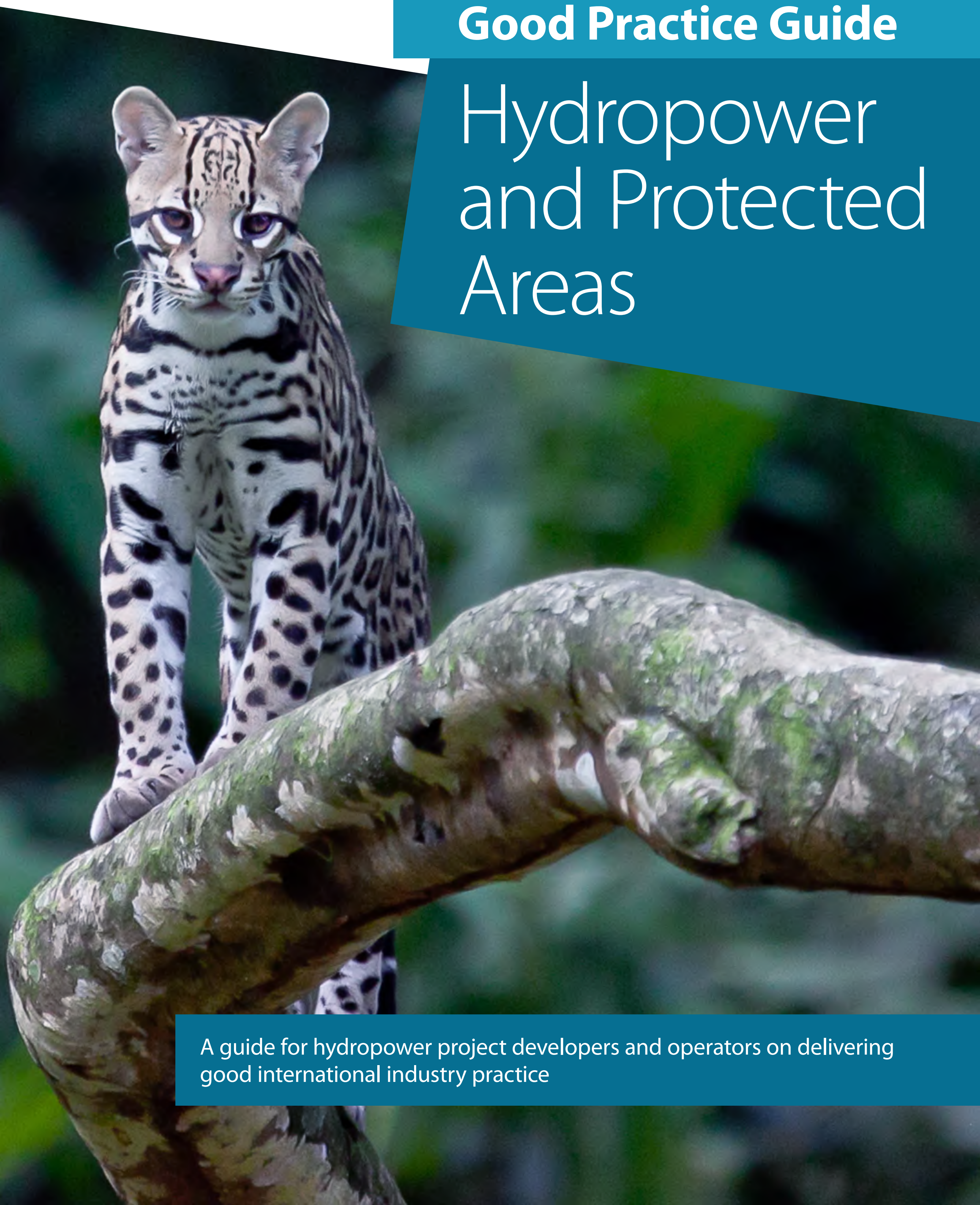
international hydropower association

Good Practice Guide

Hydropower and Protected Areas



A guide for hydropower project developers and operators on delivering good international industry practice

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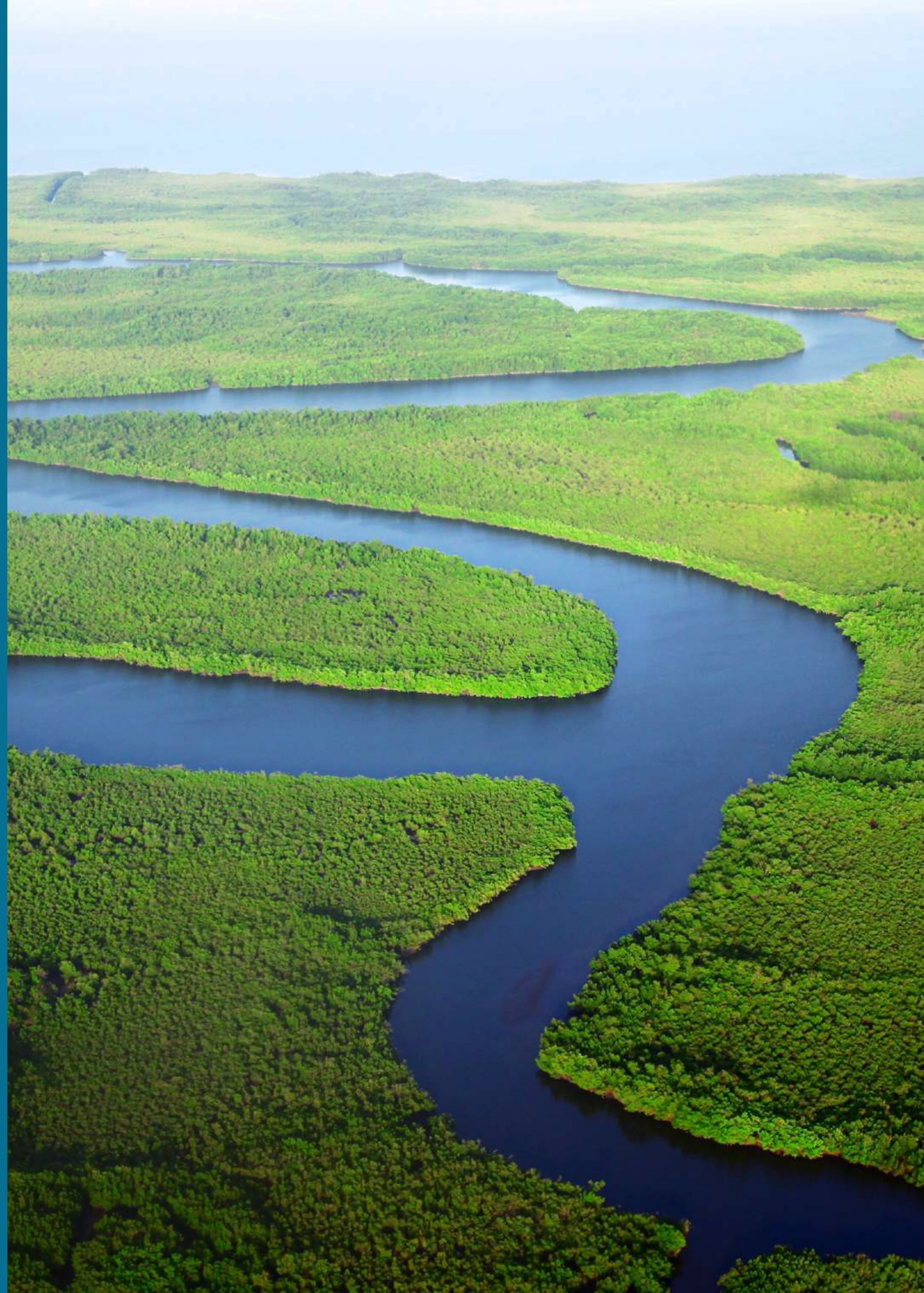
Cover Photo Caption: The ocelot is an animal of the cat family, commonly distributed in Costa Rica.
Photo Credit: Instituto Costarricense de Electricidad



Foreword from the Chair of Working Group on Protected Areas (WGPA)

Today marks an important milestone for the hydropower sector. The International Hydropower Association, through direct consultation with key global environmental organisations, has set out a new and forward-looking set of commitments on World Heritage Sites and protected areas to address the impacts of the hydropower sector on protected areas and help preserve the value of our most important ecosystems.

The 2019 World Hydropower Congress marked a defining moment between the International Hydropower Association (IHA) and key organisations involved in conservation and protected areas, including the World Wide Fund for Nature (WWF), the International Union for Conservation of Nature (IUCN), the Nature Conservancy (TNC) and the UNESCO World Heritage Centre (UNESCO-WHC), engaged in discussions on the relationship between hydropower development and protected areas. Building on this momentum, the multistakeholder Working Group on Protected Areas (WGPA) was formed to bring tangible results and recommendations to the next World Hydropower Congress scheduled for 2021.

Protected areas are one of the most important tools to halt the global loss of biodiversity. They help provide basic goods and ecosystem services, such as the provision of and access to food, fibre, shelter and security, and in many cases clean water. They are recognised as crucial tools to protect biodiversity, including the most endangered species on our planet. World Heritage sites present the most iconic examples of the global protected area system. Hydropower projects can offer clean energy, various water services, and regulate water flow. They have the potential to promote the sustainable development of the communities they serve, yet these projects inevitably alter the existing conditions of the river basins they operate in and can affect protected areas, as well as the values they seek to protect.

The challenge for the working group was to better understand the impacts of hydropower on protected areas, as well as their relationship and dynamics, and use that knowledge to discuss appropriate due diligence processes, promote good practice and transparency, and ensure environmental protection and social equity. This good practice guide is the outcome of this work and ambition. The discussions in the working group further inspired IHA to propose a set of new and forward-looking commitments on protected areas, which will be presented at the 2021 World Hydropower Congress.

The WGPA operated with transparency, goodwill and aimed at consensus. All WGPA members heard and respected the diversity of views on many topics. Ultimately, the guide and commitments reflect discussions and debates rather than unanimous support for the final text. Despite some disagreement it goes further in terms of commitments to protected areas and World Heritage Sites than I have seen from any other industry sector.

I would like personally to thank the members of the WGPA and the IHA staff for their continued enthusiasm, commitment and support over the last two years. Thanks to the dedication and constructive input of these individuals, we are able to mark a historic moment for the hydropower sector and welcome an ambitious leap forward to bridge the gaps between hydropower development and ecosystems preservation.

We look forward to continuing the dialogue between the hydropower sector and the conservation community in finding the balance between effective biodiversity conservation and the transition to clean energy required to tackle climate change.

Warmest regards

Guy Debonnet
Chair of the WGPA

Acknowledgements

This publication contributes to increasing knowledge and understanding of the practical measures that can be undertaken to meet good international industry practice with regard to hydropower development and protected areas.

This guide was authored by Joerg Hartmann, independent consultant, and Accredited Lead Assessor for the Hydropower Sustainability Tools, and Kendra Ryan, independent consultant.

This guide was prepared with the help and input of many organisations and experts. In particular, our sincere thanks go to members and observers of the Working Group on Protected Areas (WGPA) and the staff of the International Hydropower Association for their helpful comments, additions and suggestions.

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Acronyms

CBD	Convention on Biological Diversity
EDF	Électricité de France
ESIA	Environmental and social impact assessment
FONAFIFO	Fondo Nacional de Financiamiento Forestal
FPIC	Free Prior and Informed Consent
GBIF	Global Biodiversity Information Facility
HPP	Hydropower project
HST	Hydropower Sustainability Tools
IBA	BirdLife's Important Bird and Biodiversity Area
IBAT	Integrated Biodiversity Assessment Tool
ICE	Instituto Costarricense de Electricidad
IHA	International Hydropower Association
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MAB	Man and the Biosphere
OUV	Outstanding Universal Value
PA	Protected Areas
PADDD	Protected Areas downgrading, downsizing and de-gazettement
PES	Payments for Environmental Services
SINAC	Costa Rica's National System of Conservation Areas
TNC	The Nature Conservancy
UNESCO	United Nations Educational, Scientific and Cultural Organization
VEC	Valued Environmental Components
WGPA	Working Group on Protected Areas
WWF	World Wide Fund for Nature

Contents

Mountain gorilla in Virunga National Park in Democratic Republic of Congo.

Executive Summary

Two equally important policy imperatives of our times are to resolve the twin crises of the Earth's biodiversity and its climate. Key solutions to these crises are protected areas, the 'backbones' of biodiversity conservation, and renewable energy. Hydropower is still the largest source of renewable energy and will be a key enabler of variable energy sources. Both protected areas (PAs) and hydropower projects (HPPs) are legitimate and important users of our land- and waterscapes. Both are growing, bringing them increasingly into competition for the same spaces, and sometimes into (highly visible) conflicts.

This guide is the outcome of a recognition by both the conservation community and the hydropower sector, that they each have an interest in minimising conflicts and ensuring compatibility. Indeed, in some situations HPPs and PAs can be mutually supportive: PAs can protect the watersheds on which hydropower depends, while hydropower can support PAs, and in some cases, create new habitats worthy of protection.

Following an introduction, Chapter 2 of this guide starts with a review of the different categories of PAs, with their different management objectives and legal protections. PAs can only fulfil their objectives if they are representative, connected and well managed. Some areas are not yet legally protected, but have high conservation values and should be protected from development; this applies to many freshwater ecosystems. Isolated areas and fragmented rivers are unlikely to maintain their conservation values, which reminds us that impacts from outside the legal boundaries of PAs may be just as important as those from within them. The objectives and status of some PAs may allow energy development, while for others, such projects would be incompatible.

There are many different types of interactions between PAs and HPPs, over time and across the landscape. Some PAs were created first and were then affected by planned HPPs, while in other cases the HPPs were built first and a PA created afterwards. Project components such as dams, transmission lines and roads may be inside or outside the PA. Quantitative data on these interactions are scarce, but there is a consensus that their number is increasing.

