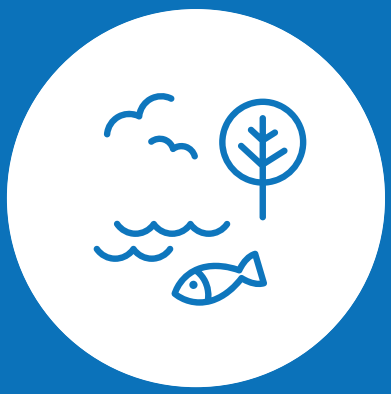

# Biodiversity and Invasive Species

***This guideline expands on what is expected by the criteria statements in the Hydropower Sustainability Tools (HST) for the Biodiversity and Invasive Species topic, relating to assessment, management, conformance/compliance and outcomes. The good practice criteria are expressed for different life cycle stages.***

***In the Hydropower Sustainability Assessment Protocol (HSAP), this topic is addressed in P-19 for the preparation stage, I-15 for the implementation stage and O-15 for the operation stage. In the Hydropower Sustainability ESG Gap Analysis Tool (HESG), this topic is addressed in Section 6.***

This guideline addresses the implications of hydropower projects and operating facilities on biodiversity, ecosystems and habitats, including specific values or issues frequently associated with project development and operations such as threatened species, fish passage, and invasive species. The intent is that there are healthy, functional and viable aquatic and terrestrial ecosystems in the project affected area that are sustainable over the long-term; that biodiversity impacts arising from project activities and from the operating hydropower facility are managed responsibly; and that commitments to implement biodiversity and invasive species measures are fulfilled.

**Biodiversity** is the variety of life forms (animals, plants and micro-organisms), their genes, and the ecosystems of which they are a part. Biodiversity is critical to functioning and maintenance of the natural environment and has recognised aesthetic, spiritual, cultural, recreational and scientific values.

An **ecosystem** is a community of living organisms in conjunction with the non-living components of their environment (e.g. air, water, soil) interacting as a system. These biotic (living) and abiotic (non-living) components are linked together through nutrient cycles and energy flows. Significantly different ecosystems are found in wet versus dry and hot versus cold areas or regions. A **habitat** is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. The term typically refers to the zone in which an organism lives and where it can find food, shelter, protection, and mates and appropriate conditions for reproduction. Examples of various riverine habitats include riparian zones (i.e. the shoreline), deep pools, riffles, large woody debris, sand bars, gravel bars, backwaters, wetlands, and floodplains.

Aspects of biodiversity that require attention include the following.

- Endemic species, which are unique to a defined geographic location.
- Keystone species, which provide a key ecological role such that their loss would lead to severe degradation of the entire ecosystem.
- Species of conservation significance, which may be rare, threatened or endangered species or ecological communities. These species may be listed in national legislation or regulations, as well as addressed by international organisations and conventions (e.g. the so called Red Lists of the International Union for the Conservation of Nature (IUCN), the Ramsar wetlands convention and the Convention on Biological Diversity). In some cases, the project studies highlight species at risk that may not yet have formal protection status.
- Biodiversity hotspots, which are areas of very high diversity and/or where many endangered species are found.
- Ecosystem connectivity and biodiversity corridors, which are important for species reliant on a certain size area of habitat for their long-term survival or reliant on functional migration routes.
- Alien species, which are species that have been accidentally or purposely introduced into an area outside of their natural range, some of which may be invasive, i.e. spreading to such an extent that they are a threat to local native species or ecosystem function.
- Culturally significant species, which are those that have symbolic or practical significance for communities that will be affected by project-related changes.

While avoidance of impact is the first approach of the mitigation hierarchy (avoid, minimise, mitigate, compensate), complete preservation of the original biodiversity conditions is not a realistic expectation for any hydropower development. Changes in biodiversity are likely due to the physical changes in habitat and ecosystems that accompany a hydropower development, for instance flowing water (a lentic ecosystem) changing to still water (a lotic ecosystem) by creation of an impoundment. For this reason, compensation is included as good practice for the biodiversity topic, with an emphasis on offsets.

