HYDROSELECT

(**Hydro**power **S**ustainability **E**arly Stage D**ec**ision-making **T**ool)

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Consultation Disclaimer

The Hydropower Sustainability Early Stage Decision-making Tool (HYDROSELECT) has been prepared by the Hydropower Sustainability Alliance and the multistakeholder Working Group on Early Stage Decision Making. Respondents are invited to provide feedback and comments on the various sections of this Consultation Paper through a series of open-ended questions via this online feedback form.

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AZE	Alliance for Zero Extinction
CBD	Convention on Biological Diversity
CH_4	Methane
CIA	Cumulative Impact Assessment
CO_2	Carbon Dioxide
CR	Critically Endangered
CSO	Civil Society Organisation
CSV	Comma-Separated Values
EN	Endangered
ESG	Environmental, Social and Governance
ESIA	Environmental and Social Impact Assessment
FPIC	Free, Prior and Informed Consent
GBIF	Global Biodiversity Information Facility
GEF	Global Environment Facility
GHG	Greenhouse Gas
GDIS	Global Drought Information System
GLOF	Glacial Lake Outburst Flood
GPCC	Global Precipitation Climatology Centre
GWP	Global Water Partnership
HAS	Hydropower Sustainability Alliance
HSS	Hydropower Sustainability Standard
IBAT	Integrated Biodiversity Assessment Tool
ICIMOS	International Council on Monuments and Sites
IEA	International Energy Agency
IFC	International Finance Corporation
IFI	International Financial Institution
IHA	International Hydropower Association
IHP	International Hydrological Programme
IP	Indigenous People
IPCC	Intergovernmental Panel on Climate Change
IRBM	Integrated River Basin Management
IRENA	International Renewable Energy Agency
IUCN	International Union for Conservation of Nature
IWGIA	International Work Group for Indigenous Affairs
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
KBA	Key Biodiversity Area
NASA	National Aeronautics and Space Administration

NGO	Non-Government Organisation
PFF	Potential Fatal Flaw
PS	Performance Standard
RAP	Resettlement Action Plan
REN21	Renewable Energy Policy Network for the 21st Century
SEA	Strategic Environmental Assessment
TNC	The Nature Conservancy
TOR	Terms of Reference
UN	United Nations
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNEP	United Nations Environment Programme
UNPFII	United Nations Permanent Forum on Indigenous Issues
USGS	United States Geological Survey
VU	Vulnerable
WCMC	World Conservation Monitoring Centre
WWF	World Wide Fund for Nature

Introduction to HYDROSELECT

Welcome to HYDROSELECT! Using this decision support tool supports the process of going from identified energy needs towards hydropower project concept(s) that are most likely to be sustainable and bankable.

The ideal sequence of steps, and where HYDROSELECT fits, is shown in Figure 1.

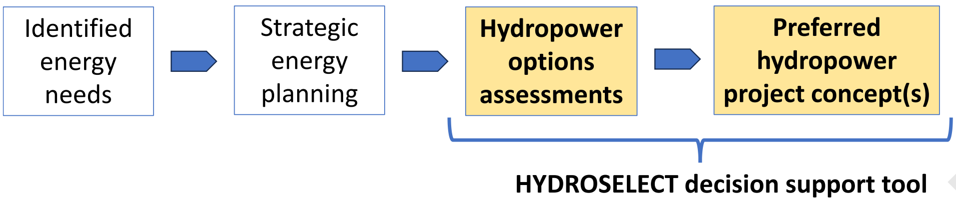

Figure 1 – The early stage sequence and the steps supported by the HYDROSELECT decision support tool

Expectations of developers, governments, financial institutions, power off-takers and civil society increasingly concern hydropower sustainability. Sustainability is a broad, holistic concept that includes Environmental, Social and Governance (ESG) as well as longevity and cumulative impact and benefit aspects of proposed project concepts. Increasingly there is recognition that historical approaches focused on project-level options are far less efficient and cost-effective than broader regional analyses, particularly from a sustainable river basin perspective where hydropower is amongst the options[1].

Strategic energy planning should look at a range of potential energy technologies alongside other energy management approaches (e.g. demand management) to narrow down which are potential energy need solutions. At the earliest stages, strategic energy planning should seek to identify if hydropower is an appropriate technology, and if so, what suites of locations could potentially deliver desired energy services whilst minimising cumulative ESG impacts. Hydropower should be considered as part of an energy options assessment due to its renewable nature, ability to provide reliable baseload power, and potential for mitigating greenhouse gas emissions compared to fossil fuel alternatives. Hydropower is a good complement to wind and solar energy because it offers reliable, dispatchable power generation that can compensate for the intermittency of wind and solar resources, thus enhancing grid stability and energy reliability.

Whilst HYDROSELECT is not designed to provide guidance on strategic energy planning, the considerations it includes may be incorporated, as feasible, into broader strategic energy and hydropower planning frameworks. Hydropower strategic planning has benefited greatly from advances in computational capacities and data availability, and is ideally a precursor to and consistent with HYDROSELECT application. Tools that inform strategic hydropower planning and master plans increasingly include Strategic Environmental and Social Assessments, whole-of-river basin planning and optimisation, and ‘Hydropower by Design’.

If there are viable hydropower options, HYDROSELECT assists in the selection of project concepts that are best positioned with regards to environmental, social and sustainability issues, and most likely to get public acceptance, permits, and financing. HYDROSELECT addresses the stage before a decision has been made by a developer to invest in the preparation of a specific hydropower project, or when a selected hydropower project concept is undergoing early evaluation of potential risks, noting that developers can include the private sector, governments, and/or financial institutions. The earlier in project development that sustainability aspects are considered, the greater the overall confidence in a project

[1] Further information on strategic hydropower planning can be found at Almeida, R.M. et al (2022) “Strategic planning of hydropower development: balancing benefits and socioenvironmental costs”, Current Opinion in Environmental Sustainability 56: 101175; https://doi.org/10.1016/j.cosust.2022.101175

concept. Developers that are late to consider sustainability aspects often have to spend unplanned time and money getting a project back on track, or even abandon a project after significant investment.

Hydropower Sustainability Tools

Many sites with some technical and commercial potential for hydropower will never, and possibly should never, be developed. Too often developers have, with unsubstantiated optimism, put considerable funds into projects that they should know from the outset have fatal flaws. The challenge for developers is to focus on potential hydropower projects at locations and with design concepts that are worth developing. HYDROSELECT can assist with the evaluation of multiple hydropower project concept options or a single proposed project concept.

HYDROSELECT is aligned with and complements the Hydropower Sustainability Standard (HSS)[2] which would be applied at later stages. The HSS is an assessment framework that sets out the sustainability performance requirements for hydropower in a manner that is globally applicable. The HSS is made up of three stand-alone assessment tools designed for the later stages of project development. Figure 2 shows the link between the HSS and HYDROSELECT. Importantly, a hydropower project development that contains fatal flaws as flagged in HYDROSELECT would be highly challenged to later meet the HSS minimum requirements.

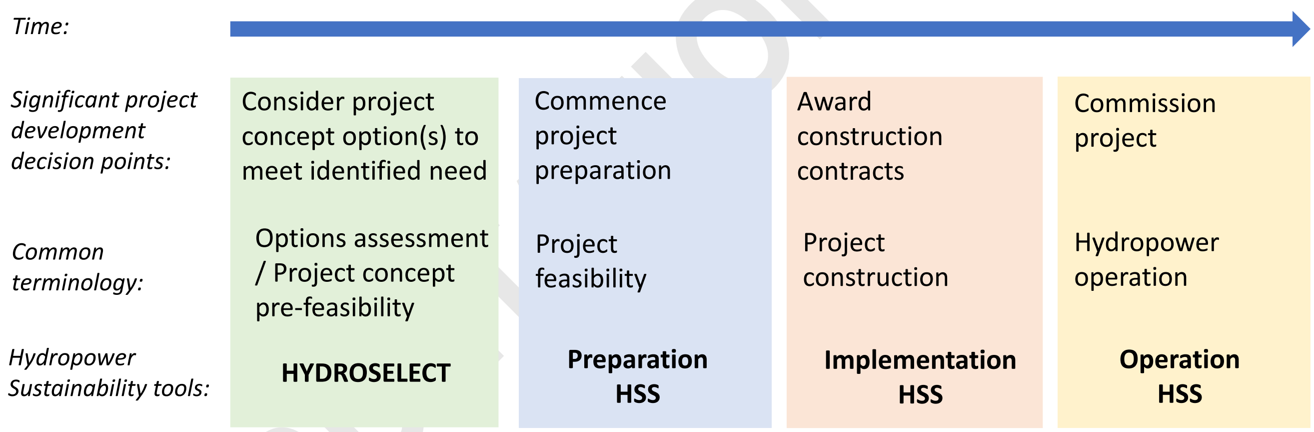

Figure 2 – Link between HYDROSELECT and the Hydropower Sustainability Standard (HSS) tools

[2] https://www.hs-alliance.org/hs-standard

HYDROSELECT Purpose, Outcomes and Users

HYDROSELECT can be applied at the early stage to any type of hydropower project concept – reservoir, run-of-river, pumped storage, multi-purpose – and at any scale and configuration, in any part of the world. It can be applied to a single project concept, to variations on a single project concept, or to a number of project concepts that may cover a wide geographic area. Evaluation of a range of hydropower project concepts against HYDROSELECT criteria may lead to a conclusion that hydropower is not the right choice, and that more effort needs to go back to strategic energy planning and strategic hydropower planning.

HYDROSELECT is designed for application before or during the pre-feasibility stage. Often at the early stage there is little or no focus on environmental or social issues. HYDROSELECT combines conventional areas of early stage focus (hydrology, geology, finance) with ESG aspects that can be evaluated based on readily available information. It also highlights both sustainability risks and opportunities for which early awareness and investigation would be highly beneficial.

HYDROSELECT has four core purposes:

1. To provide a framework for early stage evaluation of hydropower project concept option(s);
2. To highlight hydropower project concepts that contain Potential Fatal Flaw(s) and should be avoided;
3. To better inform sustainability risks and opportunities for any hydropower project concept under consideration; and
4. To help inform developer planning for time, costs, and expertise based on known areas of greater sustainability-related risk and opportunity if a hydropower project concept proceeds to the Preparation Stage.

HYDROSELECT will enable developers to:

- Demonstrate how a hydropower project concept has been selected, or which project concepts have not been selected and why, based on consideration of sustainability factors;
- Stimulate early project planning including “front-end loading” on sustainability matters;
- Understand important sustainability risks and opportunities that should be evaluated more fully and/or have preparation actions undertaken during the feasibility stage; and
- Inform Terms of Reference for Environmental and Social Impact Assessments (ESIA), feasibility, hydrology, climate and other preparation studies specifically for the project concept.

HYDROSELECT can be used by anyone for the purpose of considering project concept options and for early identification of sustainability risks. Benefits of use of HYDROSELECT for various users are:

- Hydropower developers – HYDROSELECT provides a structured evaluation tool that can help guide removal of some hydropower project concept options from further consideration, guide further assessment priorities, and support recommended project concept option(s). It is noted that developers may include companies, governments, and/or financial institutions.
- Consultants – HYDROSELECT provides a tool that consultants can use when proposing hydropower project concepts, providing hydropower options evaluations, and undertaking project concept risk assessments at the early stage.
- Investors and financial institutions – HYDROSELECT helps inform screening processes to assess hydropower proposals seeking investments and loans. Investors and financial institutions can consider the Potential Fatal Flaws, risks and opportunities included in HYDROSELECT alongside their own project evaluation processes.
- Government planners – HYDROSELECT requires information that can be provided by

strategic planning processes, such as Integrated Resource Plans or SEAs and so, ideally, these strategic planning processes have preceded application of HYDROSELECT. HYDROSELECT is not offered as a substitute for those processes, but in some countries, development decisions are being made with limited availability of strategic planning. In those contexts, HYDROSELECT can provide system-scale and strategic insights that could improve planners' ability to make planning and regulatory decisions.

- Civil Society Organisations (CSOs) and Non-Government Organisations (NGOs) – HYDROSELECT provides an internationally-accepted framework for early considerations about hydropower project concept options that should be applied at the early stage by project developers, noting that often these early stage considerations are undertaken on a confidential basis. CSOs and NGOs can ask questions informed by HYDROSELECT once any announcements are made about developer intentions for a particular hydropower project.
- Members of the public – As well as the same benefits as for CSOs and NGOs, HYDROSELECT provides insights for all members of the public on important sustainability questions and focal areas for hydropower project concepts.

> Use of HYDROSELECT does not lead to project sustainability certification. At the early stage, there is typically not yet a clearly formulated project, only a weak basis of information often drawn from broader regional databases and pre-feasibility investigations, and studies are often of a confidential nature. The use of the HSS Preparation tool is appropriate once a decision has been made to begin the project's development, site-specific data collection begins, and the project moves towards a feasibility study and ESIA report.

Structure of HYDROSELECT

HYDROSELECT is made up of three main parts:

(1) **Fatal Flaws Analysis;**
(2) **Additional Sustainability Risks; and**
(3) **Sustainability Opportunities.**

The Fatal Flaws Analysis in Part 1 sets out ten Potential Fatal Flaws (PFFs), with rating options and guidance information for each. The highest risk rating is Extreme Risk; this represents those risks that are too substantial to mitigate. Project concepts with any Extreme Risk are better avoided altogether, by abandoning, fundamentally re-locating, and/or re-designing the project concept. More information on PFF ratings and how these can best be used is provided in Part 1.

The Additional Sustainability Risks in Part 2 sets out risk factors that can be potentially avoided-minimised-mitigated-compensated. Sustainability Opportunities in Part 3 sets out potential positive contributions of a project concept that will greatly benefit from early planning and actions.

The mitigation hierarchy is fundamental to management of sustainability risks and informs the structure of HYDROSELECT. The mitigation hierarchy is a sequential approach to addressing potential project impacts, prioritising impact avoidance first, followed by impact minimisation, then impact mitigation, and lastly, compensation for residual impacts.

The Fatal Flaws Analysis can be viewed as a way of identifying potential risks that can be largely, or only, addressed through "avoid." For project concepts that can confidently continue past the Fatal Flaws Analysis, the PFFs then become sustainability risks that should be minimised and mitigated. Likewise, any additional sustainability risk may emerge as a PFF and lead to a conclusion to avoid that project concept.

1. ***Impact avoidance*** seeks to prevent or reduce impacts. Avoidance is prioritised as the

initial step in the mitigation hierarchy, as it is often the most cost-effective and efficient way to guarantee reducing potential impacts. For hydropower project concepts, it is often achieved through site selection and establishment of overall operational objectives. The Fatal Flaws Analysis seeks to inform this initial step of the mitigation hierarchy.

2. ***Impact minimisation*** seeks to reduce the area and/or extent of impacts when outright avoidance is not feasible. For hydropower project concepts, impact minimisation is often achieved through choices in lay-out and design, and planned operational strategies. Both PFFs and Additional Sustainability Risks help inform impact minimisation measures for those project concepts confirmed to be Low Risk or Very Low Risk with respect to the PFFs.

3. ***Impact mitigation*** seeks to reduce the duration, intensity, and/or extent of residual impacts that cannot be avoided and are still present after minimisation measures have been fully implemented. For hydropower project concepts, impact minimisation measures such as downstream flow releases, fish passage and sediment through-flow features will never fully avoid impacts, although if designed and operated well they can achieve some impact miminisation. Impact mitigation will still always be required, and typically involves implementation of carefully researched and designed impact management plans. Revegetation and rehabilitation of degraded areas from the construction process is a good example of impact mitigation. Plans require clear objectives, processes, resources, monitoring, evaluation, and adaptations over time (as needed). Both PFFs and Additional Sustainability Risks help inform impact mitigation measures for those project concepts confirmed to be Low Risk or Very Low Risk with respect to the PFFs.

4. ***Impact compensation*** addresses the residual, unavoidable impacts after all avoidance, minimisation and mitigation measures have been implemented. Compensation involves commitments and actions to protect, enhance, restore or otherwise improve similar resources to those that have been impacted, with the resources focused on for compensation measures referred to as ‘offsets’. ‘Offsetting’ quantifies how much compensation is required for a residual impact. Ideally, offsets should as close to the point of impact as possible, and “like-for-like”[3]. This step of the mitigation hierarchy can be informed by all 3 parts of HYDROSELECT.

The ten PFFs, nine Additional Sustainability Risks, and seven Sustainability Opportunities are shown in Table 1.

