Research Report 2020/1

Rivers, Hydropower and Eflow: Development & Conservation Challenges in Nepal

Institute for Social and Environmental Transition-Nepal

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Photo: Cover page: Aadhikhola hydropower project (9.4 MW), Shyanja District

Back page: Jhimruk hydropower project (12 MW), Pyuthan district

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Rivers, Hydropower and Eflow: Development & Conservation Challenges in Nepal

Rashmi Kiran Shrestha[1] and Ajaya Dixit[2]

Preamble

Assessing the connectivity of 12 million km of rivers globally and identifying which are still free flowing in their entire length, Grill et al. (2019) suggest, is important for our conservation efforts. "The flow of rivers", they remind us, "enables the movement and exchange of water and of the organisms, sediments, organic matter, nutrients and energy that it conveys throughout the riverine environment. This supports diverse, complex and dynamic ecosystems, providing important societal and economic services. Infrastructure development threatens the ecosystem processes, biodiversity and services that these rivers support." Examination of river flow in the river basins of South Asia can offer especially useful insights as rivers here exhibit both floods and low flow and their consequences, flood disasters and droughts. Of particular interest are the Ganga and Indus rivers and their tributaries, both of which support millions of people living but neither of which flows freely from source to ocean. Even in their main tributaries, multiple dams and barrages obstructs river system, all built to divert water to irrigation systems and hydropower plants.

One of the largest tributaries of the Ganga, the Koshi River has three main tributaries in Nepal, the Sun Koshi, the Arun, also draining areas in Tibet, and the Tamor. They meet at Tribeni before being joined by the Trijuga River and flowing southwards into Nepal's Tarai and on into India. The Kosi joins the Ganga at Kursela, Bihar. The Koshi's shifting courses and annual flooding have historically affected large geographical areas and populations, both in Nepal's south-eastern plains and in Bihar India. Since the late 1890s, governments and engineers in India have focused on the challenges of containing the Koshi River. In 1954, almost 150 years after the first discussions began, the governments of Nepal and India signed an agreement for controlling and using the river for irrigation and hydropower generation. The river and its tributaries also meet various ecological function.

A Political Economic Analysis (PEA) of the Koshi basin found that ecological values are at the periphery of the conventional approach to development and management and that there are very few conversations at various scale about challenges facing the basin. [3] Though Koshi's water has multiple use at multiple scales, management approach is sectoral and interest of citizens and state and local users differ and that trans-boundary nations' priorities are also different. To examine these limitations, institute of Social and Environment Transition Nepal ISET-Nepal and Gorakhpur Environmental Action Group respectively carried out dialogues in Nepal and in India with various stakeholders. The first theme was flood and inundation and multiple uses and meaning of water. And the second theme was environment flow (Eflow). Dialogues with different stakeholders in Kathmandu and in the villages located on the back of the Bhote Kosi River (Khadichaur and Barahbise, Sindhupalchowk, District) were held. Bhote Koshi was selected because it is a trans-boundary sub-basin draining Tibet (China) and Nepal. It faces multiple hazards like Glacial lake flood, cloudburst, earthquake, flooding and landslide induced dam breach.

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[3] See Dixit et al (2017)

In Kathmandu, ecologists, academia, Independent Power Producers' Association, Department of Environment and Forest, Department of Energy Development, and Water and Energy Commission secretariat took part in the dialogue. ISET Nepal hold dialogues with a large group and one-to-one basis. The subjects covered polices and compliance to various policies of water. Major focus was on Eflow policy of Government of Nepal (GoN)'s. There is a Hydropower Development Policy 2001 to release 10% of the minimum monthly average discharge (Environment-flow/or E-flow) or minimum suggested by EIA. In most hydropower projects, however, this policy is not complied with while the adequacy of a stipulated amount is unclear. Lack of flow downstream of dams impacts fish passage and production, local irrigation, aquatic ecology, livelihood, water-based tourism and faith-based rituals.[4]

The participants brought diverse perspectives to the dialogue and as expected there was no consensus on various issues. Views on how river should be managed and developed were sectoral. The participants did recognize that the water landscape was becoming more complex and emerging constraints make them more complex. Micro issues are poorly understood at macro level and vice versa. Everyone agreed on one value, that "Rivers must have minimum clean flowing water". There was no consensus on how to achieve or ensure compliance to the GoN's policy on E-flow. Lack of access to information was recognize as a major limitation. The participants also felt that there is a need of a state of art knowledge product on status of E-flow in Nepal. This research report is guided towards meeting this stipulation.

This report focusses on the status of tributaries of the Ganga River that lie in Nepal from the perspective of the freeness of their flow. This perspective is important given the global discourse on sustainable hydropower development. In addition, it is recognized that interventions in rivers intended to promote economic development result in hydrological fragmentation. Making E-flow its central point of discussion, the report reviews the changes in the journey of global dam-building in the 20th and 21st centuries. Furthermore, the report presents the global discourse on E-flow. Finally, this report draws lessons for Nepal, a county in which many dams of different sizes and configurations are being built.

River Systems in Nepal

The interaction between the formation of the Himalaya and the pattern of monsoon and winter rainfalls have shaped the landscape, river systems and social context of South Asia (Zollinger, 1979). About 70 million years ago, as Indian plate began pushing towards the Eurasian plate, the Tethys Sea shrank and the Himalayan system emerged. Before the Himalayan range was formed, rivers like the Kali Gandaki and the Arun flowed into the Tethys Sea. Thus, when the colliding plates pushed up the range, these rivers cut through it, creating some of the deepest gorges in the world, including that formed by the Arun as it flows between Kanchenjunga and Mount Everest (Sagarmatha/Chomolongma) in the East and by the Kali Gandaki (or the Krishna Gandaki, as it is known in the upper reaches) as it flows between Annapurna and Dhaulagiri ranges in Central Nepal. The gorge created by the flowing of the Bhote Koshi (also called the Sun Koshi) between Jugal and Langtang ranges in central Nepal is less dramatic, but no less impressive. The Karnali flows from the region southeast of Kailash mountain in Tibet. As the two plates continued to collide, the Mahabharat Range was formed to the south of the Himalaya range, becoming a barrier to the south-flowing rivers. These rivers were forced to flow parallel to the range until they could cut through and form yet shallower gorges. Today, as the rivers flow into the Tarai plains, the

[4] Rijal, Narayan, Shrestha, HK.,Bruins, B. (2018). *Environmental Flow Assessment of Hewa Khola A and Lower Hewa Khola Hydropower Projects in Nepal* (23), 71-78.

remnants of the Tethys Sea, they meander and deposit the sediment loads that they carry down from the mountains.