**Offsets** are measurable conservation outcomes resulting from actions designed to compensate for significant adverse residual biodiversity impacts from project development. Residual impacts are those that persist after avoidance, minimisation, and restoration measures have been taken. Generally, offset measures are not within the project site but within a comparable landscape or habitat type. Biodiversity offsets should be designed to: achieve measurable, additional and long-term conservation outcomes through compensatory actions; achieve 'no net loss' of biodiversity at a minimum; and ideally demonstrate 'like-for-like or better' outcomes compared with the unimpacted project site.

## Assessment

*Assessment criterion - Preparation Stage: An assessment of terrestrial biodiversity; aquatic biodiversity including passage of aquatic species and loss of connectivity to significant habitat; and risks of invasive species has been undertaken with no significant gaps.*

The project Environmental and Social Impact Assessment (ESIA) should include evaluation of the biodiversity impacts of a hydropower project. A systematic approach needs to be taken to identify and evaluate biodiversity values and potential impacts and risks associated with the project.

The preparation stage assessment starts with establishment of the pre-project baseline, involving inventories of the terrestrial (land-based) and aquatic (water-based) flora and fauna, ecological communities and habitat types. Terrestrial fauna need to include mammals, birds, reptiles, amphibians, and invertebrates (i.e. without backbones), and terrestrial flora need to include trees, shrubs, herbs, vines, grasses, and epiphytes (these depend on host plants, such as orchids and mosses). Aquatic fauna need to include fish, amphibians, macroinvertebrates including crustaceans (e.g. shrimp, crabs), and zooplankton. Aquatic flora need to include riparian vegetation, aquatic macrophytes (plants that grow in or near water) and algae (including phytoplankton). As far as practical, inventories should aim to establish the species diversity (i.e. the variety and abundance of species that inhabit a region or area) and abundance (the number

of representatives of an individual species in a region or habitat type) within the project area; they should also map vegetation and habitat types.

The geographic scope of the assessment should include: the river system upstream and downstream of the project (downstream as far as the project-induced influence is discernible, see the Downstream Flow Regimes topic guideline); the future reservoir area; off-site activities such as quarries, waste disposal areas, transmission line corridors and switchyards; areas utilised for various mitigation measures such as revegetation, fish hatcheries and visitor centres; as well as activities related to off-site impacts within the supply chain.

The baseline should establish important ecosystem, habitat and life cycle aspects of the biodiversity present in the area, with particular attention paid to those that may experience changes due to the hydropower development or operation. The assessment should note important interdependencies between aquatic and terrestrial biodiversity; the protection and management status of legally-protected project affected areas and any accompanying management objectives and plans; as well as ecosystem services utilised by humans (e.g. food supply, recreation, cultural significance, tourism relevance, commercial or industrial importance).

The biodiversity assessment should describe all aspects of the ecosystems that will change and the consequences for biodiversity. This includes the effects of changes in flows, water levels, water quality, food supply, habitats, vegetation cover and exploitation patterns. Project activities and locations of physical changes should be clearly identified and linked to potential impacts. In all cases where potential impacts are identified, the likelihood, significance and severity of biodiversity impacts need to be assessed.

The assessment of potential biodiversity-related risks during construction should include the effects caused by: direct habitat loss; altered flow regimes; disturbance due to noise, water quality impacts (e.g. polluted discharges into the river system); vibration or dust from excavation, drilling, blasting, or heavy machinery; construction-related sediment loads to the river; loss of habitat connectivity due to removal of linking habitat areas or creation of barriers; roadkill due to new roads and more frequent vehicle movements; introduction of invasive flora or fauna species; flora or fauna predation and/or exploitation by workers; increased tree cutting by workers and locals for fuelwood; and the actions of primary suppliers.