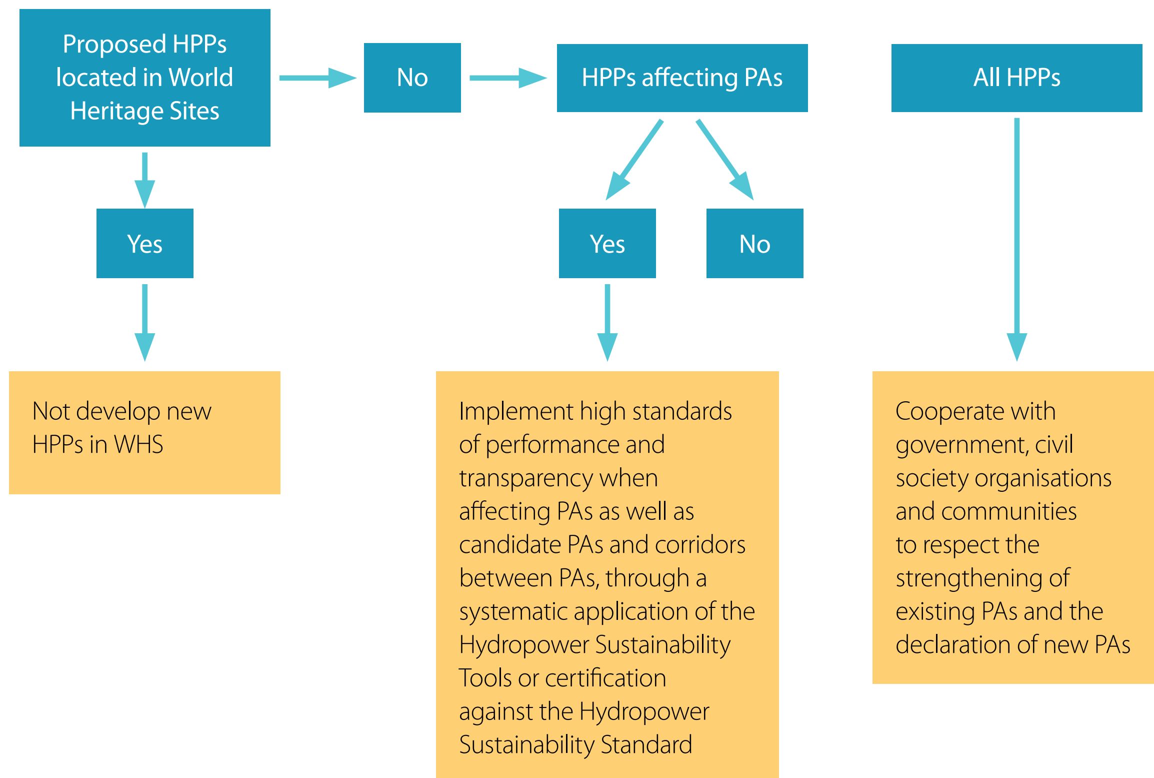
Chapter 3 reviews typical impacts of HPPs on PAs. Negative impacts are related to temporary construction impacts, as well as permanent loss of areas and of terrestrial and aquatic connectivity, increased human access to formerly remote areas, and downstream impacts resulting from the operations of HPPs. There can also be positive impacts, such as support for existing and new PAs, and in some cases the quality of PAs can be improved by removing obsolete HPPs.

Chapter 4 provides a country case study for Costa Rica, the host of the 2021 World Hydropower Congress. All countries with a potential for hydropower have developed their own approach to managing the interactions between PAs and HPPs. Some countries such as Costa Rica have gone so far as to disallow any renewable energy projects inside PAs, showing that high levels of renewable energy can coexist with high levels of protection. Even in these cases, however, there are remaining interactions that need to be managed, such as the impacts of HPP operations on downstream PAs.

Regardless of the national regulatory framework, there is an increasing consensus on good practices for managing the interactions, which are reviewed in Chapter 5. The mitigation hierarchy calls for a timely consideration of potential impacts, at an early stage in project selection and preparation, in order to avoid impacts on high-value areas, while minimising, mitigating and compensating for impacts in the case of medium-value areas. The Hydropower Sustainability Tools (HST), in combination with this guide, provide practical approaches for developers and regulators to apply the mitigation hierarchy throughout the life cycle of an HPP. They also provide practical approaches to identify opportunities for positive impacts. This guide does not duplicate content provided in the series of How-to Guides issued by IHA (particularly those so far published on environmental impact assessments, biodiversity, downstream flows and sediments), but applies them specifically to the interactions between HPPs and PAs.

The concluding Chapter 6 discusses a way forward for the conservation community and the hydropower sector, based on a new pledge of mutual recognition, awareness and support between the two sectors. De-conflicting the two sectors and identifying win-win situations is in everybody's interest. The working group between conservation and industry representatives that developed this guide also formulated recommendations for commitments by the hydropower sector, to be adopted by business associations such as IHA, as well as individual companies.

Figure 1. Recommended commitments for the hydropower sector



1 Introduction

Introduction

Throughout history, humans have modified an ever-increasing share of the Earth's surface. Natural ecosystems are being replaced by agricultural lands, settlements and infrastructure, and resources are being extracted from most remaining natural areas. More recently, humans have started changing even the basic determinants of life on Earth, such as the chemistry of the atmosphere and oceans, rainfall, temperature, sea levels and river flows. Cumulatively, these direct and indirect impacts on ecosystems are leading to massive losses across many different values, including habitats of other species, protection from floods or droughts, recreation opportunities, and a sense of place.

As a response to these losses, from the late 19th century, countries started setting areas aside to protect them from development and to preserve some of these values. This approach rapidly spread, and currently there are some 248,000 terrestrial or continental protected areas (PAs). Collectively they protect over 20 million km^2, or 16% of the land surface. PAs are the most important conservation tool, sometimes called the 'backbone of nature conservation', and countries are still expanding their networks of PAs.

Over the same period, energy demand grew exponentially, and tens of thousands of hydropower projects (HPPs) were built globally. These include more than 10,000 large dams, as well as many smaller ones and run-of-river projects, with a total capacity of more than 1,300 GW. Hydropower is generally a low-cost and flexible technology, and plays an important role in spreading access to reliable energy. It is also generally considered a low-carbon technology, and has thus helped to slow climate change and associated indirect impacts on ecosystems. While development has slowed down in recent years, some global scenarios for future low-carbon energy systems predict a significant expansion of hydropower.

However, many HPPs have significant impacts on ecosystems, including in some PAs, for example by inundating valuable lands and stretches of rivers. Dams were planned and sometimes built in PAs from the very beginning, including in such iconic PAs as Yosemite and the Grand Canyon in the United States. In some countries such as Australia, protests against dams in PAs contributed to the origins of their environmental movements.

Conflicts between the objectives of protecting ecosystems and generating more hydropower have increased as the number of PAs and HPPs have grown. Most PAs were established in areas that were assumed to be not used by humans – for example, because they were remote, mountainous and/or wet – or lightly populated, sometimes by Indigenous People or nomadic tribes. As power grids expanded, these same areas became attractive hydropower sites. As Rehbein et al. (2020) described, nature conservation and renewable energy are typically planned separately, and *"by intending to avoid conflicts with local communities and other agricultural or natural resource operations, both objectives may unknowingly target the same sites."*

This conflict can be particularly serious in the case of rivers. While freshwater ecosystems constitute a small part of PAs, they often have the greatest species diversity per unit area, a larger portion of threatened species and unsustainable uses, and both aquatic and terrestrial species depend on. *"Rather than a marginal part of management, freshwater* *conservation is central to sustaining protected areas and their biodiversity"* (Pittock et al. 2015).

With an ever-increasing human footprint and demand for land and water resources, it is now imperative to make more rational and systematic choices. The use of our land- and waterscapes should no longer depend on whether conservation planners or hydropower planners get there first. If properly planned, HPPs and PAs can coexist and be compatible with each other, and in some cases even support each other, rather than being in conflict. Resolving this issue can be of great importance for the future of hydropower, as well as the future of conservation.

One way in which PAs and HPPs can learn from each other is, perhaps surprisingly, in terms of public acceptance. Plans for new PAs and HPPs both require land and water resources to be set aside and dedicated to a particular use. Both may interfere with previous uses, and in some cases even require the resettlement of people. Both the hydropower sector and PA agencies have learned that broad public acceptance requires the sharing of benefits with local people. Both have experienced public backlashes when trying to impose HPPs or PAs against the will of local stakeholders. De-conflicting PAs and HPPs is not just an exercise in spatial planning, but also requires understanding and moderating stakeholder interests.

Objective and scope of this guide

The Hydropower Sustainability Tools do not contain a separate topic on PAs. This can be considered as a cross-cutting issue, relevant to many individual topics such as siting and design, hydrological resources, biodiversity, cultural heritage, Indigenous Peoples, or downstream flows. This guide is therefore not directly based on the tools, but it uses the same approach of establishing a systematic framework for sustainable management, based on the assessment of issues, their management through the mitigation hierarchy, stakeholder engagement, and compliance.

Ultimately, the performance of HPPs is measured by outcomes. With regard to their interactions with PAs, the outcome should be a successful coexistence where the HPPs do not undermine the conservation objectives of any PAs, and contribute to PA performance. In terms of outcomes for PAs, their primary objective is to protect the values they were created for, while not imposing unnecessary restrictions on other stakeholders, including HPP operators. Ideally, they will additionally deliver ecosystem services, such as flow regulation, which HPPs benefit from.

The objective of this guide is to provide HPP and PA planners, managers and stakeholders with the tools to understand and manage interactions to achieve coexistence and compatibility. The guide also provides a set of recommendations for the hydropower sector.

By extension, many of the issues in this guide also apply to other renewable energy technologies, such as solar, wind or geothermal power, as well as to non-hydropower dams, or other infrastructure works and industrial developments that may affect PAs. Although the focus is on natural PAs, many issues would also apply to sites, monuments and landscapes protected for their cultural heritage value.

Structure of this guide

Chapter 2 establishes the context with an overview of PAs, HPPs and their interactions. While PAs and HPPs are very site-specific, and their interactions can be very diverse, Chapter 3 describes typical impact categories. Chapter 4 then provides an example of how these interactions play out in one country, Costa Rica, in the context of public policies and spatial planning, and the lessons to be learnt from that experience. Chapter 5 describes a systematic framework for planners, developers and operators, to follow good practices throughout the project cycle and apply practical steps for each of the identified impacts, structured according to the mitigation hierarchy. Chapter 6 provides conclusions and recommendations for the way forward.

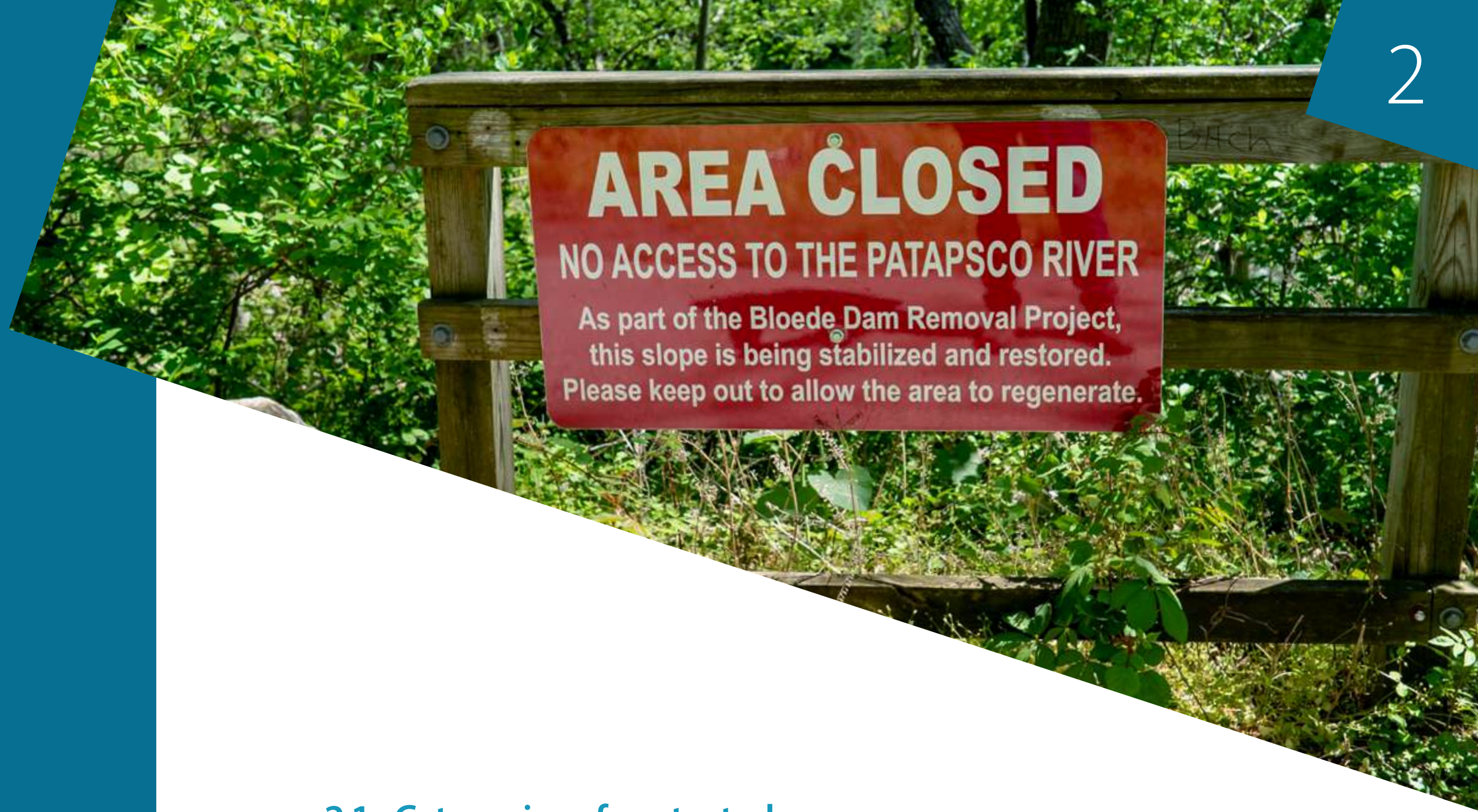
Glines Canyon Dam removal on Elwha river, 2014. *Photo Credit: J Daracuna*

2 Background: protected areas, hydropower projects and their interactions

Sandillal hydropower project in Costa Rica.
Photo Credit: Instituto Costarricense de Electricidad

Background: protected areas, hydropower projects and their interactions

There are many thousands of protected areas and of hydropower projects, with great diversity. A structured framework for these types of PAs and HPPs and a sense of scale, are essential for understanding their interactions.



2.1 Categories of protected areas

2.1.1 IUCN categories

According to the International Union for Conservation of Nature (IUCN), an umbrella organisation of governments and civil society groups created in 1948, 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."* Different geographical spaces contain very different combinations of values, leading to very different conservation objectives and management approaches.