[3] Further information on biodiversity offsets is set out in https://www.oecd.org/environment/resources/Policy-Highlights-Biodiversity-Offsets-web.pdf

Table 1 - Summary of PFF Risks, Additional Sustainability Risks, and Sustainability Opportunities

Potential Fatal Flaws (PFFs)
• PFF1 – Demonstrated Need and Strategic Fit • PFF2 – Hydrological Resource • PFF3 – Geological Conditions • PFF4 - Transmission Lines, Roads and Ancillary Requirements • PFF5 – Greenhouse Gas (GHG) Emissions • PFF6 – River System Connectivity • PFF7 – Biodiversity and Critical Habitats • PFF8 – Resettlement and Livelihood Impacts • PFF9 – Indigenous Peoples • PFF10 – Critical Cultural Features
Additional Sustainability Risks
• Erosion and Sedimentation • Downstream Flows • Water Quality • Infrastructure Safety • Cumulative Environmental and Social Impacts • Political Risk including Corruption, Conflict and Transboundary • Institutional Capacities • Corporate Governance and Procurement • Community Acceptance and Social Licence
Sustainability Opportunities
• Regional Development • Integrated Water Resource Management • Project Benefits and Benefit Sharing • Local Content • Local Capacity-Building • Legacy Environmental and/or Social Issues • Biodiversity Enhancements

How to Use HYDROSELECT

Whilst users may find value out of all parts, Figure 3 shows a potential sequence of use that may be helpful for developers and government planners.

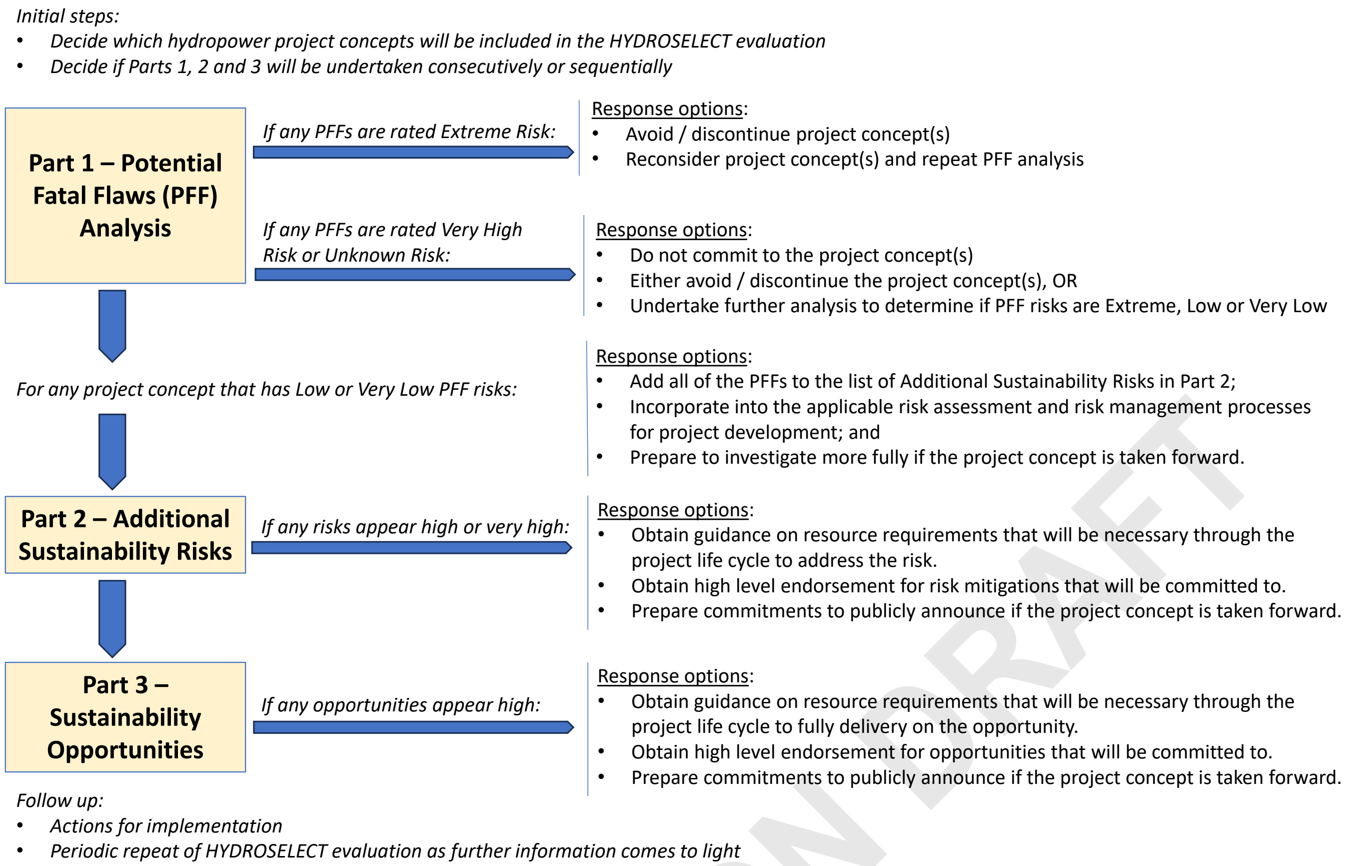

Figure 3 – Potential sequence of use of the three parts of HYDROSELECT

The PFF analysis in Part 1 should be conducted as an essential early exercise. Any PFF rated Red (Extreme Risk) should result in a project concept being avoided, i.e. discontinued.

Any PFF rated Orange (Very High Risk) or White (Unknown Risk) should be investigated further as a matter of priority, and that project concept considered to be in doubt until it can be confidently rated Yellow (Low Risk) or White (Very Low Risk).

For project concepts that will be progressed, all PFFs should be added to the Additional Sustainability Risks in Part 2, and continue to be assessed regularly following established risk assessment and management processes.

For those project concepts that are likely to continue, Part 3 is highly recommended for early consideration so that the opportunities that the future hydropower project can bring are given sufficient planning, time and resourcing.

Part 1 – Fatal Flaws Analysis

1.1 Overview of Potential Fatal Flaws

Part 1 sets out ten Potential Fatal Flaws (PFFs), each with a rating analysis for multiple project concepts under consideration, summarised in Table 2.

The ten PFFs should be priorities to include in a high-level comparative assessment of hydropower project concept options, and in any risk assessment for a project concept. They should carry significant influence in any evaluation of whether to proceed with a particular project concept.

The PFF ratings are:

- RED - Extreme Risk, if any PFF is Red, discontinue the project concept
- ORANGE - Very High Risk, do not progress with the project concept unless a Yellow or Green rating can be demonstrated
- WHITE - Unknown Risk, further research required, do not commit to the project concept until a Yellow or Green rating can be demonstrated
- YELLOW - Low Risk, progress with care
- GREEN - Very Low Risk, most favourable to progress

If there is insufficient information to inform a risk rating, the developer should not commit to the project concept until a more confident rating can be obtained. Orange and White ratings should be used by the developer to get further information to clarify if the PFF is an Extreme Risk (Red) and should be avoided, or a Low or Very Low Risk (Yellow or Green) which would support progressing with a project concept whilst continuing to manage the risk.

Table 2 - Summary of Potential Fatal Flaws (PFFs) and their Risk Ratings

PFF1 Ratings – Demonstrated Need and Strategic Fit				
The project concept will not meet widely-accepted power and/or water needs, and is inconsistent with one or more key policies and plans	The project concept appears unlikely to meet widely-accepted power and/or water needs, or fit with key policies and plans	Further work is necessary to show that the project concept will meet widely accepted power and water needs, and that it fits with key policies and plans	The project concept will meet widely accepted power and water needs, fit with key policies and plans, and is a preferred alternative	The project concept is demonstrated to be the best option to significantly meet widely accepted power and water needs, and fit with key policies and plans
PFF2 Ratings – Hydrological Resource				
Preliminary data shows that the hydrological resource available, including climate change forecasts, is insufficient to meet project concept objectives	Preliminary data shows that the hydrological resource available, including climate change forecasts, may not be sufficient to meet project concept objectives	Further analysis is necessary, including climate change forecasts, to show the hydrological resource available will meet project concept objectives	Preliminary data including climate change forecasts shows a likelihood of sufficient hydrological resource available to meet project concept objectives	Preliminary data including climate change forecasts confirms the hydrological resource available should meet project concept objectives

PFF3 Ratings – Geological Conditions				
Preliminary data shows adverse geological conditions that will make the project concept's constructability and infrastructure safety unviable	Preliminary data shows adverse geological conditions that may make the project concept's constructability and infrastructure safety unviable	Further analysis is necessary to show adequacy of the geological conditions for the project concept's constructability and infrastructure safety	Preliminary data shows adequate geological conditions favourable for the project concept's constructability and infrastructure safety	Preliminary data confirms suitable geological conditions favourable for the project concept's constructability and infrastructure safety
PFF4 Ratings – Transmission Lines, Roads and Ancillary Requirements				
Early indications are that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are not feasible	Early indications show that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements may not be feasible	Further analysis is necessary to show the feasibility of the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements	Early indications show that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are likely to be feasible	Early indications confirm that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are fully feasible
PFF5 Ratings – Greenhouse Gas (GHG) Emissions				
The project concept has a power density less than 5 W/m^2, and will not facilitate lower grid emissions	The project concept may have a power density less than 5 W/m^2, and may not facilitate lower grid emissions	Further analysis is necessary to show to a power density more than 5 W/m^2 and that the project concept will facilitate lower grid emissions	The project concept is estimated to to have a power density more than 5 W/m^2, and is likely to facilitate lower grid emissions	The project concept is demonstrated to have a power density more than 5 W/m^2, and will facilitate lower grid emissions
PFF6 Ratings – River System Connectivity				
The project concept is the first barrier to be built on the main stem of a river basin, significantly impacting river connectivity	The project concept is located on the river main stem and not part of an existing hydropower cascade, and may have high impacts on river connectivity	Further analysis is necessary to assess impacts of the project concept on river connectivity	The project concept is likely to have limited impact on river connectivity	The project concept will be part of an existing hydropower cascade or will be located on a tributary to the river main stem, and is demonstrated to have no impact on river connectivity
PFF7 Ratings – Biodiversity and Critical Habitats				
Project concept impacts on critical habitats are likely and significant, and offsets appear unfeasible	Project concept impacts on biodiversity and critical habitats appear likely, and offsets are likely to be required and may not be feasible	Further analysis is necessary to assess project concept impacts on biodiversity and critical habitats, and the feasibility of offsets	Project concept impacts on biodiversity are likely to be manageable, offsets appear to be feasible, and no critical habitats are affected	The project concept is demonstrated to have no significant impacts on biodiversity
PFF8 Ratings – Resettlement and Livelihood Impacts				
The scale of physical and economic displacement is not commensurate with the project concept capacity, and sufficient replacement land is not available	The scale of physical and economic displacement is significant compared to project concept capacity, and may not be manageable	Further analysis is necessary to assess the extent of physical and economic displacement from the project concept, and how it is best managed	The scale of physical and economic displacement is low compared to the project concept capacity, replacement land is available, and displacement is likely to be manageable	The project concept is demonstrated to have no physical or economic displacement

PFF9 Ratings – Indigenous Peoples (IPs)				
Even with considerable effort with the project concept, It appears impossible to achieve FPIC of IPs	FPIC of IPs is possible for the project concept, but achieving it will require considerable time, resources and effort	Further analysis is necessary for the project concept on the presence of IPs and prospects for FPIC	The project concept is likely to achieve FPIC of IPs	The project concept is demonstrated to have no effect on IPs
PFF10 Ratings – Critical Cultural Features				
The project concept will affect one or more sites that are nationally or internationally recognised for critical cultural features, and it appears that the impacts cannot be mitigated	The project concept is likely to affect at least one site that is nationally or internationally recognised for its critical cultural features, and the impacts may not be able to be mitigated	Further analysis is necessary to show that the project concept will not affect a site that is nationally or internationally recognised for its critical cultural features and that the impacts can be mitigated	The project concept is likely to have insignificant effects on sites recognised to have critical cultural features, and any impacts can be mitigated	The project concept is demonstrated to not affect a site that is nationally or internationally recognised for its critical cultural features

Effort to seek preliminary data will support the most realistic early indications. Sources of information are indicated for each PFF, and guidance on indicators if little or no information is available. The rating options for project concept fatal flaw analysis rely on objectivity and evidence-based determinations. Ratings are objective if they are based on readily available and authoritative knowledge at the time. Initial ratings may decline or improve based on further information. Perceptions of the degree of risk or significance may vary according to who is doing the evaluation, and expectations of key stakeholders. Users are encouraged to apply a cautious, well-justified, and pragmatic approach to ratings, and to back the selection with evidence as far as possible.

In many cases at the early stage, due to little site-specific data, indications need to be obtained from global, regional or national databases or high-level data from broader-scale or parallel river basin studies. It may not be possible to rate a number of common fatal flaws with any certainty or confidence. Each PFF has a list of globally-accessible sources that will help provide an initial rating. If there is still a lack of confidence in the initial rating, than the WHITE rating (Unknown Risk) is appropriate.

Each PFF is still a sustainability risk, and should be evaluated along with the Additional Sustainability Risks in Part 2.

1.2 PFF1 – Demonstrated Need and Strategic Fit

Table 3 - Risk Ratings for PFF1 Demonstrated Need and Strategic Fit

Extreme	***Very High***	***Unknown***	***Low***	***Very Low***
The project concept will not meet widely-accepted power and/or water needs, and is inconsistent with one or more key policies and plans	The project concept appears unlikely to meet widely-accepted power and/or water needs, or fit with key policies and plans	Further work is necessary to show that the project concept will meet widely accepted power and water needs, and that it fits with key policies and plans	The project concept will meet widely accepted power and water needs, fit with key policies and plans, and is a preferred alternative	The project concept is demonstrated to be the best option to significantly meet widely accepted power and water needs, and fit with key policies and plans

Stakeholders will want to know that the project development is the best option to address widely accepted power and water needs. This should take a long-term view, considering climate physical and transition risks. This applies to both energy and water services, since hydropower sits at the nexus of these two sectors. Power needs can include: provision of electricity to meet demand; low carbon power; facilitation of intermittent renewable generation; improved grid stability and flexibility; provision of peak load; provision of dry season electricity; and provision of ancillary benefits (e.g. spinning reserve, system regulation, load following, black start). The most significant water needs often associated with hydropower projects are water for flood management and water for irrigation.

There is a broad array of policies and plans that the best option would demonstrate it is consistent with, and an early analysis should ensure no major inconsistencies. Policies and plans relevant to the location in which a particular project concept is being considered may address, for example: renewable energy zones, water developments, irrigation plans, flood management plans, biodiversity, climate, conservation, land use, climate change adaptation, and/or urban and regional infrastructure planning. Water policies and water management plans may address water rights, water allocation, water quality, water security, and environmental flow requirements. There may be specific zoning plans for industry, economic activities, transport, and communications infrastructure. Specific social and environmental plans may address, for example: food security, fisheries protection, and protection of high value sites (e.g. heritage, biodiversity). Areas may be identified as part of a regional decarbonisation plan for renewable energy hubs, or for carbon sinks or carbon offsets.

Sources of information:
- All relevant energy and water policies and plans.
- National and/or regional publications and websites addressing energy and water needs.
- Relatively recent national or state energy master plans.
- Relevant water resource, river basin, or integrated water management plans.
- CSO and NGO research and assessments.
- Geographically-relevent development, climate change, land use, and/or environmental and social related plans.
- A GIS analysis to evaluate a project concept fit with spatial plans or zoning.
- A robust Analysis of Alternatives to show how a project concept fits, and whether it is the best option, with energy, water and other policies and plans.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should reference any of the following online sources:

- National energy ministries and agencies, which in most countries publish reports and data on national energy needs, policies, and plans.
- The International Energy Agency[4] (IEA) provides country-specific information on energy production, consumption, and policies.
- The World Bank[5] regularly publishes reports on energy access, consumption, and policies worldwide.
- Renewable Energy Policy Network for the 21st Century[6] (REN21) produces country-specific information and trends on renewable energy.
- International Renewable Energy Agency[7] (IRENA) provides country-level data on renewable energy.

A project concept that is potentially fatally flawed or involves very high risks might be any of the following:
- Contrary to the objectives and/or requirements of relevant legislation, policies or plans.
- Contrary to proposed solutions to identified needs for energy and water for the region.
- Reliant on more water than is available under existing water-related policies or plans.

4 https://www.iea.org/
5 https://www.worldbank.org/en/what-we-do
6 https://www.ren21.net/reports/ren21-reports/
7 https://www.irena.org/Data

- A source of actual or potential future conflict for access to the water resources.
- Located in an area with land use constraints.

A project concept with lower risks could be:

- Consistent with objectives and/or requirements of relevant legislation, policies or plans.
- Consistent with proposed solutions to identified needs for energy and water.
- Specifically listed as a high-ranking option in a relatively recent energy master plan.
- In a priority location for power development opportunities, such as close to transmission lines, off-takers, existing or planned industrial developments, etc.
- Specifically listed in or consistent with a relevant Integrated Water Resource Management plan, river basin management plan, and/or transboundary water resource management plan.
- Consistent with any relevant land use, climate change adaptation, social, environment and/or development-related policy or plan.