The Sapta Koshi River flows onto the plains through the gorge at Tribeni, where the Sun Koshi from the west and the Tamor from the east join with the Arun from the north. The other four tributaries of Sapta Koshi River, whose name means "seven," are the Indrawati, Tama Koshi, Likhu and Dudh Koshi. The Gandaki River also has seven major tributaries, including the Trishuli, Marshyangdi and Kali Gandaki. The Trishuli after Galchi and Kali Gandaki downstream of Ramghat in Palpa flow in an east-west direction north of the Mahabharat Range. The Trishuli, Marshyangdi and Kali Gandaki along with the Seti, Daraundi, Madi and Burhi Gandaki form the Sapta Gandaki River. It exits the Mahabharat Range at Dev Ghat in Chitwan Nepal. Downstream of Dev Ghat, the river flows through the valley between the Mahabharat and Chure (Siwalik) ranges uplifted most recently, geologically by the collision of Indian and the Eurasian plate. The Sapta Gandaki crosses the Chure and flows into Bhaisalotan, a town close to the border between Nepal and India. In the Karnali basin, the Bheri comes from the east to meet the Karnali River at Chisapani. The West Seti River comes from the west, meeting the Karnali some distance upstream of the confluence of the Bheri and Karnali rivers. The combined Karnali River then flows through the gorge at Chisapani, across the Tarai and into Uttar Pradesh, India. Now called Ghagara, the Karnali river joins the Ganga River in Uttar Pradesh. The Mahakali River, another tributary of the Ganga, flows along the boundary between India and Nepal. As the river hurtles south, it is not joined by the kind of large, east-west-flowing tributaries such as the Sun Koshi Koshi, Kali Gandaki and Bheri in the Koshi, the Narayani and the Karnali basins. Water from snowmelt sustains the low flows of the tributaries of these basins in the upper reaches. In the middle hills, rainfall and inter-flow feed these tributaries as a major source of water.

The Ganga River also receives flow from non-snow-fed rivers that originate in Nepal's Mahabharat and Chure ranges. The Kankai, Kamala Bagmati, West Rapti, Babai and Tinau rivers drain the Mahabharat range and each flow into the Tarai through gorges less dramatic than the Himalayan gorges. The rivers originating in the Chure are flashy: their hydrology is characterized by individual peaks suggesting that rainfall in the upper catchments has a substantial influence on their discharge. When there is no rainfall, these rivers exhibit low-flow condition, almost zero in the upper reaches. As they flow south into their lower reaches, however, groundwater and base flow contribute to the discharge. These lower reaches may contain flow even in the dry season. These rivers are used extensively for local irrigation, and during the monsoon, they cause widespread flooding.

In the mountainous landscape, the channels are deep and formed of coarse materials that erosive forces carry downstream. All rivers in Nepal flow through the Bhabar zone, a strip of land 1 to 10 km wide running parallel to the Chure range. This zone is characterized by deposits of large-grain particles. These particles foster the percolation of water into groundwater aquifers. The bhabar zone is one of the primary areas of recharge of the deep aquifers of the Nepal Tarai and plains further south in India's Uttar Pradesh and Bihar. In recent decades the Bhabar zone has undergone major land-use changes because of the construction of roads, housing colonies and extraction of construction-grade materials from riverbeds and the Chure range itself.

Hydropower and Rivers

Traditionally, many rivers in the mountains and Tarai were dammed for irrigation using *syauli bandh*, or diversions made of stones, timber and vegetation. They usually extended only partway across a river and, because they were porous, allowed water seepage to lower reaches. The downstream river reach, for this reason, would not be completely dry. To generate motive power, communities in the mountains used water mills (*ghatta*). The communities sourced their drinking water from springs and stone water spouts. In the Tarai and lower valleys, in contrast, people sourced drinking water from open wells that tapped into groundwater. While people could meet their drinking water needs, poor sanitation and unhygienic practices meant that their health was poor. Women were the primary water collectors in the past and remain so today.

Modern water infrastructures first came to Nepal in 1888, 1911 and 1928 respectively, when Kathmandu's Bir Dhara, Chandra Jyoti Electrity and Sharada irrigation barrage were built. Bir Dhara was built more than a hundred years ago to supply drinking water to palaces and members of the ruling class. In 1911, Nepal's first hydropower plant was built to supply power to palaces. The major benefit of the Sharada barrage built in 1928 was irrigation water for Awad (present day Uttar Pradesh).

How do the above structures relate to free-flowing rivers in Nepal? Till 1950, most rivers in Nepal, other than the Mahakali and the Trijuga, (In which modern infrastructure such as Sharada Barrage and Chandra Barrage obstructed the river). The free-flowing status of the Koshi changed in 1959, when the Koshi Barrage was completed on the Nepal-India border after Nepal and India signed the Agreement on Koshi. Today, the upper reaches of the Sun Koshi are blocked by hydropower dams, but its reach downstream of Khadichaur flows free up to the Koshi barrage. This status will change if the dams proposed for the Sun Koshi River are built. Two of these proposed dams will divert the Sun Koshi's flow to Kamala and Marin basins through tunnels in the Mahabharat range. The Arun River flows freely from the Nepal-Tibet border to the Koshi barrage and so does the Tamor. Their free flowing status too, will be restricted once the dams being built and proposed are built. In the Gandak basin, the Trishuli River flows freely from Nuwakot to the barrage at Bhaisalotan, while the Karnali flows free from its origin to the Kailashpuri barrage in Uttar Pradesh just a few kilometer south of Nepal border. The Tanakpur and Sarada barrages (including the lower Sarada) impeded the main stem of the Mahakali River. Dams have been built across the Mahakali's tributaries in both India and Nepal.

In 1990, the country reinstated a multi-party democratic polity and new hydro power act allowed entry of the private sector hydropower development. Recent dam-building activities in Nepal have focused on one use of rivers alone—hydropower. Irrigation, too, receives some attention, but aquatic biodiversity, river ecology, livelihoods, and culture are neglected. In an era in which solar and wind power offer ever more viable and cheap alternatives, it is important to recognize the trade-off between these alternatives although the hegemony of the business- bureaucratic-political complex is maintaining the momentum of dam-building. Because the government has focused on hydropower development and inter-basin transfer projects, rivers in Nepal will undergo hydrological transformations and uses of rivers other than energy are likely to be neglected. In addition, rivers in Nepal face abuse from pollution and the unregulated extraction of construction-grade sand and aggregates. Policies make provisions for undertaking EIAs of water projects and river mining sites and implementing measures to mitigate negative impacts. Compliance with the policies are poor.

While the state of the rivers deteriorates, there is a propensity of issuing license for building hydropower plants. The economic benefits of hydropower plants obscures dominants and other uses of water. How does one balance the need for obtaining the economic benefits of rivers through hydropower development with the other services that a river provides? The answer to these questions needs to be situated in the context of the modern water development paradigm and the management system evolved in its wake. This paradigm is a hybrid mix of the model that began in the United States in the early 1900s and the model pursued by the colonial state in India.