The assessment of potential biodiversity-related risks during operation should include the effects caused by: permanent loss of habitat area and species through conversion of land to reservoir; impacts due to poor water quality from physico-chemically altered water, with many possible sources; impacts due to rapid flow and water level fluctuations; high sediment loads to the river through land-use changes; low sediment loads to the river through trapping in the reservoir; impacts to terrestrial species due to aquatic ecosystem changes; terrestrial species loss due to drowning during reservoir filling; wildlife losses due to unsuitable relocation areas; spread of invasive flora or fauna species; reductions in diversity or abundance of particular species due to shifts in ecosystem balance or dynamics from changes in influencing factors; impacts to riparian habitats through riverbank erosion; loss of connectivity in the river system; risk of fish passage facilities mixing fish communities where fish migration was previously naturally interrupted (due to natural barriers such as waterfalls); fish mortality caused by fish passing or pausing through or at the dam and other project facilities; and over-exploitation of species due to increased fishing pressures at new focal points.

Biodiversity-related opportunities should be identified where possible. These may include: employing or working with local communities to act as wardens for protected areas, monitors of wildlife and protected area regulations, collectors of monitoring data, and in delivery of wildlife mitigation measures; research and development; strategic partnerships; addressing and mitigating pre-existing negative impacts to biodiversity and ecosystems (e.g. invasive species management); education and awareness; creation of new protected areas or an increase in the level of protection and/or resources for existing areas; improved catchment protection; creation of expanded or rehabilitated habitat areas; use of innovative technologies such as fish-friendly turbines; and expanded fish habitats in reservoirs providing opportunities for aquaculture and recreational fisheries.

The biodiversity assessments should be undertaken using appropriate expertise and local knowledge. Experts for biodiversity assessment studies may include aquatic ecologists, terrestrial ecologists, zoologists, botanists and other environmental science professionals. They should closely liaise with other experts conducting parallel studies, such as in hydrology, water quality, geomorphology and sociology.

## Assessment

*Assessment criterion - Implementation Stage: Biodiversity issues relevant to project implementation and operation have been identified through an assessment process utilising appropriate expertise; and monitoring is being undertaken during the project implementation stage appropriate to the identified issues.*

*Assessment criterion - Operation Stage: Ongoing or emerging biodiversity issues have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

Biodiversity-related issues determination during the implementation and operation stages should be based on changes to baseline biodiversity that may be or are incurred and the implications of these changes for other social, environmental and/or economic objectives.

Biodiversity monitoring objectives need to be clearly expressed, linked to risks and impacts, and defined separately for the construction and operation stages. The basis for the locations, timing, parameters and methodologies adopted should be clearly explained. Sampling locations and techniques used for the baseline data gathering during the ESIA work should be continued as far as practical. Parameters used for biodiversity monitoring may be some or all of the following:

- Aquatic habitats: river width, depth, gradient, current velocity, water quality, substrata characteristics, instream and riparian vegetation extent and condition;
- Terrestrial habitats: extent, condition and community composition; often done with aerial photo or satellite imagery analysis with ground-truthing;
- Fisheries: Catch Per Unit Effort (CPUE) in terms of numbers and biomass by species (which in turn can be used to generate various indicators); number of full-time, part-time and occasional fishers; fishing timing and time spent; type of gear;
- Fish status, migration patterns and behaviours: Size or age, health, diet, reproduction, condition, species-specific information on migration patterns (as far as possible this should include distances travelled, timing, start/end/resting places for migration);
- Benthic fauna: macroinvertebrates monitored for community composition, status, distribution (habitat types) and abundance.
- Aquaculture and reservoir fisheries (when applicable): species, production quantity and value, inputs and costs, profitability;
- Terrestrial plant species: status, distribution, abundance, etc., normally based on transects or sample plots;
- Terrestrial animal species: status, distribution, and densities through direct observation based on transects, trapping, camera trapping, tagging, bat detectors, netting (for birds, bats, dragonflies, butterflies), searching for signs (e.g. dung, feeding signs, footprints, burrows and dens), noise monitoring and aural recognition (for birds), active searching and trapping for herpetofauna (reptiles and amphibians).