Actions that could reduce the risk of a project concept might include:

- In the absence of recent plans, liaise with government to identify key principles and priorities for developments.
- Alter the project concept to better align with the principles and/or objectives of relevant plans.

1.3 PFF2 - Hydrological Resource

Table 4 - Risk Ratings for PFF2 Hydrological Resource

Extreme	Very High	Unknown	Low	Very Low
Preliminary data shows that the hydrological resource available, including climate change forecasts, is insufficient to meet project concept objectives	Preliminary data shows that the hydrological resource available, including climate change forecasts, may not be sufficient to meet project concept objectives	Further analysis is necessary, including climate change forecasts, to show the hydrological resource available will meet project concept objectives	Preliminary data including climate change forecasts shows a likelihood of sufficient hydrological resource available to meet project concept objectives	Preliminary data including climate change forecasts confirms the hydrological resource available should meet project concept objectives

As a significant water resource development, a hydropower project requires a very good understanding of water inflows to and outflows from the future operating hydropower facility, over the project's likely very long life. Poor estimations of water availability can lead to inefficient design and operation of the hydropower facility and reduce its production potential. Misunderstanding of the magnitude, timing, variability and extremes of the patterns of water inflows can also raise significant infrastructure safety risks. Over-estimation of water availability can lead to over-investment in the hydropower facility and future financial viability issues. Insufficient consideration of other water users, including downstream, can lead to conflict over water resources.

The degree of hydrological variability can be extreme in many areas of the world. The correct analysis of water resources and proper allocation between competing uses for that resource are critical to the viability and operation of a hydropower facility. Analysis of future climate scenarios is essential to include in the hydrological resource assessment.

Sources of information:

- All meteorological and hydrological data available for analysis. The length of flow record used to inform project design should be greater than 10 years for a relatively small project (e.g. run-of-river or small impoundment) and greater than 25 years for a major storage project.
- Longer-term records from nearby and comparable sites will need to be analysed and

professional judgements made.

- Analysis of climate change forecast scenarios, including extreme climatic conditions and uncertainty.
- Assessment of other water resource users relying on the river system, regarding risks to hydrological inflows, water quality, and downstream flows.
- Determination of potential future water resource developments and risks to assumptions on water availability (and quality) to the project.
- Assessment of upstream land use changes in the watershed that may impact water availability and quality (e.g. forestry, mining, other developments).
- In time, collecting extensive field data over long periods, alongside incorporating predictive climate change models, increases confidence in planning for hydrological resource risks. As historical hydrological patterns may not accurately predict future conditions, a dual approach allows for more robust and adaptable project design.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should reference any of the following online sources:

- National meteorological and hydrological services, which are in most countries. They are typically responsible for monitoring weather, climate, and water resources, and provide detailed data, forecasts, and reports on meteorological and hydrological conditions.
- Satellite data providers are organisations that collect and distribute often world-wide satellite data on weather, climate and hydrology, for example National Aeronautics and Space Administration[8] (NASA).
- The Global Precipitation Climatology Centre[9] (GPCC).
- The Global Drought Information System[10] (GDIS).

A project concept that is potentially fatally flawed or involves very high risks might be any of the following:

- In an area of known low rainfall.
- In an area that has experienced significant droughts in recent years.
- In an area where the water resource is shared, and there may be potential political or transboundary risks or even conflicts over water use.
- On a river where large storage projects could be developed upstream, especially if transboundary.
- In a location where land use changes in the catchment that can influence run-off are occurring or likely (e.g. plantation establishment).
- In a region where existing climate modelling shows a lessening of or more variable rainfall in the future.

A project concept with lower risks could be:

- In an area of known very high rainfall now and projected into the future.
- In a region with no identified catchment developments.

Actions that could reduce the risk of a project concept might include:

- Ensure all sources of hydrological information and data have been identified, accessed, and preliminarily assessed.
- Install hydrometric stations at the project site and additional locations up and downstream as early as possible in order to build up a credible set of hydrological data to confirm or calibrate older time series and/or modelled future time series.
- Ensure qualified hydrological expertise is able to provide a credible assessment of the

[8] https://climate.nasa.gov/nasa_science/history/
[9] https://www.dwd.de/EN/ourservices/gpcc/gpcc.html
[10] https://gdis-noaa.hub.arcgis.com/

hydrological resource.

1.4 PFF3 - Geological Conditions

Table 5 - Risk Ratings for PFF3 Geological Conditions

Extreme	Very High	Unknown	Low	Very Low
Preliminary data shows adverse geological conditions that will make the project concept's constructability and infrastructure safety unviable	Preliminary data shows adverse geological conditions that may make the project concept's constructability and infrastructure safety unviable	Further analysis is necessary to show adequacy of the geological conditions for the project concept's constructability and infrastructure safety	Preliminary data shows adequate geological conditions favourable for the project concept's constructability and infrastructure safety	Preliminary data confirms suitable geological conditions favourable for the project concept's constructability and infrastructure safety

Suitable geology to build a dam is a priority consideration for any hydropower project, and is typically the key determinant of dam location, type and design. Geological considerations will be based on numerous factors, including valley configuration, occurrence of bedrock, competency of rocks to provide stable foundations, effects of associated geological structures (folds, tilts, faults, joints), etc. A dam site should be as geologically sound as possible in terms of strong, impermeable and stable rocks.

Influences on the evaluation of this risk might include the presence of:

- laterites, limestone and/or conglomerates and their implications for porosity;
- slates and alternating hard and soft beds of rock and their inherent weaknesses;
- high weathering and consequent reductions in geotechnical strength and durability;
- faulted beds which are generally undesirable; faults increase porosity, reduce competence and cause reservoir leakage; and active faults can cause displacements at the site and increase seismic risk.

Location of the powerhouse is often dictated by the project type and objectives, geographic setting, and the geology. Above ground options include at the dam toe, downstream of the dam, or on an adjacent river. Underground options may be considered where there is a high visual impact concern, or for pumped storage hydropower projects.
Underground powerhouses are more expensive to build and will have unique infrastructure safety considerations.

Areas where excavated rock and spoil from underground caverns and tunnels is placed need their own environmental, social and public safety impact assessment and planning.

Sources of information:
- High level geological maps.
- Aerial photography and satellite imagery analysis.
- Site visits.
- Shallow sampling.
- In time, site-specific geology will need to be determined through drilling programs, combined with an iterative approach to build and refine a geological model. Field investigations should consider suitability of different types of rocks, the influence of weathering, geological structures, and effects of occurrence of intrusions and fracturing. This information is critical to determine viability of a project at a location, and also the costs required for treatment measures to increase competency, cohesion etc. Also, local availability of aggregate materials for construction is an important planning matter.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should reference any of the following online sources:

- National geological surveys are in most countries, and are responsible for mapping and assessing geological resources within their territories. They typically provide detailed reports, maps, and databases on mineral deposits, energy resources, groundwater, and geological hazards.
- Ministries or government departments responsible for mining, energy, and natural resources often publish reports and data on geological resources.
- National geological survey organisations that also provide global geological information and information on earth observations (e.g. earthquakes, landslides, volcanoes, fires), such as the United States Geological Survey[11] (USGS).

A project concept that is potentially fatally flawed or involves very high risks might be any of the following:
- Located in rock with low geotechnical strength, low durability, and/or a likelihood of high leakage;
- Located in an active fault zone.
- Located in an area of extreme seismic risk.

A project concept with lower risks could be:
- In an area that regional maps show to have suitable geological conditions.
- In an area where preliminary visits show outcrops of strong durable rock.

Actions that could reduce the risk of a project concept might include:
- Ensure all sources of geological information and data have been identified, accessed, and preliminarily assessed.
- Ensure qualified geological expertise provides preliminary evaluations.
- Conduct geotechnical surveys as early as possible.
- Consider alternative locations.

1.5 PFF4 - Transmission Lines, Roads and Ancillary Requirements

Table 6 - Risk Ratings for PFF4 Transmission Lines, Roads and Ancillary Requirements

Extreme	***Very High***	***Unknown***	***Low***	***Very Low***
Early indications are that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are not feasible	Early indications show that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements may not be feasible	Further analysis is necessary to show the feasibility of the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements	Early indications show that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are likely to be feasible	Early indications confirm that the siting and extent of the project concept's transmission lines, roads and/or other ancillary requirements are fully feasible

Ancillary requirements are essential to build and/or operate the project. They always include the transmission lines, almost always include roads, and are likely to include sub-stations, quarries, landfills and waste disposal areas. As they are often located away from the main dam and powerhouse construction areas, they may or may not be considered part of the core project from an administrative perspective, i.e. they may be delivered by different agencies through different funding mechanisms. However, they are always part of the project from a sustainability perspective. Late and insufficient attention to sustainability aspects of ancillary requirements can give rise to reactive management with associated schedule delays and increased costs.

Transmission lines and roads may involve many of the same social and environmental impacts that arise with a hydropower project, or may present new and different impacts. In

[11] https://www.usgs.gov/

the case of long transmission lines and/or roads in highly sensitive locations, the extent of impacts can emerge or increase, such as land acquisition requirements and physical and economic displacement, cultural heritage impacts, and biodiversity and visual impacts. High voltage transmission line proposals may struggle to get a social licence in many parts of the world, as affected communities and stakeholders do not want to accept the associated impacts, and in cases advocate for these or key sections to be put underground.

Power off-taker options include all or some power going to a single off-taker, power going into a regional or national grid, or power going to a small and isolated grid. Some hydropower projects are built for a single off-taker or for a large regional or national grid, and project electricity may not be going into a local grid. This can raise major issues if the project affected communities are not going to receive any electricity.

Sources of information:

- Analyses of power evacuation options.
- Analyses of location options for sub-stations, quarries, roads, landfills, and waste disposal areas.
- GIS analyses of social and environmental features and values along routes and at locations of transmission lines, roads and other ancillary requirements.
- Historical review of and local knowledge about past conflicts relating to transmission lines, roads and other ancillary requirements.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should reference any of the following online sources:

- Government agencies responsible for transportation and infrastructure planning may provide detailed information on planned and ongoing road and transmission line projects on their websites.
- International Financial Institutions (IFIs) often finance infrastructure projects, including roads and transmission lines, in various countries. Their websites and publications may contain information on planned projects and investment priorities.
- Regional development banks and organisations also support infrastructure development in specific regions and countries. They may offer information on planned road and transmission line projects in their respective areas of operation.

A project concept that is potentially fatally flawed or involves very high risks might have any of the following:

- Very long new transmission lines and/or roads.
- Transmission lines and/or roads required to be built in settled areas with difficulties to acquire land.
- Transmission lines and/or roads required to go through protected areas or other areas of high environmental and/or social sensitivity.
- No accessible or suitable locations for quarries, landfills or waste disposal sites.

A project concept with lower risks could be:

- Very short transmission lines and roads through areas involving no settlements or protected areas.
- Many alternative routes for transmission lines and roads.
- Suitable and feasible locations for quarries, landfills and waste disposal sites.

Actions that could reduce the risk of a project concept might include:

- Locate the project where there will be relatively short transmission lines and roads that are not through sensitive areas.
- Ensure that a number of alternative transmission lines and road routes are identified.
- Ensure that a number of alternative sites are identified for quarries, landfills and waste disposal.
- Asses the alternatives as early as possible.

1.6 PFF5 - Greenhouse Gas (GHG) Emissions

Table 7 - Risk Ratings for PFF5 Greenhouse Gas (GHG) Emissions

Extreme	Very High	Unknown	Low	Very Low
The project concept has a power density less than 5 W/m^2, and will not facilitate lower grid emissions	The project concept may have a power density less than 5 W/m^2, and may not facilitate lower grid emissions	Further analysis is necessary to show to a power density more than 5 W/m^2 and that the project concept will facilitate lower grid emissions	The project concept is estimated to to have a power density more than 5 W/m^2, and is likely to facilitate lower grid emissions	The project concept is demonstrated to have a power density more than 5 W/m^2, and will facilitate lower grid emissions

The Greenhouse Gas (GHG) emissions intensity of a hydropower project can potentially present a fatal flaw if it is as high as a fossil fuel alternative. The Intergovernmental Panel on Climate Change (IPCC) states that hydropower has a median GHG emission intensity of 24 gCO_{2eq}/kWh, which is the grams of carbon dioxide equivalent per kilowatt-hour of electricity generated over the project's life cycle. By comparison, the median figure for gas is 490 gCO_2-eq/kWh.

Emissions relating to the construction and operation of a reservoir vary depending on its type, size and location. Emissions from reservoirs tend to be highest in the first 10 to 20 years immediately following reservoir impoundment, then decrease over time. Once filled, factors such as a reservoir depth and shape, the amount of sun reaching its floor, and wind speed affect the different biogeochemical pathways by which carbon dioxide (CO_2) and methane (CH_4) are created and released to the atmosphere. A reservoir will release greenhouse gases due to the decomposition of flooded organic material under certain conditions. In other conditions, a reservoir may act as carbon sink: absorbing more emissions than it emits.

As a practical and easily calculated proxy that can be used at the early stage, hydropower projects with a power density above 5 W/m^2 (or >5 MW/km^2) will typically have a GHG emissions intensity below 100 gCO_{2e}/kWh, which can be considered a low emissions project. This is aligned with the minimum requirements for certification under the Hydropower Sustainability Standard's Section 12 Climate Change Mitigation and resilience.

Sources of information:

- Calculations of power density based on estimated energy production capacity and the average surface area of the reservoir.
- Lenders will want an estimate of calculated emissions, even if power density is above 5 W/m^2. Projects that have a power density below 5 W/m^2 will typically have a GHG emissions intensity above 100 gCO_2e/kWh, and for these the application of the GHG Reservoir (G-res) Tool[12] is recommended in order to get a more exact forecast. The G-res Tool takes into account local emissions including construction and reservoir impoundment, and calculates net GHG emissions due to creation of the reservoir.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should:

- Make reasonable estimations based on the core criteria for the project concept relating to capacity and reservoir area. Estimations should allow a worst case scenario to be calculated.

A project concept that is potentially fatally flawed or involves very high risks might have any of the following:

[12] https://www.hydropower.org/g-res

- A power density below 5 W/m^2 (<5 W/m^2).
- A high potential GHG emissions as shown by applying the G-res tool.

A project concept with lower risks could have:
- A power density above 5 W/m^2 (>5 W/m^2).

Actions that could reduce the risk of a project concept might include:
- Calculating the likely power density for a range of project concepts so that only the low carbon emission options are further considered.
- Consideration of alternative design or location.
- Use a higher accuracy method of reservoir size determination to increase confidence in initial estimation.

1.7 PFF6 - River System Connectivity

Table 8 - Risk Ratings for PFF6 River System Connectivity

Extreme	***Very High***	***Unknown***	***Low***	***Very Low***
The project concept is the first barrier to be built on the main stem of a river basin, significantly impacting river connectivity	The project concept is located on the river main stem and not part of an existing hydropower cascade, and may have high impacts on river connectivity	Further analysis is necessary to assess impacts of the project concept on river connectivity	The project concept is likely to have limited impact on river connectivity	The project concept will be part of an existing hydropower cascade or will be located on a tributary to the river main stem, and is demonstrated to have no impact on river connectivity

Hydropower projects inherently involve effects on river system connectivity. Disruption of continuity of fluvial aquatic processes include aquatic species migration both upstream and downstream, and nutrient and sediment passage downstream. An associated impact is loss of riverine habitat along river lengths submerged by the reservoir, making projects with extensive loss of riverine habitat have relatively higher impacts to river system connectivity. Further sources of impact are caused by the length of dewatered reaches in the river, and the lengths of reaches where flows are significantly regulated. Inter-basin transfers cause high impacts to river system connectivity.

The location of the dam is a major factor in the degree of fragmentation created by a hydropower project. Siting of dams on a main stem river rather than a tributary stream will have a much greater impact to the aquatic ecosystems in the river basin. Siting of a dam on the last remaining free-flowing river reach within a river basin can have significantly adverse consequences for aquatic biota. Strategic hydroplaning tools such as ‘Hydropower by Design’ can help assess project configurations in a river basin that will have the lowest impacts on river connectivity.

Design features are often proposed to mitigate impacts on connectivity, but the overall experience of, for example, fish passage facilities is that they can be very ineffective. Importantly, it is not okay to build a hydropower project on an important fish migration route and assume that all will be fine by including a fish passage in the project design. Design features assisting sediment through-flow and aquatic species passage at a minimum need to be carefully researched, properly designed and operated, and have ongoing monitoring and evaluation to assess their effectiveness. Options such as removing an existing dam or weir that presently causes high impacts to river system fragmentation can be useful to consider as an offset measure, as this may open up greater opportunities for aquatic species migration throughout much of the river basin compared to aquatic species passage at an upstream damsite. The use of offsets is also worth exploring for river fragmentation impacts, although aquatic offset measures are very rare.