Era of Dam-Building

In 1902 the U.S. Congress passed the Reclamation Act, perhaps the most transformative legislation in the history of the country and enabled urban, energy, and irrigated agricultural development (Ho et al., 2017). The Reclamation Bureau established under it constructed major dams to provide irrigation water and generate hydropower in Western US (Jones, 2008 and Ho et al., 2017). During the Great Depression that began in the 1930s, undertakings such as the Hoover Dam on the Colorado River (1931 to 1935), the Grand Coulee Dam on the Columbia River (1933 to 1942), and the Shasta Dam of California's Central Valley Project (1938 to 1945) (Jones, 2008) were authorized and built. This period coincided with the advent and end of the Second World.

In subsequent decades, the US built 18,833 dams, including some of the largest in the world (Graf, 1999). From the late 1950s to the late 1970s, the volume of reservoir storage in the US saw its greatest rate of increase ever (Graf, 1999). According to the National Inventory of Dams (NID), the US today has nearly 84,000 dams (FEMA, 2012). Gradually, however, the dam-building enterprise, with the US as its catalyst, shifted to other countries of the world. One of the most significant, yet largely hidden outcomes of the Cold War was the proliferation of hundreds of large-scale multipurpose dams throughout Asia, Africa, the Middle East, and Latin America, all of which were built under the auspices of water resource development programmes developed as technical assistance by various organs of the US government (Sneddon, 2012).

In 1969, Assistant Commissioner of the Bureau Gilbert Stamm (1969:1) reflected, 'The Bureau of Reclamation has provided technical assistance in the field of multi-purpose water resource development to over 108 countries in an effort to narrow the ever-widening gap in technology between the developed and developing countries' (Sneddon, 2012). A later overview in 1973 noted that Lebanon, Sudan, Tukey, Ethiopia, Thailand, India, Australia, Afghanistan, Brazil, China, Korea, Jordan, Egypt, Israel, Iraq and Iran had all received substantial assistance. From 1952 to 1974 dams were built across the world, from the Litani River basin in Lebanon to the Mekong in Thailand (Ibid). Altogether, over 57,000 dams with heights 15 m or more and more than 300 dams at least 150 m high (International River, 2019) have been built around the world. China has the most dams over 23,000, followed by the US with 9,200. India, Japan and Brazil round out the top five most-dammed countries. (International River, 2019). Today nearly half of the world's major rivers have at least one large dam. The dam-building trend reached a peak in the 1970s, when every day saw an average of two or three new large dams commissioned somewhere in the world (WCD, 2000).

From the 1930s to the 1970s, the construction of large dams was, in the eyes of many, synonymous with development and economic progress (Graf, 1999 and WCD, 2000). Viewed as a symbol of modernization and humanity's ability to control and use nature's resources, dam construction saw a dramatic increase (WCD, 2000). India's Prime Minister Jawahar Lal Nehru, while inaugurating the Bhakra Nangal project, offered one such laudatory perspective in 1954, identifying dams as 'temples of modern India'. By 1958, however, he had observed that India might be suffering from "the disease of gigantism". In a letter to chief ministers in 1957, Nehru recognized the need to balance development projects and environmental protection.[5] By then however, the dam-building enterprise had consolidated itself and paid scant heed to social and environmental costs.

That investment in dam-building has undeniably brought benefits. For example, dams have helped food production keep pace with population growth[6], provided energy and, to some extent,

[5]https://www.hindustantimes.com/editorials/it-is-time-to-rethink-the-big-dams-model-of-development/story-Q8aMISORnsxIr6o8MjuHEP.html. Accessed on 15th August 2019

[6]The use of pumps and groundwater also has played a major role in improving food security.

mitigated the air pollution associated with the burning of fossil fuels such as diesel. Most developed countries in Europe and North America were able to provide a reliable supply of clean drinking water and thereby to eliminate many waterborne diseases prevalent in the late 1800s (Gleick, 2000). By the 1950s, as economies expanded and populations increased, the role of dams as a means to meet water and energy needs further consolidated. Nearly half of the rivers in the world today house at least one large dam, hydropower produces over 50% of the electricity in one-third of countries across the world, and large dams generate 19% of electricity overall (WCD, 2000). Half of the world's large dams were built exclusively or primarily for irrigation, and 30–40% of the 271 million ha irrigated worldwide rely on these infrastructure (WCD, 2000). Regional development, job creation, and the fostering of an industrial base with export capability are cited as additional contributions of large dams.

In the US, the pace of dam-building increased after 1902. Its 85,000 dams collectively store almost one year of mean annual natural runoff and the equivalent of around 5000 m^3 of water per person (Graf, 1999). Dams have changed the economic landscape of the US; in fact, that landscape would be unrecognizable without these structures. They also dramatically changed the face of the West in the US. Demographers say that the West is now the country’s most urbanized region (based on the percentage of the population living in cities) and also the one with the greatest population growth (Jones, 2008). Similar changes occurred in many other parts of the world. The rate of dam-building slowly lost momentum, however, as discussed in the next section.

Dam-Building: Social and Environment Flow

On December 3, 1901, U.S. President Theodore Roosevelt, in his first State of the Union address, highlighted the need to “regulate and conserve the waters of the arid region.” He claimed, “It is as right for the National Government to make the streams and rivers of the arid region useful by engineering works for water storage as to make useful the rivers and harbors of the humid region by engineering works of another kind.” He further said, “In the arid region it is water, not the land, which measures production. The western half of the United States could sustain a population greater than that of our entire country today if the water that now run to waste were saved and used for irrigation.” (Jones, 2008).

Two major points that emerged from this statement dominated the global dam-building enterprise in the 20th century: first, that the hydrologic cycle needed to be modified by the construction of engineering projects for flood control, water supply, hydropower, and irrigation for human benefit and, second, that a free-flowing river is a waste. The colonial government in India had a similar viewpoint: it designated water not used to increase agricultural productivity and, in consequence, revenue, through irrigation as wasted water.

The government of the United Province in India used the language of “wasted water” to push through the Sarada Irrigation Canal Project, a project which had lain on the back burner for almost 40 years[7] because of the longstanding objections of the Talukdars of Awadh, who had begun their protest in 1872. In 1911, the government decreed that the waters of the Sarada River, which, in its view were being ‘wasted’ because the people of Awadh were not using them optimally, would be transferred to Punjab via the Agra Canal. The Talukdars opposed this transfer, but eventually the government prevailed. Construction of the Sarada Canal Project began in 1920 and was completed in 1928. Its barrage is built on the Nepal-India border across the Mahakali River, which is called Sharada in the plains.

[7] The proposal for this canal was first made in 1869, but its implementation was held up due to local opposition, particularly by the influential Talukdars of Awadh, landowning magnates on whom the British depended to maintain their rule in the region.

This language of waste and modification by structural intervention guided global dam construction for decades, but, over time, the negative consequences of such interventions on the riverine environment and society became clear and dams' contribution to development was questioned. Social activists and dam developers still debate how many dams promote development. Citing evidence from research, environmental degradation and displacement, activists call for a moratorium on dam-building. Proponents, in contrast, argue that dams are needed and must be built. They point out that every development endeavor has social and environmental costs.