## Management

*Management criterion - Preparation Stage: Plans and processes to address identified biodiversity issues have been developed for project implementation and operation with no significant gaps.*

The biodiversity section of the project Environmental and Social Management Plan (ESMP) should contain, at a minimum, the following outlined separately for construction and operation:

- all identified potential risks and impacts for biodiversity;
- mitigation measures for all risks and impacts listed, with objectives and measures of success;
- monitoring schedules clearly linked to the risks and mitigation objectives;
- reporting schedules and formats;

- budgets and responsible parties, including any handover arrangements to different agencies or stakeholders over time;
- audit, review and evaluation provisions.

Ideally, adaptive management measures for unpredicted biodiversity impacts will also be included. These would focus on issues that might be identified through the monitoring and surveillance and what the response would be (including responsible parties and contingency budget set aside).

There is considerable knowledge and experience globally of the mitigation measures that can be employed to avoid, minimise, mitigate and compensate biodiversity-related impacts from hydropower developments.

## Terrestrial mitigation

Measures to address **terrestrial** biodiversity risks and impacts could include some of the following:

- Measures to mitigate direct terrestrial habitat loss: siting and design should minimise loss of terrestrial habitat to that which is justified by the project's technical requirements, prioritising locations for infrastructure that are already modified or degraded; significant floral species retrieved, relocated and replanted where feasible prior to impact; seedbanks, nurseries and/or gardens created; and as a last resort significant residual impacts can be compensated through biodiversity offsets.
- Measures to mitigate disturbance due to noise, vibration or dust from excavation, drilling, blasting or heavy machinery: terrestrial biota studies to identify sensitive areas (e.g. near nests) or times of year (e.g. during migratory, breeding or hatching/birthing) and appropriate controls to restrict impacts of blasting, drilling or heavy machinery.
- Measures to mitigate loss of habitat connectivity due to removal of linking habitat area or creation of barriers by new infrastructure (buildings, roads): terrestrial biota studies to identify species ranges, critical habitat and corridors, and migratory routes; avoidance of important habitats; creation of new habitat corridors.
- Measures to mitigate increased roadkill due to new roads and more vehicle movements: education and awareness-raising; use of warning signs to avoid roadkill; speed controls, especially at active times for animals (e.g. dawn, dusk); alert devices on vehicles to deter animals from approaching the road; fines for road kills.
- Measures to mitigate the introduction or spread of invasive flora or fauna species: education and awareness-raising; regulations prohibiting introductions without a permit; extra care to avoid invasive species being brought in with construction equipment (such as in soil, ballast, containers or plant materials) through wash-downs, sprays, or inspections; routine surveys; treatments to contain invasive species spread (e.g. weed management, traps, culling); management measures for species at risk of decline due to invasive species; eradication campaigns.
- Measures to mitigate flora or fauna predation and/or exploitation by workers: labour colonies located away from forest or wildlife areas; education and awareness-raising; regulations which prohibit hunting, fishing, animal collections or sale, flora or timber harvesting; fines issued for violations.
- Measures to mitigate increased tree cutting by workers and locals for fuelwood: education and awareness-raising; distribution of alternative cooking solutions (e.g. kerosene oil stoves, pressure cookers, solar cookers) and fuel sources (e.g. construction of LPG depots).
- Measures to mitigate impacts to biodiversity caused by the actions of primary suppliers: suppliers to provide environmentally-certified products; suppliers to demonstrate that they avoid degradation of natural or critical habitats.
- Measures to mitigate impacts to terrestrial species due to aquatic ecosystem changes: terrestrial biota studies to identify important life cycle needs relating to aquatic ecosystems; mitigation measures for flows, water quality, erosion and sediments and biodiversity designed to ensure terrestrial biota needs are met.
- Measures to mitigate terrestrial species loss due to inundation during reservoir filling: Fauna: wildlife rescue and relocation programmes; compensation of losses through offsets; Flora: collection and transplanting of important flora species in the inundation area; nurseries to propagate flora species lost in the inundation area; compensation of losses through offsets.
- Measures to mitigate wildlife losses due to unsuitable relocation areas: wildlife relocation programmes carefully planned to ensure wildlife are moved to areas that they are able to successfully occupy (i.e. dependencies such as elevation range, food supply, and nesting sites are considered as well as competition and crowding factors); species are not relocated to an area just outside the reservoir rim, which is often unsuccessful due to prior occupation by existing wildlife ( i.e. competition for territory).

