

## CHAPTER 5

### KEY ISSUES FOR SEA IN THE HYDROPOWER SUB-SECTOR

#### 5.1 EXISTING SEA GUIDANCE/GUIDELINES FOR THE HYDROPOWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA (identified only one specifically focused on the hydropower sub-sector whilst there are numerous guidelines for conducting environmental impact assessments (EIA) for hydropower projects<sup>1</sup>.

The report of the World Commission on Dams (WCD 2000) set out comprehensive guidelines for dam building. It describes an innovative framework for planning water and energy projects that is intended to protect dam-affected people and the environment and ensure that the benefits from dams are more equitably distributed.

Subsequently, a broad and extensive literature has become available on hydropower development. Some selected examples include general guidelines (but not concerned with SEA) covering issues such as social impacts and risks<sup>2</sup>, environment and climate<sup>3</sup>, tools<sup>4</sup>, indigenous people<sup>5</sup>, health and safety<sup>6</sup>, developers and investors<sup>7</sup>, affected peoples and livelihoods<sup>8</sup> and infrastructure safety<sup>9</sup>.

In 2021, the International Hydropower Association (IHA) launched its Hydropower Sustainability Standard which covers topics relevant to SEA in the hydropower sub-sector (Box 5.1).

#### Box 5.1: IHA hydropower sustainability standard

The IHA Hydropower Sustainability Standard is a global certification scheme (the first of its kind for renewables), outlining sustainability expectations for hydropower projects around the world. It aims to help ensure that hydropower projects provide net benefits to the local communities and environments they interact with. The standard covers 12 environmental, social and governance (ESG) topics, including: biodiversity and invasive species, cultural heritage and more.

In support of the standards, the IHA has published a suite of hot-to-guides offering a deep dive into specific sustainability topics such as resettlement, labour and working conditions, and benefit-sharing. Embedded in the standard are three key project-based tools: guidelines of good industry practice; the hydropower sustainability assessment protocol (HSAP); and the hydropower sustainability ESG gap analysis tool (HESG).

All documents are available at [www.hydropower.org](http://www.hydropower.org).

<sup>1</sup> e.g. REMA 2008; UKEA 2009, IHA 2021c

<sup>2</sup> e.g. Cernea (2004); EIB (2019)

<sup>3</sup> EIB (2019)

<sup>4</sup> e.g. HSC (2020)

<sup>5</sup> e.g. HSC (2022); IHA (2022), IHA (2022b)

<sup>6</sup> e.g. IFC (2018)

<sup>7</sup> e.g. IFC 2015b

<sup>8</sup> e.g. IHA 2020)

<sup>9</sup> e.g. IHA (2021)

## 5.2 HYDROPOWER INSTALLED CAPACITY

Since 1995, the hydropower sub-sector has more than doubled in size from 625 GW to over 1,300 GW, with China having, by far, the greatest installed capacity (see Table 5.1 and Figure 5.1).

**Table 5.1: Hydropower installed capacity in 2021**

Source: IHA (2022c)

| Country           | Installed Capacity (GW) |
|-------------------|-------------------------|
| China             | 391                     |
| Brazil            | 109.4                   |
| USA               | 101.9                   |
| Canada            | 82.3                    |
| Russia            | 55.7                    |
| India             | 51.4                    |
| Japan             | 49.6                    |
| Norway            | 33.4                    |
| Turkey            | 31.5                    |
| France            | 25.5                    |
| Italy             | 22.6                    |
| Spain             | 20.4                    |
| Vietnam           | 17.3                    |
| Switzerland       | 16.8                    |
| Sweden            | 16.5                    |
| Venezuela         | 15.4                    |
| Austria           | 14.7                    |
| Mexico            | 12.6                    |
| Iran              | 12.2                    |
| Colombia          | 11.9                    |
| Rest of the world | 268.1                   |
| <b>Total</b>      | <b>1360</b>             |

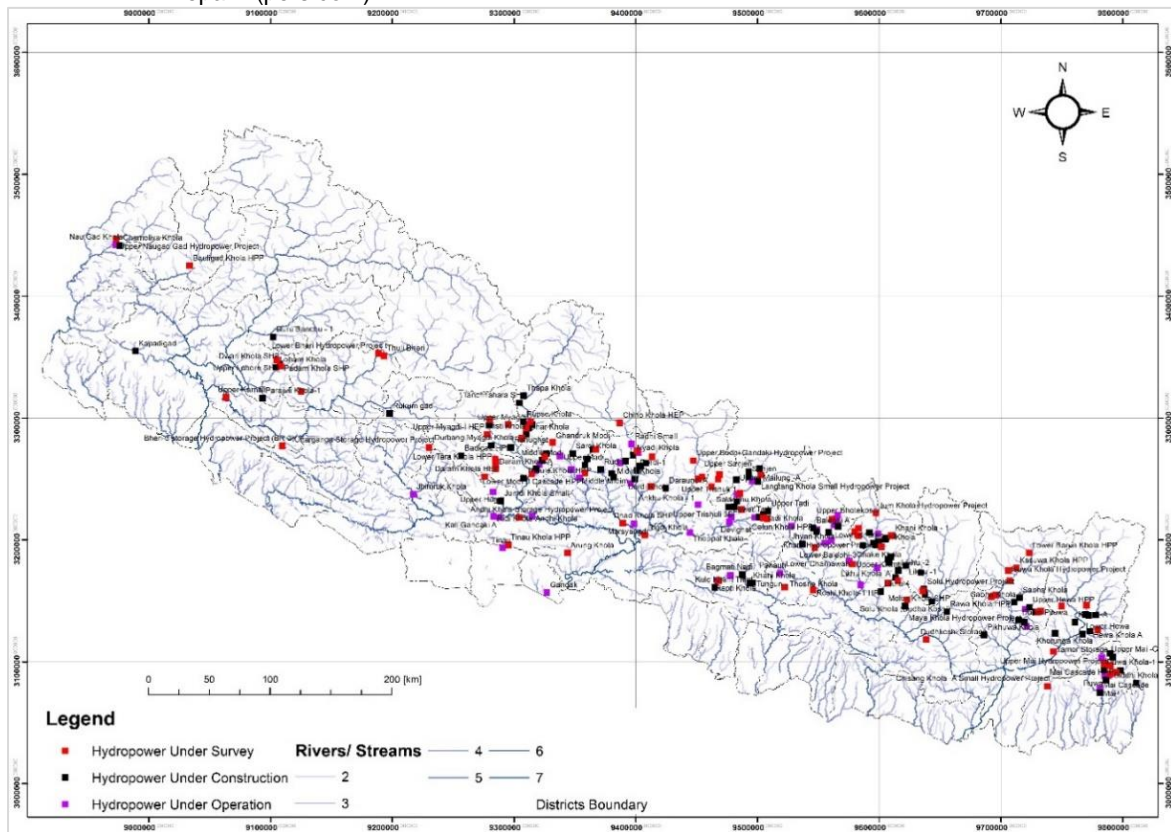
According to the International Hydropower Association<sup>10</sup>, hydropower generated around 4,300 terawatt hours (TWh) of clean electricity worldwide in 2021; and Paraguay and Costa Rica achieved a 100% renewable electricity supply, with hydropower as the backbone. In some countries, almost all electricity generation comes from hydropower, e.g. Norway and Nepal (Figure 5.2)

<sup>10</sup> IHA (2022c)

Figure 5.1: Spatial distribution of hydropower resources and production in China (2014)

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Figure 5.2: Map showing location of hydropower schemes in Nepal, 2020  
 (Source: Prepared by Ajay Mathema based on data from Department of Electricity Development, Nepal<sup>11</sup> (pers.com))



<sup>11</sup> School of Environmental Science and Management, Kathmandu, Nepal. Map based on data from Department of Irrigation, Nepal)

### 5.2.1 Application of SEAs in the hydropower sub-sector

A recent international inventory identified 34 SEAs conducted for the hydropower sub-sector during the period 1995 – 2019<sup>12</sup> (Table 5.2). 16 (43%) of these were specifically focused on hydropower PPPs, whilst 16 (43%) addressed hydropower as part of broader PPPs for the overall energy sector. A few (5, 13%) dealt with hydropower as part of multiple PPPs covering multiple sectors.

**Table 5.2: SEAs for energy sector, multi-sector and hydropower sub-sector, for regions (columns) and type of PPPs (rows) for the period 1995-2019**

Source: Kolhoff and Sloomweg (2021)

| Type of PPPs per sector*                      | Asia      | Africa   | Europe   | Americas | Total     |
|---|-----------|----------|----------|----------|-----------|
| <b>Energy sector, including hydropower</b>    |           |          |          |          |           |
| International                                 | 1         | 1        |          |          | 2         |
| National**                                    | 5         | 4        | 4        |          | 13        |
| State/provincial                              |           |          |          | 1        | 1         |
| <i>Sub-total</i>                              | 6         | 5        | 4        | 1        | 16        |
| <b>Hydropower sub-sector</b>                  |           |          |          |          |           |
| International river basin                     | 1         |          |          |          | 1         |
| National**                                    | 6         |          | 1        |          | 7         |
| State/provincial                              | 3         |          | 1        |          | 4         |
| River (sub-basin)                             | 3         |          | 1        |          | 4         |
| <i>Sub-total</i>                              | 13        |          | 3        |          | 16        |
| <b>Multiple sectors, including hydropower</b> |           |          |          |          |           |
| International river basin                     |           | 1        |          | 1        | 2         |
| National river basins(s)**                    | 2         | 1        |          |          | 3         |
| <i>Sub-total</i>                              | 2         | 2        |          | 1        | 5         |
|   |           |          |          |          |           |
| <b>Total</b>                                  | <b>21</b> | <b>7</b> | <b>7</b> | <b>2</b> | <b>37</b> |

\* Includes all SEAs applied for PPPs in the energy sector at international, national and state level have been included in the inventory. In two of these SEAs hydropower is not included as an energy source. All SEAs applied for PPPs in multi-sectoral PPPs are included, in which hydropower is considered. All SEAs applied in the hydropower sector are included in the inventory.

\*\* Selected cases: National energy plan Viet Nam; National hydropower plan Myanmar; State level hydropower plan India and Pakistan; Multi-sector River basin plan Rwanda.

## 5.3 BACKGROUND TO HYDROPOWER GENERATION

There are two types of renewable energy generation: **dispatchable** (sources of electricity that can be dispatched on demand at the request of power grid operators) and **variable** (intermittent renewable energy sources (IRES) are renewable energy sources that are not dispatchable due to their fluctuating nature, such as wind power and solar power).

