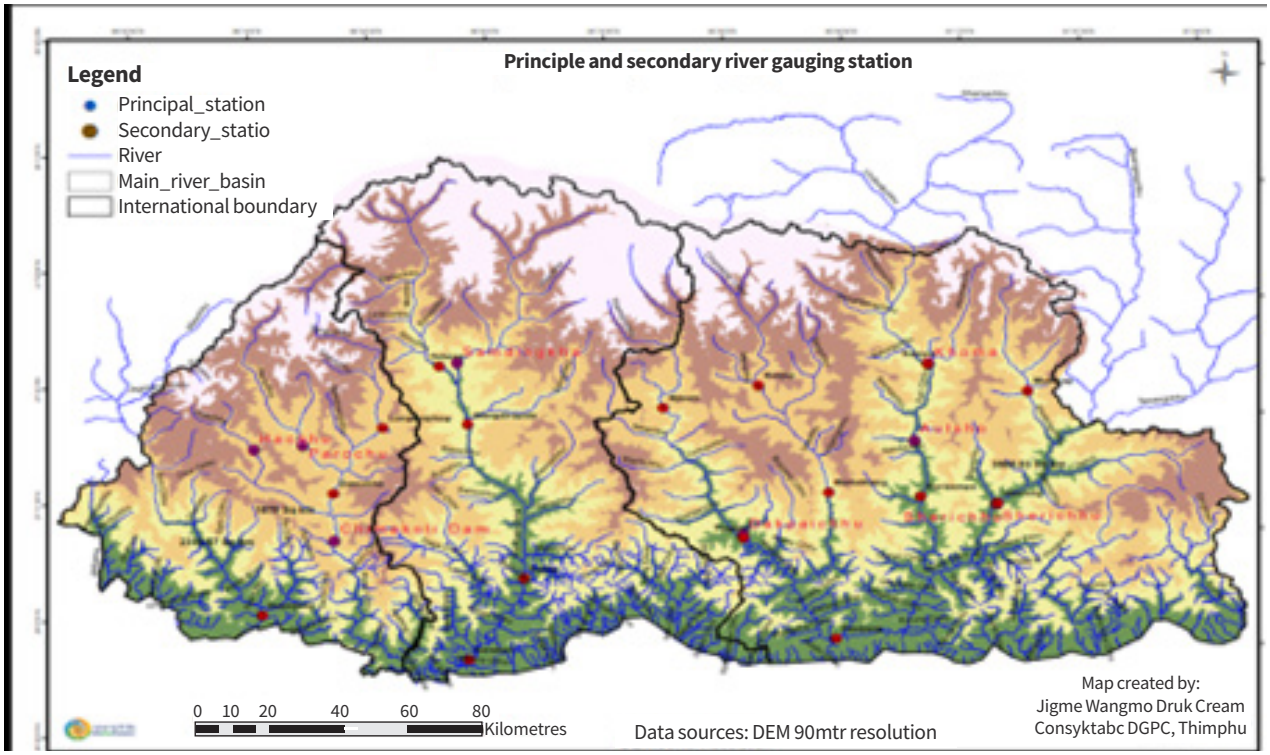
FIGURE 2 **DIVISION OF SEDIMENT MONITORING RESPONSIBILITIES IN BHUTAN**



The importance of sediment monitoring was demonstrated during the 1020 MW Tala HPP shutdown when national revenues from hydropower sales to India took a serious hit. In July 2021, around Nu.317 million was lost in just one week. The Tala HPP had not been flushed since it was commissioned in 2006 and the plant was shut down from January to March 2022 when the reservoir was emptied. Sediment deposits upstream of the dam could not be flushed, reducing the live storage for peaking.

The importance of sediment measurements is now very well understood in Bhutan and monitoring programmes are in place.

FIGURE 3 **SEDIMENT MONITORING STATIONS IN BHUTAN**



SECTION 6

Surveillance and monitoring of sediment

Professor Ole Gunnar Dahlhaug of NTNU/ Kathmandu University presented key features of surveillance and monitoring of sediment load including their concentration, size distribution and mineral content. He noted that as a mechanical engineer, he realises the importance of turbine maintenance and surveillance.