At one end of the spectrum, a geographical space may contain a uniquely high value (e.g. the only remaining habitat of a species). The objective is then to protect that habitat, with no activities allowed that would threaten that objective. For example, only about 60 Javan rhinoceros (*Rhinoceros sondaicus*) are left, all within one national park. At the other end of the spectrum, a geographical space may be a cultural landscape that was created by modifying an original ecosystem. In a broader sense, almost all of the Earth's surface, except for wilderness areas, could be considered a cultural landscape, while in a stricter sense, only the best examples of such landscapes are specifically protected and managed. The objective of maintaining that landscape may require continuing activities such as controlled burning or grazing, even if this reduces its value for certain species and ecosystem services.

Among ecosystem services delivered by PAs, those of most direct relevance for hydropower are the hydrological and erosion control services that PAs in upstream catchments provide. PAs may be designated for a different primary objective, such as habitat protection, but deliver a range of secondary objectives such as hydrological services.

By far the most widely applied system to classify PAs is the IUCN's PA categories. IUCN encourages national PA agencies to use these categories as organising principles for their national PA systems. Most governments use definitions of PAs that are aligned with the IUCN categories, due to two advantages:

- They provide a clear link between conservation values, objectives, and management approaches.
- They provide a standardised approach across countries, so that governments and other stakeholders can cooperate and address objectives that are not contained within national boundaries.

Table 1. IUCN Protected Area categories

Category	Definition	Primary Objective
Ia: Strict Nature Reserve	Protected areas that are strictly set aside to protect biodiversity and also possibly geological/ geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.	To conserve regionally, nationally or globally outstanding ecosystems, species (occurrences or aggregations) and/or geodiversity features: these attributes will have been formed mostly or entirely by non-human forces and will be degraded or destroyed when subjected to all but very light human impact.
Ib: Wilderness Area	Protected areas that are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, and which are protected and managed so as to preserve their natural condition.	To protect the long-term ecological integrity of natural areas that are undisturbed by significant human activity, free of modern infrastructure and where natural forces and processes predominate, so that current and future generations have the opportunity to experience such areas.
II: National Park	Large natural or near-natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area. They also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.	To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation.
III: Natural Monument or Feature	Protected areas set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave, or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.	To protect specific outstanding natural features and their associated biodiversity and habitats.
IV: Habitat/ Species Management Area	Protected areas aiming to protect particular species or habitats, and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.	To maintain, conserve and restore species and habitats.
V: Protected Landscape/ Seascape	A protected area where the interaction of people and nature over time has produced an area of distinct character, with significant ecological, biological, cultural and scenic value. Safeguarding the integrity of this interaction is vital for protecting and sustaining the area, and its associated nature conservation and other values.	To protect and sustain important landscapes/seascapes and the associated nature conservation and other values created by interactions with humans through traditional management practices.
VI: Protected area with sustainable use of natural resources	Protected areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management, and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.	To protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial.

The categories do not imply that one PA is inherently better than another. One category may provide more protection for high biodiversity values, while another category focuses on high recreational values. The categories are complementary, each playing a distinct role in a broader PA network or system. Table 1 shows an overview of the different categories.[1]

To provide an order of magnitude for the number and size of PAs in the strictest categories, there are approximately 16,615 category 1 PAs with a total area of 6.8 million km^2, and approximately 5,915 category II PAs with a total area of 6.2 million km^2.[2]

It should be noted that industrial and infrastructure development is not explicitly included or excluded in most of the above definitions. Most PAs contain some dedicated infrastructure such as roads for visitors and buildings for staff, and many PAs include significant human settlements and natural resource uses such as farming, grazing, hunting or recreation. The key criterion is whether and at what scale human activities would remain compatible with the PA objectives. As described in a recent guide on solar and wind developments, in most cases these are likely to be incompatible, *"as the likelihood of their impacts on the objectives of the protected area would be very high"* (Bennun et al. 2021).

While several sources have aimed to define 'strict' PAs (often categories I–IV, as in Table 2), there is no universal agreement over a threshold for 'strictness', and an automatic exclusion of industrial and infrastructure development from some IUCN categories. The 2016 IUCN World Conservation Congress called on governments *"to prohibit environmentally damaging industrial activities and infrastructure development in all IUCN categories of protected area"*.

2.1.2 Categories based on international agreements

While protection of parts of their territories is primarily a concern for national governments, it is also embedded in international agreements. Almost all governments are members of international organisations and parties to international treaties and conventions related to protected areas. The most notable are listed here:

- The 1992 Convention on Biological Diversity (CBD) is the primary intergovernmental treaty on biodiversity. The 2011–2020 Strategic Plan included 20 targets, also known as the Aichi targets, one of which was that *"by 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes."* This was only

1 Further guidance on other objectives, distinguishing features, role in the landscape/seascape, etc., of each category can be found at https://www.iucn.org/theme/protected-areas/about/protected-area-categories.

2 The authors' calculations based on the World Database on Protected Areas. The numbers are approximate because they include marine PAs, and because not all countries assign IUCN categories to their PAs.

partially achieved. A draft strategy for 2021-2030 includes a target of 30% of the planet being under some form of protection (known as '30x30').

- The United Nations Educational, Scientific and Cultural Organization (UNESCO) acts as the secretariat for the 1972 World Heritage Convention. Under this convention, to date, 1,121 World Heritage Sites (classified as either cultural, natural, or mixed) with "*outstanding universal value*" (OUV) have been nominated by governments and accepted by the World Heritage Committee. The primary responsibility remains with the nominating state, while the international community commits to providing support for protection. The 252 natural and mixed heritage sites cover approximately 7% of the surface area of all terrestrial PAs, or 1% of the Earth's land surface area. These sites are intended to represent the 'crown jewels' of the world's PA system, although this is not based on a systematic worldwide assessment but rather on the choices of individual governments. While the majority of World Heritage Sites are cultural heritage sites, such as individual monuments, cultural landscapes and ancient cities, these are not the focus of this guide.
- UNESCO also operates the intergovernmental Man and the Biosphere (MAB) programme (1972), under which more than 700 biosphere reserves are testing innovative approaches to sustainable development, with protected core and/or buffer zones.
- Under the 1971 Convention on Wetlands, or Ramsar Convention, governments have designated over 2,400 wetlands of international importance, covering more than 2.5 million km^2. Wetlands is a broad category that encompasses marine, coastal, inland and man-made wetlands. It also includes river reaches, although most Ramsar Sites cover inland and coastal lakes, lagoons and marshes.
- The IUCN, as mentioned above, is primarily a knowledge-management organisation. Among its functions, it hosts the secretariat of the Ramsar Convention and provides advisory services to the UNESCO World Heritage Committee. The technical work by IUCN and its networks of experts includes evaluations of new nominations for World Heritage sites, monitoring the status of existing sites, and addressing threats to sites.

Both the World Heritage and the Ramsar Conventions include processes to support host governments when designated PAs are at risk, due to encroachment, infrastructure or other causes, and to delete or withdraw PAs from the lists when they no longer meet the criteria. For example, the Operational Guidelines for the Implementation of the World Heritage Convention state that "*the World Heritage Committee invites the States Parties to the Convention to inform the Committee, through the Secretariat, of their intention to undertake or to authorize in an area protected under the Convention major restorations or new constructions which may affect the Outstanding Universal Value of the property. Notice should be given as soon as possible (for instance, before drafting basic documents for specific projects) and before making any decisions that would be difficult to reverse, so that the Committee may assist in seeking appropriate solutions to ensure that the Outstanding Universal Value of the property is fully preserved.*"

It is rare for sites to lose their status, given that countries nominate them partly out of national pride and are reluctant to lose the reputation associated with the international recognition. Sites at risk are listed under the Montreux Record for the Ramsar Convention, or as World Heritage in Danger. Two examples of World Heritage Sites that are listed as in danger are the Selous Game Reserve in Tanzania, among other reasons because of the construction of the Julius Nyerere HPP inside the reserve; and Lake Turkana in Kenya, partly because of the Gibe III HPP upstream in Ethiopia. Thus far, no World Heritage Site has lost its status over a hydropower project. Where there are disagreements over the threat to a site (for example, between a host government that wants to develop an infrastructure project, and an IUCN monitoring mission), the World Heritage Committee must take a position.

Other international agreements on PAs include regional efforts such as the European Union's Natura 2000 network of PAs, and bilateral or transboundary PAs, such as the 'Peace Parks' in southern Africa.

2.1.3 Other high conservation value areas

Lands and rivers located outside PAs may be just as valuable, in terms of biodiversity and other characteristics, as those areas that are already protected. A number of efforts have been made at national, regional or global scales to map and list areas of high conservation values, whether already protected or not. The most comprehensive of these efforts are the more than 16,000 Key Biodiversity Areas (KBAs), identified by a consortium of conservation organisations. Their total surface area is more than 20 million km^2, similar to the total area of protected terrestrial areas. However, only 19% of these KBAs are fully and 42% partially covered by PAs, indicating that the global PA network has significant gaps regarding biodiversity protection, and that it contains many areas dedicated to other objectives.

Other approaches have identified biodiversity hotpots, endangered ecosystems (the IUCN Red List of Ecosystems), Alliance for Zero Extinction sites, BirdLife's Important Bird and Biodiversity Areas (IBAs), remaining wilderness areas, as well as mapping exercises at different scales for specific issues, such as distribution maps for endangered species on the IUCN Red List of Threatened Species, or for high conservation value rivers at the scale of a basin or country. Many of these are accessible through portals such as the Integrated Biodiversity Assessment Tool (IBAT), Protected Planet database, and the Global Biodiversity Information Facility (GBIF).

The CBD targets include "Other Effective Area-Based Conservation Measures", which are areas that are not formally protected but *"governed and managed in ways that achieve positive and sustained long-term outcomes for the* in situ *conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socioeconomic, and other locally relevant values."* Examples of such areas may be watersheds, indigenous lands or military bases, where other uses are restricted. There are also a number of other regulations and non-formal protection mechanisms that protect some rivers from development.

2.1.4 Protected area system design

Individual PAs are highly site-specific in their values and objectives, but they are also components of larger PA systems or networks. There are national and international targets for such systems, which are often a combination of quantitative and qualitative criteria. For example, a national PA target may include protecting 20% of the country's land area, while representing all species and ecosystems, and ensuring that PAs are connected with each other, rather than isolated. Connectivity is important for migratory species, as well as those that require large territories, genetic exchange between small populations, and adaptation to climate change through range shifts. It can be achieved through biodiversity corridors (e.g. along a river) or through 'stepping-stones' (e.g. along a flyway for migratory birds). By undertaking a gap analysis of the species or ecosystems that are not currently well represented, priorities for PA system expansion can be identified. Specialised conservation planning software is available to achieve PA system objectives at the lowest cost, i.e. by imposing the least amount of restrictions on other land uses.

Of particular relevance for this guide is the conservation of freshwater ecosystems. While these cover only a few per cent of the Earth's surface, they contain about 10% of all species and one-third of all vertebrates species, and provide a disproportionate amount of ecosystem services. A number of analyses show that many freshwater ecosystems are underrepresented in PA systems (e.g. rivers in Asia and large rivers in general), and that freshwater populations are declining faster than terrestrial and marine populations (Opperman et al. 2021; WWF 2020). Even rivers within terrestrial PAs are often not effectively protected, for example because of a lack of expertise and management focus, or because of upstream and downstream impacts. Some countries have specific PA categories, or other protection mechanisms focused on rivers, such as the United States' Wild and Scenic Rivers system, in which federal hydropower licensing and other activities are prohibited (Perry et al. 2021).

PA system design also depends on practical issues, such as budgets available for effective management. Some PAs are so remote or of so little economic interest that they practically protect themselves. Others are highly attractive for farming, hunting, visitation or other uses, and need resources for formulating and enforcing management plans. When countries have limited resources, system managers face hard choices about resource allocation, and some PAs may be ineffective (sometimes called 'paper parks'), suffering from encroachment and loss of values.

PAs are designated for the long term. However, as their context changes over time, the PA system may no longer fit with evolving conditions and objectives. For example, new conservation needs may arise as the population of a species declines. Opportunities for conservation may emerge as people move from rural to urban areas, activities such as mining or logging cease in an area, or public opinion moves in favour of conservation, and more resources are made available. Higher government priorities such as the discovery of mineral resources may lead to the downgrading, downsizing and de-gazettement (PADDD) of some PAs. Because of climate change, the distribution range of target species may shift to higher latitudes or elevations. Adaptive management, through periodic reviews and continuous adjustments of PA systems, is therefore advisable.

As described above, efforts are underway globally and nationally to expand and adjust PA systems. Infrastructure planners should therefore be aware not just of existing PAs, but also potential future or candidate PAs. If these are ignored during the planning process, problems may arise during permitting or during operations, potentially leading to operating constraints or even demands for their removal.

2.2 Categories of hydropower projects

Hydropower is a highly site-specific and non-standardised technology, with project sizes ranging from 'pico' plants (under 5 or 10 kW) to the largest power plants on Earth (over 20 GW). They include run-of-river plants with little or no active water storage, peaking run-of-river plants, plants with substantial storage, and pumped-storage plants, which can be located on- or off-stream. Spatial requirements of a hydropower plant include the following components:

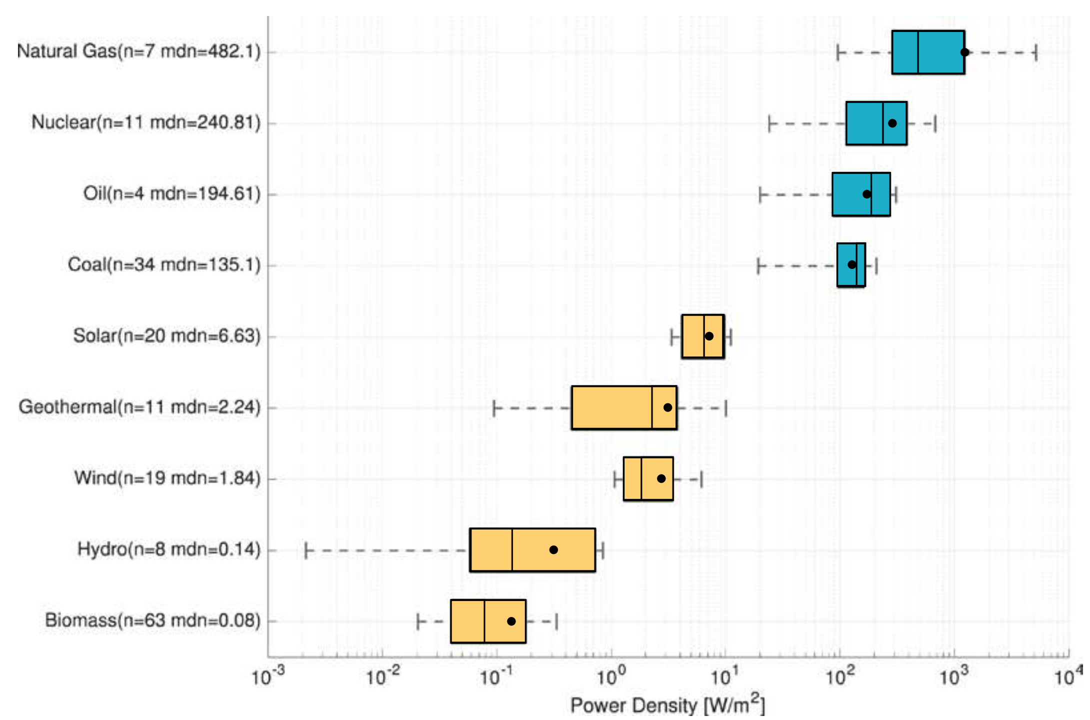
- Reservoir – Ranging from very small headponds above low-head diversion weirs, to multiple-purpose reservoirs, to large natural lakes whose level is controlled by hydropower dams at their outlets.
- Permanent infrastructure – Includes all aboveground installations such as dams, the powerhouse and other buildings, waterways such as penstocks and canals, roads, switchyards and transmission lines, and resettlement areas.
- Temporary infrastructure – Includes cofferdams, quarries, construction camps, and other installations, some of which can be located within the future reservoir, while others can be rehabilitated.