Large-scale hydropower projects can generate and supply large amounts of dispatchable electricity in a consistent manner. Currently, they generate around 16% of the world's electricity<sup>13</sup>. Pumped-hydropower schemes can also be used as a "battery" by moving water to higher elevations during times of surplus electricity and releasing it through turbines to generate electricity at times of high demand. In this manner, pumped storage can support wind and solar projects which have more intermittent generation. Hydropower projects that include a reservoir can act as a source of flood mitigation in some circumstances, as the reservoir can store peak flows and control the release of water to the downstream river course. Hydropower projects can have many environmental and social impacts that vary in scale and significance depending on the location, size, and project design.

<sup>12</sup> Kolhoff and Sloomweg (2021)

<sup>13</sup> IHA (2022c)

### 5.3.1 Installation types

Hydropower projects come in many different sizes, designs, and configurations. The nature of their environmental and social impacts is determined by how they store and use water. Broadly there are four distinct types of hydropower schemes: run-of-river, reservoir, pumped storage and offshore hydropower:<sup>14</sup>

- **Run-of-river hydropower:** a facility that channels flowing water from a river through a canal or penstock to spin a turbine. Typically a run-of-river project will have little or no storage facility. Run-of-river provides a continuous supply of electricity (base load), with some flexibility of operation for daily fluctuations in demand through water flow that is regulated by the facility.
- **Storage hydropower:** typically, a large system that uses a dam to store water in a reservoir. Electricity is produced by releasing water from the reservoir through a turbine, which activates a generator. Storage hydropower provides base load as well as the ability to be shut down and started up at short notice according to the demands of the system (peak load). It can offer enough storage capacity to operate independently of the hydrological inflow for many weeks or even months.
- **Pumped storage hydropower:** provides peak-load supply, harnessing water which is cycled between a lower and upper reservoir by pumps which use surplus energy from the system at times of low demand. When electricity demand is high, water is released back to the lower reservoir through turbines to produce electricity. Learn more.
- **Offshore hydropower:** a less established but growing group of technologies that use tidal currents or the power of waves to generate electricity from seawater (usually referred to as tidal power (discussed in Chapter 10).

Facilities can be also classified as (a) single-purpose—which are only used for hydroelectricity generation, or (b) multipurpose—which are designed and used for other purposes such as water supply, irrigation, aquaculture, or flood control. Hydropower power plants can also be classified on the basis of installed capacity, e.g.<sup>15</sup>:

- Very Large: 5,000 – 10,000 MW, feeding into a large grid;
- Large: exceeding 100Mw, and usually feeding into a large grid;
- Medium: 15 v- 100MW, usually feeding into a grid;
- Small: 1 – 15 MW, usually feeding into a grid;
- Mini: 100 kW – 1 MW, either isolated or feeding into a grid;
- Micro: 5 Kw – 100 kW, usually provides power for a small community or rural industry in remote areas away from the grid, and
- Pico: from a few hundred Watts up to 5 kW.

However, classifications vary from country to country as there is currently no common consensus among countries and hydropower associations regarding the upper limit of small-scale hydropower plant capacity. For instance, some European Union countries like Portugal, Spain, Ireland, Greece, and Belgium accept 10 MW as the upper limit for small-scale hydropower installed capacity, while others place the maximum capacity from 3 to 1.5 MW. Outside the EU, this limit can be much higher, as in the USA (30 MW) and India (25 MW).

<sup>14</sup> <https://www.hydropower.org/iha/discover-types-of-hydropower>

<sup>15</sup> [Classification of Hydroelectric Power Plants \(engineeringnotes.com\)](#)

### 5.3.2 Hydropower installation components

The most important components of a hydropower project: dams, spillways, power stations and water ways.

#### **Dams**

Dams are the most recognizable features of hydropower facilities. They are constructed to create water storage or diversion that provide a continuous supply of water to turn the turbines. The type of dam depends on a range of factors including:

- Height (or head) of water to be stored;
- Shape and size of the valley at the proposed construction site;
- Geology of the valley walls and floor;
- Availability, quality and cost of construction materials, and
- Availability and cost of labour and machinery.

The ability of a dam to withstand the pressure of water built up behind it depends on its weight and/or shape. The dam also needs to be made of or contain material that prevents water flowing through it.

#### **Spillways**

Dams must be designed to cope with floods. Spillways are built to provide a path for water to flow over or around the dam. On concrete dams, spillways are usually constructed to allow water to flow over the top. These are not normally appropriate for embankment dams because of the damage that floodwater can cause to loose rock on the downstream side. Spillways on embankment dams take the water around the side of the dam and away from the downstream face. Alternatively, a dam may rely on gates to release water during floods.

#### **Power stations**

Power stations (or power houses) (see Figures 5.3 and 5.4) contain the turbines and generators that generate electricity from moving water. They may be located near the water storage or up to several kilometres away. Their location is determined by the topography and foundation conditions. The lower part of the power station houses the turbines. Water enters the station on one side, spins the turbines, and flows out the other side. The choice of turbine type will depend on the water quantity and head that it needs to accommodate. Above the turbines are the generators. They are securely fastened to solid concrete foundations. Some power stations are built underground—the decision to do so may be based on a lack of suitable surface sites, or benefits gained by creating extra height (or head) through which the water can fall, or for social or environmental reasons to minimize the impact an above-ground power station would cause.

**Figure 5.3: Inside a hydro powerhouse**

Photo redacted pending securing copyright permission to use. If you have a good image showing the inside of a hydro powerhouse that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

**Figure 5.4: Major components in a hydroelectric plant**

Image redacted pending securing copyright permission to use. If you have an image showing the components in a hydroelectric plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

### **Waterways**

Water is conveyed to power stations situated near storages through intakes and down vertical shafts and inclined tunnels (penstocks). Power tunnels are often lined with concrete or steel to maximize integrity and prevent leakage of high-pressure water into the surrounding rock. A typical intake is fitted with control gates and a steel mesh trash rack that prevents rubbish such as logs being carried down into the turbines. Where reservoirs are situated some distance from the power station, channels need to be constructed to carry the water overland. If the topography is relatively flat, open channels are used. In rugged topography, it is cheaper to channel the water through tunnels and pipelines. Above the power station, the overland channels feed water into vertical shafts, power tunnels or high-pressure steel pipes (penstocks). Large towers (surge towers) are often built near the top of these structures, and are used as a pressure neutralizer in a hydropower water systems to resist excess pressure rise and pressure drop conditions during operations.<sup>16</sup>

## **5.4 IMPACTS OF HYDROPOWER DEVELOPMENT**

Table 5.3 summarises the key environmental and socio-concerns issues often associated with hydropower development.

---

<sup>16</sup> <https://theconstructor.org/water-resources/surge-tank-types-function/12946/>

Table 5.3: List of key environmental and socio-economic issues often associated with hydropower

| ISSUE   | COMMENT   |
|---|---|
| <b>Environmental</b>                            |   |
| Loss of habitats and biodiversity (terrestrial) | <ul style="list-style-type: none"> <li>• Inundation by dams and reservoirs and loss of important terrestrial habitats</li> <li>• Deforestation (for hydropower sites, dams, roads and transmission lines, and release of stored carbon)</li> <li>• Fragmentation of habitats and creation of barriers to wildlife movements</li> <li>• Clearing for access roads and transmission lines and consequent disturbance to migration and increased road kills</li> <li>• Increased poaching and hunting due to increased access to areas</li> <li>• Disturbance to fauna from noise, vibration, and dust from blasting and other construction</li> <li>• Drowning of species during reservoir impoundment</li> <li>• Introduction of invasive species</li> <li>• Changes in diversity or make up of the plant and animal communities due to changes in ecosystems</li> <li>• Impacts on ecosystem services such as trees used for fuel</li> <li>• Submersion of caves used by bats</li> <li>• Impacts on terrestrial fauna from changes to aquatic ecosystem (e.g., loss or reduction of food sources)</li> <li>• Loss of riparian habitat due to erosion</li> <li>• Collision of birds and bats with overhead power lines leading to electrocution</li> </ul> |
| Loss of habitats and biodiversity (aquatic)     | <ul style="list-style-type: none"> <li>• Loss of riparian habitats through inundation or changes to river flow regime</li> <li>• Change from lentic (fresh water) to lotic (moving water) habitat in new reservoir</li> <li>• Dam walls prevent migration of fish to breeding areas</li> <li>• Organic matter decomposition in the base of the dams over time can deplete water oxygen and kill fish and aquatic organisms</li> <li>• Fish killed by powerhouse turbines and/or by tail races/spillways</li> <li>• Increased fishing (overexploitation) due to (a) increased access (e.g., to previously inaccessible areas), via access roads and transmission lines, or as result of workforce in the area; and (b) creation of popular fishing areas where fish concentrate</li> <li>• Blockage of fish movements</li> <li>• Fragmentation of aquatic systems</li> <li>• Change in sediment and nutrient flows due to river flow changes can affect biodiversity, and can decrease sediment loads downstream</li> </ul>  |



| ISSUE                     | COMMENT  |
|---------------------------|--|
|                           | <ul style="list-style-type: none"> <li>• Change in riparian habitats due to hydropeaking<sup>17</sup> and aggressive river effects in the event of releases: loss of interface between land and the river due to riverbank erosion</li> <li>• Fragmentation and loss of or changes to aquatic ecosystems and connectivity in river system: animal migration, fish movements and plankton drift can be blocked both up and downstream by a dam</li> <li>• Loss of downstream floodplain habitat: regulation of a river by a dam and reservoir reduces the magnitude and duration of flood flows, which reduces downstream flooding and sediment transport</li> <li>• Introduction of invasive alien plant and animal species leading to changes in ecosystem structure and composition</li> </ul>   |
| Land-use changes          | <ul style="list-style-type: none"> <li>• Inundation of land leading to direct loss of productive land or loss of habitat</li> <li>• Changes in nutrient flows and sediment transport leading to indirect loss of agricultural land downstream</li> <li>• Changes in river flow regime leading to less productive agricultural land downstream (e.g., river no longer flooding crops when required)</li> <li>• A dam or hydropower infrastructure may alter access to an area leading to indirect changes in land use such as loss of productive land</li> </ul>  |
| Erosion and sedimentation | <ul style="list-style-type: none"> <li>• Clearance and disturbance to vegetation and soil in areas surrounding dams and rivers, resulting in erosion and sediment runoff into the river</li> <li>• Landslides: ground movements such as mudflows and debris flows that occur due to project construction</li> <li>• Erosion and instability of riverbank or bed (and adjacent areas, e.g., following changes in river flow and geomorphology)</li> <li>• Erosion of rim or boundary of reservoir and increased sedimentation in reservoir</li> <li>• Intense rainfall on cleared land may lead to gullying and increased runoff, erosion, and sedimentation (during construction and in a reservoir catchment)</li> <li>• Changes in the geomorphology of river channels and increased erosional forces downstream due to sediment retention</li> <li>• Increased sediment runoff into rivers or streams at vehicle crossing points during construction</li> <li>• Sediment retention and accumulation over time (e.g., in dam bottom—reducing dam capacity, or locally in riverbeds):</li> <li>• Release of sediment-laden water can cause issues downstream</li> </ul> |
| Air quality               | <ul style="list-style-type: none"> <li>• Air pollution from machinery and vehicles (construction equipment, lorries, workers' buses, etc.)</li> <li>• Dust from land clearing and construction, vehicles on dirt roads</li> <li>• Dust from exposed areas of dam margin following drawdown operations</li> </ul>   |
| Water quality             | <ul style="list-style-type: none"> <li>• Sewage, solid waste, and polluted runoff into dams and rivers during construction (runoff from dumping of excavated materials)—can contaminate surface and groundwater</li> </ul>   |