- Measures to mitigate reductions in diversity or abundance of particular species due to shifts in terrestrial ecosystem balance or dynamics from changes in influencing factors: follow-up monitoring and studies identify trends and root causes of species reductions and enable the design of appropriate adaptive management measures; increased controls or levels of protection are implemented for affected species or habitats; increased food sources or artificial shelters are provided for affected species.
- Measures to mitigate over-exploitation of species due to increased hunting or collecting pressures at new focal points: risk mapping which identifies likely focal points of illegal logging or poaching; education and awareness-raising, particularly at new focal points; regulations which prohibit hunting, fishing, animal collections or sale, flora or timber harvesting; increased surveillance; fines for violations.

## Aquatic mitigation

Measures to address **aquatic** biodiversity risks and impacts could include some of the following:

- Measures to mitigate impacts due to altered flows, including hydropeaking: project siting upstream of a significant tributary; minimum downstream flow releases; seasonally or monthly adjusted downstream flow releases; flow ramp-up and ramp-down rules for power station releases; a re-regulation weir (see the Downstream Flow Regimes topic guideline for further details).
- Measures to mitigate high sediment loads to the river through land-use changes and follow-on activities: catchment management protection; erosion treatment; stricter policies on land degradation and rehabilitation; sediment check dams.
- Measures to mitigate impacts due to loss of species-preferred habitats through conversion to reservoir area: protection of unregulated river systems as offsets; compensation measures for species affected, such as catching below the dam or in other rivers, or breeding in hatcheries, and then releasing upstream of the reservoir.
- Measures to mitigate impacts to riparian habitats through riverbank erosion, which may be caused by hydropeaking and aggressive river effects: well-considered environmental flow releases to minimise riparian erosion risks; bank protection with natural approaches such as placement of large woody debris; strategic planting of riparian flora species; habitat rehabilitation strategies; operating rules for power station releases.
- Measures to mitigate loss of connectivity in the river system due to the dam blocking fish migration and plankton drift: fish passage facilities (where applicable); fish hatcheries; catch-and-release programmes; protection of unregulated river systems as offsets.
- Measures to mitigate fish mortality due to downstream passage through turbines and spillways: fish-friendly turbines; fish bypasses; fish screens; fish-friendly spillway designs; turbine positioning to minimise barotrauma, i.e. injuries to fish caused by increased water pressure when passing through the turbines; operating rules for power station releases.
- Measures to mitigate loss of downstream floodplain habitat and/or off-stream waterbody connectivity: environmental flow approaches relating to floods and inundation of off-river waterbodies; creation of connecting channels from the river to the floodplain.
- Measures to mitigate introduction of invasive flora or fauna species: strict controls regarding species introductions; careful research ahead of any aquaculture proposals; physical removal; or containment; education and awareness-raising; restrictions on location of facilities in flood-prone locations.
- Measures to mitigate over-exploitation of significant aquatic species due to cumulative impacts of the project (e.g. creation of popular fishing areas where fish concentrate): fishing regulations and effectively implemented enforcement actions.