Sources of information:

- Topographic map analysis of the river system to calculate the length of river and tributaries affected by the reservoir as well all affected downstream reaches, and calculation of unaffected river reach lengths to determine overall project impact on the river system.
- Scientific literature review and consultation with experts regarding important aquatic biota migratory routes and patterns and important riparian habitats.
- Scientific literature review and consultation with experts regarding sediment and nutrient passage to estimate amounts, timing and important downstream dependencies.

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should review any of the following sources of topographic maps showing rivers and tributaries in any country:

- National mapping agencies in many countries often provide online portals or map services where users can access and download topographic maps, including those showing rivers and tributaries.
- Google's mapping services Google Earth and Google Maps offer satellite imagery and terrain views that show rivers and tributaries in various parts of the world. While not traditional topographic maps, these platforms provide valuable visualizations of geographical features, including water bodies.

A project concept that is potentially fatally flawed or involves very high risks might have any of the following:

- The project dam as the first barrier to be built on the river main stem.
- The project dam located on the last remaining free-flowing tributary in the river basin.
- A large proportion of the river reaches in the river system lost or modified by creation of a very large reservoir or long downstream affected reaches.
- A project concept that includes no provisions in its design to address river system connectivity objectives (e.g. sediment and nutrient passage, aquatic biota passage, and environmental flows).

A project concept with lower risks could be:

- The project dam located in an already developed tributary in the river basin (i.e. part of a cascade).
- The project dam located high in the river basin, well upstream from the river mouth.
- The project dam at a pre-existing natural barrier (such as a waterfall).
- The project dam on a river without migratory species.
- The project run-of-river facility with a minor impact on sediment transport.

Actions that could reduce the risk of a project concept might include:

- Modify siting and design to minimise impacts on river system connectivity.
- Plan for downstream flow release facilities to be built into the dam structure.
- Research the need for, benefits of and design of a fish passage facility, compared to alternative investments into mitigating existing aquatic biota impacts (e.g. existing weir removal).
- Research the need for, benefits of and design of a sediment flushing or sediment passage facility. It is important to consider the ranges and transport characteristics of various sediment sizes. The same considerations may be able to be applied to the passage of nutrients through the system.
- Incorporate offset(s), i.e. compensation measures, such as increasing river system connectivity through existing barrier removal, and/or protecting a free-flowing river system or river reach.

1.8 PFF7 - Biodiversity and Critical Habitats

Table 9 - Risk Ratings for PFF7 Biodiversity and Critical Habitats

Extreme	Very High	Unknown	Low	Very Low
Project concept impacts on critical habitats are likely and significant, and offsets appear unfeasible	Project concept impacts on biodiversity and critical habitats appear likely, and offsets are likely to be required and may not be feasible	Further analysis is necessary to assess project concept impacts on biodiversity and critical habitats, and the feasibility of offsets	Project concept impacts on biodiversity are likely to be manageable, offsets appear to be feasible, and no critical habitats are affected	The project concept is demonstrated to have no significant impacts on biodiversity

Changes in biodiversity are likely with hydropower projects, due to the physical changes in habitats and ecosystems. The major physical aquatic habitat changes are the conversion of flowing water (a"lotic" ecosystem) to still water (a "lentic" ecosystem) by creation of an impoundment; and changes to the downstream hydrology (for projects other than run-of-river). The major physical terrestrial habitat change is loss of terrestrial habitat due to impoundment. Physical changes will cause changes to the biodiversity of species that are dependent on those physical habitats.

A habitat is the place or type of site where an organism or population naturally occurs. A critical habitat is a habitat area with high biodiversity conservation significance, formally defined using thresholds for its importance as an area with:

- critically endangered or endangered species;
- restricted range or endemic species;
- globally significant concentrations of migratory and/or congregatory species;
- highly threatened and/or unique ecosystems; and/or
- supporting key evolutionary processes.

An endemic species is an organism that is native to one particular geographic locality, and not found elsewhere. A restricted range species has a geographically restricted area of distribution.

Critical habitats include important bird areas, hotspots of endemism, habitats for threatened species, etc. Areas of habitat may be identified as critical if they are crucial to the survival of, and support recovery of, species listed as threatened.

Key Biodiversity Areas (KBAs) are those sites contributing significantly to the global persistence of biodiversity in terrestrial, freshwater and marine ecosystems. The key function of KBAs is to highlight areas that are not yet protected[13]. Ramsar sites are an example of a key biodiversity area. Ramsar sites are wetlands of international importance that have been officially designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare or unique wetland types, or for their importance in conserving biological diversity[14].

Threatened species are those species included in the Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) categories of the International Union for Conservation of Nature (IUCN) Red List[15]. The IUCN Red List of Threatened Species is the world's most comprehensive inventory of the global conservation status of plant and animal species, recognised as the most authoritative guide to the status of biological diversity due to its strong scientific base. It uses a set of quantitative criteria to evaluate the extinction risk of thousands of species. These criteria are relevant to most species and all regions of the world. In addition to obtaining a global perspective, it is important to recognise that a species can also be threatened locally.

[13] www.keybiodiversityareas.org
[14] https://www.ramsar.org/
[15] https://www.iucnredlist.org/

River reaches or land areas with threatened species found nowhere else would be identified as critical natural habitats. Ideally, these would receive permanent protection. A protected area is a clearly defined geographical space, recognised, dedicated and managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values. The land must be managed to protect and maintain biological diversity according to one of the six international classes developed by the IUCN. Classes vary according to their management objectives, which range from strict nature conservation to multi-use reserves. Importantly, protected areas can be threatened by a project even if not located in the area of direct impact.

Sources of information:

- IBAT sites. The Integrated Biodiversity Assessment Tool[16] (IBAT) identifies areas of biodiversity importance within 1, 10 and 50 km of the site, and an inventory of potentially-present species. World Heritage Sites[17] (designated for outstanding universal value) are integrated into the IBAT. IBAT can produce a biodiversity data report delivered as a package that includes a pdf document, raw data in CSV format, and map files. Report templates include a simple proximity report, a World Bank Group risk report, and a freshwater report. Initial lists of potential critical habitat triggers generated by IBAT should be used to scope biodiversity surveys, i.e. any particular species or areas for which the most thorough surveys are required.
- AZE sites. The Alliance for Zero Extinction[18] (AZE) is a joint initiative of biodiversity conservation organizations from around the world to prevent extinctions by promoting the identification and ensuring safeguarding and effective conservation of key sites that are the last remaining refuges of one or more Endangered or Critically Endangered species.
- Further global databases such as the IUCN Red List, and Ramsar wetlands.
- Determining whether an affected habitat is critical is done on a project-by-project basis. Extensive inventories and field studies of aquatic and terrestrial flora and fauna are typically undertaken during the ESIA for a hydropower project.
- International Hydropower Association (IHA) How-to Guide for Biodiversity and Invasive Species[19].

If needed, users of HYDROSELECT should review any of the following further sources of online information:

- National parks services and environmental agencies may maintain databases and websites with information on biodiversity and critical habitats within their jurisdictions.
- The website of World Wide Fund for Nature[20] (WWF) offers interactive maps and reports on critical habitats worldwide.
- The website of International Union for Conservation of Nature (IUCN) provides information on protected areas, key biodiversity areas, and conservation initiatives.
- Global Biodiversity Information Facility[21] (GBIF) is an international network that provides free and open access to biodiversity data, including species occurrences and distribution maps.
- The website of UN Environment Programme[22] (UNEP) publishes reports and assessments on biodiversity and ecosystems, including the Global Biodiversity Outlook and the Ramsar Convention on Wetlands, and offers information on protected areas,

[16] https://www.ibat-alliance.org/
[17] https://whc.unesco.org/en/list/
[18] https://zeroextinction.org/
[19] https://www.hs-alliance.org/how-to-guides
[20] https://www.worldwildlife.org/places
[21] https://www.gbif.org/
[22] https://www.unep.org/unep-and-biodiversity

biodiversity hotspots, and ecosystem services.

A project concept that is potentially fatally flawed or involves very high risks might have any of the following:

- Inundation or otherwise conversion and impacts to an area that is designated a Ramsar wetland, AZE site, World Heritage Site for its environmental values, threatened ecosystem, critical habitat, or in a regional protection system (e.g. in Europe, the EU Natura 2000 protected areas network[23], and/or the Emerald network sites[24]).
- Inundation or otherwise conversion and impacts to an area where there is one or more species included in the Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) categories of the IUCN Red List.
- Significant impacts on great ape habitat.
- Effects on a significant proportion of a category I or II protected area.

A project concept with lower risks could be:
- A project that does not affect any species or habitats of biodiversity significance.

Actions that could reduce the risk of a project concept might include:
- Alternative locations and designs so the project can avoid any protected area or areas of high biodiversity significance.
- Offset (i.e. compensation measure) options for biodiversity impacts.

1.9 PFF8 - Resettlement and Livelihood Impacts

Table 10 - Risk Ratings for PFF8 Resettlement and Livelihood Impacts

Extreme	***Very High***	***Unknown***	***Low***	***Very Low***
The scale of physical and economic displacement is not commensurate with the project concept capacity, and sufficient replacement land is not available	The scale of physical and economic displacement is significant compared to project concept capacity, and may not be manageable	Further analysis is necessary to assess the extent of physical and economic displacement from the project concept, and how it is best managed	The scale of physical and economic displacement is low compared to the project concept capacity, replacement land is available, and displacement is likely to be manageable	The project concept is demonstrated to have no physical or economic displacement

The most widely recognised social impact of a hydropower development is physical displacement, i.e. causing households to lose their homes. Physical displacement is the relocation, loss of residential land, or loss of shelter as a result of acquisition of land or restrictions on use of or access to land. Potential physical displacement includes anyone who will have to relocate because of the project, either temporarily or permanently. International good practice for mitigation of physical displacement is to ensure that living standards and livelihoods of all affected households are improved in the long-term.

Economic displacement typically affects more people than does physical displacement, as it applies to any people who will suffer from impacts to their livelihoods due to the project. Economic displacement is defined as the loss of assets, access to assets, income sources, or means of livelihoods. Livelihoods are the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. Households that are physically displaced are usually also economically displaced.

[23] https://www.eea.europa.eu/themes/biodiversity/natura-2000
[24] https://www.coe.int/en/web/bern-convention/emerald-viewer

The risk of economic displacement is often overlooked, and issues often arise during project construction that were not anticipated. Often, a project at the early stage is focused on land acquisition, and calculating costs of likely compensation as an inclusion in the early financial evaluation. Land acquisition can result in both physical and economic displacement; however it is not the only reason. Economic displacement can occur as a result of acquisition of land, changes in land use or access to land, restrictions on land use or access to natural resources, and environmental changes leading to health concerns or impacts on livelihoods. For example, transport may be disrupted, access routes may be impeded or blocked entirely, crops may be affected by construction road dust (for periods of many years), fisheries may decline due to pollutants, etc. Therefore the assessment needs to include those who will lose land but also those in the area who may not be able to continue with their existing livelihoods, temporarily or permanently.

In many parts of the world, productive replacement land is not readily available, which means the project has the difficult problem of trying to help farmers make the same living from smaller areas of land, or help them move to a non-farm livelihood. This is why resettlement is so often a failure. In Africa and Asia, the practice of shifting cultivation makes it even harder. Hydropower often takes the best land, as people farm in the river valley for a reason. It is imperative that this is more clearly recognised and articulated.

Sources of information:

- Topographic map analysis to identify and estimate numbers of households likely to be affected by physical and/or economic displacement. It is important to consider all aspects of the project, including the inundation area, temporary infrastructure sites, transmission lines, roads and other ancillary features.
- Estimation of potentially physically displaced people should include those who reside on the land in a seasonal or migratory manner, and those who reside on the land without formal land titles. Important inclusions are those who undertake artisanal mining, and pastoralists with affected dry season grazing and migration routes.
- Estimation of potentially economically displaced people should include a focus on river-dependent livelihoods, including river-based transport, and the degree and locations of hydrological change and/or impacts to transport routes in relation to these.
- Estimation of vulnerability is important when considering displacement. Even a small number of affected households may be highly significant in the case of high vulnerability.
- Topographic map analysis and field visits regarding available replacement land of a suitable quality and quantity to replace that which is lost.
- IHA How-to Guide for Resettlement[25].

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT should review:

- Google's mapping services Google Earth and Google Maps offer satellite imagery and terrain views. These can be carefully analysed to evaluate any signs of housing or commercial activity in the possible future reservoir area, in the catchment surrounding the possible future reservoir area, in the possible future dam and power station site(s) and surroundings, and along the downstream river system.

A project concept that is potentially fatally flawed or involves very high risks might have any of the following:

- A scale of physical and/or economic displacement by the hydropower project and/or transmission lines, roads and/or other ancillary requirements not commensurate with the capacity of the project. For example, a 20 MW project displacing 500 HHs is clearly not a commensurate impact. A rough rule-of-thumb could be the number of households

[25] https://www.hs-alliance.org/how-to-guides

physically and economically displaced should not exceed the project's MW capacity.

- A majority of affected households that can be considered vulnerable.
- Insufficient replacement land of a comparable or better quality and quantity to that which is lost.

A project concept with lower risks could be:

- The project will not cause significant physical or economic displacement.
- Conservative estimates of the number of households physically and economically displaced indicate it will be less than the number of MW of the project's generation capacity.
- The developer has a strong commitment to ensure all households physically and economically displaced experience long-term improvements in living standards and livelihoods.

Actions that could reduce the risk of a project concept might include:

- Obtain robust estimates of the numbers of displaced households and people as early as possible; do not wait for the Resettlement Action Plan (RAP) surveys.
- Explore alternative locations and designs so the project can avoid or minimise the number of households who will be displaced.
- Discuss with government any process requirements for physical and economic displacement, noting that meeting international standards may require going beyond local compliance requirements.
- Give early consideration to the important timing aspects of physical displacement processes in the context of the overall project development timeline.
- Include early establishment of long-term improvements plan for living standards and livelihoods for all affected communities.
- Plan for timely establishment of the socio-economic baseline for those potentially physically and economically displaced.
- Identify and secure potential resettlement and land replacement locations.

1.10 PFF9 - Indigenous Peoples (IPs)

Table 11 - Risk Ratings for PFF9 Indigenous Peoples (IPs)

Extreme	*Very High*	*Unknown*	*Low*	*Very Low*
Even with considerable effort with the project concept, It appears impossible to achieve FPIC of IPs	FPIC of IPs is possible for the project concept, but achieving it will require considerable time, resources and effort	Further analysis is necessary for the project concept on the presence of IPs and prospects for FPIC	The project concept is likely to achieve FPIC of IPs	The project concept is demonstrated to have no effect on IPs

In the Hydropower Sustainability Tools, Indigenous Peoples (IPs) are defined as a distinct social and cultural group possessing the following characteristics in varying degrees:

- self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;
- collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
- customary cultural, economic, social or political institutions that are separate from those

of the dominant society or culture; and

- an indigenous language, often different from the official language of the country or region within which they reside.

There is broad recognition internationally that IPs have special individual and collective rights and interests. A number of standards and instruments have been developed to recognise and safeguard their unique rights. The most prominent recognition is the United Nations Declaration on the Rights of Indigenous Peoples[26] (UNDRIP), adopted by the UN General Assembly in 2007.

Some of the most relevant rights that can be impacted by a hydropower development include:

- rights to lands, territories and resources;
- economic, social and cultural rights;
- equality and non-discrimination;
- environment; and
- self-determination.

Free, Prior and Informed Consent (FPIC) is a uniquely formulated expression for stakeholder support by IPs, and is recognised in a number of international instruments. FPIC comprises both a process and an outcome. FPIC does not require unanimity in the indigenous community and does not grant individuals or groups veto rights over a project. The principle of proportionality stipulates that the extent of consultation and consent required is proportional to the nature and scope of the IP rights that are impacted by the project.

Sources of information:

- Some government agencies publish reports and information on Indigenous Peoples' demographics, rights, and policies. These sources may provide official statistics, surveys, and legal documents related to indigenous issues in specific countries or regions.
- Collect and collate basic demographic information on the ethnicities present, drawing on census and other administrative data and local knowledge.
- Conduct interviews to inform an assessment of the willingness of the developer and the government to recognise IP rights and the need for FPIC.
- IHA How-to Guide for Hydropower and Indigenous Peoples[27].

In the situation of little to no sources of information relevant to the area of the project concept, users of HYDROSELECT can review:

- International Work Group for Indigenous Affairs[28] (IWGIA) provides information on indigenous issues, publications and country profiles.
- United Nations Permanent Forum on Indigenous Issues[29] (UNPFII) provides information on Indigenous Peoples' rights, issues, and events worldwide.