<sup>17</sup> Hydropeaking refers to frequent, rapid, and short-term fluctuations in water flow and water levels downstream and upstream of hydropower stations. Such fluctuations have far-reaching effects on riverine vegetation.

| ISSUE                | COMMENT  |
|----------------------|--|
|                      | <ul style="list-style-type: none"> <li>• Oil or chemical spills during construction or operation</li> <li>• Pollution from the catchment can collect in reservoirs</li> <li>• Release of heavy metals from sediments</li> <li>• Reservoir stratification: separation of reservoir water into oxygenated and deoxygenated zones (due to organic decomposition) and unseasonal temperature water released to downstream</li> <li>• Change in water quality due to sedimentation during construction, and altered flows during operation – with increased turbidity: increase in the cloudiness or haziness of water caused by individual particles</li> <li>• Organic decomposition: decomposing of organic material during the early years of operation leading to the consumption of oxygen</li> <li>• Decreased air quality during drawdown operations and exposure of reservoir areas</li> <li>• Changes in flow regime may increase the concentration of pollutants and result in the release of nutrient-laden water, there may also be inflows of sediment, and pollution or hazardous substances from construction and from the wider catchment, and dumping of excavated materials</li> <li>• Contamination of surface and groundwater—particularly during construction</li> <li>• Impacts of degraded water quality downstream</li> <li>• Eutrophication due to fertilizer runoff in the catchment (nitrogen, phosphorus, and other nutrients) and enrichment in dams</li> </ul> |
| Hydrology            | <ul style="list-style-type: none"> <li>• Flow of rivers can be changed significantly due to presence of a dam or weir</li> <li>• Reduced water for downstream use (e.g., irrigation, consumption)</li> <li>• Changes downstream: significantly reduce or alter patterns of flow between the intake and the powerhouse</li> <li>• Altered flow regime and sediment flows downstream of the powerhouse</li> </ul>  |
| Greenhouse gases     | <ul style="list-style-type: none"> <li>• Hydropower can reduce GHG emissions where it displaces coal as a fuel source</li> <li>• GHG emissions (carbon dioxide, methane, nitrous oxide) from reservoirs (particularly from decomposition of submerged vegetation) and from vehicles and fuels used in machinery and camps during construction</li> </ul>   |
| Noise and vibration  | <ul style="list-style-type: none"> <li>• Noise and vibration impacts during construction (from machinery, vehicles, blasting, drilling, machinery)</li> </ul>  |
| Spoil                | <ul style="list-style-type: none"> <li>• Significant amounts of spoil material may require disposal (where reuse is not an option) due to tunneling and excavation activities</li> </ul>   |
| Flooding             | <ul style="list-style-type: none"> <li>• Inundation of new areas to create impounded reservoir</li> <li>• Flash floods downstream (due to breaches, overtopping, emergency releases)</li> <li>• Dam break resulting in loss of life, communities, infrastructure and biodiversity, erosion</li> <li>• Reservoirs can be used to regulate water flow and control flooding</li> <li>•</li> </ul>   |
| <b>Socioeconomic</b> |  |

| ISSUE                              | COMMENT  |
|------------------------------------|--|
| Physical and economic displacement | <ul style="list-style-type: none"> <li>• Physical displacement and relocation of people and their structures due to reservoir impoundment</li> <li>• Loss of economic and livelihood activities, such as agriculture, animal grazing, fishing</li> <li>• Loss of income from small business and enterprise activities</li> </ul>   |
| Cultural heritage                  | <ul style="list-style-type: none"> <li>• Loss of (and loss of access to) religious, cultural, historical and archaeological sites, and properties submerged by dam and in downstream locations; or destroyed or damaged due to transmission lines and access roads</li> </ul>  |
| Employment and labour conditions   | <ul style="list-style-type: none"> <li>• Job opportunities with hydropower companies and their contractors</li> <li>• Loss of jobs with existing enterprises and public administration when people are relocated</li> <li>• Forced labour and child labour on hydropower projects</li> </ul>   |
| Health and safety                  | <ul style="list-style-type: none"> <li>• Pollution of downstream and upstream areas</li> <li>• Insufficient and poor-quality water quality for worker camps—due to the water source being affected</li> <li>• Influx of migrant workers may lead to an increase in communicable diseases (infectious diseases such as influenza, sexually transmitted infections [STIs], and HIV/AIDS), drug and alcohol use, gender based violence and conflict</li> <li>• Impacts on fish and human health from methyl mercury releases from sediment into the water column and food chain</li> <li>• Increased road traffic accident and fatalities, particularly during construction</li> <li>• Accidental drowning in reservoirs</li> <li>• Risks of dam failure and natural disasters, land slides</li> <li>• Impacts on communities due to rock blasting</li> <li>• Electrical safety incidents</li> <li>• Fatalities at the construction site and substandard accommodation of workers.</li> <li>• Pressure on health services (e.g. high demand on essential drugs) during construction</li> <li>• Potential for increase in vectors for human transmissible disease e.g. malaria and schistosomiasis (particularly due to dams)</li> </ul> |
| Migration                          | <ul style="list-style-type: none"> <li>• Influx of people looking for work during construction</li> <li>• Tension between immigrants and workers</li> <li>• Retrenchment of construction work forces</li> </ul>  |
| Gender and vulnerability           | <ul style="list-style-type: none"> <li>• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk</li> <li>• Increased domestic and gender-based-violence due to relocation</li> <li>• Gender equity and employment opportunities on new projects</li> <li>• Opportunities for vulnerable groups to acquire new skills and learn new technologies</li> <li>• Opportunities for vulnerable groups to engage in the decision-making processes and in inclusive dialogue about hydropower development</li> </ul>   |

| ISSUE                              | COMMENT   |
|------------------------------------|---|
| Public services and infrastructure | <ul style="list-style-type: none"> <li>• Loss and relocation of public services and infrastructure due to inundation by dams</li> <li>• Pressure on local pre-existing health services and infrastructure, equipment, human resources. due to projects, immigration, accidents during construction, etc.</li> <li>• Increased pressure on the host communities' public services when displaced people relocate</li> <li>• Improvement (investment) to infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings)</li> <li>• Heavy vehicles and transportation damage existing roads and bridges</li> </ul> |
| Community cohesion and engagement  | <ul style="list-style-type: none"> <li>• Weakened community cohesion resulting from self-relocation and community relocation</li> <li>• Risk of internal conflict due to increased stress as result of lost income</li> <li>• Opportunities for communities to engage in the decision-making processes about hydropower development</li> <li>• Increased tension between the communities, NGOs, activists, and hydropower companies</li> </ul>  |
| Conflicts                          | <ul style="list-style-type: none"> <li>• Conflicts over lack of perceived project benefits accruing to local communities(e.g. access to power and water services)</li> <li>• Conflicts over loss of land or access to resources/areas used for livelihoods or cultural activities</li> <li>• Conflicts of working conditions amongst those employed in construction or operation</li> <li>• Tensions between immigrants and local workers/communities</li> </ul>  |

### 5.4.1 Environmental Issues and Impacts

#### Hydrology

A hydropower project will normally change the hydrological flow regime of a river. Depending on project design, this may be a significantly reduced or altered pattern of flow between the intake and the powerhouse (typical for run-of-river projects), or it may be an altered flow regime downstream of the powerhouse (typical for reservoir projects). Rivers that are already regulated by either hydropower or irrigation projects can be less sensitive to new hydrological impacts, so it is better to develop projects on rivers or tributaries that are already impacted by flow regulation<sup>18</sup>, although multiple schemes on a river can also result in significant cumulative environmental and social impacts on habitats and species and downstream users.

Changes to a river's hydrological regime can negatively impact its aquatic ecosystem and can disrupt important ecological processes. The health and integrity of a river system will usually depend on a range of high, medium, and low flows. Most rivers experience natural annual low flows which reduce connectivity and limit species migration. This may be positive for native species which can often out-compete invasive species that have not adapted to low flows. So, maintaining low flows at their natural timing and level can maintain the abundance and survival rate of native species (Figure 5.5). Medium or base level flows will usually occur during most of the year. These flows maintain the hydro-geomorphology of a river which, in turn, maintains habitat, temperature, and dissolved oxygen levels to support aquatic species. Short high flow events are also important to prevent vegetation from encroaching on river channels and to move sediment and organic matter downstream. High flows can also reduce water temperature and increase dissolved oxygen, which can trigger ecological processes such as spawning and migration. Consequently, river flows altered by a hydropower project can lead to a reduction in health and integrity of the river system<sup>19</sup>.

**Figure 5.5: Dam at Nam Theun 2, Lao People's Democratic Republic, with downstream flow provision.**



(Photo credit: A. Javellana/ADB) ]

In some very large storage reservoirs, the filling of the reservoir may take more than one year, with a risk that downstream flows will not be adequately maintained, and this can lead to the degradation of downstream ecosystems and potential loss of habitats and biodiversity.