Additional spatial requirements include areas influenced by the construction and operation of an HPP (e.g. along the downstream river) and areas affected by the supply chain (e.g. for production of cement and aggregates). From this wide range of components, it is easy to see how estimates for spatial requirements can use quite different scopes and assumptions.

This applies even more to comparisons across different power generation technologies. As an example, Figure 2 (van Zalk and Behrens 2018) shows estimates from 177 studies in the United States, for the power density of nine different power generation technologies, including median and mean values, the typical range, and outliers. This meta-analysis attempted to make estimates comparable in a number of ways, for example by correcting for capacity factors. Note that the underlying studies did not include off-site impacts (such as the downstream impacts of hydropower). Even when allowing for the remaining methodological uncertainties and different types of power services provided by different technologies, spatial requirements for hydropower are relatively high. Power densities for small-scale hydropower projects on local tributaries are the lowest for any generation technology, meaning that these projects can be quite inefficient in terms of their spatial requirements.

The wide range of power density estimates for hydropower emphasises the need to select sites that allow the use of spatially efficient designs. This reduces the need for acquisition of private land, and the direct footprint on public land, whether inside or outside PAs.

Figure 2. Spatial requirements for a range of power generation technologies in the US



2.3 Types of interactions

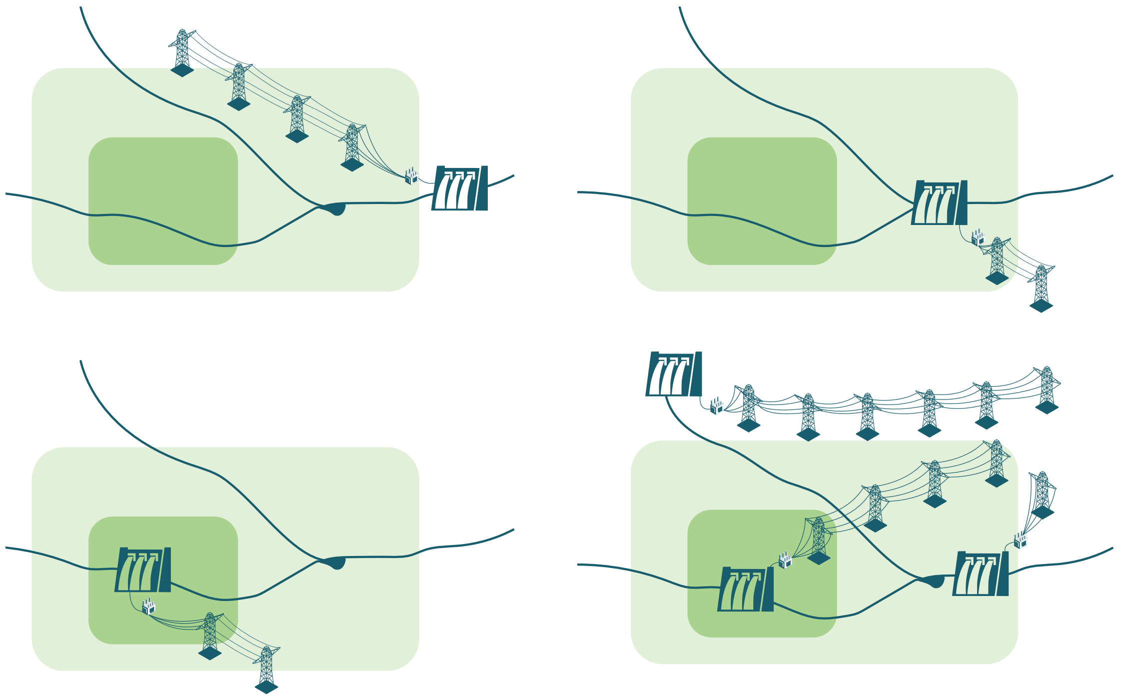
2.3.1 Temporal perspective

As described in the introduction, PA and HPP systems have grown over time. When they occur in the same landscape, several scenarios can result:

- A PA is established first, and an HPP is permitted and built afterwards. In some cases this leads to a PADDD, while in other cases they coexist. The conservation value of the PA may be affected by the footprint of the project, a reduction in connectivity, or changes in the downstream river. There may also be some positive effects on the PA, for example through increased financial resources for its management.
- An HPP is built first, and a PA is established afterwards. In some cases, the PA is created around the HPP immediately upon construction, to protect the watershed and compensate for negative impacts. In other cases, declaration of the PA may come much later, when the conservation value of that area is better understood. It is possible that eventually the HPP is removed because it is seen as incompatible with the PA's objectives, or that it is maintained because it actually supports the PA's objectives.

While revisions of the status of a PA (e.g. a PADDD event) or the removal of an HPP may be warranted as circumstances change, they also have major disadvantages. Removal of an HPP can be costly, results in a loss of generation capacity that must be replaced by other projects, and entails its own environmental considerations and planning needs, such as the management of accumulated sediment. A PADDD event reduces the confidence

Figure 3. Some possible configurations of HPPs, with respect to the core (dark green) and buffer (light green) zones of a PA



in a country's commitment to conservation and can threaten the integrity of the PA system.

2.3.2 Spatial perspective

From a spatial perspective, there are many variations on what was described above as the two systems "occurring in the same landscape":

- A complete or partial overlap between the PA and the HPP.
- An overlap limited to some of the HPP components (such as the reservoir or the transmission line).
- An overlap within the core or the buffer zone of a PA.
- The HPP could be upstream, downstream or next to a PA, at various distances.

Distance is an important determinant of how substantial an impact is. Some impacts are only noticeable at a short distance – for example, construction noise may only be audible within a few kilometres, and a dam in a mountain landscape may only be visible within a small viewshed. Other impacts may reach long distances: for instance, a large HPP can change flows, temperature, sediment and migratory fish populations in a river for hundreds of kilometres.

2.3.3 Direct and indirect impacts

Internationally, there is little consistency in the designation of 'direct' and 'indirect' impacts, and 'impact' or 'affected areas' are often defined quite arbitrarily. For example, direct impacts may be defined as those that occur within the direct footprint of a project, plus a 0.5 km buffer zone. Such definitions are often used in regulatory frameworks and the scope of preparatory studies, such as environmental and social impact assessments (ESIAs), as well as concessions and permits.

The Hydropower Sustainability Tools use a definition of direct impacts that is based on how relevant, substantial or significant the impacts are. 'Directly affected stakeholders' are those with substantial rights, risks and responsibilities in relation to an issue. The spatial overlap with, or distance from, an HPP is only one indicator or determinant of direct impacts. It is quite probable that stakeholders and values outside the direct footprint of an HPP (including downstream impacts) will experience substantial impacts. Indirect impacts would then be those that are insignificant or insubstantial.

Another perspective on direct and indirect impacts is whether these are initial, primary or first-order effects, or induced, secondary or second-order effects. Impact assessments are typically focused on first-order effects. For example, if people need to be resettled from an HPP footprint, the focus is on their losses and the compensation arrangements over the short term. But the subsequent effects of their resettlement may be just as relevant. Will people move to a designated resettlement area? Will the new livelihoods arrangements in their resettlement area be sufficient, or will they turn to illegal hunting and logging? If their livelihoods improve, what will they spend their incomes on? What supply chain effects does this have?

Impact predictions are difficult because both biophysical and socio-economic aspects around the HPP will continue to evolve dynamically over time. What will fishing families do if their traditional fishing grounds are affected – will they adapt by taking up fishing in the reservoir, focus on farming instead, or move to the city? How will populations of animals adapt to the modified landscape? How will power markets, hydrology, and the live storage volume of the reservoir evolve over time? How will this change the operations of the HPP? Some of these issues can be predicted through modelling, but such modelling is rarely included in impact assessments.

Because of these complexities regarding direct and indirect impacts, this guide will try to avoid such terminology and instead rely on the concept of significant or substantial impacts. All substantial impacts on PAs that are reasonably predictable should be considered, whether they are positive or negative, close to the HPP or far away, and occurring from the beginning or at a later stage.

This is consistent with the 1992 CBD, which states that "*… where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat.*" It is a reasonable assumption that there are high biodiversity and other values in a PA, and that these could be threatened by an HPP. The precautionary principle calls for a higher standard of proof than when non-protected areas are affected, commensurate with the higher values at stake, to demonstrate that there will be no significant residual impacts after mitigation. For example, an EIA would have to be extremely thorough to be accepted as justification for an HPP in a PA which is the last known habitat of an endangered species. The burden of proof should be on the developer, who is likely to have more information on the planned siting, design and operations of the HPP, and more resources available to conduct relevant studies than other stakeholders, including potentially the PA administration. And because absolute proof of no harm is impossible, and some impacts – as well as the effectiveness of mitigation measures – are difficult to predict, arrangements must be made for monitoring and adaptive management.

2.3.4 Single-project and cumulative impacts

HPPs operate in a power grid, consisting of multiple infrastructure components across a landscape. A PA may be surrounded by different grid components, or affected by a group of similar components, such as an upstream cascade of HPPs. PAs are also part of the same landscape, a mosaic of multiple areas with different conservation values and status. Because of this, a one-on-one analysis of impacts (what is the impact of one HPP on one PA) is often insufficient.

Cumulative analysis is most useful during the master planning stage. In practice, neither PA systems nor power grids are planned from scratch, starting from a blank slate. Master planning, both for PA systems and for power grids, has to focus on expanding and adjusting realities that already exist on the ground. Even the consideration of an individual PA or HPP proposal needs to be informed by a landscape perspective.

During the scoping process of an ESIA, it should be determined whether there are substantial cumulative impacts that require more in-depth analysis. The preferred method for cumulative analysis is based on Valued Environmental Components (VECs), which may be affected by multiple power grid components. A simple example of a VEC analysis is the impact on a wilderness PA. The impact assessment could define a minimum distance to the nearest infrastructure (such as 10 km) as the criterion for wilderness, and could then calculate by how much the wilderness area is reduced as a result of different HPP siting and design options.

2.3.5 A quantitative perspective

Historically, discussions of interactions between PAs and HPPs were often based on anecdotal information. Few data were available on how frequent these different types of interactions were. Recent studies have now provided the first quantitative data, although these are still based on partial datasets, different methodologies, and focused on direct overlaps. Thieme et al. (2020) reported that there are:

- 68,781 PAs with rivers flowing through them, many of which could be potential dam sites;
- 984 of these PAs containing one or more large dams, amounting to 1,249 large dams;
- 278 of these dams are primarily used for hydropower;
- 509 additional large hydropower dams proposed within PAs; and
- 51 dam-associated PADDD events, accounting for about 1% of all known PADDD events globally.

Figure 4 indicates some regional concentrations of these overlaps. It is notable, for example, that existing dams overlap with PAs mostly in higher-income regions (e.g. in North America, western Europe and Japan), while most overlaps of proposed HPPs occur in emerging economies (e.g. in Latin America, the Balkans, south and south-east Asia).

By comparing the establishment years of HPPs and PAs (for those dams for which both these dates were available), Thieme et al. (2020) also found that

- 80% of dams were commissioned before the PA was gazetted;
- 2% of PAs were gazetted the same year the dam was commissioned; and
- 18% of dams were commissioned after the PA was gazetted.

In a large majority of cases, the PA was declared when or after a dam was built, but not enough is known to quantitatively break down the motivations for these PAs. Some have been declared to protect the HPP infrastructure, or when the dam was thought to be compatible with (or even positive for) the PA purpose. Some dams thus have enabled PAs. However, other PAs have been created to compensate for known negative impacts of the dam, or when the conservation value of the area was recognised only later. In that case, the dam may actually be detrimental to the conservation objective: for example, by inundating part of a valuable habitat.

