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"Implementing one-size-fits-all criteria to assess dam removal projects in the global context is at least useless and at most dangerous"

With a design life of 50 to 100 years, most large dams worldwide were built between 1930 and 1970, and could show signs of ageing by now. Dam decommissioning is a growing trend in the developed world as older dams become increasingly more expensive to maintain or become obsolete.

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A report by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) highlights that many of the tens of thousands of large dams built in the 20th century are operating at or beyond their design life. Increasing potential of dam failure, rising costs of repair and maintenance, and loss of functionality and effectiveness are some of the signs of an ageing dam. We interview author Dr. Duminda Perera about this emerging global risk and the implications of dam decommissioning, a relatively recent phenomenon gaining pace in North America and Europe.

With over ten years of experience primarily focusing on water-related disasters and risk management, Dr. Perera's expertise covers surface and subsurface hydrology, numerical modeling, disaster risk reduction (DRR), early warning systems, climate change impact assessments, integrated flood management, and capacity development. Before joining UNU-INWEH, he worked for many years in Japan as a research specialist at the UNESCO International Centre for Water Hazard and Risk Management (ICHARM). Since joining UNU, he has been working on climate change, DRR, and water resources variability-related themes. His current research focuses at UNU-INWEH include a global evaluation of operational flood early warning systems, assessing African water security, ageing water infrastructure, and water-related threats to megacities.

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What are the emerging trends in dam decommissioning?

Decommissioning dams is a relatively recent phenomenon but is becoming progressively more common on various scales globally and regionally; for example, it has become quite common in the USA and Europe. The dams removed are, however, primarily of smaller size. Removal of large dams is still in its infancy, although a few cases have been recorded mainly in the last ten years. The USA plays the leading role in dam decommissioning, removing nearly 1,275 dams in 21 states over the previous 30 years. However, most of the removed dams were smaller in size (< 5 m height) and privately owned. The decommissioning of the Glines Canyon and Elwha Dams which are nearly 110 years old and over 60 m high in Washington, USA, is recorded as the largest dam decommission project with a cost of about USD 325 million. In Europe also a number of dams are decommissioned, mainly in relation to their environmental impacts.

In developing countries, dam decommissioning has not significantly emerged as a solution to ageing dams yet. Those dams' functional contributions to their economies are inevitable, and still, a replaceable alternative is not feasible in terms of cost and technology.

How do the socio-economic impacts of dam decommissioning vary between low and high-income countries?

A dam decommissioning will have various societal impacts, such as changes in the local economy. Fisheries, agriculture, tourism, and hydropower will be affected by dam removal and, in turn, impact employment opportunities and livelihoods. The extent of dam removal impacts may vary based on geography and socio-economic conditions. In developed nations where water availability is reliable, many ageing dams have been rendered obsolete. Their removal may be the ideal choice to manage ageing infrastructure because of the cost-benefit and the positive ecolog-

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ical impacts of regaining a free-flowing river. However, dams may be critical infrastructure for low-income countries to provide clean water and sanitation, irrigate crops for improved livelihoods and poverty alleviation, and provide a reliable, clean energy source. In these cases, dam removal may not be a viable option. Thus, implementing one-size-fits-all criteria to assess and prioritize dam removal projects in the global context is at least useless and at most dangerous.

The agricultural sector may benefit from or be inhibited by dam removal. For low-income, developing nations in the global South, dams and irrigation systems can play a critical role in alleviating poverty (e.g., in Asia and Africa, most large dams are for irrigation purposes); hence, dam removal could have detrimental consequences to local livelihoods. Alternately, dam removal may turn out to be beneficial for people who previously relied on the reservoir footprint for agricultural lands such as pastoral societies or subsistence farming.

Hydropower generation can be significantly affected if a dam is removed. In developed economies where access to electricity is nearly universal, removing obsolete hydropower dams may have a limited impact on local societies. In contrast, in developing economies where people lack access to electricity for their homes and workplaces, a hydropower dam removal may have far-reaching negative consequences and, thus, not be a viable option to address ageing infrastructure.