Dams can both contribute to and alleviate flooding. Large reservoirs can provide storage capacity to attenuate water flow during high rainfall events, reducing downstream floods. However, in the unlikely

<sup>18</sup> Opperman *et al.* (2015)

<sup>19</sup> World Bank (2018).

event of a dam break and inappropriate timing of a large release of water can cause downstream flooding, loss of human life and biodiversity, and damage to communities and infrastructure.

### **Water quality**

There can be a range of negative impacts on water quality throughout the construction and operation phases of a hydropower project.

During construction, the main impact on surface water quality is an increase in sediment load from construction site erosion or from spoil heaps. This erosion increases suspended solids and turbidity of river water, which may affect aquatic biodiversity and downstream water users. Poorly managed sewage and solid waste from the construction camp can pose a risk to drinking water. Accidental spills of oils and chemicals used during construction will contaminate soil and can also enter water courses. The spillage of wet concrete into a river can cause serious depletion of dissolved oxygen and negatively impact on aquatic species (even resulting in deaths).

Run-of-river projects tend to have minimal impact on water quality during the operational phase, although they may change the erosion and sediment dynamic of the river (see next section).

Reservoir projects can have a significant impact on water quality in the operational phase. At the end of the construction phase, the reservoir area is typically cleared of vegetation. This can result in soil erosion and sedimentation of the river, reducing water quality. As a reservoir fills, pollutants in the surrounding soil (e.g., fuels, chemicals, and other substances from previous human activities in the area), can be washed into the reservoir and then the river system. Water quality in the reservoir can be further compromised from upstream contamination sources from industrial and human activity.

When the reservoir is full, the decomposition of dead vegetation is likely to cause an increase in biological and chemical oxygen demand and deplete dissolved oxygen in the water (and may lead to anaerobic conditions), which will reduce water quality, both in the reservoir and in the downstream river. It can also result in releases of methane. The water in the reservoir is likely to be deeper and retained for a longer period than in the river, and this will cause changes in temperature at different depths, with potential for thermal stratification. The latter can also lead to deoxygenated water accumulating at the bottom of reservoir. If this is released to the downstream river via a low-level outlet, it will kill fish in that reach. In the reservoir, anaerobic conditions can liberate contaminants such as sulphides, selenium, ferrous and manganese ions, and organic mercury from the sediments. These can be directly toxic to fish and can bioaccumulate and subsequently be toxic to humans consuming fish.

In some circumstances, during the first few years of operation after inundation, anaerobic conditions at lower levels (due to the breakdown of vegetation in the reservoir) can lead to the release of odorous hydrogen sulphide and methane and can generate grievances in the local community. Large amounts of hydrogen sulphide can be released if water is drawn from the lower levels in the reservoir and passed through the turbines. Water quality issues in reservoirs tend to be most problematic over the first 5–10 years of operation when most organic decomposition occurs, and a new equilibrium is found.

In some situations, water quality can be maintained in the reservoir and downstream (both short- and long-term) by removing biomass from the reservoir area before it is flooded<sup>20</sup>. This can improve short-term and long-term water quality in the reservoir and downstream. It can support faster stabilization of the reservoir ecosystem and improve aquatic habitat. Removing large trees improves navigation by local people and removes a risk for net fishing and development of fisheries. However, the benefits need to be assessed on a case-by-case basis—it may not always be desirable or effective (Box 5.2)<sup>21</sup>.

---

<sup>20</sup> Strengthening Environment Management-Phase II. 2010. Environmental Guidelines for Biomass Removal from Hydropower Reservoirs in Lao PDR. Vientiane.

[http://monre.mynapcloud.com/2017/emsp/images/doc/c2/biomassremovalfinal\\_6.pdf](http://monre.mynapcloud.com/2017/emsp/images/doc/c2/biomassremovalfinal_6.pdf)

<sup>21</sup> HSC (2020)

### Box 5.2: Cost–benefits of removing vegetation from Nam Theun 2 Hydropower

A detailed study for the Nam Theun 2 project in the Lao People's Democratic Republic found that the cost–benefits balance of systematic vegetation clearance was an unfavourable option. The study identified several difficulties concerning the removal of vegetation:

- Only a small fraction of the rapidly degradable biomass is located in trees or bushes;
- Cutting the vegetation alone does not address the question of disposal of this biomass. Burning is the option most often considered, but it has significant impacts on air quality. Exportation of the biomass is not practically feasible;
- Clearance of large areas is technically challenging, particularly in steep terrain which is common for a hydropower project;
- The clearing operation itself has significant environmental and social impacts and poses a risk to worker safety;
- Residues from logging activity can impact operation of the powerhouse.

As such, in many contexts' removal of trees over a certain size is selected as the best compromise.

**Figure 5.6: Reservoir at Nam Theun 2, Lao PDR, showing trees remaining**



*Photo caption: A. Javellana/ADB)*

*Source: Salignat, O., Descloux, S., Chanudt, V. To clear or not to clear vegetation prior to impoundment? Feedback experience on the Nam Theun II Reservoir (Lao PDR). Conference paper. [https://www.researchgate.net/publication/259640331\\_To\\_clear\\_or\\_not\\_to\\_clear\\_vegetation\\_prior\\_to\\_impoundment\\_Feed-back\\_experience\\_on\\_the\\_on\\_the\\_Nam\\_Theun\\_II\\_reservoir\\_Lao\\_PDR](https://www.researchgate.net/publication/259640331_To_clear_or_not_to_clear_vegetation_prior_to_impoundment_Feed-back_experience_on_the_on_the_Nam_Theun_II_reservoir_Lao_PDR).*

Pollution from human activity in the catchment can accumulate in reservoirs. This can lead to eutrophication due to excess nutrients (especially nitrates) from fertilizer runoff or sewage, untreated industrial waste discharges or the accumulation of solid waste from rubbish disposal upstream.

When water is released from a reservoir, the river downstream will be susceptible to any reduction in water quality generated in the reservoir. Variation in temperature and oxygen levels can negatively impact on aquatic species, as can the flushing of sediment (see next section).

Impacts on groundwater tend to be of a more minor nature than those affecting surface water. Groundwater may be affected by accidental spillages of construction materials and oils, or as a result of poorly designed solid waste disposal facilities. A reduction in groundwater quality can impact on communities that rely on groundwater for drinking or irrigation.

### **Erosion and sedimentation**

The clearing of and disturbance to vegetation and soil in areas surrounding dams and rivers during the development of a hydropower project usually leads to an increase in soil erosion and sedimentation of the river, mainly through the construction phase. If the local geology is unstable, landslips, mudflows and debris flows can all contribute to sedimentation of a river. During construction, earthmoving activities and road construction can increase erosion, particularly if there is inadequate attention to design and drainage. This often happens when temporary, lower cost and quality access roads are built.

In the operation phase, there is less site erosion as vegetation cover becomes established. An operational reservoir project can significantly change the sediment dynamic of a river. Dams can trap sediment, reducing sediment in the downstream reach. However, large volumes of sediment can be released to a river over a short duration, for example, if the operator needs to remove the sediment from the reservoir (e.g., to maintain storage capacity). Erosion of a reservoir rim can also occur as the water level rises and falls.

Changes to the erosion and sedimentation dynamic of a river are common issues for all hydropower projects. They affect water quality and can modify the riverbed composition and geomorphology and cause the degradation or loss of habitat for fish and other aquatic organisms.

As the dam captures sediment, the sediment load in the river downstream of the reservoir is lower than it was before the dam was constructed. This means that, for an equal volume and turbulence of water, the downstream river will have greater capacity to move bed load and to pick up sediment as suspended load. In so doing, the river will erode the riverbed or banks. The water of the river may be referred to as sediment-hungry or aggressive, or the river may be said to have **hungry-river syndrome**. The flow may erode the riverbed and banks, producing channel incision (downcutting), coarsen bed material (armouring), and remove spawning gravels used by fish. The mix of riverbed material will affect the pattern of downstream erosion: in sand-gravel mixtures (gravel bed rivers) downstream erosion will be controlled by the coarse surface armour layer; whereas in sand bed rivers the erosion will be more dynamic (IHA 2019).

Increased sediment load in the river can extend a long way downstream and can smother aquatic vegetation and habitats. This can be particularly problematic where gravel beds provide important habitat for downstream fisheries. More turbid water can also encourage fish to move to cleaner parts of the river. If sediment levels are very high, this can result in the smothering of aquatic invertebrates and can coat the gills of the fish causing death. Where significant erosion risks are likely, protection measures will be required (Figure 5.7).

**Figure 5.7: Erosion protection at Nam Theun 2, Lao People's Democratic Republic**



(Photo credit: G. Joren/ADB)



***Loss of habitats and biodiversity (terrestrial)***

Hydropower projects can have significant negative impacts on terrestrial ecosystems and their associated flora and fauna. The impacts are greater for reservoir projects due to the loss of inundated land. During the construction phase, vegetation must be cleared for dam sites, access roads and transmission lines which leads to the destruction or alteration of terrestrial habitats. Such clearance can fragment habitats by restricting the movement of fauna and potentially their access to important feeding and breeding grounds. In turn, the changes to ecosystems can lead to changes in the diversity or composition of plant and animal communities.

During construction, particularly through the displacement of soil, conditions are often created for the spread of alien species (some of which may be invasive), which can be brought in with construction equipment. Introduced invasive alien species are often able to colonize modified habitats and can out-compete and displace native species. Aquatic invasive species can also proliferate in the reservoir from upstream sources (e.g. water hyacinth).

Construction activities can cause disturbance to fauna from vibration, dust, and noise from blasting—particularly from quarrying activities. As access roads are developed in an area, there can be an increase in the number of animals killed by vehicles. Improved access can also facilitate increased poaching and hunting and overextraction of resources such as trees used for wood or fuel.

Inundation by a reservoir permanently changes the habitat. If biomass clearance is required, then trees and other vegetation will be cut down, and removed, if valuable. During impoundment, the rising water will slowly disperse fauna, but rescue may be required if animals become trapped and there is a risk that some animals may drown. Caves which provide habitat for bats can also be submerged with the habitat being permanently lost.

When a hydropower project is operational, the impacts on terrestrial fauna are much more limited. However, changes to the aquatic ecosystem may have a negative impact on terrestrial fauna when previous river food sources are lost. Similarly, riparian habitat can be lost or degraded by riverbank erosion, upstream and downstream of a hydropower project. Downstream of a dam, changes to the flow regime can lead to the loss or change of floodplain habitat. Regulation of the river by the dam and reservoir reduces the magnitude and duration of flood flows which, in turn, reduces downstream inundation of floodplain habitats.<sup>22</sup> Wildlife movements can also be fragmented or restricted by the presence of a large reservoir (IHA 2021).