The global GRanD and FHReD databases that form the basis of this analysis represent only subsets of existing and potential future HPPs, with some regions better represented than others, and they exclude

Figure 4. Overlap of PAs, existing and proposed dams
Source: https://wwf.panda.org/wwf_news/?364791/Scientists-find-over-500-dams-are-planned-in-Protected-Areas

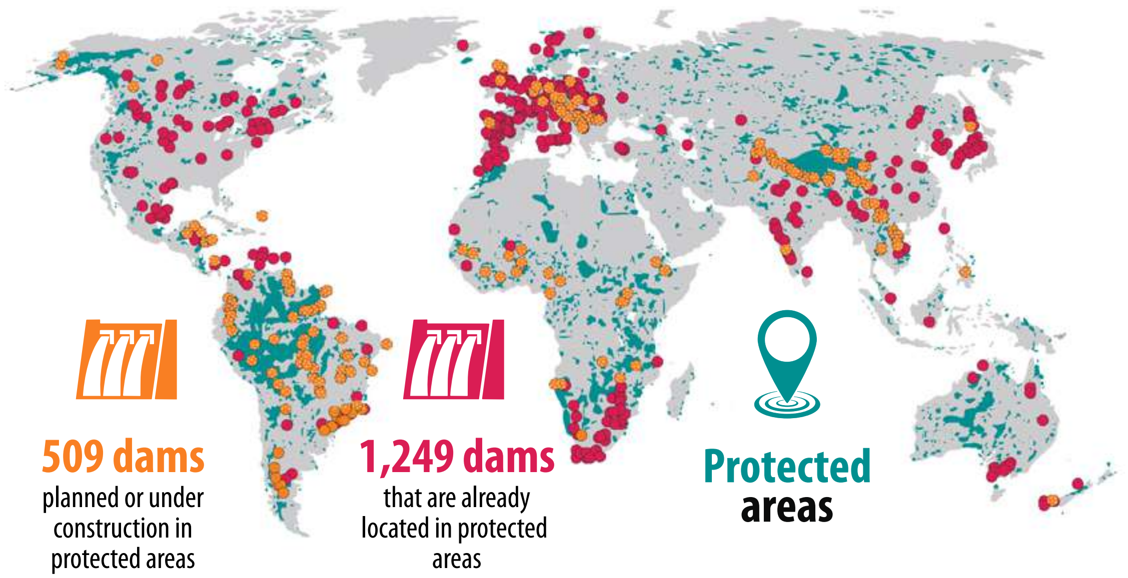


Table 2. Overlap between renewable energy facilities (operational and under development) and PAs (here called assets, and divided into strict – IUCN categories I-IV; non-strict – IUCN categories V-VI)

Important conservation areas	Criteria	Wind		Photovoltatic		Hydropower		All energy technologies		
		Operational	Under development	Operational	Under development	Operational	Under development	Operational	Under development	Combined (Op + U.d.)
Strict PAs	Number of assets affected (%)	43 (0.4)	19 (0.2)	19 (0.2)	24 (0.2)	62 (0.6)	23 (0.2)	122 (1.2)	61 (0.6)	175 (1.8)
	Number of facilities (%)	59 (12)	28 (22)	37 (25)	36 (26)	73 (19)	36 (22)	169 (17)	100 (23)	269 (19)
Non-strict PAs	Number of assets affected (%)	298 (1.6)	110 (0.6)	88 (0.5)	76 (0.4)	279 (1.5)	32 (0.2)	635 (3.4)	205 (1.1)	789 (4.3)
	Number of facilities (%)	418 (88)	102 (78)	109 (75)	103 (74)	322 (82)	127 (78)	849 (83)	332 (77)	1,181 (81)

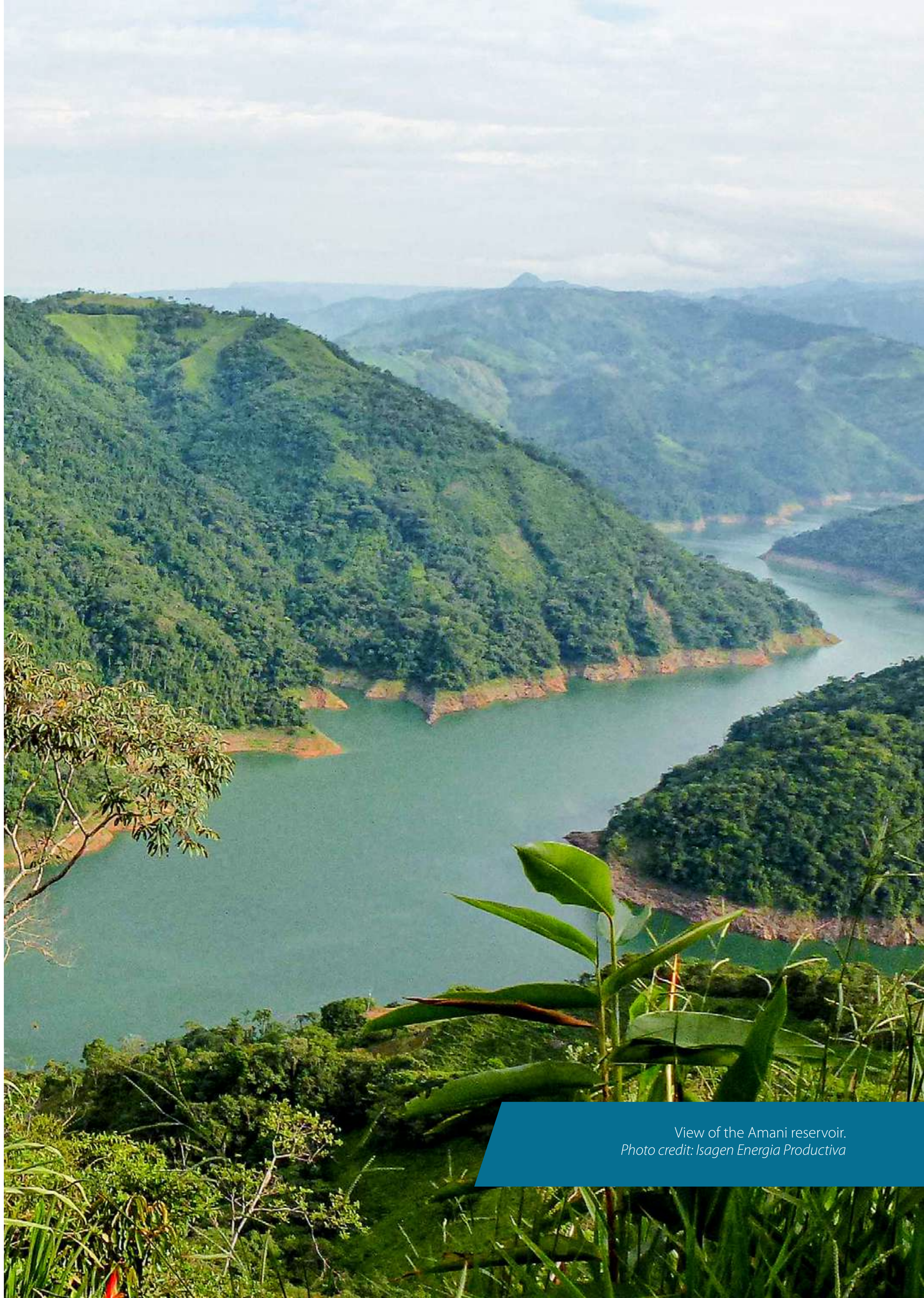
smaller HPPs. Hence, these numbers should be seen as very conservative estimates of overlaps. A finer-scale analysis for Europe was conducted by WWF et al. (2019), which identified a total of 3,936 existing, 77 under construction, and 2,396 proposed HPPs (> 0.1 MW) overlapping with PAs. This study confirmed a high number of proposed HPPs in PAs in the Balkan countries.

Rehbein et al. (2020), using different global datasets for three renewable energy technologies, found the following overlaps, with approximately 400 PAs affected by 560 HPPs (Table 2). Many of the overlaps for future HPPs were identified in Nepal and India.

Partial information exists on other types of interactions. Regarding areas that are not yet or not fully protected, Rehbein et al. (2020) reported overlaps with Key Biodiversity Areas (affected by 387 operational and 155 under-development HPPs) and Wilderness Areas (affected by 26 operational and 8 under-development HPPs). BirdLife International (2017) found that of the globally Important Bird and Biodiversity Areas (IBAs) categorised as 'in danger', 15% are threatened by dams and water management.

According to Ramsar Convention data, 253 of the 2,416 Ramsar Sites are reservoirs that became wetlands of international importance after they were built. Water regulation threatens 960 sites, and 453 sites are threatened by energy production and mining. UNESCO's monitoring of the state of conservation for the 1,121 World Heritage Sites shows that 57 sites are affected by water infrastructure, and 16 sites by renewable energy facilities. It also includes a number of other threat categories that may be related to HPPs, such as transmission lines. IUCN's most recent World Heritage Outlook (IUCN 2020) – a monitoring process that not only reacts to existing threats but also anticipates future ones – also lists dams and water management among the highest threats to natural World Heritage Sites.

In summary, while all these data should be treated with caution, as assessments of threats can be hampered by imprecise categories and limited sources, there are certainly hundreds of HPPs, existing and planned, that may have impacts on PAs. Hydropower is a relevant issue for the world's protected areas, and therefore needs to be managed with great care.



View of the Amani reservoir.
Photo credit: Isagen Energia Productiva

3 Hydropower impacts on protected areas: an overview

Hydropower impacts on protected areas: an overview

Affoldener See and Kellerwald from upper Waldeck reservoir in Germany.
Photo Credit: Joerg Hartmann

Chapter 2 has covered the background for impact analysis, by categorising the types of PAs and HPPs to be considered, and providing a sense of the scale of the issues. Based on this overview, Chapter 3 will now review typical, specific impacts of HPPs on PAs, both negative and positive. Many of these impacts can occur in any landscape, but have particularly important consequences when they affect PAs, and may therefore also be subject to specific regulations. Most examples are from developing countries, where the large majority of new HPPs are being built, and concern larger and more visible projects. However, the same types of impacts are also relevant in smaller HPPs, and in those in developed countries.

3.1 Negative impacts

3.1.1 Temporary construction impacts

Even the preparatory work for HPPs, such as geotechnical explorations, can produce impacts. During implementation, HPPs then require major civil works, resulting in impacts such as noise, dust, lights, traffic, air and water pollution, excavated materials and solid waste, sometimes across large areas and multiple work fronts (Figure 5). Impacts result not just from the main contractors but also from subcontractors, workers, camp followers and other actors (some of whom may be more difficult to supervise than the main contractors).

Construction sites also generate demand for building materials and for food, some of which may be extracted from PAs (see Section 3.1.5). If poorly managed, some impacts can persist beyond the construction stage. For example, insufficient efforts at land rehabilitation can delay the recovery of vegetation or facilitate the spread of invasive species.

3.1.2 Permanent loss of area

Inundation

The area of the reservoir experiences the most obvious changes. Rivers are widened and converted to slow-flowing or lake-like reservoirs, and riparian ecosystems are lost. Some reservoirs can be very large, such as Ghana's Lake Volta that covers 8,500 km^2 or 3.6% of the country. Entire protected areas have been lost, such as the national parks protecting the cataracts of Guairá/ Sete Quedas, by some measures the largest waterfalls in the world, which are now inundated under the Itaipu reservoir in Brazil and Paraguay.

As stated before, HPPs are very site-specific, with different configurations of their components. Figure 6 shows satellite images for one large scheme, with the inundated area (some of it a widened river stretch, some consisting of new waterways), other land-use changes (particularly around the two dams), and downstream affected areas (affected by the diversion of most of the water volume around a bypass reach).[3]

The part of the reservoir between the full supply or flood level, and the minimum operating or drawdown level, is only intermittently inundated. These areas usually do not support healthy riparian vegetation but are covered in rocks and sediment, sometimes resulting in wind-blown erosion.

3 https://landsat.visibleearth.nasa.gov/view.php?id=91083. The area affected by Belo Monte is a complex network of indigenous lands (along the river bend downstream) and agricultural, urban and forested areas. No PAs were directly affected, and it has been argued that the lack of PAs in the area has increased the risk of indirect deforestation (Da Silva Junior et al. 2018).

Figure 5. Construction of Julius Nyerere HPP at Stiegler's Gorge (Tanzania), in the Selous Game Reserve and World Heritage Site
Source: http://www.wildlife-baldus.com/selous_game.html

Other land-use change

In some projects, additional aboveground infrastructure such as dams, roads, camps and quarries can also cover significant areas, or require land-use restrictions. Areas may be cleared of vegetation, for example under transmission lines, or may be fenced off and inaccessible. This can include significant buffer and safety zones around project components. Both the reservoir and other land-use changes can reduce the aesthetic appeal and wilderness character of an area, even from a distance. The Belo Monte project (Figure 6) requires 4,600 km of high-voltage transmission lines through the Brazilian Amazon and Cerrado biomes, with their multiple indigenous areas and PAs.

3.1.3 Loss of terrestrial connectivity

Reservoirs as barriers

For many plants, animals, and also for people residing in or visiting PAs, the reservoir may be an impassable barrier. Some reservoirs are several hundred kilometres long, effectively separating populations and affecting migrations across the landscape. In northern Québec, for example, caribou try to avoid swimming across open water and prefer to cross lakes and reservoirs over ice, or to migrate around them. With climate change reducing ice cover, their migration distances could increase by another 28% over the coming decades (Leblond et al. 2016).

Linear infrastructure as barriers

Linear infrastructure such as roads, transmission lines, headrace and tailrace canals, and penstocks can also be effective barriers for some species, especially if access is restricted by fences. For example, in a planned HPP in southern Africa, a 3 km long and 120 m wide headrace canal with safety fencing on both sides may become an obstacle for the movement of elephants and other species across the landscape, which is surrounded by PAs.

Figure 6. Example for the spatial footprint of a hydropower scheme: Belo Monte, Brazil
Source: https://landsat.visibleearth.nasa.gov/view.php?id=91083

3.1.4 Loss of aquatic connectivity

Upstream migration

Many animal species have to migrate upstream to complete their life cycles, or depend on species that do. In many cases, the upper tributaries of rivers serve as fish spawning grounds. Dams, weirs, and river reaches with changed conditions (e.g. flows, temperature, gas content, turbidity or other characteristics) can impede this upstream migration, leading to reduced aquatic populations within PAs. Fish passages are rarely a fully effective solution. On high dams, they may be completely infeasible, and in most other cases they are selective in terms of the species or numbers of individuals that are able to pass. Even after navigating the dam itself, fish may be unable to pass through a reservoir, with its very different habitat conditions from those to which they are adapted. Similar impacts can occur for other aquatic species such as dolphins or otters, which may be cut off from upstream habitats, as well as for terrestrial species migrating along river corridors.

HPPs are sometimes built in locations with natural migration barriers such as waterfalls and rapids. In these cases, fish passages can be counterproductive, allowing species access to upstream habitats where they are not native.

Downstream migration

Downstream movement is also a necessary part of the life cycle of many aquatic species, and may also be affected by reservoirs and dams. Smaller fish, fish larvae and fry, and other aquatic organisms may not be able to swim through a reservoir under their own power if water velocity is too low. Survival through the dam depends on issues such as species, turbine design and pressure changes, and the ability to locate bypasses.

One example of migration impacts is the Stung Treng Ramsar Site on the Mekong River in Cambodia, one of the world's richest freshwater fish habitats both in terms of species diversity and biomass, and one of the last habitats of the Irrawaddy river dolphin. The Stung Treng HPP proposed within the site, as well as the

Don Sahong HPP, already operational just upstream of the site, are both expected to have significant impacts. Another example is on the Madeira River in Brazil and Bolivia, with more than 950 fish species. Fishways on the Jirau and Santo Antonio HPPs are difficult to design and operate for many species with different requirements, including the gilded catfish (*Brachyplatystoma rousseauxii*), the freshwater fish species with the longest known migration. The spawning habitats of this species are in the headwaters of the Madeira, an area with a number of PAs.