A project concept that is potentially fatally flawed or involves has very high risks might have any of the following:

- IPs opposed to hydro projects and similar developments.
- The developer's and/or government partners' unwillingness to recognise IP rights and the need for FPIC.
- Major negative impacts of the project anticipated on living areas and traditional

[26] https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf
[27] https://www.hs-alliance.org/how-to-guides
[28] https://www.iwgia.org/en/
[29] https://www.un.org/development/desa/indigenouspeoples/unpfii-sessions-%202.html

livelihoods of IPs.

- Significant pre-existing disputes over indigeneity and IP rights.
- Affected IPs with a poor relationship with the government and/or developer.
- Affected IPs that are numerous and dispersed, creating difficulties to consult, negotiate and make decisions, causing major risks to the project schedule and viability.

A project concept with lower risks could be:

- The project does not in any way affect the rights of IPs.

Actions that could reduce the risk of a project concept might include:

- As early as possible, establish an understanding with IPs on how they should be engaged with, and what would be necessary to achieve their FPIC (if necessary a process agreement that could eventually lead to FPIC).
- Employ staff from the IP groups to help build the relationship and help set up and maintain a dialogue process.
- Explore alternative locations and designs so the project can avoid or minimise any impacts on the rights of IPs.

1.11 PFF10 - Critical Cultural Features

Table 12 - Risk Ratings for PFF10 Critical Cultural Features

Extreme	***Very High***	***Unknown***	***Low***	***Very Low***
The project concept will affect one or more sites that are nationally or internationally recognised for critical cultural features, and it appears that the impacts cannot be mitigated	The project concept is likely to affect at least one site that is nationally or internationally recognised for its critical cultural features, and the impacts may not be able to be mitigated	Further analysis is necessary to show that the project concept will not affect a site that is nationally or internationally recognised for its critical cultural features and that the impacts can be mitigated	The project concept is likely to to have insignificant effects on sites recognised to have critical cultural features, and any impacts can be mitigated	The project concept is demonstrated to not affect a site that is nationally or internationally recognised for its critical cultural features

Cultural heritage refers to the legacy of physical artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present, and bestowed for the benefit of future generations. It is the objects, places and practices that define who we are, and the values society wants to retain, share and pass on to future generations.

The International Finance Corporation (IFC) Performance Standard 8[30] (PS8) defines cultural heritage as encompassing properties and sites of archaeological, historical, cultural, artistic, and religious significance. Cultural heritage also refers to unique environmental features and cultural knowledge, as well as intangible forms of culture embodying traditional lifestyles that should be preserved for current and future generations.

Critical cultural features are those of high recognised value. These values may be symbolic, historic, artistic, aesthetic, ethnological or anthropological, scientific or social. Critical cultural heritage is defined in IFC-PS8 as "*one or both of the following types of cultural heritage:*

(i) *The internationally recognised heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; or*

(ii) *Legally protected cultural heritage areas, including those proposed by host governments for such designation*."

[30] https://www.ifc.org/en/insights-reports/2012/ifc-performance-standard-8

In addition to obtaining a global perspective, it is important to recognise locally significant cultural features. There may be designations at a national or state level that recognise critical cultural features. Local values are essential to discern and appreciate, as not all critical cultural features are registered and/or protected.

The preliminary evaluation should consider both items and/or sites of cultural property potentially directly or indirectly affected, and whether the feature(s) would be irretrievably lost or salvageable.

Sources of information:

- Local tourism boards and cultural institutions
- Local and national heritage registers.
- World Heritage sites[31] recognised for Outstanding Universal Value for their cultural features.
- Local knowledge and investigation into sites of local festivals, visitation, and rituals.
- Interviews with local cultural heritage experts across the potential range of cultural values (historic, artistic, aesthetic, ethnological or anthropological, scientific, social), potentially associated with research institutions, civil society organisations, and/or museums.
- Tourist promotions of sites and features of note.

If needed, users of HYDROSELECT can the following further source of online information:

- International Council on Monuments and Sites[32] (ICOMOS), an organisation dedicated to the conservation of cultural heritage. Their website offers resources, publications, and guidelines on heritage conservation and management practices worldwide.

A project concept that is potentially fatally flawed or involves very high risks might:

- Inundate or otherwise convert and impact an area that is locally and/or more broadly recognised as a site of critical cultural features.

A project concept with lower risks could be:

- A project that does not affect any sites of local or broader cultural heritage significance.

Actions that could reduce the risk of a project concept might include:

- Mitigation options for cultural heritage impacts (for example, heritage features removal and relocation).

1.12 Fatal Flaws Rating Templates

Table 13 provides a template for users able to rate multiple project concept options. These may be alternative projects for development over a widely ranging geographic area, or various project concepts for one area to meet a demonstrated need.

[***Note to reviewer – Table 13 can be provided on-line once HYDROSELECT is finalised. Each cell will have a drop-down list and colouring for the 5 fatal flaw ratings, so this table can give insights into relative ratings on a number of project concepts]

[31] https://whc.unesco.org/en/list/

[32] https://www.icomos.org/en

Table 13 - PFF Risk Ratings for Multiple Project Concepts

Potential Fatal Flaw (PFF)	PFF Rating – Project Concept 1	PFF Rating – Project Concept 2	PFF Rating – Project Concept 3	PFF Rating – Project Concept 4	PFF Rating – Project Concept 5
PFF1 – Demonstrated need and strategic fit					
PCFF2 – Hydrological resource					
PFF3 – Geological conditions					
PFF4 – Transmission lines, roads and ancillary requirements					
PFF5 – Greenhouse Gas (GHG) emissions					
PFF6 – River system connectivity					
PFF7 – Biodiversity and critical habitats					
PFF8 – Resettlement and livelihood impacts					
PFF9 – Indigenous Peoples (IP)					
PFF10 – Critical cultural features					

Table 14 provides a template for users able to rate a single project concept option. It includes not only the ratings, but also further actions, timing and responsible parties for those actions, and additional notes. Table 14 can be modified to act as a very basic sustainability risk assessment for any project concept that may progress past the fatal flaws analysis, by keeping all PFFs in the table and also adding all of the Additional Sustainability Risks from Part 2. It could further add any of the Sustainability Opportunities from Part 3, and the 2nd column header modified to read Risk / Opportunity Rating.

[***Note to reviewer – Table 14 can be provided on-line once HYDROSELECT is finalised.]

Table 14 - PFF Risk Ratings for a Single Project Concept

Potential Fatal Flaw (PFF)	Risk Rating	Actions required	Timing for actions	Responsible parties	Additional notes
PFF1 – Demonstrated need and strategic fit					
PCFF2 – Hydrological resource					
PFF3 – Geological conditions					
PFF4 – Transmission lines, roads and ancillary requirements					
PFF5 – Greenhouse Gas (GHG) emissions					
PFF6 – River system connectivity					
PFF7 – Biodiversity and critical habitats					
PFF8 – Resettlement and livelihood impacts					
PFF9 – Indigenous Peoples (IP)					
PFF10 – Critical cultural features					

Part 2 – Additional Sustainability Risks

2.1 Overview of Additional Sustainability Risks

Table 15 shows a summary of the nine Additional Sustainability Risks outlined in Part 2.

Any PFF rated Red (Extreme Risk) should have resulted in a project concept being avoided, i.e. discontinued.

Any PFF rated Orange (Very High Risk) or White (Unknown Risk) should remain as a PFF until it can be confidently rated Yellow (Low Risk) or White (Very Low Risk), and investigated further as a matter of priority.

For project concepts that will be progressed, all PFFs should be added to the Additional Sustainability Risks .

For each sustainability risk in Part 2, considerations are provided that may lead to conclusions of a project concept being very high or low risk. There is no rating system provided as to how each risk should be evaluated. Sustainability-related risks should be incorporated into an overall risk rating process and management plan, which will include a number of other considerations beyond those outlined in HYDROSELECT. It is best for the user to fit all sustainability considerations (from Parts 1 and 2) into their existing risk evaluation and management system, and continue to assess these regularly following established risk assessment and management processes.

For simplicity, the term "project" or "potential project" is used throughout Part 2, although at the early stage all projects under consideration can be considered "project concepts" that may be adjusted in a number of different ways as further information comes to light.

Table 15 - Summary of Additional Sustainability Risks

Additional Sustainability Risks
• Erosion and Sedimentation • Downstream Flows • Water Quality • Infrastructure Safety • Cumulative Environmental and/or Social Impacts • Political Risk including Corruption, Conflict and Transboundary • Institutional Capacities • Corporate Governance and Procurement • Community Acceptance and Social Licence

2.2 Erosion and Sedimentation

Erosion and sedimentation presents a number of risk areas for a project, and ideally would have investigations commencing alongside those for geological conditions. Poor catchment/watershed protection is experienced almost everywhere in the world, and so erosion, mobilisation of sediments, and sediment deposition should be anticipated.

Erosion and sedimentation analyses are often limited to estimations of reservoir sediment infilling, but should in fact be broader and include:

- Sediment accumulation into the reservoir with potential to shorten project life;
- Sediment impacts on hydropower project components, such as pitting of machines;
- Sediment accumulation areas causing and exacerbating local flooding, for example in the

upper reservoir and/or at reservoir embayments where local tributaries enter;

- Downstream river channel changes (e.g. erosion, sedimentation, channel migration) due to changes in hydrology and disruption of sediment transport continuity;
- Downstream livelihood impacts associated with changes to erosion and sedimentation (e.g. river accessibility, river-based transport, downstream infrastructure stability, riverbank and floodplain soil fertility, and/or delta stability).

Sustainable hydropower should not have a 'life span'; rather, a potential hydropower project should be planned and designed to continue in perpetuity A hydropower project that has a fixed lifetime due to sedimentation cannot be said to be renewable. There are a limited number of suitable sites for storage hydropower in the world, and it is unsustainable for them to be filled with sediment in less than a century. Sediment does not simply fill up the dead storage first as is often assumed; sediment deposition forms a delta at the reservoir tail that will gradually expand and move downstream. Sediment accumulation must be managed by either lowering sediment input, moving sediment within the reservoir, or passing sediments downstream (or ideally a combination).

Sources of information:
- Catchment surveys to assess potential for erodibility. Indicators include steep slopes, erodible soils, sparse or no vegetation cover, active deforestation, intense rainfall events, and/or poor land use practices.
- Any information available on sediment yields in the catchment.
- Geomorphic information highlighting landslips, erodibility and sediment movement.
- Historical erosion and/or sedimentation effects on any existing instream structures.
- Local knowledge.
- IHA How-to Guide for Hydropower Erosion and Sedimentation[33].

A project concept that has very high risks could have any of the following:
- A highly erodible catchment, or large areas within the catchment that are highly erodible.
- Technical and/or operational constraints or limitations on sediment management options.
- Present and/or likely future land uses in the catchment causing high rates of erosion.

A project concept with lower risks could be:
- A run-of-river project with no reservoir storage.
- A project with a protected catchment area.
- A project located high in the catchment with little present or likely future catchment activities causing high rates of erosion.
- A region with very low sediment loads in rivers.
- A project with a very deep reservoir area with considerable "inactive storage" area.

Actions that could reduce the risk of a project concept might include:
- Advocate for a protected catchment.
- Liaise with authorities to limit or prevent land use changes in the catchment that could cause high degrees of erosion.
- Assess and factor in sediment through-flow or sediment flushing design features into the project.
- Design the project to ensure more than adequate area for "inactive storage".
- Include, and plan to ensure maintenance of, sediment collection structures in the catchment, such as sediment check dams.

2.3 Downstream Flows

Changes to flow regimes and sediment transport as a consequence of hydropower projects can fundamentally change aquatic ecosystem habitats and life cycle processes. These

[33] https://www.hs-alliance.org/how-to-guides

changes can result in negative impacts to, and even losses of, flora and fauna species, and potentially a large range of effects on downstream water users and river-based livelihoods (e.g. fishing, flood-recession agriculture).

Hydropower project type, operational objectives and scale are determinants of downstream hydrological changes. Characteristics on downstream flows by project type range from:

- Run-of-river hydropower, which typically has a water residence time of less than a day. These projects maintain pre-project seasonability in river flows, but can have daily water level changes as a source of impact.
- Storage hydropower, which typically has a water residence time of weeks to months and even years. With these projects, the downstream flows no longer mimic seasonal flow regimes. This significantly alters aquatic ecosystems downstream, and can be associated with high impacts and losses to aquatic biodiversity, potentially accompanied by a range of social impacts.
- Pump storage hydropower, which has at least two reservoirs, involving pumping water to the upper reservoir and generating electricity when the water flows from the upper to the lower reservoir. After first filling, there is limited ongoing impact on a river system due to the recycling of water. Important considerations to take into account for downstream flow commitments include during first filling (which can potentially take years), during reservoir inflows which will be required to address evaporation losses, and during times of flood and spill. Because of the two reservoirs, more than one river will be affected.

As well as the type and energy generation objectives of the project concept, the planned operational regime will inform the likely degree of downstream hydrological change, which in turn is critical to estimate biodiversity and livelihood impacts. Operational regimes could potentially be:

- Baseload operation, likely to be used to meet some or all of a region's continuous energy demand. These projects are likely to produce energy at a constant rate, and so downstream flows can suffer from the loss of natural variability.
- Peaking operations, also known as hydropeaking, involve discontinuous releases of water through the turbines to meet peak energy demands, which causes downstream water flow fluctuations at short time-scales.
- Load following operations, which typically involve day-to-day variations in the flow made by the hydropower plant operators, generally to better match electricity generation with demand if available water is less than their plant capacities. It will be important to analyse the variation of regulated flows from natural pre-project flow regimes.

Increasing penetration of intermittent renewables may require more peaking or pumped storage in future, including changes to existing projects.

Powerhouses located downstream of a dam can have reaches with lower flows in between the dam and powerhouse, with consequent impacts on aquatic habitat and water users in the dewatered reach.

Diversion schemes involve a powerhouse on an adjacent river to the one with the dam, which poses environmental and social risks to more than one river.

Sources of information:

- Basic characteristics of the project, namely the location, type and scale of hydropower project and key feature location(s) in the river basin.
- The planned operating regime, which along with project type and scale are the key determinants of the degree of change to the natural or pre-project flow regime and resulting downstream impact.
- Hydrology expertise engaged early in project studies to analyse how far downstream the project will affect, and to what degree.
- For pump storage hydropower involving two reservoirs, information on the (at least) two

separate downstream rivers which may have different ecosystem and community impacts.
- IHA How-to Guide for Downstream Flow Regimes[34].

A project concept that has very high risks could have any of the following:

- Dry, or low flow, river reaches due to either inclusion of a diversion and/or a power station located downstream of the dam.
- Reservoir(s) designed for storage, to hold water so that it can be released during dry seasons, very likely to have unseasonal downstream flow releases quite different to natural flow regimes.
- Baseload operation can be an issue for downstream ecosystems which have life cycle needs tied to hydrological variability.
- Intermittent raising and lowering of river levels on short timing cycles can cause riverbank erosion downstream, loss of riparian habitat, stresses and potential loss to aquatic species, and potential impacts for river-based livelihood activities and public safety. Daily regulation, even with small headponds, can result in peaking impacts downstream of the powerhouse.
- An estuary or wetland downstream whose function is reliant on the natural patterns of delivery of freshwater flows. Estuarine processes and ecosystems, and hydrological replenishment of wetlands, can be particularly vulnerable to changed hydrological and sediment regimes arising from hydropower projects.
- Communities downstream whose livelihoods have dependencies on the natural flow regimes (e.g. fishing, flood-recession agriculture, river-based transport, deltaic farming, fish farming).
- A region with socio-cultural activities that are highly dependent on flows in the river (e.g. funeral ceremonies that cremate bodies and rely on the river to transport the ashes).

A project concept with lower risks could be:
- A run-of-river project which mimics natural flow patterns and has no peaking operations.
- A project involving no river diversion.
- A project with a considerable distance between the project and a downstream estuary.
- A project with no downstream wetlands affected by flow release patterns.
- A project location on a river with a number of tributary inflows downstream of the project.
- No or few downstream communities affected by flow regime changes.
- No or few river-dependent livelihoods or socio-cultural activities.
- Cascade hydropower projects, where there is another reservoir just downstream.

Actions that could reduce the risk of a project concept might include:
- Alternative locations and designs so that the project has little or no impact on downstream flows.
- Downstream flow release mitigation measures included in project design and costings.
- A regulation pond to dampen short-term irregular water level changes.
- Offset (i.e. compensation measure) options such as protection of an unaffected downstream river reach.

2.4 Water Quality

A number of factors can affect water quality in the future impoundment and in the downstream releases. Water quality impacts are often closely associated with visual, erosion / sedimentation, biodiversity, and livelihood impacts. Anticipating the water quality and associated risks early is helpful, as potential impacts may require mitigation measures included at the design stage.