***Loss of habitats and biodiversity (aquatic)***

In the construction phase of a hydropower project, aquatic flora and fauna in the immediate proximity of the site (dam site and powerhouse) will be lost as habitat is removed. Increased sediment loads as a result of site erosion can have a negative impact on fish and aquatic invertebrates.

In the operational phase, riparian habitats can be lost when a stretch of river is inundated by a new reservoir. Habitats which are important for fish breeding and spawning (e.g., deep pools, rapids, riffles, and in-channel wetland areas) can be submerged.

Changes to river flow regime can affect aquatic ecosystems and biodiversity by changing the daily or seasonal patterns of flow. This can be particularly severe if a peaking regime is used (i.e., a project only generates electricity for a few hours of the day). Run-of-river projects will often divert water around a stretch of river many kilometres long. Such a by-passed stretch can be left dry or with insufficient flow to maintain the original aquatic habitats.

Dams fragment aquatic systems and prevent the migration of fish up and downstream. This loss of aquatic connectivity in a river system can also affect plankton drift and potentially remove important spawning grounds. To some extent, fish passes (ladders) can mitigate the impact.

---

<sup>22</sup> IFC (2015b)

The creation of a reservoir can result in a range of water quality issues, as described above. Of particular concern at the start of the operational phase is the decomposition of organic matter which can deplete water oxygen, release methane and kill fish and other aquatic organisms.

Opening up a previously undeveloped area with new access roads can lead to increased fishing. Fishing opportunities can be created by the creation of a reservoir; but dynamite fishing can be particularly damaging. Furthermore, exotic fish may be deliberately added to reservoirs by local people for fishing, and this can result in pressure being placed on native species. New access roads can also enable an increase in fish poaching. This can be a particular problem where an access road is near to or passes through a protected or ecologically sensitive area.<sup>23 24</sup>

### **Waste and spoil**

The wastes generated by a hydropower project typically range from benign to potentially very harmful (e.g., toxic chemicals and hydrocarbons). Waste also includes excess spoil or waste rock from excavation, vegetation from clearing, and sewage and wastewater. Many jurisdictions have strict controls over the handling, transport, and storage of certain types of waste. A construction site should generally have dedicated areas that provide effective storage and transport points for wastes.

Human wastes, both solid and liquid, are a management issue at the implementation stage with respect to the large numbers of construction staff and their living quarters. Large construction camps are often developed to service the construction phase of a project. Appropriate refuse, sewage and wastewater disposal need to be planned for and managed and conform to regulatory requirements. Interactions of local fauna with refuse disposal sites (scavenging) can be an issue requiring management.

Spoil is waste material that cannot be used in construction because it is either not of the required quality or specification, or because it is surplus to requirements. Significant amounts of spoil can be generated during the construction phase of a hydropower project, particularly if there is a tunnelling operation ( Box 5.3). The spoil needs to be reused or stored near to the project site to avoid significant transport costs. It is typically used to make large, terraced piles on land which is not productive for agriculture or not important for conservation. In some cases, spoil can benefit a local community by filling in a steep area of land to make it usable. Key concerns are the gradient of slopes and suitable drainage to maintain stability and avoid erosion.

#### **Box 5.3: Karot Hydropower Project, Pakistan**

One of the most significant impacts identified from the 720 megawatt Karot Hydropower Project in Pakistan was the generation of significant volumes of spoil from excavations and tunneling activities. The main impacts identified were land loss due to the large amount of space required to accommodate spoil that could not be reused, and the resulting landscape and visual impacts created by the spoil heaps.

*Source: Karot Hydropower Company. 2015. Environmental and Social Management Plan. Lahore. [https://epaajk.gok.pk/uploadfiles/downloads/Updated%20ESIA\\_Karot%20HPP\\_%20Report2-compressed.pdf](https://epaajk.gok.pk/uploadfiles/downloads/Updated%20ESIA_Karot%20HPP_%20Report2-compressed.pdf)*

Earthmoving and quarrying activities can have an impact on soil quality in the project area. Soils can be contaminated as a result of spills of oil and fuel in vehicle maintenance and fuel storage areas. Contaminated soil needs to be removed to special waste disposal sites to prevent contamination of both groundwater and soils.

<sup>23</sup> IFC (2018)

<sup>24</sup> EBRD (2017)

### **Agriculture**

The inundation of land by a reservoir can lead to direct loss of productive agricultural land. In addition, downstream agricultural land can be impacted by a reduction in nutrients in sediment carried in flood water. This occurs if the hydropower project changes the river flow regime such that it no longer provides flood water to crops when required. Flood water sediment is important for agriculture because it often carries phosphorus (dissolved and total), nitrates, and ammonium downstream. Without these nutrients, crop yields will be lower. This problem can be countered by applying fertilizers, but this can lead to further environmental problems such as inappropriate use (with associated health hazards) and pollution from fertilizer runoff.<sup>25</sup>

### **Air quality**

Hydropower projects do not normally have a significant impact on air quality. There is typical construction-related air pollution from materials extraction, machinery, and vehicles (trucks, workers' buses, etc.) and dust from land clearing and from vehicles moving on dirt roads.

### **Greenhouse gases**

Some reservoirs can be a source of methane and carbon dioxide, which are greenhouse gases (GHG). It is released if the water in the bottom of a reservoir becomes anaerobic or there are low oxygen conditions, and bacteria decompose organic matter (dead vegetation left from clearing the reservoir site). One metric ton of methane in the atmosphere has about 25 times more effect on climate than one metric ton of carbon dioxide. Many reservoirs will not be significant emitters of methane, but this risk needs to be carefully checked before a project is developed.

The potential for GHG emissions can be assessed through the IHA G-Res Tool. It uses a conceptual framework that integrates up-to-date science in an online interface to estimate the GHG emissions from reservoirs. Such tools help hydropower companies and researchers estimate and report the net GHG emissions of a reservoir without the need to conduct expensive field sampling campaigns. They are especially valuable in the prefeasibility stage as a screening tool to avoid high-emitting projects.<sup>26</sup>

### **Dam and community safety**

The most obvious risk associated with a hydropower reservoir is dam wall failure, which can have catastrophic consequences for communities, livestock, and wildlife downstream ( Box 5.4). Dam failure can be due to:

- Substandard construction materials and techniques;
- Spillway design error;
- Geological instability caused by changes to water levels during filling;
- Poor maintenance, especially of outlet pipes;
- Extreme inflow;
- Human, computer or design error;
- Earthquakes.

---

<sup>25</sup> IFC (2018)

<sup>26</sup> IHA <https://www.hydropower.org/blog/carbon-emissions-from-hydropower-reservoirs-facts-and-myths>

#### Box 5.4: Dam failure: Saddle Dam D, Lao People's Democratic Republic

On 23 July 2018, Saddle dam D on the Xe Pian-Xe Namnoy hydropower project in Champassak and Attapeu provinces collapsed following heavy rain. The Government of the Lao People's Democratic Republic (Lao PDR) immediately suspended new hydropower projects and initiated safety inspections of all existing dams. The dam failure caused devastating floods in both Lao PDR and Cambodia's Stung Treng province, which lies downstream of the dam. 49 people died and 22 were missing presumed dead. The collapse displaced thousands of people, flooding homes and villages. Over 7,000 people in 19 villages in Attapeu province experienced losses and long-term damage to houses, property, and farmlands. The floodwaters extended far downstream and across the border into Cambodia, affecting an estimated 15,000 people, damaging farms, and destroying livestock and property.

**Figure 5.8: Downstream flooding following the collapse of Saddle Dam D in Lao PDR.**

Image redacted pending securing copyright permission to use. If you have an image showing the flooding following the collapse of this dam that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Source: International Rivers. The Xe Pian-Xe Namnoy Dam Disaster: Situation Update Two Years On. [https://www.internationalrivers.org/wp-content/uploads/sites/86/2020/08/ir-factsheet-2\\_year\\_xe\\_pian\\_dam\\_collapse\\_1\\_0.pdf](https://www.internationalrivers.org/wp-content/uploads/sites/86/2020/08/ir-factsheet-2_year_xe_pian_dam_collapse_1_0.pdf).

Dam break risk may be exacerbated by climate change. Depending on location, climate change may lead to changes to (i) annual and seasonal rainfall averages, (ii) the type and seasonal distribution of precipitation, (iii) the ranges of temperatures and precipitation, and (iv) frequency and severity of extreme weather events. Changes in these conditions will have effects on hydrological and other conditions including, for example, runoff, and seasonal patterns of runoff, glacial melt or timing of glacial melt, intensity of floods and droughts, frequency or magnitude of landslides, and sediment transport. Fortunately, dam break is relatively rare due to well-established design and maintenance standards. An emerging climate change issue for hydroelectric projects and climate change in the Himalayas is the potential for dam breach associated with an upstream glacial lake outburst flood (GLOF).<sup>27</sup>

A range of risks are associated with hydropower infrastructure such as electric shock, drowning, road accidents, accidents arising from community interactions with project activities.

In the preparation phase, there can be risk linked to structures used to support site investigations, e.g., access roads, buildings, test wells, helipads, etc. During project design, adherence with safety standards is an important consideration.

A significant safety risk during the construction period is the risk of flooding. Diversions are constructed to divert water from the river around the construction site. This diversion will have a capacity that can be exceeded during river flood events in which case water can inundate the construction site and the dam which is under construction can be put at risk of failure.

Other implementation safety issues include those related to construction such as increase in traffic, heavy machinery on roads and blasting activities.

During the operational stage, there will be continuing risks of electric shock, accidental drowning and road accidents.

<sup>27</sup> <https://www.scientificamerican.com/article/glacial-lakes-threaten-himalayan-dams/>

### **Noise and vibration**

Various activities during hydropower project construction generate noise and vibrations (truck movements, excavations, removal of vegetation, transport of workers to and from site, etc.). The use of explosives for blasting rock while preparing a dam site and in quarries will create excessive temporary noise and vibration and disturbance for nearby communities as well as wildlife. Quarries may be located at some distance from the dam site, so can increase the number of communities affected by noise. During operation, noise will be limited to generation from the power station and vehicle movements.<sup>28</sup>

### **Transboundary impacts associated with hydropower projects**

Hydropower projects can have impacts beyond national boundaries if they change the flow regime of a river that runs from one country to another. It is important that potential impacts are considered on a broad spatial and temporal scale. These can include changes to: a river's hydrological regime, its sediment dynamic, and water quality, all of which can affect aquatic ecosystems as well as associated fisheries and livelihoods. Key receptors to be considered in assessing the likely downstream impacts of a hydropower project are irrigation schemes, water supply projects, wetlands, and fisheries. This issue is particularly relevant when a river runs through several countries, e.g., the Mekong River in Southeast Asia ( **Box 5.5**).