By early 1990, the debate on dams had reached an impasse. In 1997 an effort began to explore whether or not a common ground could be reached between those who thought dams supported development and those who critiqued them: the World Bank and the International Union for Nature Conservation (IUCN) jointly organized a meeting in Gland, Switzerland, to identify a way forward. The participants formed a global commission, the World Commission on Dam (WCD), which included representatives of dam critiques and supporters and of industries. After two years of work, the WCD published its report in 2000. That report attempted to reach a consensus among proponents and opponents of large dams as well as to evaluate dams and incorporate accurate estimates of their true costs and benefits (Gleick, 2000).

The WCD report challenged existing practices and proposed stringent guidelines for building dams. The report however, did not minimize the debate, however, but perpetuated it. The pro-dam lobby argued that the WCD's recommendations were unrealistic and impractical and that, if accepted, would increase bureaucratic layers, enriching consultants and impoverishing the poor by depriving them of the benefits of dams. Some believed that the report would result in a sharp decrease in investments (World Energy Council, 2015). Anti-dam activists argued that the WCD's suggestions could serve as a starting point for reforms in dam-building practices that would reduce the vulnerability of poor and marginalized indigenous communities and mitigate degradation of the environment. Others believed the guidelines were not intended as strict regulatory standards but recommendations for best practice, which, if adapted to specific national and river-basin contexts, would help avoid the oversights of the past (Moore et al., 2010). However, the WCD process soon lost steam after the World Bank, one of its main architects, withdrew from the process.

Dams continue to be constructed in developing countries, particularly for hydropower generation. Proponents argue that hydropower is a renewable energy that can reduce carbon emissions and avert climate change. When the cost of a dam's entire life-cycle, including its energy-intensive construction and decommissioning, is considered, however, that calculation changes. Besides, though environmental assessments are conducted and mitigation plans prepared, compliance with social and environmental safeguards is poor. In many developing countries local monitoring of the operation of dams is minimal. These shortcomings are compounded by limited access to information, minimal local participation, and inadequate compensation and rehabilitation of involuntarily displaced families. In many cases benefit-sharing for locals is a poorly recognized opportunity.

The US and many other developed countries that embraced the prevailing approach could meet basic needs such as drinking water and sanitation, but ignored concerns about nature and local communities. With the diversion of rivers in upstream areas, downstream deltas and wetlands became devoid of flow, rivers turned into trickles or dried up altogether, and communities and aquatic life forms dependent on the natural flow paid heavily.

A similar story played out in many developing countries, even those achieving independence from their colonizers. In the newly independent countries, when dams were built, downstream ecosystems and the concerns of river flow-dependent communities were disregarded. The issues of gender, poverty and social diversity also remained peripheral in water development and management. To make matters worse, those involuntarily displaced when dams and water-related infrastructure projects were built received little or no compensation. They lost their lives, livelihoods and cultures. It was not until the mid-1960s that social activists and the media highlight the unmitigated environmental consequences and social costs of dams and bring attention to the plight of the displaced.

When river water in upstream sections was diverted to run turbines that generated electricity, flow downstream of the dam would decline so much no water was available for downstream users and ecosystems. In many cases, the geomorphology of river reaches downstream of dam was changed by such changes in flow dynamics, and the resultant alteration in aquatic biodiversity jeopardized the livelihoods and cultures of communities dependent on the river flow.

To minimize some social and environmental costs of dams, a new idea has gained in popularity: environment flow (e-flow). If this minimal flow could be maintained downstream of a dam, it would partly compensate for the losses.

Dams: Turning Point

In the mid-1980s, the paradigm of relying on ever-larger numbers of dams, reservoirs, aqueducts and canals to capture, store and move freshwater runoff received less priority because of rising environmental, economic, and social costs (Gleick, 2000). Until the late 1970s and early 1980s, water planning and management rarely considered the environmental consequences of major water projects and e-flow, the flow required to maintain natural environmental values received little attention (Ibid). Historically, the social and economic benefits of dams were perceived to be high and took precedence over environmental values, protecting downstream water supplies, and communities and involuntarily displaced families, which did not receive adequate compensation (Ho, et al. 2017). A global overview of large river systems shows that dams have been built in 172 of the world's 292 most biogeographically rivers (59%), including the eight most biogeographically diverse (Nilsson et al. (2005). Dam-impacted catchments experience higher irrigation pressure and about 25 times more economic activity per unit of water than do unaffected catchments (Ibid).

Building new water infrastructures has become increasingly more expensive than non-structural alternatives. When the first major dam projects were being built, such alternatives were considered relatively unimportant and economic analyses were done with incomplete information and questionable assumptions (Gleick, 2000). For example, all non-market environmental and social costs were excluded because they were unquantified or unquantifiable. Economic games were also played with stretched-out repayment periods, high discount rates, low-interest loans, and a transfer of costs to non-dam parts of water developments (Ibid).

Dam-building in the US, particularly throughout the West, continued to burgeon into the 1970s, and then, in response to the emerging environmental movement, reduced federal financial support for water projects, and that the most feasible projects had already been built, slowed down (Jones, 2008). Changing societal values were reflected in the enactment of federal legislation such as the National Environmental Policy Act in 1969, the Federal Water Pollution Act in 1969, the Federal Water Pollution Control Act (Clean Water Act) in 1972, and the Endangered Species Act in 1973 (Jones, 2008). The last of the traditional large-scale reclamation projects to receive congressional approval was the Central Arizona Project, which was allowed in 1968 and began being built in 1973 (Jones, 2008).

In North America and Europe, most of the technically attractive dam sites had already been developed, often with high environmental costs (Gleick, 2000 and Jones, 2008), before the decline of dam-building (Gleick, 2000; Jones, 2008; WCD, 2000). As a result, free-flowing rivers, natural riparian systems, and many aquatic species have become rare and valuable. The desire to protect these remaining natural systems has grown worldwide (Gleick, 2000). In countries where multiple environmental coalitions and advocacy groups emphasize the need for restoring river ecology through direct interventions, people are now more conscious of the environmental impacts of dams (Ho, et al. 2017).

Driven by the WCD's findings about the impacts of dams on people, river basins and ecosystems as well as data on their economic performance, opposition to dams began to grow (WCD, 2000). By the late 1960s and early 1970s, environmental movements in many countries gained strength (Gleick, 2000; Jones, 2008). During the early stages of this movement, debates focused on specific dams and their local impacts. But gradually locally driven movements began to evolve into a more general and ultimately a global debate not just about dams (WCD, 2000) but also about development in general. While there are some concerns in developing countries that environmental limits may simply mean constraints on economic development for the benefit of industrialized nations, there is growing grassroots opposition to large projects because of their local costs, including the involuntary displacement of populations, land inundation, and ecological disruption (Gleick, 2000).