Sediment concentration is equally important as hydrological data but is often omitted. Sediment data is needed to design and construct a hydropower plant, e.g. for calculation of sand trap size, and to help turbine manufacturers choose appropriate technology and estimate maintenance costs incurred due to sediment erosion.

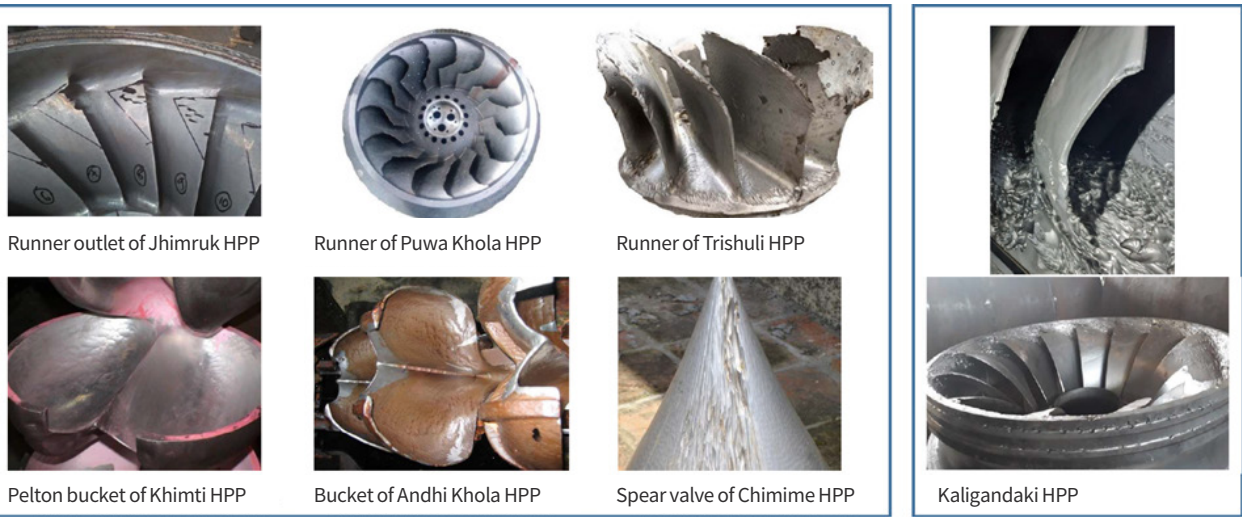
Professor Dahlhaug shared his experience using turbidity meters and calibrating them for the measurement of sediment loads in the Canon del Pato hydropower plant in Peru. He said he has never seen such a high sediment load anywhere else in the world. In the wet season the runners had to be changed every two weeks. This was not planned for, and both the power company and the nation lost a lot of revenues from electricity generation.

His recommendations for strengthening the sediment monitoring system in Nepal are:

- Start sediment measurements according to international best practices;

- Hire experienced companies like Hydrolab for development, operation, and maintenance of measurement sites.
- Make sediment monitoring and sharing of sediment data a requirement for hydropower developers

FIGURE 4 SEDIMENT DAMAGE FROM VARIOUS HYDROPOWER PLANTS IN NEPAL



SECTION 7

Group work results

Group discussions were held on opportunities and future synergies for long-term sediment monitoring, moderated by Tom Solberg, Project Director, ICH, and introduced by Mette Henriksen, NVE. The results are summarised here.

Education and training of professionals and students in sediment-related fields

- Create a platform or forum, a 'centre of excellence', to gather teaching materials, guidelines, and manuals, and organise trainings, workshops and seminars to share experience.
- Trainings could be incorporated in university curriculum or designed as specific training programmes. (ICIMOD, ICH or NEA could possibly play a role in organising these.)
- It is important to include developers and consultants/planners in sediment measurement training and data sharing.
- Encourage regional and international experts both from academia and the industry, to share knowledge and experiences.
- Hydropower plant operators: Create arenas for physical and digital sediment modelling and share results/case studies to help other professionals.
- Identify and help fill knowledge gaps regarding sediment sources, pathways, cascades, etc. This would be possible through basin-wide collaboration, such as basin organisations or utility owners' associations.