[34] https://www.hs-alliance.org/how-to-guides

Factors influencing the type and degree of future water quality risks include:

- Reservoir depth. Depending on location and climatic conditions, very shallow reservoirs may experience wind-induced mixing of bottom sediments, challenges with vegetation regrowth when the reservoir is drawn down, and also temperature and evaporation effects on water quality. Deep reservoirs can stratify, meaning the upper zone of the reservoir differs in temperature and oxygen levels to the deeper zone, which can cause issues with anoxic and cold releases downstream if there is a low intake.
- Reservoir water residence time. Inundation of existing vegetation can lead to later water quality issues as the vegetation decays and uses up oxygen. Tropical and subtropical climates typically have very rapid and dense vegetation growth, which can decay when submerged and create water quality issues. In general, short water residence times have fewer water quality issues emerging.
- Large changes in water levels. Large changes in water levels will expose banks that have been affected by submergence of varying durations. Exposed dewatered banks can give rise to erosion, landslip and wave risks which in turn can cause turbidity. These impacts may pose challenges if there are other uses of the reservoir and infrastructure around the reservoir, as well as being a potential source of visual impact. In tropical and subtropical climates, vegetation can rapidly regrow in exposed banks, and then decay seasonally and cause water quality problems upon re-submergence.
- The frequency of changes in water levels. Pumped storage hydropower, and projects operating in peaking mode, can have rapidly fluctuating reservoir water levels. Frequent changes in water levels, as well as rapid drawdowns, can cause bank erosion. This in turn can contribute to sediment accumulation in the reservoir, turbidity affecting water quality, and loss of riparian habitat. Rapidly fluctuating water levels can also pose safety concerns if there is public accessibility and other uses of the reservoir.
- Upstream or within future reservoir pollution sources. Upstream polluters can cause ongoing water quality issues for a project. The reservoir may inundate contaminated sites that are not decontaminated prior to inundation, and so have ongoing pollutants into the reservoir. Surrounding developments may not ensure appropriate water treatment measures. Downstream uses may be sensitive to poor water quality.
- Additional reservoir uses. Some reservoir uses can give rise to negative impacts, for example: bank erosion due to boat wakes; public safety risks; nutrient enrichment; and risk of algal blooms with aquaculture.

An often assumed mitigation for potential water quality risks is the clearing of reservoir vegetation. This in fact can be very challenging, as it requires excellent mapping of both vegetation and access, and proactive planning for future uses. Vegetation clearing will have its own environmental costs, as vegetation stabilises soil, and so its removal increases the risk of soil erosion. Also, undergrowth can regrow before impoundment.

Sources of information:
- Calculation of the likely reservoir water level changes (amount, rate).
- Calculation of the likelihood of stratification = (length / depth) x (mean flow / volume).
- Calculation of estimated water retention time = reservoir volume / mean river flow.
- GIS analysis, local history assessment, and local visitation to determine past and present water quality and contamination sources and issues.

A project concept that has very high risks could have any of the following:
- A relatively long water residence time (>1 week).
- A reservoir that stratifies, and anoxic waters are likely to be released.
- Past, present or likely future pollution sources upstream, in the inundation area, and/or downstream.
- Dry or reduced flow reach(es) with little opportunity for dilution or mixing.
- Affected communities whose drinking water sources and/or livelihoods will be adversely impacted by poor water quality.

A project concept with lower risks could be:
- A relatively short (<1 day) water residence time.
- No likely stratification.
- No past, present or likely future pollution sources upstream, in the inundation area, and/or downstream.
- No affected communities.

Actions that could reduce the risk of a project concept might include:
- Treat focal areas of contamination.
- Incorporate design features to ensure adverse water quality can be managed, such as multi-level offtakes, air injection and oxygenation facilities, and sufficient environmental flow releases.
- Explore alternative locations and designs so the project can avoid any ongoing external sources of pollution.
- Seek agreement with and improvements to sources of polluting activities.

2.5 Infrastructure Safety

Hydropower projects can have significant implications for public safety. Infrastructure components, and in particular dams, need to be sited, designed, built and operated to keep the public, property and the environment safe.

Preliminary infrastructure safety evaluations at the early stage need to consider:

- Geological conditions that may give rise to dam failure, and the type and design of the dam to manage these risks;
- Hydrological conditions that may give rise to dam failure, and the size and type of spillway structure and emergency water release provisions required to manage flood risks, including a long-term view that accounts for future climate scenarios;
- Natural hazard risks, which may include seismic risks, geotechnical instability (landslips, landslides), wildfires, extreme weather events, and Glacial Lake Outburst Floods (GLOFs). The natural hazard risk assessment should consider present and future climate scenarios. The evaluation would need to consider both impacts of these hazards on project safety, and impacts of the project on triggering such hazards; and
- The population at risk of dam failure (or cascade dam failures).

Sources of information:
- Regulatory requirements for the jurisdiction.
- Relevant design standards for the infrastructure.
- Consideration of preliminary geological and hydrological information, including forward climate scenarios, with respect to infrastructure safety requirements and risks.
- Topographic map analysis, field visits, and local knowledge to evaluate natural hazard risks.
- Census and other administrative data to evaluate the population at risk of dam failure.
- Site inspections (if possible) and local knowledge on the state of other infrastructure upstream and downstream of the proposed project concept.
- IHA How-to Guide for Hydropower Infrastructure Safety[35].

A project concept that has very high risks could have any of the following:
- A very large population at risk downstream.
- Unfeasible spillway requirements due to constraints in space or operations.
- Existing infrastructure implicated in any dam safety incident which does not meet or has not been maintained to ensure contemporary dam safety expectations.

[35] https://www.hs-alliance.org/how-to-guides

- Non-existent communication, emergency response and evacuation facilities making it very difficult and costly to address dam safety incidents.

A project concept with lower risks could have:
- Low or no population at risk.
- Plenty of space and capacity to feasibly include and operate spillways requirements.
- No other projects on the river, and so no cascade dam failure risks.
- Well-established communication, emergency response and evacuation facilities.

Actions that could reduce the risk of a project concept might include:
- Ensure that dam safety requirements and standards are factored into design of both the permanent infrastructure and temporary infrastructure (e.g. coffer dams) at an early stage, including future climate scenarios.

2.6 Cumulative Environmental and Social Impacts

Hydropower projects often have significant cumulative impacts, especially relating to water resources and downstream flows. International Financial Institution (IFI) boards routinely require a Cumulative Impact Assessment (CIA) of a hydropower project. A Strategic Environmental Assessment (SEA) can also help evaluate cumulative impacts and risks.

Cumulative impact management measures may be a focus of a relevant river basin plan. A frequent cumulative impact issue that needs evaluation with hydropower projects is climate change vulnerability, which should include opportunities to increase climate resilience of land, habitats and communities affected by the project.

Sources of information:
- Topographic map analysis.
- Aerial photography and satellite imagery analysis.
- Site vists.
- Local knowledge.
- Relevant regional assessments and plans.

A project concept that has very high risks could have any of the following:
- A number of existing or planned hydropower projects and/or water resource developments on the same river or in the same river basin.
- Existing sources of environmental impact on the river or in the area (e.g. industrial sites, mines, logging).
- Existing activities in the area that have a high environmental impact (e.g. hunting, sale of threatened species, land clearing, deforestation).
- Planned activities in the area with a high environmental impact (e.g. urbanisation, land clearing, new industrial activities).
- Affected communities who have been resettled by another project.
- Other existing or planned activities in the area that are or will negatively affect communities.

A project concept with lower risks could have:
- No present or foreseeable water resource developments that draw on or discharge to the river system.
- No present or foreseeable other activities that do or will also cause environmental impact to the river system.
- No present or foreseeable other activities that do or will also cause social impact to the project-affected communities.

Actions that could reduce the risk of a project concept might include:
- Do or at least scope a CIA early on in project planning, linked to river basin planning.
- Consider alternative locations and designs, and mitigation measures, so the project can

avoid any cumulative environmental and/or social issues.

- Seek agreements with the other sources of impact on managing these impacts so cumulative impacts can be minimised.

2.7 Political Risk including Corruption, Conflict and Transboundary

Political risk is a risk of financial loss or inability to conduct business faced by investors, corporations, and governments. Political risk sources include: political instability, corruption, conflict, terrorism, government policy changes, government action preventing entry of goods, expropriation or confiscation, currency inconvertibility, politically-motivated interference, government instability, or war. A low level of political support is considered a political risk. Off-taker risk should also be considered, with respect to the degree of confidence that the off-taker will be able to pay for the power.

Transboundary risks can be a significant type of political risk relevant to a potential hydropower development. Projects may give rise to transboundary considerations if the watershed or affected river reaches upstream or downstream are in different countries or jurisdictions, or if there are different countries or jurisdictions on each side of the river. Present or future water resource use conflicts can be a significant risk for transboundary rivers.

Corruption is dishonest or fraudulent conduct by those in power, typically involving bribery. Business transactions, financial records or personal finances that appear unusual or unexpected and cannot be fully explained may be indicators of possible bribery or corruption. Corruption is a very difficult area to evaluate, as it is not often visible. Whilst mitigation measures can be and should be employed to ensure ethical business practices, it can be difficult to conduct business in a region in which basic business transactions are delayed whilst participants are waiting for facilitation payments, or other forms of “the way we do business here”. In the worst of cases, it is impossible to progress a business venture whilst retaining a commitment to ethical business practices.

Corruption risks may occur:

- Within a business or other organisation, such as issues with how finances are managed (embezzlement), or recruitment and promotion (nepotism);
- From outside of the business, such as a supplier offering kick-backs, or bribery in the supply chain; or
- Bribing of public sector officials, e.g. to award a tender or concession, short-cutting of assessment or preparation requirements, non-transparent approvals, or failure to address licence or permit requirements.

Reduction or mitigation of political risks can be through, for example: energy sector reform, integrity commission or similar government initiatives, sound fiscal management, transboundary agreements, and/or anti-corruption strategies.

Sources of information:

- A political risk assessment that systematically considers political factors that may affect the developer's ability to operate effectively in a particular country.
- Review of the country’s history, government stability, and other potential political risk factors.
- Websites that assist in the identification of ongoing conflicts, such as the Global Conflict Tracker[36] or CrisisWatch[37].
- Local knowledge regarding local situations of conflict, such as warring ethnicities or communities on opposite sides of a river or upstream and downstream of the project.
- Glossaries of types of corruption, such as the Glossary of Corruption by the United

[36] https://www.cfr.org/global-conflict-tracker
[37] https://www.crisisgroup.org/crisiswatch

Nations (UN) Office on Drugs and Crime[38], and CORRUPTIONARY A-Z[39].
- World Bank Worldwide Governance Indicators for control of corruption[40].
- World Bank Ease of Doing Business rankings[41].
- Transparency International Corruption Perception Index[42].

A project concept that has very high risks could have any of the following:
- No transboundary agreement or cooperative processes.
- Evidence of politically-motivated interference.
- Evidence of government instability or insolvency.
- Likelihood of government policy changes that may impact on project delivery.
- Existing or impending conflict in the region.
- Potential disruption to supply chains due to present or future conflict.
- Present or potentially foreseeable future conflict over sharing of water resources, particularly during drought.
- Location in a region with historically known corrupt practices.
- A rating for the company or country that makes it known that corruption is likely to be an ongoing risk.

A project concept with lower risks could have:
- No transboundary issues, or a very mature and well-established transboundary cooperation framework that covers the whole river system.
- No apparent indications of government or political tensions or likely interference.
- No indication of present or future conflict.
- Located in a region with low known corruption risks.
- A developer with sophisticated and regularly tested anti-corruption and ethical business policies, procedures and practices.

Actions that could reduce the risk of a project concept might include:
- Review any transboundary frameworks and evaluate their ability to anticipate, avoid and withstand future conflict.
- Engage early and frequently with government stakeholders.
- Establish a broad base of public and political support for the project, and prevent opposition to the project from becoming politicised.
- Political and regulatory reforms.
- Political risk insurance.
- Alternative locations and designs so the project can avoid any present or future conflict.
- Avoid projects that themselves create or exacerbate conflict.
- Identify steps that a project could take to help resolve or minimise conflict.
- Incorporate ethical safeguards into all project entity policies and practices, such as: a business code of ethics; an employee code of conduct; a business integrity pact; antibribery or anti-corruption policies; procurement threholds and procedures; internal and external auditing; procedures for reporting and investigation; whistle-blowing arrangements; and confidentiality limited to legally protected information.

2.8 Institutional Capacities

Institutional capacity in this context relates to the capacity of a given institution to handle tasks (within their sphere of responsibility) relating to planning, implementation and operation of hydropower projects. This includes environmental and social issues assessment, decision-making, licensing and permitting, monitoring, auditing and enforcement. Key institutions undertaking actions essential to the project need to have

[38] https://www.unodc.org/documents/e4j/Secondary/Anti-Corruption_Glossary.pdf
[39] https://www.transparency.org/en/corruptionary
[40] https://databank.worldbank.org/databases/control-of-corruption
[41] https://data.worldbank.org/indicator/IC.BUS.EASE.XQ
[42] https://www.transparency.org/en/cpi/2022

sufficient capacities to delivery on their requirements in a predictable, responsible and timely manner.

Examples of key institutions that may be relevant to development and operation of a hydropower project include but are not limited to: the energy regulator, the environmental regulator, specific government agencies (e.g. for rivers, water supply, quarries and mines, transmission lines, roads, imports, taxes, permits, public safety, emergency response, fisheries, land clearing, waste management, public health), local and regional government, law enforcement agencies, anti-corruption organisations, grievance addressing institutions (e.g. the Ombudsman), the judiciary, and the public contracting system.

Areas of potential institutional dependencies may include: timely project assessment and licensing processes, facilitation of imports and supply chain needs, meaningful stakeholder engagement and/or support, independent review committees, monitoring and enforcement of license conditions, treatment of grievances, harmonisation of different governmental agency requirements, transparent decision-making processes, and public disclosure.

Gaps and shortfalls may be in terms of resources, numbers of staff, availability of staff, competencies and skills within an institution, and institutional processes. Complexities may relate to conflicting interests and objectives (e.g. a forest agency may want to log the whole reservoir for the economic resource prior to impoundment, whereas a balanced approach to biomass reduction may be more optimal), timing of institutional capacity availabilities, or peaks in demand for institutional attention due to other development requirements.

Sources of information:

- List institutions external to the developer who will play a role in delivery or enforcement of aspects of the project, and identify any known or potential expectations and requirements of each.
- Discuss with key agencies about the project concept requirements, potential timing, institutional capacities and any potential issues

A project concept that has very high risks could have any of the following:

- Immature or weak public sector institutional capacities in any particular area of project dependency.
- Relatively undeveloped or immature environmental and/or social regulations.
- Poor contractor capacities.

A project concept with lower risks could be:

- In a region in which all institutions likely to have a role have very high capacities and availability to meet the anticipated time requirements for the project.

Actions that could reduce the risk of a project concept might include:

- Undertake an institutional capacity assessment, and where the necessary capacities are lacking or questionable in any of sector, develop plans to mitigate shortfalls.

2.9 Corporate Governance and Procurement

All businesses are operated, regulated, and controlled according to a set of internal rules and processes that are defined as corporate governance. Different corporate processes and structures will be required depending on internal characteristics of the business (e.g a single project or multi-project entity; government-owned, privately-held or listed on the stock market; or a domestic or multi-national business). These requirements will be further shaped by the external governance environment, such as government regulatory requirements, legal frameworks, and risks.

Corporate governance requirements need to be appropriately in place and well-understood by all as they apply throughout the hydropower project development cycle. Corporate governance components typically include: the roles of the Board of Directors and the executive management team; business structure and administration; policies and processes; risk management; accountabilities and delegations; internal and external reporting; internal and/or independent auditing; independent review; compliance management; environmental and social issues management; ethical business policies and practices; corporate culture; stakeholder and shareholder relations and engagement; grievance mechanisms designed to address labour, project-affected communities, and contractors; and transparency.

Quite often new developers lack governance processes in all areas.

Multi-purpose projects can raise a number of challenges in terms of reservoir governance and management. Care needs to be taken that the ambitions and stakeholder expectations for multi-purpose are realistically able to be provided for, and do not lead to governance gaps, conflicts or have the potential for future conflicts.

Developers can be at different levels of familiarity with sustainability and ESG policy, commitments and practices. For those new to hydropower sustainability, there may be a whole new vocabulary and set of concepts to take on board that go beyond national or local compliance requirements.

From a governance perspective, procurement is both a source of potential risks (primarily corruption and conflicts of interest) and an opportunity to have a positive influence beyond the direct scope of the business. Hydropower projects involve the flow of large sums of money. Procurement is an area of high risk for corruption, and it is essential to have very good safeguards to protect procurement processes from unethical practices. At the early stage, there may already be small contracts for assistance with early analyses, options assessment, and pre-feasibility studies. Early contractor management policies and processes can provide indications of where strengthening in the procurement systems may be needed. Procurement plans and processes should include a procurement policy, pre-qualification screening, bidding, awarding of contracts, anti-corruption measures, and mechanisms to respond to bidder complaints.