Dams with potential transboundary impacts, such as Xayaburi run-of-river hydroelectric dam on the Lower Mekong River (around 30 km east of Sainyabuli [Xayaburi] town in northern Lao PDR), provide lessons about how dams can cause not only ecological and environmental impacts across an international national border, but also adverse effects on the socioeconomics of the downstream riparian states and communities.<sup>29 30</sup>

---

<sup>28</sup> IFC (2018)

<sup>29</sup> IFC (2015b)

<sup>30</sup> Young and Ear (2021).

### Box 5.5: Multiple hydropower dams on the Mekong River

The Mekong River arises in the People's Republic of China (PRC) and flows through Myanmar, the Lao People's Democratic Republic (Lao PDR), Thailand, Cambodia, and Viet Nam. In the Upper Mekong River Basin, the PRC has constructed 11 hydropower dams (of which two are large storage dams). Another 11 dams, each with production capacity exceeding 100 MW, are being planned or constructed. There are a further 89 projects in the lower basin, of which two are in Cambodia, 65 in Lao PDR, 7 in Thailand and 14 in Viet Nam. Many more dams are planned over the next 10 years, as shown in Figure 5.9.

**Figure 5.9: Map of the Mekong River Basin showing operational and planned hydropower projects**

Image redacted pending securing copyright permission to use from Mekong River Commission. If you have an image showing these hydropower projects that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

The Mekong River Commission has been established to manage the transboundary issues associated with these projects. It is an intergovernmental organization that works directly with the governments of Cambodia, Lao PDR, Thailand, and Viet Nam to jointly manage their shared water resources and the sustainable development of the Mekong River. Its aim is to promote and coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well-being.

Source: Mekong River Commission for Sustainable Development. Hydropower. <https://www.mrcmekong.org/our-work/topics/hydropower/>.

## 5.4.2 Socioeconomic Issues and Impacts

### *Physical and economic displacement*

Some hydropower projects cause economic and physical displacement of riparian communities and settlements<sup>31</sup>. Economic displacement is defined as the loss of assets, access to assets, or income sources or means of livelihoods, which could be caused by land acquisition, changes in land use or access to land, restrictions on land use or access to natural resources, or changes in the environment leading to impacts on livelihoods.<sup>32</sup> Hydropower projects can also cause physical displacement from the loss of residential land or shelter. Physical displacement involves risks for both the displaced people and for the host communities receiving them when they relocate.<sup>33</sup>

The amount of displacement will often depend on the type of hydropower project. Run-of-river schemes may cause only limited displacement. But hydropower projects that include a reservoir tend to occupy a large area of land. The land acquisition for a reservoir can affect farmland and grazing lands that are located near the river. Farmers' and villagers' incomes from farming and livestock raising will be lost or reduced when the land is flooded. Large reservoirs can also inundate residential areas and displace an entire community to a new resettlement area (Box 5.6) Business activities, whether small, medium, or large enterprises, can also be displaced, affecting their owners and workers. Furthermore, community

<sup>31</sup> Cernea, M. M. (2004).

<sup>32</sup> IHA (2020)

<sup>33</sup> WCD (2000)

public facilities such as schools, clinics, public meeting halls and cultural and religious sites may also be lost or need to be relocated. Often, associated infrastructure such as access roads and transmissions line can also cause physical and economic displacement.<sup>34</sup>

### Box 5.6 Displacement of people due to development of the Three Gorges project in China

Construction of the Three Gorges Dam on the Yangtze River (Chang Jiang) in Hubei province, China (Figure 5.9), was completed in 2006 – at the time, it was the largest dam structure in the world. The dam and accompanying hydroelectric plant were built in phases and over the course of many years. It reached its full generating capacity in 2012. The dam allows the navigation of oceangoing freighters and generates hydroelectric power. It was also intended to provide protection from floods, but efficacy on this aim remains unclear

While the construction of the Three Gorges Dam was an engineering feat, it has also been fraught with controversy: construction of the dam caused the displacement of about 1.4 million people. Hundreds (possible thousands) of towns and villages were evacuated and later submerged. The area surrounding the Yangtze contains some of the densest clusters of human life in the world.

Those forced to relocate were promised compensation for the value of their homes and land. But majority of relocated citizens were either given far too little in compensation or their dues were allegedly slimmed through corruption and embezzlement - many claim they received only half the land compensation they were promised<sup>35</sup>. This created problems for many as the cities and towns they had to move to were more expensive, driving many people deeper into poverty (Yardley 2007), landlessness, joblessness, marginalization, and food insecurity<sup>36</sup>. The displaced were often farmers with little formal education, if any. Many opted to return to the Yangtze region.

Figure 5.10: Three Gorges Dam, China

Image redacted pending securing copyright permission to use. If you have an image showing the the Three Gorges Dam location that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Flooding the reservoir has forced those farmers still in the region to migrate northwards up the mountain slopes, adding to erosion through over utilization of top soil.

The dam also resulted in the destruction of natural features and countless rare architectural and archaeological sites. The dam's reservoir is blamed for an increase in the number of landslides and earthquakes in the region.

#### Sources:

<https://www.britannica.com/place/China>

*Environmental and Social Issues of the Three Gorges Dam in China* (mandalaprojects.com)

Gleick (2009)

Hvinstendahl (2008)

Displacement can impoverish the resettled people, who are often from poor communities. Without adequate mitigation measures and compensation, the livelihoods of displaced peoples can be made significantly worse.<sup>37</sup>

<sup>34</sup> WCD (2000)

<sup>35</sup> Hvinstendahl (2008)

<sup>36</sup> Gleick (2009)

<sup>37</sup> Cernea (2004)

The construction of dams and weirs for both run-of-river and reservoir hydropower schemes can disrupt fishing activities which are often important income-generation activities of the riparian communities. For example, large-scale and transboundary dams along the Mekong River in Southeast Asia have led to less fish migration and lower fishing yields both downstream and upstream of the dams.<sup>38</sup> Hydropower projects can also displace sand mining businesses and the collecting of sand or other aggregate materials from rivers by local people.

The relocation of affected people can create pressure on the public facilities and infrastructure in the host communities, giving rise to tensions between the two groups. The losses endured by the host community can lead to weakened community cohesion and an increase in domestic and gender based violence.

### **Indigenous communities**

The development of a hydropower project may cause both positive and negative impacts on indigenous communities and people. The IFC's Performance Standard 7 and the ADB's SPS (2009) on Indigenous Peoples recognize that indigenous peoples can be marginalized due to their sometimes tenuous economic, social, and legal status and their limited capacity to defend their rights and interests. Indigenous peoples typically have strong spiritual, cultural, and economic relationships with their land and waterways. According to the International Hydropower Association's new guide on hydropower and indigenous peoples<sup>39</sup>, a major negative impact can often be loss of land under traditional use. This could be land for which their jurisdiction and management may have been previously removed by national government decisions. Impacts on IPs other than loss of communal lands include the following:

- Reduced or variable flows that could affect the safety, irrigation, water uses, and livelihoods of communities living downstream;
- Loss of ancestral land and loss of cemeteries, or reduction of their territory;
- Loss of access to or reduction of resources (e.g., water, fish and animal species, fertile land, and forested areas) and associated nutritional issues.

Box .7 provides examples of cases in which indigenous peoples have been displaced and affected by hydropower projects.

#### **Box 5.7: Indigenous peoples affected by hydropower projects: some examples**

Many indigenous groups protest about hydropower projects and denounce government approvals for projects. For example, an indigenous community on the border of Thailand and Myanmar organized a large protest against the Salween River hydropower project in 2017. [a] This unrest occurred, in part, as a result of inadequate engagement of and consultation with affected communities, and a lack of appreciation of their ties to the land.

In Cambodia, the construction of hydropower projects, such as Lower Sesan 2 dam, have caused adverse impacts on indigenous communities (nearly 5,000 people, mostly IPs and other ethnic minorities - Bunong, Brao, Kuoy, Lao, Jarai, Kreung, Kavet, Tampuan, and Kachok - who have lived in villages along the Sesan and Srepok Rivers for generations [b]. The latter were displaced which resulted in disagreements with project proponents. [c]

In Lao PDR, where ethnicity is diverse, a number of indigenous people have been affected or displaced by hydropower projects, including the multilateral development bank-financed Nam Theun 2 project. [d]

In Indonesia, displacement of indigenous people due to hydropower development projects are often reported by media outlets. For example, a 480MW-hydropower project in South Sulawesi affected Pohoneang, Hoyyane and Ambalong indigenous communities. [e]

<sup>38</sup> Young and Earl (2021).

<sup>39</sup> IHA (2022)



**Sources:**[a] *Shah and Bloomer (2018)*[b] *Human Rights Watch (2021)*[c] *Young (2020)*[d] *Nam Theun 2.com. NTPC Document Proforma (namtheun2.com)*[e] *Rusdianto (2017)*

There are also examples from Southeast Asia of renewable energy initiatives that are being driven by indigenous communities. Micro-hydro power developments in the Philippines and Malaysia are increasing access to clean energy, reducing harmful pollutants and alleviating the work burden on women as well as providing other community benefits. Groups like 'Grupo Yansa' provide support to indigenous communities interested in developing the renewable energy potential of their land.<sup>40 41</sup> In Canada, some indigenous peoples' groups are partnering with the private sector to develop and operate large energy projects<sup>42</sup>.

There are many opportunities for hydropower development to bring benefits to the indigenous communities. According to the IHA, these benefits include but are not limited to<sup>43</sup>:

- Increased safety by having flood control and regulated flows;
- Support to promote and enhance cultural traditions;
- Employment and business opportunities through the project life, including direct employment opportunities, subcontracting services during construction and maintenance, service provision such as food and transportation services, and indirect employment within local communities;
- Investment revenues from project partnerships with indigenous peoples' communities;
- Training (pre-project and during construction and operation) and improved community governance capacity.

Jobs during the construction phase are varied depending on the type and size of hydropower project. The Muskrat Falls hydropower project in Canada advertised that the construction workforce would span more than 70 different types of occupations<sup>44</sup>. While some of the expertise may not be available in indigenous peoples' communities, the range of needs, especially in larger projects is considerable, meaning the emphasis should be on matching available local skills to needs among the contracting tiers and service providers.