Standardisation of methods for sediment data collection and analysis

- Review DoED guidelines to ensure that they are aligned with industry best practices and develop standard templates for data collection and analysis (DHM, NEA could be involved).
- Standardise sediment measurement methodologies, laboratory testing procedures and databases, and introduce a policy where

project developers are required to share data with the government (before, after and during construction) to obtain a license. Consider institutionalising the database.
- Extend collaboration with international laboratories for sediment analyses.
- Stakeholders should be required to address sedimentation from the early stages of project development and have a plan for how to continue monitoring and how to deal with sediments after commissioning.
- Establish an early-warning system for large sediment events in Nepal.

Creating and updating a database with adequate quality control

- A national organisation should be formed to handle the database including validation and operation.
- Formulate policies that require hydropower developers to collect data and digitise and share them in order to obtain license for their projects. Such policy should be based on the principle of easy and free access.
- Implement quality control and ensure that producers or NEA validate collected data based on data screening standards that could be developed by DHM.
- Secure donor funding for the database and establish an owner or custodian for taking care of the database and promoting its proper use/ providing free access to users.

Explore the use of sediment data for broader purposes

- Sediment issues can be a concern for all water users as it affects drinking water, irrigation, hydropower and navigation, and data should be available for all water users. However, hydropower is the main sector directly affected by sediments in its revenue generation and therefore needs to take a leading role.
- Sediment data could be used for climate change research.
- The impact of sediment load and particularly sediment flushing on the ecosystem, aquatic life, and biodiversity.
- Explore possibilities for early warning systems.
- Use sediment data in studies of minerology of the catchment to better plan hydro projects and provide information on how to protect the inter-catchment environment.
- Employ sediment data measurements in construction planning and to create sediment monitoring and warning systems in hydropower projects.
- Use visualisation models to understand sediment behaviour and help predict deposition of sediments at settlements and infrastructure sites.

Collaboration between public, private sector, and universities/academia

- Establish a sediment monitoring system within existing regulatory bodies.
- Set up a common mechanism including all relevant stakeholders for monitoring, data collection, quality control and data sharing
- Relevant government institutions should play a central role, be a custodian.
- Public institutions like DHM, DoED, WECS; private sector entities like IPPs (IPPAN); Hydrolab universities like KU/NTNU, IOE; and potential donors would be a natural part of the above-mentioned mechanism.
- Promote coordination between local government and other stakeholders in the same river/ catchment.
- Establish training programmes for students, including relevant internships.

General comments

- Sharing sediment data is necessary for designing sustainable hydropower.
- Understanding the entire catchment from source to power plant cascade is important in training. Standardisation and digitalisation are necessary.
- It is important to collaborate with academics from both within the country and abroad. Should carry out research on this topic and encourage students to study these topics so they can contribute to developing solutions.
- Should identify a coordination body to ensure an optimally distributed network of monitoring sites to minimise duplication/redundancy, while ensuring significant gaps are not created in data collection.
- Comprehensive investment is needed in monitoring infrastructure/system set up by various agencies in the public, private and academic domains. Operational costs are important for the sustainability of the system.
- New research and development should be made available to developers and their consultants.

There is a need to build their confidence for using new technology.

- Economic analysis should be applied to sediment management practices.
- Increase the focus on sustainable reservoirs in view of environmental consequences.
- Preventative measures mean that we measure sediments at the source. Measurements of sediment load should be used in the analysis and design of projects.

SECTION 7

Concluding remarks

Kirsten Westgaard, NVE, thanked the participants for the useful discussions and valuable inputs. She emphasised the importance of ownership of the process by the stakeholders and expressed hope that the workshop had inspired the participants to launch new initiatives in this field.

On behalf of ICIMOD, Miriam Jackson thanked the participants and organisers for their enthusiasm and engagement.

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