In 1983, the UN formed the World Commission on Environment and Development (WCED). Headed by Gro Harlem Brundtland, it was mandated to propose a global agenda for change. The commission's final report, "Our Common Future" (WCED, 1987), published in 1987 and often referred to as the Brundtland Report, defined "sustainable development' as the achievement of economic growth in a way that does not damage the capacity of future generations to live upon the Earth (Little, 1995). In 1992, the Rio Conference, which was attended by 117 heads of state and government, addressed two conventions, one on biodiversity and the other on global climate change (Little, 1995). By then, awareness of the environmental and social impacts of dams worldwide had significantly increased.

While international financial institutions such as the World Bank and Asian Development Bank (ADB) and bilateral donors did finance dam projects in developing countries (Ryo & Nakamaya, 2009), there was a rapid increase in the number of transnational NGOs promoting social change in areas such as human rights, environment, and development. Some of these organizations questioned the role that bilateral and multilateral donors had played by funding large dam projects that adversely affected the environment and local communities in developing countries (Ryo & Nakayama, 2009). They also supported local NGOs in opposing dam projects. In recent years, the development of information technologies has facilitated the internationalization of dam issues (Ibid).

The trade-offs between dam construction and maintaining ecosystem health and services, food growth, and the provision of clean water are continuously discussed (Ho et al., 2017). Major international financial institutions, including the World Bank, and a large number of national governments, including China and India, did not accept the WCD's recommendations. China and India are the world's top and fifth largest dam-building countries (Ryo and Nakayama, 2009). Dam-building halted worldwide from 1999 to 2005. Since 2004, hydropower development has seen a resurgence, particularly in emerging markets and less developed countries (World Energy Council, 2015). This upsurge in hydropower dam has implications for the free flow of rivers.

Hydropower Resurgence

In 2018, electricity generation from hydropower reached about 4,200-terawatt hours (TWh), the highest ever contribution from this energy source (International Hydropower Association, 2019). The total installed capacity has grown by 27% since 2004 at an average annual growth rate of 3%. The rise was been high in emerging markets, where hydropower offers not only energy security but also provides water services and facilitates regional cooperation and economic development (Zarfl et al., 2014 and World Energy Council, 2015). An estimated 21.8 gigawatts (GW) of hydropower capacity was put into operation in 48 countries in 2018 (Ibid), representing a major upsurge in hydropower development since 2005 (World Energy Council, 2015). Questions arise. Why has there been an upsurge, and what does it mean for free-flowing rivers? To answer these questions, we first need to understand the paradox of sustainable hydropower development.

Before its post-2005 surge, from 1999 to 2005, the pace of hydropower development decreased worldwide, perhaps reflecting the impact of the WCD's guidelines for the developing new dams (World Energy Council, 2015). Though major funders and governments disagreed with the report's recommendations, the financial community was considering ways of responding to increased expectations (Ibid). According to World Energy Council, hydropower development has seen an upswing since 2005. This can be partly attributed to the impact of intensive efforts by the International Hydropower Association (IHA) and hydropower companies to negotiate sustainability guidelines for the sector. Additionally, growing investments in and by emerging economies (such as BRICS, particularly China), continued to fan interest in renewable energy, particularly that with storage capacity, fueling the surge. The emergence of carbon markets and renewable energy credits, too, played a role. In 2004, the Bonn International Conference on Renewable Energies (a declaration signed by 154 countries) and the United Nations Beijing Declaration on Hydropower and Sustainable Development both recognized hydropower as an important renewable energy source (World Energy Council, 2015).

In addition, hydropower is presented as a clean and renewable energy source that is environmentally preferable to fossil fuels or nuclear power (Renofalt et al., 2010). The continued rise in the demand for energy drives dam development, and climate change is a greater driver of hydropower expansion (Moore et al., 2010). Compared to conventional coal power plants, existing hydropower plants prevent the emission of about 3 GT of CO_2 per year, or about 9% of annual global CO_2 emissions. In general, hydropower produces few GHG emissions (Berga, 2016). According to the World Energy Council (WEC), the CO_2 emissions per GWh are 3-4 tons for run-of-river hydropower plants and 10-33 tons for storage hydropower plants with a reservoir. The volume of these emissions is about 100 times less than those from conventional thermal power (Ibid.). Furthermore, human population growth, economic development, climate change, and the need to bridge the electricity access gap have stimulated the search for new sources of renewable energy. In response to this need, major new initiatives in hydropower development are under way. The Amazon and La Plata basins in Brazil will soon have the largest number of new dams in South America, and the Ganga-Brahmaputra basin (India and Nepal) and the Yangtze basin (China) will see the highest dam construction activities in Asia (Zarfl et al., 2014).

The dramatic expansion in the world's capacity for hydropower generation will not, however, be sufficient to meet the increasing demand for electricity and will only partially bridge the electricity gap (Zarfl et al., 2014). Even if the entire technically feasible potential of hydropower is exploited, a feat which would entail a dam construction boom almost five times greater than what is currently estimated to be likely, hydropower would contribute less than half of the global demand for electricity until 2040 (Zarfl et al. 2014). In contrast, without the construction of additional hydropower dams, the share of hydroelectricity in total electricity production would drop to 12% (Zarfl et al., 2014).

Hydropower is accompanied by significant environmental impacts, including the fragmentation of rivers, prevention of the free movement of organisms, modification of river flow, and changes in temperature regimes and sediment transport rates (Renofalt et al., 2010; Zarfl et al., 2014; King & Brown, 2018; Johnston B. R., 2013; The World Bank, 2018). This focus on hydropower may reduce the number of remaining free-flowing large rivers of the planet by 21% (Zarfl et al., 2014). Many hydropower installations, especially older ones, do not maintain minimum e-flow. In these installations, water is released from dams into rivers only when flows exceed the station's installed capacity or when the plant is shut down (Renofalt et al., 2010). Constructing dams requires machinery and other hardware that uses carbon dioxide-emitting fossil fuels, and reservoirs cause the emission of methane. As explained earlier, interventions also have social costs.

Rivers and Free Flow

There is a widespread, though necessarily not universal, inertia that resists embracing new thinking regarding large-scale water resource planning. Though governments, international funding agencies and river basin organizations commit themselves to pursuing equitable development, their adherence to these principles is far from assured (King & Brown, 2018). In fact, a new wave of river degradation is underway, and the sustainable development of water resource is at greater risk than ever before. Hydropower is firmly linked to this deterioration (Ibid).

It is therefore important to work toward revitalizing rivers, ensuring that they maintain minimum flow and cater to social, cultural and environmental needs. In 2007, at the International River Symposium(IRS), the Brisbane Declaration was agreed and the concept of E-flow found resonance, as the following sections highlight.

At the 10th International River Symposium and Environmental Flows Conference (EFC) held in Brisbane, Australia, on 3-6 September 2007, over 800 scientists, economists, engineers, resources managers and policymakers from 57 nations agreed on the definition of E-flow (International River Foundation, 2007). "Environmental flows describe the quantity, timing, and quality of water required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems." Diverse stakeholders now use this definition.