Dams and reservoirs may also interrupt traditional, commercial or recreational navigation, both upstream and downstream. Most HPPs do not include ship locks, and for rafting and kayaking the reservoir itself can also diminish the value of the experience, even if the dam can be portaged.

3.1.5 Increased access

Temporary resource extraction

As mentioned above, large construction sites can attract thousands of workers, subcontractors, and camp followers such as family members, merchants, service providers and job seekers.

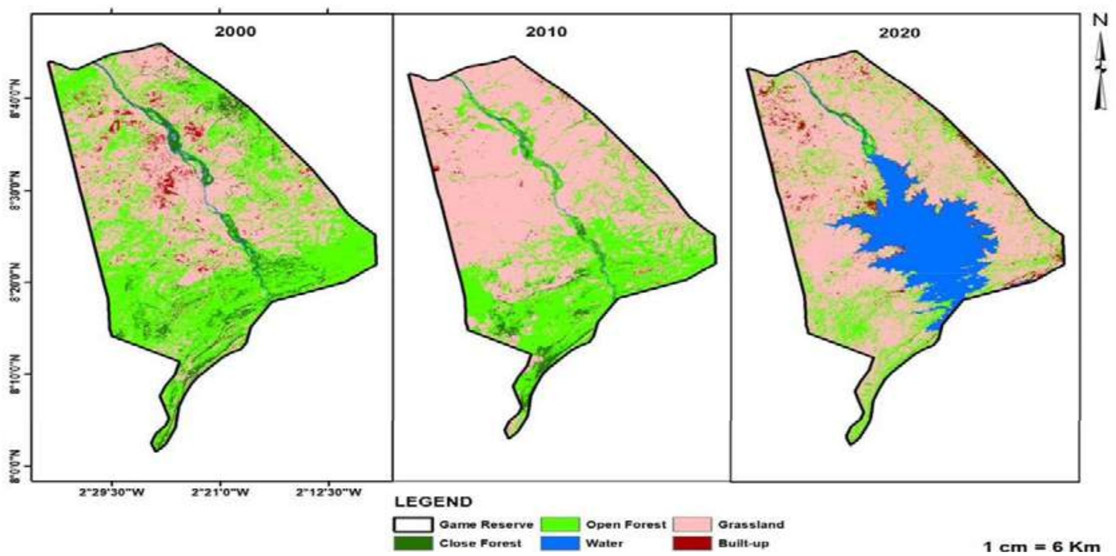
Projects can try to ensure that their direct purchasing does not lead to extraction from PAs, but it may be difficult to fully control activities across the entire supply chain, all project components (e.g. along access roads), and by all parties involved. Demand for bushmeat, timber, firewood or aggregates may be met by illegal extraction. Furthermore, increased food demand may lead to the clearing of forests for agriculture.

Permanent impacts

In comparison to the construction workforce, the permanent operating crew is much smaller, under more direct supervision, and therefore less likely to generate significant permanent impacts. However, some of the displaced people, temporary workers and camp followers may remain in the area and become permanent residents. They may have to change their livelihood strategies, leading to expanded legal and illegal resource extraction (hunting, fishing, logging, firewood extraction, farming, grazing, etc.). New access roads and reservoirs may attract additional resource users and settlers, all of whom may impact PA resources over the long term.

For example, Figure 7 shows changes in land cover between 2000 and 2020 in the Bui National Park, Ghana. Already between 2000 and 2010, land use had changed significantly as a result of ongoing demographic change across Ghana and encroachment

Figure 7. Bui National park, before and after commissioning of Bui HPP in 2013 (Ghana)
Source: https://www.biorxiv.org/content/10.1101/2021.01.28.428667v1.full



on PAs. Between 2010 and 2020, land use change was accelerated by the inundation of approximately 20% of the park's area under the Bui HPP reservoir, and multiple indirect impacts of the Bui HPP, including resettlement. This case illustrates the difficulties in disentangling and addressing the many impacts an HPP can have on local livelihoods and patterns of resource use and settlement, and the resulting difficulty of protecting a PA's conservation objectives.

In some cases, the construction of HPPs may also attract subsequent investments in water-dependent industries such as aquaculture and irrigation, or power-intensive industries such as mining, all of which can have additional impacts on PAs.

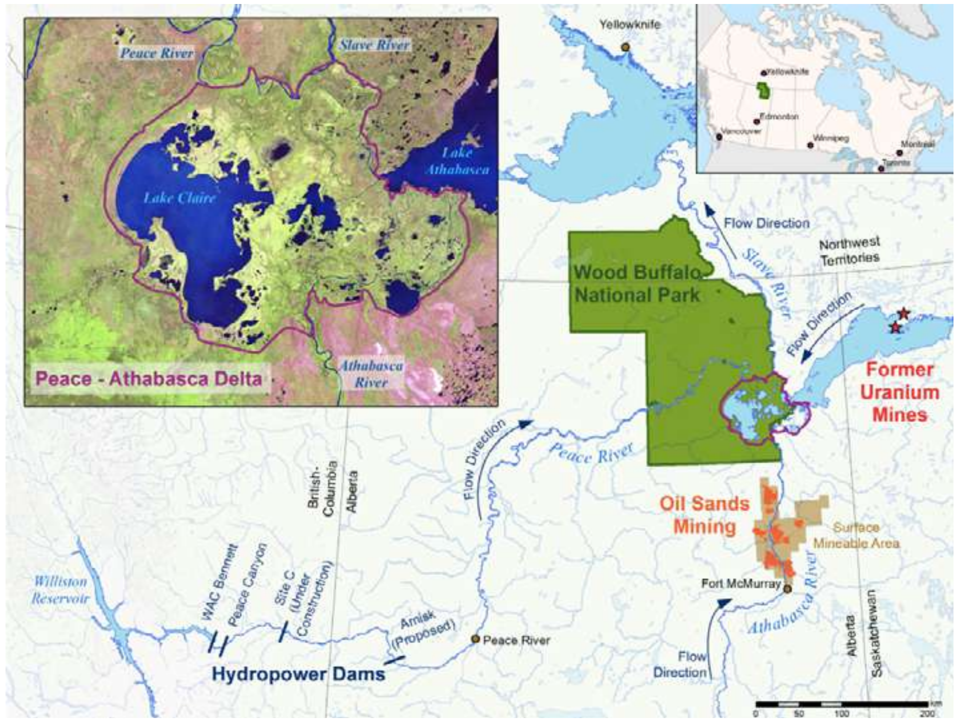
3.1.6 Downstream impacts

Flow alterations

Typical downstream impacts of HPPs include alterations to the flow regime. Total flows may be drastically reduced in a bypass reach, floods may be curtailed, flow levels may change frequently because of hydropeaking, and some reservoirs can lose large amounts of water to evaporation. Not just flow volumes, but also water quality may change – including river temperature, gas content, nutrient and pollution concentrations, and other characteristics. Such flow changes can have multiple implications for downstream ecology, river channels, landscape values, public safety and other values.

Flow alterations are a concern in a large number of PAs, including high-profile PAs such as World Heritage Sites. For example, Mana Pools National Park and Lower Zambezi National Park are influenced by the operations of the upstream Kariba Dam.[4] Other potentially affected World Heritage Sites include the Selous (Tanzania), Wood Buffalo (Canada), Río Plátano (Honduras), Lake Baikal (Russia) and Lake Turkana (Kenya). Some of these impacts are fairly direct – for example, in the Selous, the floodplain lakes below the Julius Nyerere HPP may become disconnected from the Rufiji River and dry out. Some of the impacts are complicated by long distances, complex cause-and-effect relationships (e.g. the frequency of ice-jam-related flooding in

Figure 8. Cumulative downstream impacts: Wood Buffalo National Park, Canada
Source: https://cpawsnab.org/wood-buffalo-np



4 https://whc.unesco.org/en/list/302/

Wood Buffalo), transboundary concerns, and the difficulty of distinguishing the impacts of HPPs from other cumulative impacts. In the case of Lake Turkana, while the upstream HPP cascade on the Gibe River in Ethiopia does not by itself reduce the total annual flow, it enables downstream abstraction for irrigation and curtails the annual flood pulse. In the cases of Lake Baikal and Wood Buffalo, the impacts of HPPs are compounded by mining. Sometimes a whole cascade of downstream PAs is affected. For example, the Julius Nyerere HPP not only affects the World Heritage Site in which it is located, but also the downstream Rufiji-Mafia-Kilwa Marine Ramsar Site.

Sediment transport

Soil erosion in the catchment depends on the condition of the natural vegetation and determines the sediment input into the reservoir. An HPP can continue to function even with a reservoir that is almost full of sediment, but only in a run-of-river mode, with no capacity to regulate flows, and with increased spilling and reduced hydropower generation. HPPs can increase upstream erosion by disturbing the vegetation, such as through road construction and resettlement.

Sediment transport downstream of HPPs is also highly relevant. The design and operation of the reservoir determines how much of the incoming sediment will be trapped and deposited, and how much can be passed through. Water with a reduced sediment load will erode the downstream riverbed and riverbanks. In some cases, incision and erosion may progress downstream over time from directly below the powerhouse. This changes the channel, deepens the river, lowers groundwater tables, reduces the periodic flooding of floodplains and recharge of wetlands and aquifers, and eventually reaches all the way down to the sea, affecting coastal ecosystems such as mangroves, lagoons, coral reefs and beaches.

Most PAs downstream of HPPs can expect some geomorphological changes, and in some cases major impacts. The Las Cruces HPP on the San Pedro Mezquital River in Mexico was suspended because of concerns over its impacts on the downstream Marismas Nacionales coastal wetlands, a Biosphere Reserve and Ramsar Site which is already affected by other upstream HPPs (Ezcurra et al. 2019).

There are several other potential downstream impacts that need to be reviewed. Reservoirs can also trap some of the organic content in rivers and reduce the availability of nutrients and woody debris downstream. The sediment load can also change over shorter time periods. For instance, there may be increased loads during construction periods and during reservoir drawdowns, sometimes specifically for sediment flushing. River ecosystems are adapted to changes in sediment load, but these short-term variations may be outside the range of natural variability.

Jointly, the impacts of dams on connectivity, flows, geomorphology, water quality, fishing pressure and other determinants of fish productivity can have significant impacts on fish biodiversity and the livelihoods of fishing communities. Similarly, other impact pathways described above can jointly affect other ecosystem services, such as carbon sequestration or recreation.

The impacts on PAs reviewed up to this point (Sections 3.1.1 to 3.1.6) are typically negative and attract the most concerns. However, there are also a number of potential positive impacts, which are described in the following sections (3.2.1 to 3.2.3).

3.2 Positive impacts

3.2.1 Support for existing protected areas

Funding

PAs are typically underfunded, even in wealthier countries. Chronic underfunding of PAs leads to a lack of enforcement of use restrictions, lack of visitor facilities and other infrastructure, and little budgetary space for other management and research efforts. According to one estimate (Coad et al. 2019), less than 10% of terrestrial amphibians, birds and mammals are sufficiently represented within adequately resourced PAs. There can be trade-offs between quantity and quality if PA systems are expanded without also increasing PA funding.

Few analyses have been conducted of PAs' actual funding and funding needs. However, one recent study (Waldron et al. 2020) estimated that USD 67.6 billion per year are required to adequately manage the existing global PA system, and between USD 35.5 billion and USD 110 billion per year to reach the 30x30 target mentioned above. If government agency budgets are insufficient to cover this, a diversification of revenue streams for PAs needs to be explored. Among these could be one-time or recurring contributions from large projects and corporations, such as HPPs. These might be in recognition of ecosystem services that an HPP benefits from (such as water and sediment regulation), or be among the causes supported through corporate sponsorship.

In-kind contributions

HPPs can also contribute in-kind to PAs. For example, a buffer zone around a reservoir or land that was temporarily required during construction might be transferred to the management or ownership of an adjacent PA. Facilities such as construction camps that are no longer needed could be used as offices, workshops, research stations, visitor centres or ranger housing by a PA administration. Access roads and boat ramps could be used by PA visitors. Biodiversity research during an EIA, and continued monitoring, could be integrated into a PA research programme. Furthermore, a direct contribution can be the supply of reliable power from HPPs to park operations, which are often in remote locations.

Alternative livelihoods

PAs' objectives are often affected by illegal (but difficult to control) agricultural encroachment, logging, hunting, mining, and other resource uses. People living inside or around a PA may not be aware of restrictions on resource uses, or may not accept them, as they have few alternatives. HPPs can provide direct employment during construction and operation, make compensation payments, invest in local supply chains, and provide improved infrastructure, including for power supply, pay taxes and royalties, etc. All of these contributions can stimulate the local economy and provide alternative livelihoods, making illegal resource extraction from PAs less attractive.

In some cases, small HPPs have been specifically built with this purpose, but more frequently, local development will be a side effect of HPPs built near PAs.

3.2.2 Creation of new protected areas

Catchment protection

In areas with an advancing 'agricultural frontier', or other detrimental activities in the watershed, the long-term viability of the HPP may be at risk from hydrological effects (reduced or irregular inflows), and from excessive watershed erosion and sedimentation of the reservoir. Large HPPs can represent critical infrastructure for a country, and are in some cases the largest single investments a country has ever made. Their long-term protection should equally be seen as a critical national task, in particular as climate change further increases the variability of inflows and erosion in their catchments. Even for smaller and privately owned HPPs, there can be a commercial incentive to engage in catchment protection.

The declaration of the catchment as a PA, if effectively managed, will generally lead to more even runoff, reduce spilling, and increase the portion of inflows that can be used for power generation. In some cases, it may also increase total annual inflows, although that depends on the rates of evapotranspiration and infiltration with natural and with modified vegetation covers. Cloud forests, in particular, are thought to increase total runoff, if well protected. Natural vegetation almost always has less erosion than modified vegetation (although it does not necessarily protect from mass movements when soils are most saturated, during major storms). By preserving vegetation and reducing erosion, PAs in catchments can reduce costs from other reservoir sediment management measures (such as flushing and dredging) and extend the reservoir's useful life. They can also limit sediment damage to HPP equipment such as turbines.

Depending on its size and the existence of other PAs in the area, the catchment can be managed as a new public PA, can be added to existing public PAs, or – if owned by the HPP company – be managed as a private PA.

For example, the large Canaima National Park and World Heritage Site protects the headwaters of the Caroní River, where most of Venezuela's electricity is generated. The national power company has cooperated with the park's agency in catchment protection activities, but has also planned transmission lines through the park.