Sources of information:
- Independent review of corporate governance policies and processes, with particular attention to their transposition from a higher corporate level to the project level.

A project concept that has very high risks could have any of the following:
- A developer with not well-established corporate policies, commitments, staff, or other project examples that provide evidence of established corporate governance practices.
- An absence of key policies such as for transparency, stakeholder engagement, social and environmental management, or anti-bribery; key roles not filled; a lack of internal financial controls and weak audit processes; internal corruption risks; poor documentation of compliance; a lack of Board- or Executive-level focus on key performance indicators related to sustainability (e.g compliance, safety, working conditions, environment, stakeholders); or a lack of project management or other relevant capacities.
- Deficiencies in procurement plans and processes regarding procurement policy, pre-qualification screening, bidding, awarding of contracts, anti-corruption measures, and mechanisms to respond to bidder complaints.

A project concept with lower risks could have:
- A developer with well-established and comprehensive corporate policies, commitments, staff, and/or other project examples that can provide evidence of well-established corporate governance practices.
- Well established procurement plans and processes including a procurement policy, pre-qualification screening, bidding, awarding of contracts, anti-corruption measures, and mechanisms to respond to bidder complaints.

Actions that could reduce the risk of a project concept might include:

- Independent review of corporate governance policies and processes, with particular attention to their transposition from a higher corporate level to the project level.
- Develop corporate governance policies and processes.
- Recruit specialist staff with environmental and social expertise in areas likely to be challenging.
- Review and plan for procurement processes to be demonstrably equitable, efficient, transparent, accountable, ethical and timely.
- Develop a robust procurement strategy for project construction, including pre-qualification, tendering, contract package strategy, support for local content, contract templates to include ESG expectations and requirements.

2.10 Community Acceptance and Social Licence

Whilst at the early stage the evaluation of one or more hydropower project concepts is usually confidential, a major sustainability risk as any project concept emerges into community and public awareness is a lack of community and public acceptance. A major incentive for applying HYDROSELECT is so that any project concept that is taken forward is most likely to gain community acceptance and social licence.

Community acceptance refers to the general approval or support from the potential project-affected communities for a hydropower project. Community acceptance is important for hydropower project development because it ensures that the concerns, needs, and perspectives of local communities are considered and addressed throughout the project lifecycle, fostering social acceptance, minimising conflicts, promoting sustainable development, and enhancing the project's overall success and long-term viability.

A closely related concept is social licence, or social licence to operate, which refers to the broader societal approval or consent for a project and its operations by its contractors, employees, stakeholders, and the general public.

Experience shows that critical success factors gaining community acceptance and social licence are legitimacy, credibility and trust. When the project and developer have community acceptance and social licence, they can benefit from collaboration and political support. In general, the broader the social, economic and environmental impacts of a project, the more difficult it becomes to get community acceptance and social licence. In the worst case, signs that social licence is withheld or withdrawn include shutdowns, blockades, boycotts, violence/sabotage, and/or legal challenges.

Engagement and transparency are key to gaining community acceptance and social licence. Stakeholder engagement involves the systematic identification, analysis, planning and implementation of sharing information, obtaining local knowledge and views, and responding to stakeholder inputs and views with actions. Transparency refers to the clear, open, and accessible communication of information and decision-making processes by the project developer to stakeholders (including affected communities, government agencies, NGOs, and the general public) regarding project plans, environmental and social impacts, mitigation measures, and regulatory compliance. A high degree of attention to both fosters trust, accountability, and informed participation throughout the project lifecycle

Sources of information:

- Identification of potentially project-affected communities through analysis of the overlay of key project concept features on map views that show community locations.
- Media and potential stakeholder website and social media analyses to discern any strong past or current views or positions taken on aspects that may be affected by the project concept.

A project concept that has very high risks could have any of the following:

- Prior anti-hydro positions adopted by the potentially affected communities.

- A developer that fails to understand the local community (social profile) and the local 'rules of the game' and so is unable to establish social legitimacy.
- A developer with poor credibility due to a lack of or unreliable information about the project, or failure to deliver on promises made to the community.
- A developer that fails to show respect and listen to the community.
- A developer that under-estimates the time and effort required to gain social licence.
- A developer that over-estimates or assumes the quality of the relationship with the community.
- Delays and shortcomings in stakeholder engagement.
- Insufficient time for stakeholder relationship building.

A project concept with lower risks could have:
- No prior history of anti-hydro positions taken by the potentially affected communities.
- Robust stakeholder analyses.
- Effective delivery of engagement plans underpinned by stakeholder mapping.
- Mapping of stakeholder engagements, issues raised, and follow up.
- Early engagement with key stakeholders to obtain local knowledge.
- An early engagement track record of responding to stakeholder information needs and delivery of commitments.

Actions that could reduce the risk of a project concept might include:

- The developer commits to internal public disclosure and transparency policy and processes, to ensure commitments are consistent with actions.
- Analyses of the potentially project-affected communities to form an early view on any discernible social profiles .
- Plan and implement engagement and disclosure from an early stage of the project.
- Develop a robust communications and consultation strategy. This should ensure that: consultations are meaningfully timed to project life cycle stages and community-affecting project activities; offer opportunities for local influence; and cater for local needs of particular community sub-groups (e.g. the aged, youth, illiterate, language differences, internet access, ethnicity, remoteness, etc).
- Develop a Stakeholder Engagement and Communications Plan (including disclosure, grievance mechanisms, etc) to implement during project preparation.
- Research into stakeholder engagement, such as provided by the Association for Project Management[43].
- Research into social licence and how to gain and measure it, such as from The Social Licence to Operate website[44].

[43] https://www.apm.org.uk/resources/find-a-resource/stakeholder-engagement/#:~:text=Stakeholder%20engagement%20is%20the%20systematic,those%20business%20needs%20are%20met.

[44] https://socialicense.com/index.html

Part 3 – Sustainability Opportunities

3.1 Overview of Sustainability Opportunities

Part C of HYDROSELECT addresses the follow component of the overall objectives:

- to better inform sustainability opportunities for a hydropower project concept under consideration; and
- to identify areas of greater sustainability-related opportunity that will require extra investment and planning if a hydropower project concept proceeds to the Preparation Stage

Sustainability Opportunities in Part 3 sets out some of the potential positive contributions of a project concept that will greatly benefit from early planning and actions. This content should not be considered the sum entirety of opportunities, but a starter to illustrate potential areas. It is hoped that the users can generate longer lists applicable to any project concept that looks viable to take forward. Again, the following text uses the term “project” or “potential project” for convenience, on the understanding that at this early stage any project under consideration is a project concept that may well change.

Table 16 shows a summary of the Sustainability Opportunities covered in Part 3.

Table 16 - Summary of Sustainability Opportunities

Sustainability Opportunities
• Regional Development • Improved Water Resource Management • Project Benefits and Benefit Sharing • Local Content • Local Capacity-Building • Legacy Environmental and/or Social Issues • Biodiversity Enhancements

3.2 Regional Development

Hydropower project development may be able to contribute to regional development in several possible ways:

- Infrastructure development, which in rural and remote areas can potentially improve connectivity, access to markets, and quality of life for local communities.
- Job creation, through direct and indirect jobs during the construction and operation stages (see Section 3.4 Project Benefits and Section 3.5 Local Content).
- Revenue generation through electricity sales, royalties, taxes, and fees, which can provide a significant source of income for governments and local communities. This revenue can be reinvested in regional development initiatives (see Section 3.4 Project Benefits).
- Energy access, which hydropower projects can potentially improve, particularly in rural and off-grid areas where access to electricity is limited.
- Industrial development, which can be stimulated by access to reliable and affordable electricity from hydropower projects. Regional development strategies may seek economic diversification in the region, such as with manufacturing, agro-processing, and tourism.
- Improved water management (see Section 3.3 Improved Water Resource Management).

Sources of information:

- Research into the region of the potential project concept such as through:
  - government reports;
  - NGO / CSO, academic or industry reports;
  - census data; and
  - satellite imagery.
- Published assessments using the Hydropower Sustainability Tools on the Hydropower Sustainability Alliance (HSA) website[45] to see what initiatives other hydropower projects have taken to support regional development.
- International Financial Institution (IFI) websites to see how they support regional development opportunities.

A project concept that has a high opportunity might have:

- A larger scale.
- Clearly identifiable regional development needs.
- A high degree of local interest.
- Potential partnership organisations and institutes.
- A strong commitment from the developer.

A project concept with lower opportunity could have:

- A small scale with limited regional development contribution capacity.
- A remote location far from market access and skilled labour.
- Limited infrastructure development requirements.
- Low revenue generation or unfavourable economic conditions constraining the ability to support regional development initiatives.
- An intent to primarily serve energy export markets or the energy needs of large urban centres.
- A lack of developer interest or capacities.

A project concept could respond to the opportunity with actions that might include:

- Clarify developer interest, capacity and likely extent of regional development support.
- Look for opportunities to embed regional development "win-wins" into the project design if and as it moves forward.
- Make plans to engage with relevant stakeholders, including government agencies, local communities, indigenous peoples, and other key stakeholders, to identify regional development priorities, concerns, and opportunities.
- Identify and make plans to establishing partnerships and dialogue early in the project development process.

3.3 Improved Water Resource Management

Hydropower projects are water management projects. A project concept may benefit, involve or affect other water management activities beyond energy generation, such as flood control, irrigation, and water supply. Water quality changes and aquatic ecosystem changes may in turn have consequences for other water uses.

Integrated Water Resources Management (IWRM), Integrated River Basin Management (IRBM), and catchment management are related concepts that focus on managing water resources in a holistic, integrated and sustainable manner:

- IWRM is a comprehensive approach to managing all water resources (rivers, lakes, groundwater, and reservoirs) that considers the entire water cycle, from precipitation to consumption to wastewater treatment; emphasises integration of social, economic, and

[45] https://www.hs-alliance.org/sustainability-assessments

environmental considerations; and seeks to balance competing water uses and needs.

- IRBM specifically focuses on managing water resources within a river basin or watershed in an integrated and coordinated manner. It emphasizes the importance of basin-wide planning, stakeholder engagement, and collaborative decision-making to address water-related challenges and promote sustainable development.
- Catchment management is a localised approach to managing water resources within a specific catchment or drainage area, typically involving a range of stakeholders, including landowners, farmers, local communities, and government agencies, working together to address water-related challenges and opportunities. While catchment management is often used interchangeably with river basin management, it may refer to smaller-scale watersheds or sub-catchments within a larger river basin.

All of these frameworks seek to address the complex challenges associated with water resources management, including water scarcity, pollution, climate change, and competing water demands. Hydropower development within an integrated water resource management framework can potentially help to also bring benefits and greater reliability to agriculture, water-intensive industries, and other water users in the region.

Sources of information:

- Analysis of the hydrological resource undertaken for the fatal flaws analysis (Part 1) should give a good understanding of the overall water management situation in the catchment and river basin, as well as other present and potential future water users.
- Early identification of environmental and social risks (Parts 1 and 2) should inform water-related potential management issues.
- Web-based resources on IWRM, such as by the:
  - Global Water Partnership[46] (GWP)
  - International Water Management Institute[47] (IWMI)
  - UNESCO International Hydrological Programme[48] (IHP).

A project concept that has a high opportunity might have:

- Evidence of water stresses or potential competing water uses and demands across economic, social and environmental uses and values.
- A high degree of present or foreseeable future water uses beyond electricity generation, such as flood control, irrigation, water supply, or recreation.
- A supportive regulatory environment with clear water governance frameworks, policies, and institutions.
- A high degree of local interest.
- Potential partnership organisations and institutes.
- A strong commitment from the developer.

A project concept with lower opportunity could have:

- A hydropower project concept designed solely for electricity generation without consideration of other water-related benefits or uses.
- A hydropower project concept located in a region with abundant water resources and low water stress.
- Low developer interest and/or capacities.
- A lack of local interest or capacities.

46 https://www.gwp.org/en/gwp-SAS/ABOUT-GWP-SAS/WHY/About-IWRM/
47 https://www.iwmi.cgiar.org/
48 https://en.unesco.org/themes/water-security/hydrology/programmes/iwrm

A project concept could respond to the opportunity with actions that might include:

- Clarify developer interest, capacity and likely extent of integrated water management support.
- Look for opportunities to embed integrated water management "win-wins" into the project design if and as it moves forward.
- Make plans to engage with relevant stakeholders, including government agencies, local communities, Indigenous Peoples, and other key stakeholders, to identify integrated water management priorities, concerns, and opportunities.
- Identify and make plans to establishing partnerships and dialogue early in the project development process.
- Plan to conduct more detailed risk and opportunity mapping to identify potential water-related risks, such as water scarcity, flooding, or pollution, as well as opportunities for optimising water use, enhancing ecosystem services, and promoting sustainable development.
- Plan to conduct scenario analyses to explore different future scenarios and their potential implications for water resources management, including climate change, population growth, land use changes, and other drivers on water availability, quality, and demand.
- Plan to build capacity and provide training to project stakeholders, including project developers, government agencies, and local communities, on IWRM principles, practices, and tools.

3.4 Project Benefits and Benefit Sharing

Acceptance of projects can be facilitated through a well-considered programme of project benefits. This strongly overlaps with regional development opportunities, but looks more closely at how the project concept can potentially bring better outcomes for project-affected communities.

Whilst project benefits can include aspects of project development (e.g. employment, roads), benefits additional to the core project can be designed to have positive outcomes for both the project and the community. An example is a catchment protection programme that pays households to maintain or improve vegetation cover, thus reducing soil erosion and improving water quality in rivers and streams.

Some benefits are entirely oriented towards community interests and outcomes, as a result of a deliberate effort by the project to contribute to local area development. Examples include contributions to local infrastructure, local services, and livelihood enhancement opportunities. Such contributions may be in-kind or financial, and may be temporary during construction or permanent. Additional benefit delivery could be, for example, through a community development fund or a revenue-sharing arrangement.

Benefit sharing in the context of hydropower developments refers to the equitable distribution of socio-economic benefits, such as revenue, employment opportunities, infrastructure development, and environmental conservation, among project-affected communities to ensure that all community members share in the positive outcomes generated by the project. Revenue sharing is a specific type of benefit sharing involving distributing a portion of the income generated from the sale of electricity or other project-related activities for the benefit of project-affected communities.

Sources of information:

- Web and media research to find examples from other developments in the country or region in which benefit sharing was prioritised.

- IHA How-to Guide for Benefit Sharing[49].
- Published assessments using the Hydropower Sustainability Tools on the Hydropower Sustainability Alliance (HSA) website[47] to see what initiatives other hydropower projects have taken to address project benefits and benefit sharing.

A project concept that has a high opportunity might have:

- A clear willingness and commitment of the developer to investigate and where feasible provide local project benefits and benefit sharing.
- Staff capacity to investigate and, if the project concept progresses, to facilitate, monitor and evaluate local project benefits and benefit sharing.
- Supportive government policies, regulations, and incentives that promote and facilitate socio-economic benefits from hydropower developments.

A project concept with lower opportunity could have:

- A lack of developer willingness or interest to consider local project benefits or benefit sharing.
- A lack of staff capacity to know how to progress this area and/or to have the time and focus on this area.
- An absence of supportive government policies, lack of political will, regulatory barriers, and bureaucratic hurdles.

A project concept could respond to the opportunity with actions that might include:

- Clarify developer interest, capacity and likely extent of potential for project benefits and benefit sharing.
- Make plans to build developer, government and key stakeholder capacities in this area.
- Look for specific opportunities to embed project benefits in the proposed project concept.
- Allowing extra budget and resources to ensure the ability to deliver on project benefits over the long-term.

3.5 Local Content

Closely tied to Section 3.2 Regional Development and Section 3.4 Project Benefits and Benefit Sharing, job creation is almost always cited as a regional and local benefit of hydropower project development, and employment opportunities may be part of a project benefits strategy. An indicator of the degree to which this opportunity is implemented successfully is referred to as “local content”.

Local content in the context of hydropower development refers to the extent to which the project incorporates goods, services, labor, and expertise from local sources within the project area or region. It encompasses various aspects of project development, including workforce participation, supplier diversity, and community engagement, with the aim of maximising socio-economic benefits for local communities and stakeholders. Local content aims to maximise opportunities for local economic development, job creation, skills transfer, and community empowerment. It reflects a commitment to responsible and sustainable project development that creates shared value for local communities and stakeholders.

Local content can include:

- The employment and participation of local residents, including skilled and unskilled workers, in project construction, operation, and maintenance activities. This may involve hiring local labor, providing training and skill development opportunities, and prioritising

[49] https://www.hs-alliance.org/how-to-guides

local employment.

- Procurement of goods, materials, and services from local suppliers and contractors within the project area or region. This may involve sourcing construction materials, equipment, and services locally, promoting supplier diversity, and supporting the growth and competitiveness of local businesses.