The EFC recognized that freshwater ecosystems are the foundation of our social, cultural, and economic wellbeing and that freshwater ecosystems are seriously impaired and continue to degrade at alarming rates. It called upon all governments, development banks, donors, river basin organizations, water and energy associations, multilateral and bilateral institutions, community-based organizations, research institutions, and private sectors across the globe to commit to the following actions for restoring and maintaining e-flows:

- Immediately estimate e-flows needs everywhere,
- Integrate e-low into every aspect of land and water management,
- Establish institutional frameworks,
- Integrate water quality management,
- Actively engage all stakeholders,
- Implement and enforce E-flow standards,
- Identify and conserve a global network of free-flowing rivers, and
- Build capacity and learn by doing.

In 2017, the 20th IRS was held in Brisbane, Australia, to revisit the declaration and the agenda adopted a decade earlier in 2007 (Arthington et al., 2018). A variety of E-flow assessment methods were developed and used. These methods considered the socio-cultural and indigenous aspects of water use, not just its ecology. The conference found that while progress in E-flow science and water management since 2007 had been encouraging, challenges remained in protecting and restoring the integrity of freshwater ecosystems and the ecological services that sustain human cultures, economies, livelihoods, and wellbeing (ibid). In fact, in spite of admirable global efforts, there is no single global record of E-flow implementations nor an understanding of why some projects have succeeded while others have failed even to get off the ground (ibid). Major obstacles to E-flow implementation (Moore, 2004; Le Quesne et al., 2010; Harwood et al., 2017) include the lack of political will and public support; constraints on resources, knowledge and capacity; institutional barriers and conflict of interests (ibid).

The 2018 Brisbane Declaration redefined E-flow to include the cultural and indigenous values of rivers: "Environmental flows describe the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being" (2018 Declaration). The declaration makes an urgent call for action to protect and restore e-flows and aquatic ecosystems in recognition of their biodiversity, intrinsic value, and ecosystem services, and to make this action a central element of integrated water resource management and the foundation for the achievement of water-related sustainable development goals (SDGs).

E-Flow in Nepal

Generating electricity from hydropower is a key component in Nepal's approach to economic development (Thapa & Basnet, 2015) and during its Energy Development Decade (2016-2026) Nepal aims to mitigate its energy deficit. The country has seen a substantial increase in the pace of hydropower development. Currently, 92 run-of-river hydropower projects and one reservoir project with a total installed capacity of 1236 MW are being operated in 60 rivers across the country (DoED, 2020), and 198 small- and medium run-of-the river projects are under construction in 136 rivers (DoED, 2020). The government of Nepal (GoN) plans to harness 10,000 MW by 2026 through different privately and state-owned projects (IPPAN, 2017). Ultimately, the GoN plans to harness 42,000 MW, the country's economically feasible hydropower potential.

Water is mostly treated as an economic good, and hydropower generation is thought as important sector for economic growth. In the quest for generating more energy, the GoN has accorded little consideration to water for other sectors. Although, GON is attempting to reconcile the emerging environment and social challenges, however the policies are conflicting. In one hand, Hydropower Environment Impact Assessment Manual 2018 is one step toward creating sustainable hydropower development. But, on the other hand, existing policies such as making environmental impact assessments (EIAs) mandatory for projects with a capacity of 10MW or above is now amended to apply to projects with a capacity greater than 50 MW. Similarly, Nepal's 2001 Hydropower Development Policy recognizes hydropower as an alternative to biomass and thermal energy that protects the environment. The policy acknowledges the need to mitigate adverse environmental impacts likely to result from the construction and operation of hydropower projects. This policy has a provision for implementing the programs EIA reports addressing the direct adverse impacts of a project by requiring the release of at least 10% of the minimum monthly average discharge of the river or the minimum required amount as mentioned in the EIA report. However, these provisions are neither adhered by the hydropower projects nor there is regular compliance monitoring of this policy. Following paragraphs will details the cases of eflow in Nepal's rivers.

In many rivers, the impacts of hydropower are clear. Along Modi Khola, which flows through Kaski and Parbat districts, the three operational plants and the three under construction have blocked the passage of fish, decreased fish production and prevented the performance of many cultural activities in their dewatered zones (JVS, 2016). Rijal (2018) reports that the release of water from the dam in Hewa Khola, Phidim District, was insufficient for downstream irrigation. Shrestha and Crootof (2018) point out that the lack of water in the dewatered zone downstream of the 12 hydropower projects they studied in the Gandak River basin has adversely impacted local livelihoods and riverine environments. The suggestions made in EIA reports are not implemented and because monitoring by GoN is poor and there is no compliance (JVS, 2016). Besides, even in projects with capacities less than 50 MW downstream flow requirements were more than the amounts stated in EIAs (Rijal, 2018). Clear discrepancies exist between EIA reports and the ground reality of dams.

The Mai River in Eastern Nepal has seven operational projects and three under construction, and many rivers, including the Trisuli, Modi, Likhu, Khimti, Puwa, Marsyangdi, Kaligandaki, Hewa

Khola, Madi Khola, Bhote Koshi and Dordi, have more than five operational or under-construction projects back-to-back. Their impacts vary. Nepal does not have any policy stipulating a minimum distance between two projects and while ecological, social and cultural impacts are visible, they have not been quantified. Nor has the country laid out any policies for a cascade of projects in the same river though many such projects have been built in the same river. Many people complain that local springs have dried up and there is not enough water to perform cultural activities. To address these shortcomings, it is necessary to assess the ecological, social and cultural impacts of projects and the tradeoff between electrical energy and the ecosystem service benefits of rivers.

Further, there is a need of revisiting Eflow provision in Nepal. Is 10% water to be released enough for downstream use? Should this provision be applied to all types of hydropower projects, including storage, peaking, cascade and run-of-river? Who should decide how much water is required for economic, social and ecological wellbeing? What kind of regulatory framework should be in place for compliance and monitoring? These questions remain unanswered because of the lack of scientific study, lack of awareness, and government policies. In the ongoing drive for hydropower development in Nepal, there is an obvious need for the engagement of and dialogue among stakeholders to arrive at a decision on e-flow.

Lessons for Nepal

How should we answer the many questions raised above? Dams provide benefits, true, but they also fragment rivers and negatively impact ecology and biodiversity (Dynesius & Nilsson, 1994; Nilsson et al., 2005). In recent years, in the countries like the US where modern dam-building technology evolved, there has been movement towards letting rivers flow freely again. Furthermore, countries like Australia, New Zealand and the US recognize the indigenous and cultural values attached to rivers and ensure that a minimal river flow be mandatorily maintained. How these trends will influence developing countries like Nepal, which sees dam-building as a nation-building enterprise, is unclear. Yet lessons must be heeded. The following sections examine why free-flowing rivers are essential in Nepal's economic, ecological/biodiversity, and socio-cultural contexts.