Offsets

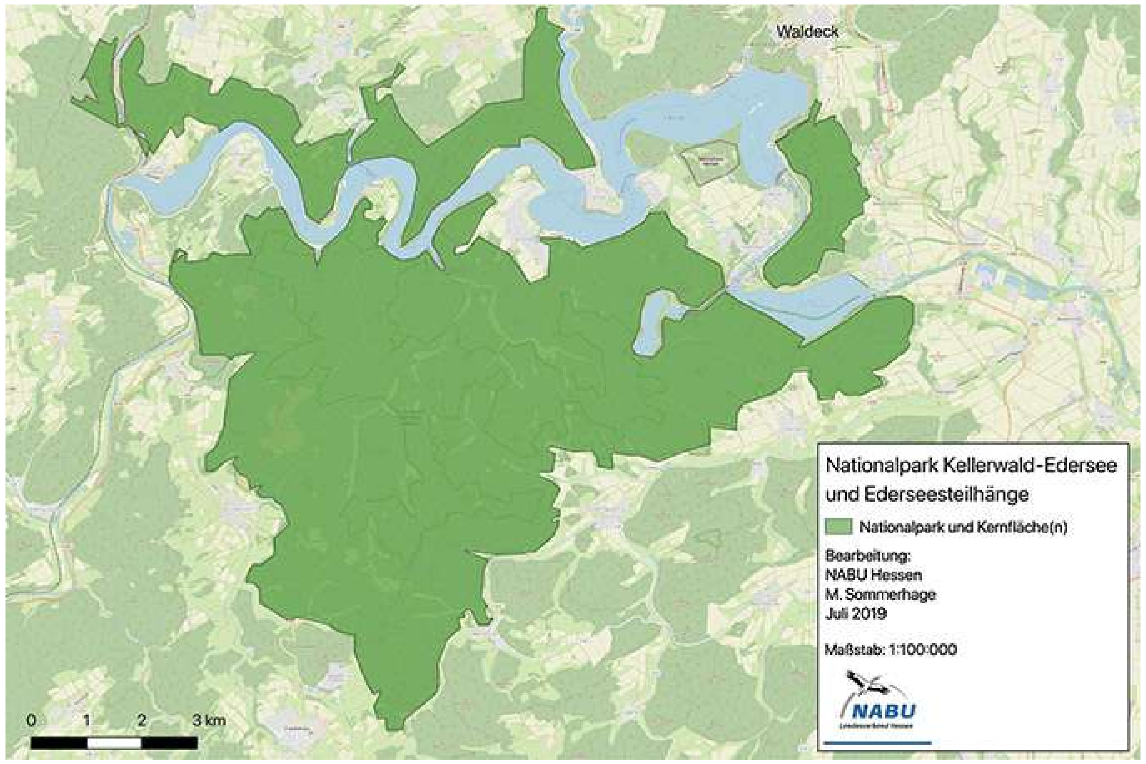
In countries or under project finance mechanisms where residual impacts have to be compensated through biodiversity offsets, one type of offset that is frequently used is the creation of a new PA, or enlargement or strengthening of an existing PA. In some countries, such as Brazil, payments into the PA system budget may be required (typically 0.5% of project costs in the case of large HPPs). Other countries require more specific offsets, including, in recent years, the first examples of aquatic offsets, i.e. the protection of equivalent river stretches to compensate for the ones that are lost to a new HPP. Two examples are the protection of the Parismina River in Costa Rica, an offset for the Reventazón HPP (see Chapter 4), and the protection of the Kalagala rapids on the Nile River in Uganda, an offset for the Bujagali HPP. The latter case illustrates some of the problems with offsets, as the protection of Kalagala was weakened only a few years later to make way for the Isimba HPP.[5]

Reservoir habitats

Over time, reservoirs can become valuable aquatic habitats, and in some cases become formally protected. As described in Section 2.3.5, a significant number of reservoirs have actually been nominated as 'wetlands of international importance' under the Ramsar Convention.

Figure 9 shows a complex mosaic of four hydropower reservoirs and protected areas in Germany. The HPPs were commissioned between 1914 and 1974 and include a 20 MW plant with a large multi-purpose reservoir (Edersee), two pumped storage plants (Waldeck I and II, 140 MW and 480 MW) with a joint lower reservoir (Affoldener See), and a 2.4 MW run-of-river plant downstream. Of particular interest for nature conservation is the 1.65 km^2 Affoldener See, which has been protected since 1975 as an important migratory bird site: because of the pumped storage plants, this lake never freezes over. The Kellerwald-Edersee National Park around the reservoirs was created in 2004, became part of a World Heritage Site of European Beech forests in 2011, and was extended to the northern shore of the Edersee in 2020.

Figure 9. A landscape of hydropower reservoirs and PAs: Kellerwald-Edersee region
Source: https://hessen.nabu.de/naturundlandschaft/waelder/naturwaelder/hessensnaturwaelder/26684.html



5 https://www.inspectionpanel.org/sites/www.inspectionpanel.org/files/publications/Emerging%20Lessons%20Series%20No.%205-Biodiversity%20Advisory.pdf

Two additional aspects of the integration of PAs and HPPs in this area are worth mentioning. Firstly, in 1983 the HPP owner refurbished a funicular that was first built in 1929 to transport materials to the upper reservoir construction site, for passenger transport – this has become a popular way for visitors to experience the region. Secondly, an expansion of the Waldeck II pumped storage plant by another 300 MW is planned. This would have no additional footprint, as all components are underground, and additional storage in the upper reservoir is achieved by raising the reservoir walls.

Other conservation areas

Not all PAs are owned and managed by government agencies, and some countries have specific PA categories, such as 'private reserves'. Additionally, many other areas in public, private, corporate or communal ownership are managed for conservation purposes, without being specifically recognised and listed as PAs (see discussion of "Other high conservation value areas" in Section 2.1.3). A number of hydropower companies have created their own private reserves. For example, ESKOM in South Africa manages an 8,000 ha grasslands nature reserve around the large pumped storage scheme Ingula, protecting an ecosystem that is underrepresented in South Africa's PA system.

3.2.3 Dam removal

Among the positive hydropower-related impacts on protected areas can be the removal of hydropower infrastructure. From a practical point of view, the question of whether a dam should have been built in the first place is mostly of historical interest – the more relevant question is how to improve a protected area from the current baseline situation.

Some older HPPs may become 'part of the landscape' and develop their own value as industrial heritage sites, habitats or recreation areas. However, in cases where they either become obsolete or incompatible with PA objectives, the best option may be removal. Many old dams are in government ownership, or have been abandoned by previous owners, and the costs of removal may be significant, thus requiring government involvement. The location within or near a PA can help prioritise their removal.

One example of the removal of dams is on the Elwha River (Figure 10) in the US, historically a major salmon river until two hydropower dams were built in the early 1900s. In 1938, the Olympic National Park was created, which is now also a World Heritage Site. After many years of debate, the Glines Canyon dam inside the park, and Elwha dam just downstream, were removed between 2011 and 2014. Currently, 24 million square metres of sediment that had accumulated in the two reservoirs over a century are being gradually eroded and transported to the coast, and native fish species such as salmon are recolonising the river.

3.3 Legal and regulatory frameworks, voluntary commitments, and lending safeguards

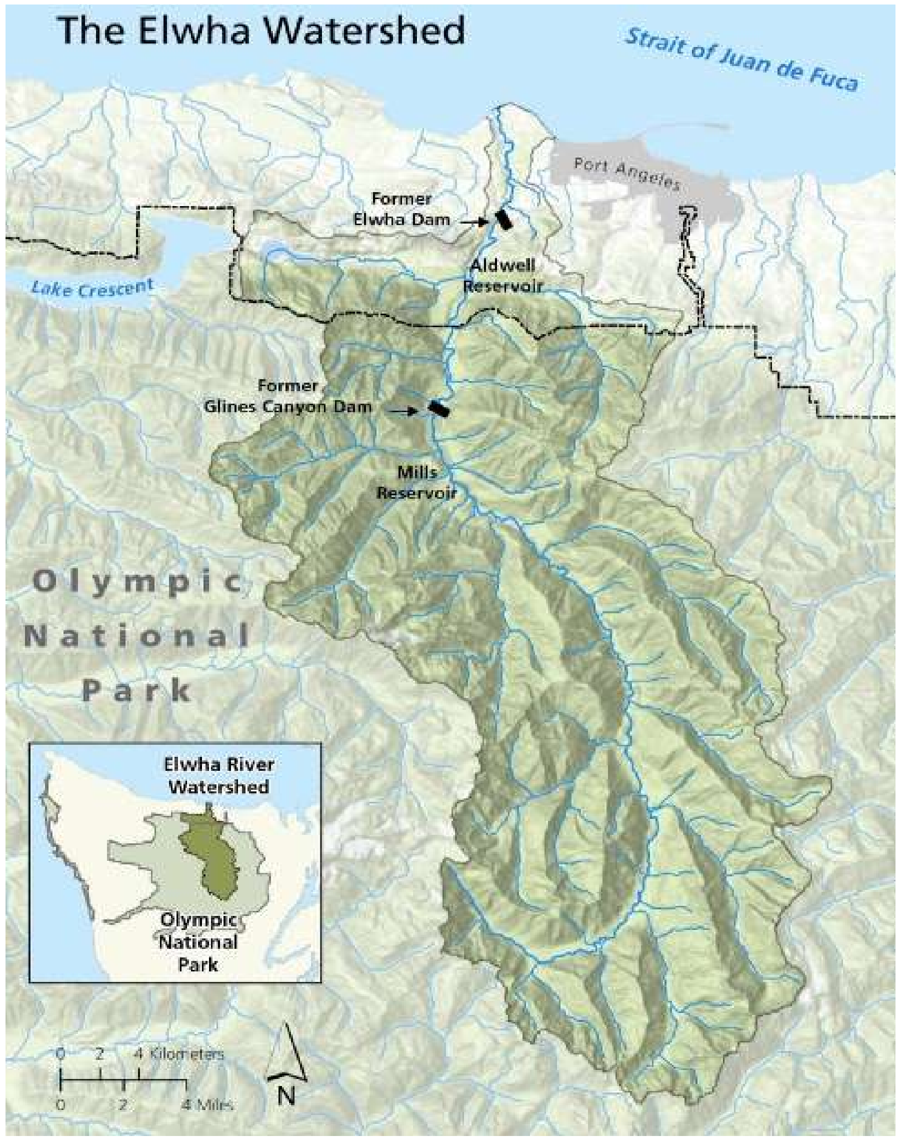
A number of binding and voluntary frameworks regulate the interactions between HPPs and PAs. At the highest legal level are relevant international conventions (see Section 2.1.2), although they are typically not directly enforceable and need to be translated into national law and administrative practice. The conventions themselves are complemented by operational guidelines, decisions of the state parties, resolutions of congresses such as the IUCN World Conservation Congress, and other instruments of 'soft law'. Box 1 shows one example concerning World Heritage Sites.

As intergovernmental instruments, conventions are inherently political, with decisions taken by conferences or committees of the state parties.

Different state parties have different interests and views on the compatibility of infrastructure with PAs registered under the conventions. Decisions such as those in Box 1 represent a majority but are not necessarily respected by all state parties. Some state parties have been said to want to 'have their cake and eat it too', i.e. by getting the reputational advantage of a site registration without restricting development.

At the national level, power sector planning and criteria to be used in site selection may be subject to national regulations. For purposes of HPP licensing and other government actions, the relevant regulatory instruments are laws concerning PAs, as well as officially approved PA management plans, zoning and land-use plans, water allocation plans – and possibly a number of other regulations, depending on the jurisdiction. For example, Mexico has established environmental water reserves for most river basins, often including the water requirements of PAs, which need to be respected by dam operators. In some jurisdictions, HPPs may be allowed in some types of PAs, but with special restrictions.

Figure 10. Elwha River dams removal (USA)
Source: https://theplanetmagazine.net/a-coastal-perspective-on-dam-removal-1e0369e6fe50



Box 1: Decision adopted during the 40th session of the World Heritage Committee (Istanbul/ UNESCO, 2016)

The Committee ... notes with significant concern that an increasing number of properties are facing potential threats from major dam projects, considers that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urges States Parties to ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the Outstanding Universal Value (OUV)...

More broadly speaking, most jurisdictions have general legal provisions that require all persons and organisations to avoid any behaviours or omissions that could reasonably be foreseen to cause harm. The scope of this 'duty of care' differs from country to country, but often includes potential environmental harm, sometimes with a focus on penalties for breach of duty, and sometimes more as a general principle to encourage prevention of harm. It is reasonable to assume that a higher level of duty of care applies in PAs, as it was already identified that high values are at stake.

While both the general duty of care and the specific licence for an HPP should be subject to ongoing compliance monitoring, as described above, in some countries the supervision and enforcement of licensing conditions and PA regulations may be hampered by a lack of resources or political will.

Most large HPPs are developed and owned by public sector corporations, which are expected to follow their government's regulations and commitments regarding PAs. A number of private companies and their associations from different sectors (such as BP, Shell, Total, CEMEX, Barclays and Standard Chartered banks, and the International Council on Mining and Metals, ICMM) have made voluntary commitments not to finance, construct or operate projects in high-value PAs such as World Heritage Sites.

HPP developers are not required to seek funding from any particular source, but in practice many funding sources apply their own requirements that can go beyond national laws. Modern bank safeguards, such as the IFC's Performance Standard 6, require, among other things:

- that projects in PAs and internationally recognised areas (World Heritage Sites, MAB reserves, KBAs and Ramsar Sites) are formally permitted, consistent with management plans and consulted on with PA management and stakeholders, and provide tangible conservation benefits;
- that requirements regarding natural and critical habitats are met (e.g. if critical habitats are identified, proponents need to demonstrate that there are no viable alternatives, and develop an Action Plan leading to net biodiversity gains, including avoidance, minimisation, restoration and offsets measures); and
- in some areas, including World Heritage and Alliance for Zero Extinction sites, it is unlikely that critical habitat requirements can be met, and hence they are excluded from financing (*"with the possible exception of projects specifically designed to contribute to the conservation of the area"*).

These principles apply to most commercial project-financing institutions, and similar commitments have been made by leading insurance companies. Besides regulating funding for individual projects, one of the main functions of bank safeguards is also capacity building. By introducing new concepts into client countries' own regulatory frameworks, development banks can have an impact beyond the projects that they finance directly.