## Management

*Management criterion - Implementation Stage: Processes are in place to ensure management of identified biodiversity issues, and to meet commitments, relevant to the project implementation stage; and plans are in place for the operation stage for ongoing biodiversity issues management.*

*Management criterion - Operation Stage: Measures are in place to manage identified biodiversity issues.*

During the implementation and operation stages, the biodiversity-related plans developed based on the ESIA assessment work are put into action. For projects that did not have such thorough biodiversity assessment work as outlined in this

guideline, biodiversity management plans can still be developed based on assessment work focussed on identifying issues and risks.

The important management requirements at the implementation and operation stages are to ensure that processes are in place that will enable biodiversity issues to be identified and responded to. Such processes may include: clear statements of business commitment to biodiversity within an environmental or sustainability policy; dedicated staff with biodiversity-related qualifications and role requirements, and/or partnerships with more biodiversity-focussed organisations; allocation of budget and resources to enable monitoring and issues identification and response; regular assessment (e.g. annual) of known and emerging risks, issues and management responses, and decision-making processes to ensure that issues arising have actions assigned (e.g. through a corporate environment committee).

## Conformance/Compliance

*Conformance/Compliance criterion - Implementation and Operation Stages: Processes and objectives in place to manage biodiversity issues have been and are on track to be met with no significant non-compliances or non-conformances, and biodiversity related commitments have been or are on track to be met.*

Good practice requires evidence that biodiversity measures are compliant with the relevant legal or administrative requirements, which may be expressed in licence or permit conditions or captured in relevant legislation. Compliance requirements may relate to, for example, standards to be met, the frequency and type of monitoring to be performed, and reporting to be submitted. Conformance refers to delivering what is in the plans. Commitments may be expressed in policy requirements of the developer or owner/operator or in company statements made publicly or within management plans. Evidence of adherence to commitments could be provided through, for example, internal monitoring and reports, government inspections, or independent review. Variations to commitments should be well-justified and approved by relevant authorities, with appropriate stakeholder liaison.

The significance of not meeting a commitment is based on the magnitude and consequence of that omission and will be context-specific. For example, a failure to demonstrate delivery of a fish passage facility commitment is a significant non-conformance, whereas a slight delay in delivery of a monitoring report could be a non-significant non-conformance.

## Outcomes

*Outcomes criterion - Preparation Stage: Plans avoid, minimise, mitigate, and compensate negative biodiversity impacts arising from project activities with no significant gaps.*

*Outcomes criterion - Implementation Stage: Negative biodiversity impacts arising from project activities are avoided, minimised, mitigated, and compensated with no significant gaps.*

*Outcomes criterion - Operation Stage: Negative biodiversity impacts arising from activities of the operating facility are avoided, minimised, mitigated, and compensated with no significant gaps.*

To show that plans avoid, minimise, mitigate and compensate negative biodiversity impacts from project activities, it should be possible to directly link mitigation measures in the plans to all identified biodiversity values, issues and risks. The assessment and planning should be informed by appropriate expertise. The assignment of responsibilities and resource allocation for implementation, monitoring and evaluation should be appropriate to the planned actions.

An evidence-based approach should demonstrate that negative biodiversity impacts arising from project implementation and operation activities are avoided, minimised, mitigated and compensated with no significant gaps. The developer and owner/operator should demonstrate that responsibilities and budgets have been allocated to implement biodiversity plans and commitments. Monitoring reports and data in the implementation and operation stages should clearly track performance against commitments and objectives, and capture biodiversity impacts. It should be possible to

provide examples to show how identified risks from the assessment were avoided or minimised. It should also be possible to table evidence to show that mitigation plans have been implemented and the outcomes are being monitored. Implementation of measures for biodiversity, such as the creation of protected areas, new habitats, tree planting, fish hatcheries, fish passage facilities, nurseries, and minimum flow releases, should be evident, and monitoring should show how these measures are achieving their stated objectives.