In some countries, companies choose (for business reasons) or are regulated to offer impact benefit-sharing agreements. One report from British Columbia in Canada identifies several reasons for entering into benefit-sharing agreements with Ips including: to further social license to operate, as matter of good neighbour policy, and to provide a competitive advantage to meet consumer demand for ethically produced products.<sup>45</sup> The report indicates that such agreements are not a cure for all conflicts and uncertainties and will not resolve complex legal, political, cultural and historical issues; nor should one company or project be expected to bear all of the burdens of history. But each fairly negotiated benefit-sharing agreement is an important step forward that will help reconciliation efforts.

### **Health and safety**

---

<sup>40</sup> Shah and Bloomer (2018)

<sup>41</sup> UNDESA (2021)

<sup>42</sup> CHA (2018)

<sup>43</sup> IHA (2022b)

<sup>44</sup> Muskrat Falls jobs. Nalcor Energy. Accessed October 2013.

<sup>45</sup> Woodward & Company (undated)

Community health and safety issues are associated with hydropower development during both the construction and operational phases.<sup>46</sup> The IHA's guide<sup>47</sup> on hydropower infrastructure (2021) identifies the following issues: road safety; safety around water bodies associated with the hydropower complex; blasting, and other construction activities; electrical safety; natural hazards; underground geotechnical hazards; and pressurized conveyance hazards.

During the construction phase, the large amounts of heavy vehicle movements can also increase road traffic, affect road and bridge conditions, and cause accidents. A major issue is the excavation of large quantities of soil and rock, drilling and creation of tunnels. Such work creates significant health and safety risks for both workers and local communities, from dust, noise, and vibrations; eutrophication; waste disposal; and the potential spread of communicable diseases.

ESIA guidance for hydropower published by the Netherlands Commission for Environmental Assessment (NCEA) identifies numerous vector-borne and tropical diseases associated with the development of reservoirs.<sup>48</sup> These risks are exacerbated in low-income countries in Southeast Asia where water quality regulatory enforcement remains limited. In addition to health risks, both construction and operation of hydropower plants can involve structural failure and flooding. An example is the Dhauliganga hydroelectric station in India. In June 2013, there was an unprecedented flash flood, causing massive debris accumulation and the complete submergence of the power house. Damage caused electrical equipment replacement and loss of total generation capacity for more than six months<sup>49</sup>.

The IFC hydropower guidance (footnote **Error! Bookmark not defined.**) notes that some infectious diseases can spread around hydroelectric reservoirs, particularly in warm climates and densely populated areas. Some diseases (such as malaria and schistosomiasis) are borne by water-dependent vectors (mosquitos and aquatic snails, respectively); others (such as dysentery, cholera, and hepatitis A) are spread by contaminated water, which is frequently present in stagnant reservoirs. Hydropower development projects can also increase other communicable diseases (infectious diseases such as influenza, STIs, and HIV/AIDS), increased drug and alcohol use and the potential for increased crime and domestic and gender based violence due to the immigration and large-scale influx of workers.

As the COVID-19 pandemic has shown, the large workforces often required by hydropower projects need to be managed to avoid being a spreading point for diseases, but there can be challenges, as illustrated by the experience of Karot Hydropower Project in Pakistan ( **Box 5.8**).

Hydropower projects usually involve the use of heavy goods vehicle fleets to transport materials and staff on-site. In many cases, hydropower projects require new access roads or upgrades to existing roads and bridges to transport heavy equipment, but key risks can be neglected in policies, procedures and monitoring programs: unsafe road design and conditions, unsafe vehicles, speeding, non-use of seatbelts and helmets, lack of driver training, driving under the influence of alcohol or drugs, inadequate post-accident care, and lack of enforcement of traffic rules. Without mitigation measures for these risks, a hydropower project can cause traffic related congestion, accidents, and fatalities.

### **Cultural heritage**

Cultural heritage includes:

- Tangible forms of culture such as movable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values;
- Unique natural features or tangible objects that embody cultural values (sacred groves, rocks, lakes, and waterfalls); and

<sup>46</sup> Acakpovi and Dzamikumah (2016)

<sup>47</sup> IHA (2021)

<sup>48</sup> NCEA (2018)

<sup>49</sup> [https://en.wikipedia.org/Dhauliganga\\_Dam](https://en.wikipedia.org/Dhauliganga_Dam)

- Intangible forms of culture, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles<sup>50</sup>.

---

<sup>50</sup> IFC (2021)

### Box 5.8: Karot Hydropower Project in Pakistan

Karot Hydropower Project is located on the Jhelum river in Pakistan and is nearing completion. The power company faced challenges over managing the spread of COVID-19 early on when no vaccine was available. Trade unions filed a complaint to the International Finance Corporation (IFC), project funder) that the project company undermined the rights of 3,000 workers by restricting their movement, curtailing their freedom of association and collective bargaining (particularly of workers dismissed during the COVID-19 pandemic) and violated the IFC's own performance standards on workplace safety and working conditions, terms of employment, grievance mechanisms and retrenchment.

### Figure 5.11: Karot Hydropower Project, Pakistan

Figure redacted pending securing copyright permission to use. If you have an image showing this power plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

The Hydro Sustainability Secretariat<sup>51</sup>, identifies that hydropower schemes can have impacts on cultural heritage at each stage of project development. The construction stage may cause direct and indirect damage to or loss of access to physical cultural resources as a result of excavation, soil compaction, blasting, vibrations, pollution, vandalism, theft, desecration of cultural objects and sites, and groundwater and river flow changes. Construction activities may also be perceived to disturb spirits associated with special sites<sup>52</sup>.

During project operation, impacts on cultural heritage may include the loss of sites inundated by a reservoir (

Box 5.9), downstream damage to cultural sites (e.g., through riverbank erosion or flooding) and interruption of ability to continue cultural traditions (e.g., in particular locations) or access specific sites due to changes arising from the project)<sup>53</sup>.

Hydropower projects tend to be located in remote areas where land is often claimed or occupied by vulnerable indigenous communities. The acquisition of land for the project can displace these communities and their cultural practices, such as sacred sites on land, in forests or in water.

From 2019 to 2021, a UNESCO World Heritage Centre initiative advocated for the protection of natural heritage in the context of renewable energy projects. Hydropower projects need to be effectively planned, evaluated and implemented to safeguard world heritage properties.<sup>54</sup>

The IFC's Performance Standard on Cultural Heritage (PS8)<sup>55</sup> sets out good practice for addressing cultural heritage impacts. They require the protection of cultural heritage from adverse impacts, and support for preservation and equitable sharing of benefits from the use of cultural heritage. In September 2021, the International Hydropower Association announced that no new hydropower projects should be developed in World Heritage sites. It proposed a "duty of care commitment" to implement high standards of performance and transparency when affecting protected areas as well as candidate protected areas and corridors between protected areas<sup>56</sup>.

<sup>51</sup> HSC (undated)

<sup>52</sup> HSC (undated)

<sup>53</sup> HSC (undated)

<sup>54</sup> UNESCO (2021)

<sup>55</sup> [www.ifc.org](http://www.ifc.org)

<sup>56</sup> IHA Website notification September 2021. International Hydropower Association announces new commitment to World Heritage sites and protected areas - UNESCO World Heritage Centre.

### Box 5.9: The Bujagali hydropower project and natural heritage in Uganda

The Bujagali hydropower project in Uganda was commissioned in 2011 and is still being cited as a project that negatively impacted the culture of local people. The Bujagali Falls was a place of spiritual healing and traditional culture but was blocked and inundated by the hydropower project.

#### Figure 5.12: Bujagali Hydropower Project

Figure redacted pending securing copyright permission to use. If you have an image showing this hydro project that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Source: Kabanda Umar and Francis Mwesigye. 2021. *Cultural Heritage and Renewable Energy: How Bujagali Hydro-Electricity Generation Project sparked a latent conflict*.  
<https://blogs.prio.org/2021/06/cultural-heritage-and-renewable-energy-how-bujagali-hydro-electricity-generation-project-sparked-a-latent-conflict/>

Hydropower projects can support local communities and their cultural heritage by helping to encourage tourism to their location. It is assumed that hydropower plants and accompanying infrastructure reduce the attractiveness of the areas in which they are located for tourism, but some tourists find them acceptable and desirable.<sup>57</sup> Around the world, hydropower projects organize tours and celebrate local culture, e.g., projects at Itaipu at the conjunction of Brazil, Argentina, and Paraguay, and at Niagara Falls on the border between Canada and the US.

#### **Gender and vulnerability**

A hydropower project may affect women and vulnerable groups and impair their ability to access benefits, as they often lack ownership of and rights to property, which affects their access to compensation. A sector study from India shows that<sup>58</sup> women are especially vulnerable when gender sensitivities are ignored or overlooked in the project design and planning phases of hydropower development. These vulnerabilities range from losing their traditional means of livelihood when they lose access to their land, which in turn affects their food security and often their access to water and sanitation as well. Women lose access to and control over resources such as land, rivers, forests, fodder, and must then deal with increasing workloads.

Many large hydropower projects have large workforces that are resident for several years. Their presence (often predominantly male, although this is changing) can impact on women's safety and routine activities. World Bank guidance addresses the management of the risks of adverse impacts on communities from temporary project-induced labour influx.<sup>59</sup> It identifies violent and risky behaviour resulting from an increase of predominantly male construction workers for large infrastructure projects such as hydropower. Non-local workers can be drawn to the affected area and local workers can have access to relatively high incomes. This can lead to anti-social behaviours (greater alcohol and

<sup>57</sup> Saeporsottir and Hall (2018)

<sup>58</sup> Shrestha *et al.* (2019)

<sup>59</sup> World Bank (2016)

substance misuse), a heightened risk of sexual exploitation and abuse or sexual harassment<sup>60</sup>, and long-lasting physical and mental health impacts for the community<sup>61</sup>.

Furthermore, a lack of gender diversity within the workforce can limit access for women workers to economic opportunities created by the transition to hydropower. According to the IFC's Powered by Women initiative, which surveyed 20 hydropower companies in Nepal<sup>62</sup>, women make up only 10% of the total number of employees, and only 5% hold technical jobs. Women are inhibited from taking up non-traditional roles in the industry due to various factors: gender stereotyping in the workplace; a lack of women taking up training in science, technology, engineering and mathematics (STEM); a lack of access to formal finance for women-headed businesses; and deprioritizing gender mainstreaming within hydropower companies **Error! Bookmark not defined.**<sup>63</sup>.