Actions and indicators associated with this objective include:

- Capacity-building initiatives can be aimed at developing local skills, expertise, and resources to support project development and enhance local economic development. This may involve providing training programs, apprenticeships, and technical assistance to build local capacity in areas relevant to hydropower development.
- Training and qualification opportunities offered to locals for skills sets needed for project development.
- Employment targets for the developer and the main contractors to include local content.
- Support for local businesses to participate in project contracts, often relating to supplies, transport, cleaning, equipment, etc, by setting targets for local suppliers and providing early and ongoing support on tender and business management requirements.

Clarity on the scope. Realistic assessment and appraisal mechanisms of project-affected communities are required to help focus local content objectives, as it may not be possible for all community members to benefit from local content commitments. Where there is a need for a wider pool of candidates, local content may extend beyond affected communities, but should always prioritise those directly affected.

Local content commitments will greatly benefit from partnerships with governments, regional training institutions, and/or training providers. Including staff responsible for overseeing and reporting on local content commitments can ensure this commitment remains visible and progress against targets can be accounted for.

Sources of information:

- Employment statistics from the project-affected area.
- Research into locations and capacities and focal areas of regional training institutions.
- Engagement with local government on interests and opportunities.
- IHA How-to Guide for Hydropower Benefit Sharing[50].
- IHA How-to Guide for Labour and Working Conditions[50].
- Review of published assessments such as for Jirau (Brazil) and Reventazón (Costa Rica) to see how they have delivered on local content initiatives[51].

A project concept that has a high opportunity might have:

- A strong commitment from the developer.
- A large pool of skilled labor in the project area or nearby communities.
- A diverse and competitive local supplier base capable of supplying goods and services needed for hydropower project development.
- Government policies, incentives, and regulations that prioritise local content in workforce and supplier contracts (e.g. local hiring preferences, procurement quotas, tax incentives, and subsidies for local businesses).
- A high degree of local interest.
- Potential partnership organisations and institutes.

[50] https://www.hs-alliance.org/how-to-guides
[51] https://www.hs-alliance.org/sustainability-assessments

A project concept with lower opportunity could have:

- A lack of developer willingness or interest to consider local content objectives.
- A lack of staff capacity, time and/or focus to know how to progress this area, including investigating the local situation and planning to develop a strategic procurement strategy.
- An absence of supportive government policies, lack of political will, regulatory barriers, and bureaucratic hurdles.
- A shortage of skilled labor in the project area or nearby communities.
- A small or underdeveloped local supplier base incapable of meeting the technical, quality, and quantity requirements of the hydropower project.
- Few existing opportunities promoting workforce development initiatives, such as skills training programs, apprenticeships, and vocational training centers.
- Lack of existing suitable local institutions, industry associations, and community organisations that may lend themselves to strategic partnerships and collaboration.

A project concept could respond to the opportunity with actions that might include:

- Clarify developer interest, capacity and likely extent of potential for local content.
- Make plans to build developer, government and key stakeholder capacities in this area.
- If the project concept is going to be progressed, allow extra budget and resources to plan, develop, implement and monitor local content initiatives through the project life cycle.
- Identify established parterships that could be approached to support planning and implementation.

3.6 Local Capacity Building

Distinct from the opportunity for local content, local capacity building refers to strengthening the knowledge, skills, resources, and institutions within a specific geographic area or locality. The goal of local capacity building is to empower local stakeholders to address their own needs, challenges, and opportunities effectively and sustainably. Local capacity-building may be supported by regional development initiatives, and can be a pivotal part of other opportunities such as project benefits and benefit sharing, but it can be most broadly effective if set up as its own objective.

Local capacity building initiatives associated with a hydropower project development may include:

- Skill development for individuals and organisations involved in any project development specific tasks or roles, not just the labour force or suppliers to the project.
- Strengthening the capacity of local institutions, including government agencies, NGOs and CSOs, to plan, implement, and manage regional development and/or project benefit initiatives supported by the hydropower project.
- Facilitating partnerships and collaboration among diverse stakeholders, including government agencies, development organisations, private sector companies, academic institutions, and local communities, to address common challenges and achieve shared goals.
- Empowering local stakeholders to participate actively in decision-making processes, problem-solving, and governance structures that affect their lives and livelihoods.
- Facilitating sharing and exchange of knowledge, information, and experiences among local stakeholders to foster learning, innovation, and continuous improvement.
- Promoting local ownership, leadership, and accountability for development initiatives to ensure their sustainability and long-term impact.

Local capacity building is essential for promoting sustainable development, resilience, and self-reliance at the grassroots level. It recognizes the unique strengths, resources, and potential of local communities and seeks to build upon these assets to create positive change and improve quality of life.

Sources of information:

- A well-researched stakeholder map supported by social media and web-based research on existing agencies, groups and organisations will strongly support evaluations of the potential for local capacity-building.
- Information that informed evaluation of the institutional capacity risk (Section 2.8) will also help inform evaluation of this opportunity.

A project concept that has a high opportunity might have:

- A strong commitment from the developer.
- Clearly identified areas in which capacity-building initiatives will benefit both the developer and the relevant stakeholders or organisations in the long-term.

A project concept with lower opportunity could have:

- Low developer interest or capacities.
- Poor awareness of regional or local social structures including agencies, groups and institutions.

A project concept could respond to the opportunity with actions that might include:

- Clarify developer interest, capacity and likely extent of potential to support capacity-building.
- Make plans to build developer, government and key stakeholder capacities in areas of common short- and long-term interest.
- If the project concept is going to be progressed, allow extra budget and resources to plan, develop, implement and monitor capacity-building initiatives through the project life cycle.

3.7 Legacy Environmental and Social Issues

Legacy issues are:

- the impacts of previous projects that are unmitigated or not compensated with a similar good or service;
- long-standing issues with a present (existing) project or projects; or
- pre-existing issues in the present location of a new project.

Past environmental and social impacts that a project concept may face in the area of the potential hydropower project include:

- Previous land clearing, deforestation, and habitat destruction associated with past infrastructure development (e.g. dams, mines, roads), agriculture, or logging activities. These may have led to loss and fragmentation of natural habitats, impacting biodiversity and ecosystem connectivity.
- Pollution from industrial activities, agricultural runoff, and urbanisation may have degraded water quality in rivers, lakes, and groundwater sources, leading to contamination, eutrophication, and impaired aquatic ecosystems.
- Soil erosion, sedimentation, and sediment transport from upstream land use activities may have increased sediment loads in rivers, reservoirs, and downstream water bodies, affecting water quality, aquatic habitats, and hydrological processes.
- Changes in river flow regimes due to upstream dam construction, water diversion, or

channelisation may have affectied aquatic biodiversity, riparian ecosystems, and downstream water availability.

- Past development projects, such as dams, infrastructure projects, or urbanisation, may have displaced communities, leading to loss of land, livelihoods, cultural heritage, and social cohesion, and requiring resettlement and livelihood restoration measures.
- Destruction or degradation of cultural heritage sites, archaeological artifacts, sacred sites, and traditional landscapes due to previous development activities may have undermined indigenous rights, cultural identity, and intangible cultural heritage.
- Competition for water resources among different users, such as agriculture, industry, and municipalities, may have led to conflicts over water allocation, water rights, and downstream water availability, exacerbating social tensions and inequities.
- Pollution, contamination, and environmental degradation may have adversely impacted human health, leading to waterborne diseases, respiratory illnesses, malnutrition, and other health problems among local populations.
- Disruption of traditional livelihoods, such as fishing, agriculture, and forestry, due to environmental degradation, habitat loss, or displacement, may have affected local communities' economic opportunities, food security, and social stability.

Legacy social issues can create deeply entrenched negative community views towards development projects, enterprises, or resettlement. This may be due to prior experiences with hydropower or with the developer, in which impacts were not adequately or effectively mitigated, there were no apparent benefits for local communities, and commitments made to them were not fulfilled. This may also arise because of strongly-held community values for place-based features which they do not want to lose.

Addressing any of these past environmental and social impacts will require comprehensive impact assessments, stakeholder consultations, mitigation measures, and restoration efforts.

On the plus side, if past impacts have happened in an area, a new project has greater potential for positive change. It may be a good thing for a new project to come along with the resources to address legacy issues. Most environmentally-sensitive stakeholders would prefer a project that rehabilitates abandoned industrial or mining operations that have not been rehabilitated, rather than creating new impact to pristine forest. Pumped hydropower opportunities to rehabilitate old abandoned mine sites are a good example of incorporating rehabilitation of legacy impacts into the project concept.

Sources of information:

- Aerial photos and satellite imagery of the area.
- Media reviews, review of websites of community advocacy organisations, and understanding of local history.
- Knowledge about legacy issues via local sources.

A project concept that has a high opportunity to address legacy issues might be in an area that has:

- Abandoned industrial or mining operations that have not been rehabilitated.
- Legal or illegal dump sites from previous operations.
- Prior land use activities that have resulted in high risk of erosion or landslips.
- Affected communities who are or were already negatively affected by other developments.

A project concept with lower opportunity could be in an area that has:

- No identifiable past environmental or social impacts or issues.

- Limited availability of data, studies, and information on past environmental and social impacts from previous development activities in the area.
- Complex ownership, land tenure, and property rights issues in the project area, including disputes over land ownership, customary land use, and indigenous rights.
- Limited financial resources or budget constraints available to the developer to invest in comprehensive impact assessments, mitigation measures, and restoration efforts effectively.
- Pressures to meet project deadlines, secure financing, and start construction may lead to rushed decision-making processes and limited time to incorporate sufficient assessment, consultation, and planning regarding addressing past impacts.
- Political instability, social unrest, or economic challenges in the project area or country may create barriers to addressing past environmental and social impacts.
- Weak institutional capacity, expertise, and resources within government agencies, regulatory bodies, and local communities.

A project concept could respond to the opportunity with actions that might include:

- Desk-based research and stakeholder mapping to assist with early evaluation of this opportunity and what it may take to deliver on it.
- Proactively assess the legacy of previous developments (failed or successful) to identify lessons learned, and demonstrate that the developer wants to learn from the legacy issues.
- Explore where and whether rehabilitation measures could be feasibly incorporated into the project concept.
- Plan to undertake scoping studies or rapid assessments to evaluate the scope, scale, and severity of past environmental and social impacts in the project area and the possibly relationships with the project concept.

3.8 Biodiversity Enhancements

Whilst development of a hydropower project entails a number of areas of biodiversity impact (see Section 1.8 Biodiversity and Critical Habitats), there may be opportunities to include biodiversity enhancements into the overall project concept. Example strategies include:

- Habitat restoration efforts may involve reforestation, wetland restoration, and the creation of artificial habitats to support diverse species.
- Identifying and protecting critical habitats and species may include implementing buffer zones around sensitive areas, relocating species to suitable habitats, and establishing conservation areas to preserve biodiversity.
- Incorporating green infrastructure elements such as green roofs, permeable pavements, and vegetated swales into project designs can provide habitat for wildlife, improve soil quality, and promote biodiversity.
- Efforts to restore degraded habitats and create new habitats for wildlife may involve reforestation, wetland restoration, creation of spawning habitats, or establishment of wildlife corridors to connect fragmented habitats.
- Including wildlife crossings such as overpasses, underpasses, and culverts can help facilitate the movement of animals across roads and railways, reducing the risk of collisions and enhancing connectivity between habitat patches.
- Integrating infrastructure planning with land use planning can help identify areas of high ecological value and prioritise their conservation. This can involve zoning regulations, land-use planning tools, and conservation easements to protect important habitats.

Creating new protected areas or increasing the level of protection for existing areas can be seen as a relatively feasible enhancement for biodiversity conservation and ecosystem preservation. However, there may be more to consider than initially foreseen, for example:

- Conducting thorough assessments to identify areas with high biodiversity value, unique ecosystems, or significant ecological importance is essential to identify priority areas. Priority areas may include habitats for endangered species, critical ecosystems like wetlands, and areas with high levels of species diversity.
- Establishing legal protections and institutional frameworks is necessary to ensure the effective management and long-term conservation of protected areas. This may involve enacting legislation, establishing protected area management agencies or authorities, and securing funding for conservation activities.
- Involving local communities, Indigenous Peoples, and other stakeholders in the decision-making process is crucial for the success of protected areas. Building partnerships, promoting co-management arrangements, and incorporating traditional ecological knowledge can enhance local support and ensure the sustainable use of natural resources.
- Developing comprehensive management plans that outline conservation objectives, zoning regulations, monitoring protocols, and enforcement mechanisms is essential for protected area management. Plans should ideally be adaptive and science-based.
- Securing sustainable funding sources for protected area management is essential for long-term conservation success. This may include government budgets, philanthropic support, tourism revenue, payments for ecosystem services, and innovative financing mechanisms such as conservation trusts or public-private partnerships.
- Implementing robust monitoring programs to track changes in biodiversity, ecosystem health, and human activities within protected areas is critical for adaptive management. Enforcement of regulations and anti-poaching measures are essential to combat illegal activities and ensure compliance with protected area rules.
- Considering the impacts of climate change on protected areas and implementing adaptation measures is increasingly important. This may involve habitat restoration, species translocation, and adjusting management strategies to mitigate the effects of climate change on biodiversity.

Effective planning, collaboration, and adaptive management are essential for achieving these goals. Any biodiversity enhancement needs to be very well researched and managed so that quantifiable enhancements in biodiversity parameters (e.g. species diversity, population sizes, genetic variability, overall ecosystem vigor) can later be demonstrated.

Sources of information:

- Review of web-based information from government departments responsible for environment, conservation, or natural resources related to biodiversity conservation and protected areas.
- Review of NGO, university and conservation group web-based information related to biodiversity conservation and protected areas.
- Google Earth analysis of areas that appear to be of relatively higher biodiversity value and of existing protected areas to help pose questions and hypotheses.
- Web-based publications, reports, guidelines and resources related to biodiversity enhancement efforts globally, such as:
    - Convention on Biological Diversity[52] (CBD).
    - Global Environment Facility[53] (GEF).
    - World Conservation Monitoring Centre[54] (WCMC).

[52] https://www.cbd.int/
[53] https://www.thegef.org/
[54] https://www.unep-wcmc.org/en

- The Nature Conservancy[55] (TNC).

A project concept that has a high opportunity might have:

- A strong commitment from the developer.
- Potential partnership organisations and institutes.
- A likely or apparent high degree of local interest.
- Areas with diverse habitats that support a wide range of species, or one or more areas that support high value species.
- Locations that serve as ecological corridors, facilitating the movement of species between fragmented habitats.
- Sites with degraded or disturbed habitats.
- Supportive policy and regulatory frameworks that prioritise biodiversity conservation

A project concept with lower opportunity could have:

- Uncertain developer commitment and capacities.
- A lack of local interest or capacities.
- A project area with few remaining natural habitats or with degraded ecosystems.
- A project area with limited habitat diversity (e.g.monoculture plantations, homogeneous land cover).
- A project area that lacks populations of endangered or threatened species or does not contain key habitats of conservation significance.
- A project area with isolated or fragmented landscapes with little habitat connectivity.
- Weak environmental regulations or limited enforcement capacity.
- Limited space or constrained budgets associated with the project concept.

A project concept could respond to the opportunity with actions that might include:

- Review of early stage information collected for Section 1.8 Biodiversity and Critical Habitats to assist with early evaluation of this opportunity and what it may take to deliver on it.
- Explore where and whether biodiversity enhancement measures could be feasibly incorporated into or in the area of the project concept.
- Identify developer capacity needs and potential parterships to support planning and implementation if the opportunity has merit and the project is likely to progress.

55 https://www.nature.org/en-us/

What Next?

Well done for getting through and applying HYDROSELECT !

A number of further actions arising from this assessment should be undertaken in the early stage. As appropriate, more detailed analyses should be followed up through Preparation Stage studies including the Environmental and Social Impact Assessment (ESIA). Guidance on planning for the ESIA can be found in the IHA How-to Guide for Hydropower Environmental and Social Assessment and Management[21].

Project concepts that do not raise Very High or Extreme risk ratrings for any PFFs, and incorporate many features that support lower additional sustainability risks and potential for sustainability opportunities, are going to be the most appealing to financial investors.

Many of the PFFs and risk areas highlighted in this HYDROSELECT guide are fundamentally tied to financial risks. Sustainability risk mitigation requirements may cause greater costs and time than assumed. However, access to finance may not be feasible unless sustainability credentials of a project concept can be well-demonstrated and verified.

From the questions in this tool, you should have formed a view on areas of sustainability risks and challenges applicable to a project concept, or project concept options, under consideration. You should have a summary of your PFF ratings, and information and actions to follow-up regarding PFFs and sustainability risks and opportunities. This information will considerably strengthen the planning and preparation for any hydropower project.

The HSS Preparation Stage tool is recommended for use once a project has been publicly announced, and feasibility studies and assessments are underway

Best wishes for your hydropower sustainability journey!!