Economic**:** Nepal's aims to increase its status from a least developed country now to a middle-income country by 2030[8]. For this to happen, it needs to encourage sufficient foreign development investment (FDI). It hopes to do so by getting investors to harness its hydropower potential and export the generated energy to India and, recently, Bangladesh. This level of investment can bring benefits that will complement other efforts to advance to middle-income status. This approach is not, however, going to be a cake walk as was the 20th century dam-building enterprise. In those days, the economic benefit of dams was inflated and the costs to society and environment largely excluded. Incomplete information and questionable assumptions were used to estimate economic benefits when the first major dam projects were built and social and environmental costs were considered relatively unimportant (Gleick, 2000). Environmental and social costs that were unquantified or unquantifiable were simply excluded. To prove dams were cost-effective, governments and corporations played economic games—stretched-out repayment periods, high discount rates, low-interest loans, and a transfer of costs to non-dam parts of water development (Gleick, 2000).

In addition, there is no guarantee that the planned hydropower projects can be implemented without financial overrun. The lesson from India is relevant. There, the state government of Sikkim signed agreements with 30 investors to build 30 hydropower projects. A decade and a half later only seven of those projects have been completed or are under construction. Many investors

[8]https://www.adb.org/sites/default/files/publication/185557/envisioning-nepal-2030.pdf. The National Planning Commission drafted the Development Strategy, 2030, to serve as a guideline for Nepal's graduation from least developed country status by 2022, achieving the SDGs in the post-MDG era, and becoming a middle-income country by 2030.

abandoned hydropower projects in Sikkim and Himachal Pradesh in the middle of the construction because they went bankrupt. Closer to home, the GMR, which has the license to build Upper Karnali project, has not been able to achieve financial closure though deadlines have been extended many times. Similarly, many "national pride" hydropower projects in Nepal have faced economic, social and geo-political controversies. Underlying these warnings lies a larger contradiction in the management of Nepal's energy: the quest of harnessing hydropower for export rather than that for internal uses. Does investment in developing Nepal's full hydropower potential make economic sense? Perhaps a more practical approach would be to build projects that can meet domestic energy demands with the fewest social and environment costs to people and the country.

Ecological**:** The impact of hydropower dams on aquatic ecologies and the natural environment has not been well researched in Nepal. The generally accepted narrative is that because Nepal's hydropower projects are almost all small, run-of-the river types, they have little impact on aquatic ecologies. A few recent studies on fish populations downstream of hydropower projects suggest, however, that there are significant impacts—and not positive ones. In Modi River fish populations have declined, and species have vanished (JVS, 2016). This river has seven back-to-back projects over a short distance, four operational and three under construction. During field visits one of the authors of this paper made to 12 hydropower projects in the Gandaki Basin in 2017, many local residents complained that the population of snow trout had decreased. Unfortunately, no systematic scientific studies to assess the impacts of reduced flow on fish species as a result of hydropower projects have been carried out. EIA studies do provide details on the potential impact hydropower projects will have on the populations of various fish species, but few hydropower projects have built fish ladders and where they do exit, water often does not flow. Even where it does, the performance of fish ladders is not assessed. Since no systematic monitoring follows the completion of projects, there is no evidence to assess the post-project status of a river's aquatic diversity.

That said, there is evidence from research elsewhere that dams fragment rivers and reduce downstream flows, both changes which adversely impact aquatic ecology and biodiversity. The dam-building enterprise has not been able to overcome this shortcoming. In fact, the inability to ensure a link between sufficient flowing water and the ecological health of rivers is perhaps the greatest failing of 20th century water policy (Fanaian, et al. 2015). Dam-building alters river flows in a fundamental way, transforming rivers and their ecosystems. The process disrupts the dispersal of riverine organisms and changes sediment dynamics, thereby altering riverine biodiversity composition and stock (Renofalt et al., 2010). In a fragmented riverine ecosystem, the stock of many types of freshwater biodiversity is lost and/or decreases (Dynesius and Nilsson, 1994). Similarly, the creation and operation of reservoirs changes flow regimes, affecting fish and the functioning of aquatic ecosystems (Fanaian et al., 2015). There is good and bad news. The bad news is that actions to avert the impacts of hydropower are few and far between. The good news is that understanding of the negative environmental impacts of dams has increased (Ho et al., 2017).

Twentieth-century water resource planning, development and dam-building must undergo a paradigm shift (Gleick, 2000). In the US today, the public perception of dams is vastly different from what it was in the early 20th century (Ho et al., 2017). People accord higher value to maintaining the integrity of water resources, flora and fauna, and human community that live around dams than they used to (Gleick, 2000). This in some cases has resulted in the decommissioning of dams that either no longer serve a useful purpose or have caused such egregious ecological impacts as to warrant removal. Nearly 500 dams in the US and elsewhere have already been removed and movements toward river restoration have accelerated (Gleick, 2000; Gleick, 2010). In some cases, results have been remarkable: within a few months after the Edwards Dam in Maine was removed in mid-1999, salmon, striped bass, alewives, and other fish species returned to the river upstream of the old dam site. They had been absent for almost 162 years (Gleick, 2000). Such lessons are important for Nepal. It is time for stakeholders to reflect on the hydropower development pathway they have chosen and the need to balance the needs for development and to maintain the integrity of rivers.

The emergence of the concept of "environmental flow is the result of increasing concerns for minimizing negative impacts of dam building" (Fanaia et al., 2015) on rivers. Confronted by the increasing pace of dam-building in the last decade, water scientists and freshwater ecologists have recognized that the designated "minimum flow" is arbitrary and inadequate. The structure and function of a riverine ecosystem and adaptations of its biota are dictated by patterns of temporal variation in river flows referred to as the "natural flow-regime paradigm" (Ritcher et al., 1996; Poff et al., 1997; Lytle & Proff, 2004, cited in Arthington et al., 2006). Today scientists and managers agree that to protect freshwater biodiversity and maintain the essential goods and services provided by rivers, it is necessary to mimic the components of natural flow variability and consider the magnitude, frequency, timing, duration, rate of change and predictability of flow events (e.g. floods and droughts), and their sequencing (Arthington et al., 2006).

In order to maintain natural ecosystems, minimum water requirements in a river stretch must be determined, provided for, and protected (Renofalt et al., 2010). Determining the nature and characteristics of these requirements can be difficult. Sometimes they are related to minimum flow requirements or temperature limits; other times, they are related to the need for peak flows during certain periods or water of a certain quality (Ibid). As difficult as they are, these requirements must be met as a fundamental condition of water resource development. Otherwise, humans increase the risk of depriving themselves of natural resources and undermining the natural support structures on which human life depends (Arthington et al., 2006).