### **Employment and labour conditions**

Globally, the numbers of workers employed in the renewable energy sector increased from 8.1 million (1.3 in hydropower) in 2015 to 12 million in 2020 (2.2 million in hydropower)<sup>64 65</sup>. The Asia and Pacific region had the greatest new hydropower capacity in 2020 (almost 14,500 MW) followed by Europe (just over 3,000 MW) and South and Central Asia (just over 1,600 MW)<sup>66</sup>, providing significant employment. The development of a hydropower project can create job opportunities for local people, as well an opportunity for vulnerable groups and indigenous communities to acquire new skills through working on the project<sup>67</sup> (**Error! Reference source not found.**). There are gender gaps with women underrepresented (**Error! Reference source not found.**).

#### **Box 5.10: Long-term employment opportunities in the hydropower sub-sector in the Philippines**

In 2021, a Japanese renewable energy developer invested in the development of a 17.4MW hydropower project in Ifugao Province in northern Luzon, Philippines. After the completion of construction, the wider and extended portfolio of hydropower projects is expected to provide the region with clean energy and long-term employment opportunities for local communities. In the Philippines<sup>68</sup>, the large and small hydropower sector employed close to 53,600 workers in 2021, and this number continues to rise.

*Source: Rivera (2021)*

<sup>60</sup> Such factors should be combined with an understanding of wider sociocultural risk factors within the country context (i.e., pervasive gender inequality, poverty and discrimination, restrictive social and gender norms) to determine the steps needed to safeguard women and girls from harm. For more guidance, see: EBRD, IFC, CDC (2021)]

<sup>61</sup> See World Health Organisation (2021) <https://www.who.int/news/item/25-11-2021-gender-based-violence-is-a-public-health-issue-using-a-health-systems-approach> [Accessed 22/03/2022]

<sup>62</sup> IFC (2020)

<sup>63</sup> IFC. Bringing Gender Equity into Hydropower Development from the Start.

[https://www.ifc.org/wps/wcm/connect/news\\_ext\\_content/ifc\\_external\\_corporate\\_site/news+and+events/news/bringing+gender+equity+into+hydropower+development+from+the+start](https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/bringing+gender+equity+into+hydropower+development+from+the+start)

<sup>64</sup> IRENA (2021a)

<sup>65</sup> OECD (2017)

<sup>66</sup> IHA (2021b)

<sup>67</sup> HSC (2022)

<sup>68</sup> INFRACOASIA (2021)

### Box 5.11: Gender gaps in the hydropower sub-sector

A recent study for the World Bank looked at gender gaps in the hydropower sector. It was carried out by the Energy Sector Management Assistance Program in partnership with the IHA and the Global Women's Network for the Energy Transition (GWENET) 69. The study reports that women remain underrepresented in the sub-sector, as they are in the overall energy sector in general. It was difficult to determine the degree of underrepresentation since sex-disaggregated data and gender statistics on employment in the sub-sector are scarce. The report notes that hydropower generates almost two-thirds of renewable energy electricity, and it employs over two million people globally. Hence, the sub-sector has the potential to make a significant contribution to improving diversity and gender equality across the energy workforce

While labour conditions may vary from one hydropower project to another, there is also a possibility that such projects can breach labour rights. It is common for construction monitoring to identify excessive use of overtime, working successive days without required days of rest, and excessive use of temporary or contract workers. The latter can create a two-tier workforce with repercussions for staff morale, workers not being paid correctly or not being correctly signed up for safety net systems.

The need to engage large workforces in remote areas (where hydropower schemes are often located) can lead to companies providing poor working conditions. In such remote areas, labour inspectors may not be able to regularly monitor projects. Some of the ILO Indicators of Forced Labour<sup>70</sup> were frequently breached by companies during the COVID pandemic, e.g., restriction of workers' movements, isolation, abusive working and living conditions and excessive overtime. They can also be breached by remote, large-scale construction activities such as hydroelectric projects.

One of the key elements of ensuring just renewable energy transition is ensuring that the workforce includes people from marginalized groups.

### Migration

A hydropower project may lead to an influx of migrants and skilled workers seeking business and employment opportunities. Incoming workers and followers, including job seekers and squatters, can lead to adverse socioeconomic impacts on local communities residing near hydropower projects. According to IFC guidance on project-induced in-migration<sup>71</sup>, this may have a wide range of positive and negative impacts. Positive impacts include, among others, business opportunities, improved range of accessibility to goods and services, higher skill base and increased local tax revenue. Negative impacts include, among others, pressure on services and land, demand for and shortfalls in products and services, boom and bust cycles related to the construction phase, tensions and disputes among different groups related to benefit distribution, alteration in existing levels of communicable disease, increased incidents of social vices and increased potential for domestic and gender-based violence.

According to the IFC's guidance, the amount of in-migration can be influenced by various factors:

- Larger projects lead to a greater impact of in-migration; small projects lead to a lesser impact of in-migration;
- Low capacity leads to a greater impact of in-migration, high capacity leads to a lesser impact of in-migration;
- High concentration leads to a greater impact; low concentration leads to a lesser impact of in-migration;

<sup>69</sup> Energy Sector Management Assistance Program. 2021. World Bank-ESMAP Launches Survey on Gender Gaps in Hydropower Sector - As Part of New Study to Support Women's Employment in the Sector | ESMAP. 19 July.

<sup>70</sup> Rivera (2021)

<sup>71</sup> IFC (2009).

- Many opportunities for compensation and benefits speculation lead to a greater impact of in-migration; few opportunities lead to a lesser impact of in-migration;
- Projects far from urban centres lead to a greater impact of in-migration; projects close to urban centres lead to a lesser impact of in-migration.
- Migration can cause both socioeconomic and cultural tensions between the local community and migrant workers from other regions or countries—especially if there is displacement of local people, economic loss, and loss of sites and religious or cultural practice of significance due to project development.

### **Public services and infrastructure**

Hydropower projects often fund improvements to and new local infrastructure and facilities, not least to support their own workforces ( Box 5.12). They also require the construction of new access roads or upgrading of existing nearby roads to transport equipment and for the construction of transmission lines or substations as associated infrastructure. While local communities benefit from new or upgraded roads, tensions can arise when transmission lines are built—particularly since the electricity generated is not distributed locally (hydropower projects are typically permitted as generating facilities and are not allowed to distribute electricity to local communities).

#### **Box 5.12: Hydropower Project Nam Theun 2, Lao, People's Democratic Republic: Contribution to improved public infrastructure and facilities**

Before the Nam Theun 2 project began, basic infrastructure and public facilities in the remote Nakai District was lacking or inadequate. Even in the dry season it took half a day or more to travel between the district and provincial capitals. During the wet season, the Nakai Plateau was virtually inaccessible. The average distance to the nearest health facility was 11 kilometres, usually travelled on foot. Initial health surveys reported poor health conditions for both adults and children, high mortality rates for children under five (120.5 per thousand), widespread stunting and malnutrition, and remarkably high prevalence of parasite infection (59%). 63% of the population on the Nakai plateau lacked access to education, a situation that was of even greater concern for women, most of whom were illiterate. Electricity and communication services were not available to most households.

With project support, basic infrastructure and public facilities have improved. Households have access to electricity and telecommunication services, and most households own at least one mobile telephone. Traders and brokers can now access the plateau and northern villages by road to buy fish. Pigs and ducks can now be sold to collectors or at the market. The project supported the construction of new kindergartens, 14 primary and two secondary schools. 90% of the children are currently enrolled in primary school, compared to 37% before. Two new dispensaries provide improved and convenient access to primary health care. In five years, child mortality of those under five decreased from 120 to 59 per thousand.

*Source: Nam Theun 2 dam website. NTPC Document Proforma (namtheun2.com)*

Many hydropower projects will build permanent housing for their operational workforce. By comparison, other types of renewable energy (in particular, wind and energy) tend to have smaller operational workforces and construct much less housing, and more of it is temporary.

As indicated in the section on physical and economic displacement, the resettlement of affected people (e.g., due to the construction of a hydropower reservoir) can increase pressure on the use of the host community's public facilities (schools, clinics, hospitals) and infrastructure.



The IHA guide people/communities affected by hydropower projects<sup>72</sup> notes that such projects can cause permanent or temporary closures of local infrastructure and services if inundation is required. This may include schools, health centres, shops, roads, bridges, footpaths and tracks, and boat/ ferry transport, transmission and telephone lines, and pipelines. For example, in Sikkim, India, hydropower companies support local area development programs for affected areas through community development projects such as school repair, road and footpath construction, provision of electrification and water supply for villages, and livelihood skill development<sup>73</sup>.

### **Community cohesion and engagement**

Hydropower development projects can have both positive and negative impacts on community relations and engagement. The impacts on community cohesion can include, but are not limited to<sup>74</sup>:

- Impacts to or loss of community resources (e.g., roads, gardens, land, forest, fisheries) and community assets (e.g., community meeting areas, culturally significant features);
- Conflicts between the workforce and the local population and exposure to anti-social behaviour;
- Conflicts within the local population. These can arise for a range of reasons, often relating to issues of inequity, including, for example: compensation measures ( which may arise from a lack of clarity on cut-off dates), eligibility criteria or entitlement provisions (e.g., duration); access to and extent of training and support; and access to and extent of project benefits.

While the introduction of outsider culture and relationship issues are often raised in hydropower development projects, there are opportunities that projects can improve social relations and engagement (see example in Box ).

#### **TIPS FOR PRACTICE**

Advantages of SEA for hydropower schemes include<sup>75</sup>:

- Better understanding of the cumulative impact of a series of individual hydropower projects (cascades), and preventing costly and unnecessary mistakes;
- Better insight in the trade-offs between environmental, economic and social issues, enhancing the chance of finding win-win options;
- Easier project-level ESIs because strategic decisions, for instance on locations and power generation capacity needs, have already been decided upon;
- Better alignment of decisions and information requirements lead to more efficient assessments;
- Enhanced credibility in the eyes of affected stakeholders, leading to swifter implementation;
- Easier access to funding from international development banks.

The potential for cumulative impacts is significantly increased when multiple hydropower dams are located along a single river or in a particular catchment

<sup>72</sup> IHA (2020)

<sup>73</sup> Chandy *et al.* (2012)

<sup>74</sup> IHA (2020)

<sup>75</sup> Kolhoff and Slootweg (2021)