Rivers are rarely dammed for the sole purpose of fishery creation, and in most cases, damming a river results in losses of riverine fisheries. Dam removal can increase fishery yields that are important for local populations. Dam removal may stimulate the local economy by increasing tourism, but reservoirs can also attract tourists, e.g., swimming, fishing, and boating, which may be lost if the dam is removed.

The cost of dam removal is estimated to be an order of magnitude less than that of repairing. Do you think the cost will be a primary driver to choose dam decommissioning over repair?

Costs for repair and decommissioning are critical factors in the decision-making process of a dam's fate. However, public safety, continuous maintenance

costs, sedimentation, and environmental impacts are equally important factors to be considered.

According to the report, both constructions of a new dam and its later decommissioning must consider various positive and negative economic, social, and environmental impacts. To what extent does decommissioning, in those countries where it is already taking place, follow regulatory procedures similar to those necessary for dam construction?

Dam decommissioning is still practicing primarily in North America and Europe especially on smaller dams. There are published guidelines by several states in the USA to follow in dam removal; their main focus is on privately owned dams. In Canada, provincial governments, e.g., Ontario, have published a decision-making framework to implement dam removal. Likewise, regional procedures are available; however, this issue is emerging globally. Therefore it is essential to develop standard or commonly used regulatory procedures.

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Extreme weather events as a result of climate change can increase the threat of ageing large dams designed using historical hydrological data. On the other hand, a recent study by Japan's National Institute for Environmental Studies exposes the role of dams in mitigating flood risk under climate change. Do you think climate change should be another factor to consider when making decisions about the future of dams?

Yes, absolutely. Climate change-induced extreme events, primarily floods and droughts, can cause significant impacts on these ageing structures. Increased intensity and frequency of extreme flood events can challenge dams' structural integrity and capacity. Overtopping is a common cause of several dam failures recorded in the past. Also, the dams in the tropics will face high evaporation rates in the future due to increased temperatures leading to storage losses. Eventually, these events are threats to the effective functioning of dams.

Flood control is one of the major functions dams were designed for. We agree that dams play a big role in mitigating flood risk. Due to the loss of stationarity of the hydroclimatic data as a result of climate change, it is challenging to

predict future events based on past data. Therefore, the decision about ageing dams should be made considering the uncertainties in future events, capacities of dams, and their structural integrity.

Large dams are still planned in some regions. To what extent do you think the implications of dam decommissioning should be taken into account during the planning phase for a new dam, similarly to other major projects, such as mines which include planning for future reclamation activities?

> **Decommissioning is an issue emerging globally, therefore it is essential to develop a standard or commonly used regulatory procedures**

Irrigation and hydropower are the main driving factors for planning dams in some regions. We do not know how far those project planners have considered the planned structure's decommissioning after its lifespan. However, the dams built in the 60s and 70s are reaching the end of their lifespans are now facing the ageing issue; these cases suggest present-day dam planners ought to consider decommissioning as the end component of a dam's life cycle.

The report calls for protocols to guide the process of dam removal, to understand processes and outcomes. What do you see as the path ahead for this to become a reality? Are any countries leading in this regard?

Over 90% of large dams are located in 25 countries. The majority of them are in the developed world, which is economically and technologically advanced enough to find sustainable alternatives for the ageing dams, including dam decommissioning as a solution. So far, dam removal is limited mainly to small dams in North America and Europe. However, sharing the lesson learned, technology, and experience can lead the other nations to develop sound plans for dam removal in their soils. Ultimately, value judgments will determine the fate of many of these large water storage structures. It is not an easy process, and thus distilling lessons from and sharing dam decommissioning experiences should be a common global goal. Lack of such knowledge and lack of its reflection in relevant regional/national policies/practices may progressively and adversely affect the ability to manage water storage dams properly as they age.