Nepal must change its one-size-fits-all policy of 10% minimum flows downstream of a dam or weir. As discussed above, every river basin has different topography, vegetation, downstream dependency on rivers and livelihoods. Thus, the minimum flow applicable to, say, rivers in the Koshi basin may not apply to the rivers of the Gandaki or Karnali basin. Similarly, it makes little sense to have the same minimum flow standard for all type of projects, whether small or large, or to lump all rivers, rather snow-fed, Mahabharat or Chure together. Every river is unique and demands its own unique approach to management.

A minimum flow of 10% may not even be adequate; in fact, many suggest it should be higher. Determining an appropriate figure, however, is a challenge to river ecologists because each basin and river needs its own specific rules of management (Arthington et al., 2006). Governments, citizen groups and the private sector need to engage in answering the following questions: How much can the flow regime of a river be changed before aquatic ecosystems begin to decline? How should daily flows, floods and interannual patterns of variability be managed to achieve the desired ecological outcomes?" (Ibid.). Research outside of South Asia suggests that a region-by-region and country-by-country analysis using hydrological calibration could establish E-flow guidelines within a decade (Arthington et al., 2006).

What is needed is a comprehensive study with multi-stakeholder engagement. Researchers should accomplish the following goals:

1) Conduct an inventory of dams and their free-flow baselines that includes details about the river basins they lie in and the multiple uses of water in any given stretch of the rivers they effect.
2) Establish the following types

   a. Run-of-river without peaking discharging into the same river
   b. Run-of-river without peaking involving inter-basin transfer

c. Run-of-river with peaking discharging into the same river
d. Run-of-river with peaking involving inter-basin transfer
e. Cascaded in a river stretch
f. Reservoir discharging into the downstream of the same river
g. Reservoir involving inter-basin transfer

3) Assess performance of existing fish ladders
4) Assess the scientific basis of the E-flow for the Mahakali, Karnali and West Rapti river basins stipulated in local acts: 25% of the minimum flow.
5) Develop approaches for local monitoring and ensuring compliance with e-flows.

Socio-culture**:** Local communities are particularly sensitive to the use of and intervention in freshwater. The unique perspectives of indigenous communities on water to reflect their identities as well as their custodial obligations to natural resources including water (Tipa, 2009) and must be considered. The contamination, diversion and depletion of water bodies have implications for health and wellbeing, but they also impinge on the collective identities and survival of indigenous peoples (Jackson, 2017). Until about the mid-19th century, water quality the key issue considered when intervening in river and streams, but today a range of issues, including the impact of reductions in river flows socio-cultural wellbeing, are explored (Tipa, 2009). In many cases, the prevailing policies and practices of water management, which are grounded in the biophysical sciences, have failed to take cognizance of these issues and can therefore be termed "exclusionary" (Jackson, 2017). Many of the techniques developed to address these issues rely solely on professional expertise and scientific philosophies and ignore local knowledge and cultural values (Tipa, 2009). Taking cognizance of the intangible values that local and indigenous people regard as critical to their identities, cultural practices, spiritual beliefs, and customary management practices and livelihoods poses a challenge to quantitative and competitive methods of resource allocation that pursue market-based reform agenda (Jackson, 2017) as well as to the state-led bureaucratic approach.

Many studies have aimed attempted to assess cultural values in their E-flow assessments (Jackson, 2017), though they are intangible. These studies include consideration of the e-flows needed by i) sacred places and ecological conditions in South Africa ii) ghats used in ritual ablutions in India (Lokgariwar et al., 2014) and iii) culturally significant aquatic biota such as river dolphins and qualities such as the presence of life (Tipa, 1999). In their study, Shrestha and Crootof (2019) point out that in the Bhilangana river basin in Uttarakhanda, there was too little flow downstream of a hydropower dam for people to carry out cremations and religious festivals. The inadequacy of water flow had sparked conflicts between local people and the hydropower company.

Many countries have recognized the cultural dimension of river management and the concerns of indigenous communities and taken initiatives towards reconciling them. The World Water Forum, the UN Declaration on the Rights of Indigenous People, and some national water policy frameworks recognize indigenous people's special interest in water management. The degree to which indigenous claims to water entitles them to have a determinative stake in development decisions and wider water management issues is, however, contested (Behrendt & Thompson, 2004; Ramazotti, 2008; Ruru, 2009, as cited in Jackson, 2017). Over the past 20 years, for example, the focus of Australian policy objectives has shifted from developing inland water resources to conserving and reallocating water to the environment (Jackson, 2017). Water represents a means of empowering and mobilizing people, and indigenous groups in many Australian regions have organized at the regional scale to address the implications of water governance reform for their communities (Jackson, 2017). In New Zealand, the Maori have, for generations, voiced their concerns about the continual modification of the waterways within their tribal territories (Tipa, 2009).

Unless the social, cultural and environmental dimensions of water are integrated into governance, interventions in rivers will continue to threaten local livelihoods significantly (Jackson, 2015). In South Asia, part of the problem is also because of the seasonal nature of river hydrology: rivers have too much water during the monsoon season and too little in other months. This problem will grow when a cascade of projects is built in the same river. If no water is allocated to a river, that river itself may cease to flow in the dewatered zone during non-monsoon months. Even small hydropower projects have spawned conflicts over water flow. A different schema for developing and managing rivers, one that recognizes the water needs of multiple uses, is necessary. The needs of local communities, livelihoods and cultures must be considered.

Conclusions

Dam-building continues to receive priority around the world, especially in the developing economies, though dam construction did decline towards the end of the 20th century and in the beginning of 21st century. There is no platform that engage in conversation of whether or not dams should be built is limited. The debate should be about the sustainability of freshwater biodiversity and river ecology and how dams can be built to meet economic, environment and social requirements. In addition, the debate should focus on how we can build dams with the least impact on the environment and local communities. The debate should focus on how water should be allocated to riverine environments and how the integrity of water flow can be maintained.

Maintaining free flow in rivers is a challenge in developing countries, where very few rivers flow free, and plans to build more dams will further limit the scope for free flow. If rivers are to become healthy, three things need to happen. First, technological innovation needs to focus on alternative sources of clean energy that, from the economic, social and environmental perspective, are cheaper than hydropower. Second, our understanding of rivers and ecosystem services must be enhanced which requires continuous investigation into hydrology and river morphology. The following questions must be answered: What is the value of a flowing river to the economy, society and environment? How much water does a river need to sustain its ecology? Attempts must be made to quantify the intangible value of rivers to deepen our dialogue about the E-flow and free flow of rivers. Third, we need a new societal ethos for the stewardship of water.

Simultaneously, we must examine the way we balance river conservation and hydropower development. Doing so requires undertaking studies designed to increase our understanding of the nature of rivers as well as their use by communities, economies and the environment. This knowledge must be used to engage stakeholders who can bring diverse perspectives to the issue. Such a process can help move us towards a better understanding of the water required by a river and make informed decisions about e-flows. Without regular monitoring of rivers and compliance with policies designed to improve river management so that it sustains river health, defining and preserving E-flow will remain an elusive goal.

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