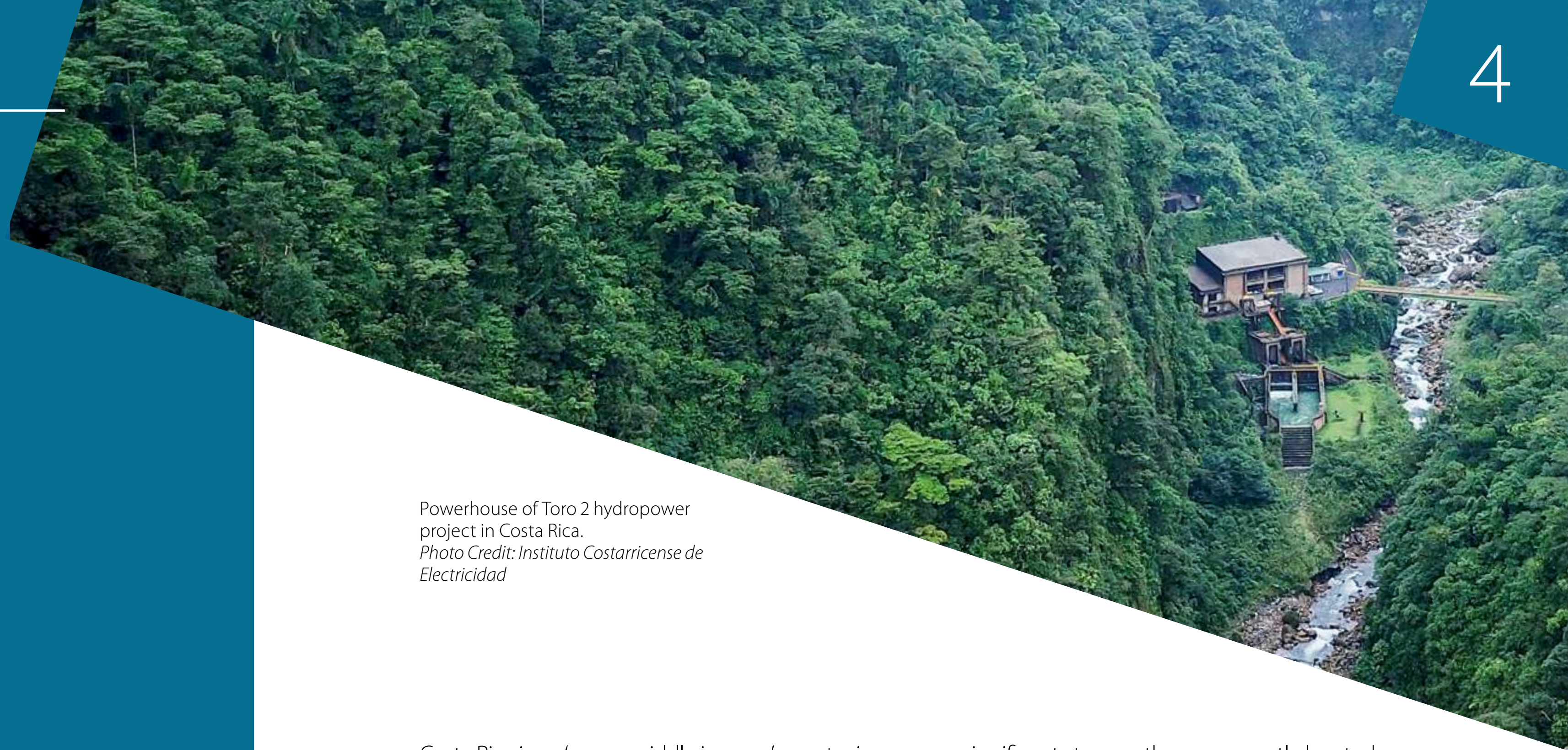
Chapters 2 and 3 have provided a qualitative and quantitative overview of PA and HPP interactions. The following Chapter 4 will now bring these issues together in an example of one country, showing the importance of considering the entire landscape, and the public policies behind the power and conservation sectors.

4 Country case study: Costa Rica

Elephants at the Rufiji floodplain lake in Tanzania.
Photo Credit: Joerg Hartmann

Country case study: Costa Rica

This chapter provides an overview of Costa Rica's achievements and challenges, as a case study to inform and illustrate the recommendations of this Guide. It starts with overviews of its power generation sector and its PA system, then highlights several issues and examples of interactions between HPPs and PAs, and draws out some lessons learnt.



Powerhouse of Toro 2 hydropower project in Costa Rica.
Photo Credit: Instituto Costarricense de Electricidad

Costa Rica is an 'upper-middle income' country in Central America, with 5.1 million inhabitants. It is a global leader in generating practically all its electricity from renewable sources, with a strong reliance on hydropower, which provides nearly 67% of total installed capacity (CENCE 2021). It is also renowned for its biodiversity and its commitment to conserving its natural heritage, as well as to a carbon-neutral future. Costa Rica doubled its forest coverage in recent decades and has protected a remarkable share of the national territory. It shows that with appropriate precautions, hydropower can coexist and be compatible with PAs, with both contributing to sustainable development.

4.1 Power generation

Costa Rica has abundant water resources, and in 2020 it generated approximately 72% of its electricity from hydropower, as well as 15% from geothermal sources, 12% from wind, and 1% from biomass and solar photovoltaics. Technical potential is available to further expand all of these renewable sources. The national utility, Instituto Costarricense de Electricidad (ICE), owns about 70% of the installed capacity and is also responsible for system planning, transmission, distribution and dispatch.

The total installed hydropower capacity is 2,331 MW, with eight plants larger than 100 MW that are all owned by ICE, and many small and medium run-of-river plants. Some of the larger plants have significant storage: these are mostly located in the Reventazón basin in the east of the country, and at the Arenal reservoir in the north.

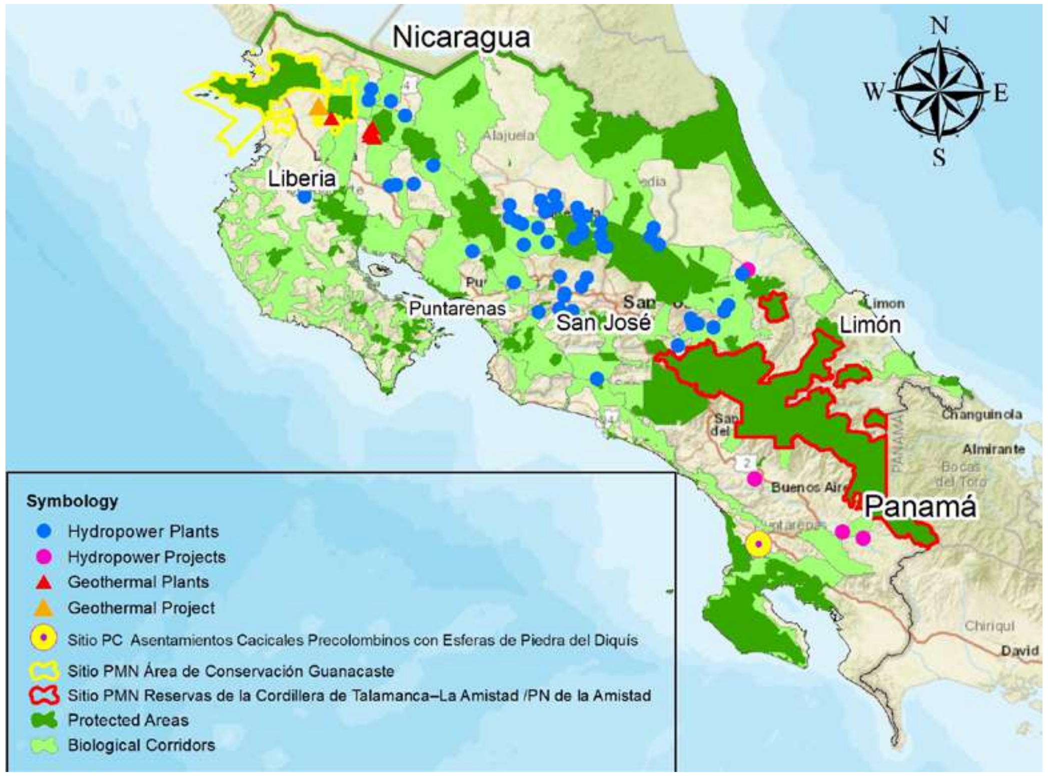
The last update of ICE's national generation expansion plan covered the period 2018–2034. Generation projects that are already operational or committed to (including privately owned HPPs) are deemed sufficient until 2026. For development in 2027–2034, a mix of geothermal, wind and solar is currently recommended as the least-cost scenario (ICE 2019).

4.2 Protected areas

Costa Rica's National System of Conservation Areas (SINAC) is an agency under the Ministry of Environment and Energy (MINAE), which administers the country's more than 140 protected areas. These include 29 national parks, as well as a number of other PA categories, which collectively cover 25.3% of the land and 2.6% of the marine area (www.sinac.go.cr, accessed 2021). Like all PA systems, the SINAC has grown organically and opportunistically over time, expanding into areas that were not yet taken for other uses and possess special values for biodiversity, tourism or other values. For example, a number of volcanoes in the central mountain ranges were protected because of their unique landscape values.

The PAs are generally considered well-managed. SINAC's budget for 2020 was approximately USD 75 million, financed largely by government transfers,

Figure 11. Map of Costa Rica, showing some of its PAs, HPPs and geothermal fields
Source: http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/wwdr4-2012/



but also reflecting some of the services that the PAs provide (Ministerio de Hacienda 2019a). For example, some 30% of the budget comes from visitor fees and 3% from water rights fees (*'Canon de Aprovechamiento de Agua'*). The hydropower sector is the largest single contributor to this water fee mechanism, 25% of which is channelled to the PA system (MINAE 2016).

In recent years, a number of studies have analysed different services that the PA system provides. Its value to the national economy in 2018 was estimated at almost USD 2 billion, with 82% of the benefits from the tourism sector and 14% from hydropower (Moreno Díaz 2020, based on total sales in those sectors that can be attributed to PAs), or about USD 3,000 per hectare per year.

With regard to biodiversity conservation, the representation of some taxonomic groups in the PA system has been analysed. For example, it has been shown that habitats for most terrestrial mammal species are covered in the PA system, but that many PAs provide habitats for similar species, while some endemic and threatened species are under-protected (González-Maya et al. 2015).

A gap analysis for terrestrial, marine and freshwater ecosystems in Costa Rica was conducted in 2006–2007 (Paaby 2008). Sixty-four different river ecosystems were identified for the 48,796 km of rivers. Forty-seven of these ecosystems were represented in the PA system, and 23 met certain conservation objectives (e.g. for rare ecosystems with a total river length of less than 25 km, at least 5% should be protected). The study proposed the additional protection of a total of 471 km of river length and 1,223 square kilometers of catchment areas, as well as a number of lakes and habitats for endemic aquatic species.

In practice, even though the current national PA system may not protect all relevant values, significant practical limits prevent a further expansion. The focus has therefore shifted to managing the entire landscape, as a mosaic of units with different ownership, conservation status and land use. The country is administratively divided into 11 conservation areas, overseen by divisions of SINAC (Biodiversity Law No. 7788). The responsibilities of SINAC outside the PAs include, for example, the management of 45 biological corridors, which connect the PAs and represent 33% of Costa Rica's land area (SINAC-SE-DPCG-065-2018). Other conservation measures include watershed management committees for some of the most important watersheds, such as COMCURE for the Reventazón; government commitments not to develop some areas, even if they are not included in PAs; and more than 200 small private PAs. Notable improvements have been documented, such as a significant increase in vegetation cover, increase in water quality, and reduction of sediment input into reservoirs in the Reventazón watershed (Porras 2012).

4.3 Payments for Environmental Services

The national Payments for Environmental Services (PES) scheme, administered by the Fondo Nacional de Financiamiento Forestal (FONAFIFO), is perhaps the best-known PES mechanism globally, and has significantly contributed to the maintenance and growth of forests on private lands. Some of these private lands are inside PAs, and FONAFIFO compensates some of these private landowners for use restrictions. For instance, in 2018 about 21% of payments went to 26,000 ha of private land inside or next to PAs (Moreno Díaz 2020).

With regard to hydrological ecosystem services, HPPs receive inflows from approximately 24% of the national territory. 52% of these catchments are covered by forests (which is not significantly different from the national average), and 31% are within protected areas (Leguia et al. 2008).

Most of FONAFIFO's 2020 budget of USD 33 million is sourced from fuel taxes, but the fund has also received direct contributions from ICE and other hydropower companies over the years, as well as 25% of the water fees described above (Ministerio de Hacienda 2019b). Contrary to some initial expectations, direct financial contributions from HPPs to FONAFIFO have remained limited to a few cases with a direct need to protect catchments in private ownership (Blackman and Woodward 2009), or where a terrestrial offset for the impact of an HPP required use restrictions on private lands. For example, this applies to migratory corridors for jaguars and other species around the reservoirs of ICE's Reventazón, Peñas Blancas and Cariblanco projects. Additionally, there have been a few cases where HPPs did not go through FONAFIFO but directly contracted with private forest owners for catchment protection (e.g. Rojas and Aylward 2002). However, in general, the hydropower sector has relied on catchment protections already provided through PAs and FONAFIFO's general programme.

4.4 Relationships between power plants and protected areas

Historically, ICE conducted a number of preliminary studies for HPPs inside existing PAs (Ormad 2014), but under the current regulatory regime, neither public nor private developers may build any infrastructure or industrial facilities inside PAs, with the sole exception of telecommunications towers (Article 8 of DECRETO N°41129-MINAE-MICITT-MH). Recent ICE generation expansion plans have therefore excluded all projects in PAs and in indigenous areas. This excludes 21% of the country's hydropower potential that is located in PAs, and another 35% in indigenous lands. However, this was not considered overly restrictive, because there were multiple other options outside these areas.

Some of these options have also been curtailed through other instruments. Through a 2015 presidential decree, a moratorium of 25 years was declared for HPP development on the Pacuare and Savegre Rivers, which are outside PAs but important for rafting and other social and environmental values. Other restrictions exist as well, for example on the Parismina River, a section of which was protected from development as part of an offset arrangement resulting from the Reventazón HPP. The Parismina has now been recognised by SINAC as one of its biological corridors, named the 'Bobo Fish Route' after an important fish species (*'Ruta del Pez Bobo'*, SINAC-SE-DPCG-065-2018).

ICE's implementation of the Parismina River offset has achieved improvements in several biological aspects, such as the increased richness of fish species, the number of individuals of migratory species, and water quality. It has also been an opportunity to create institutional cooperation and engagement with different stakeholders in the project's area of influence. The Bobo Fish Route is the first 'blue corridor' in Costa Rica, with a focus on the protection of water resources and fluvial connectivity from the central volcanic mountain range to the Caribbean coast. The new corridor filled a conservation gap in the middle basin of the Parismina River, and it was a matter of pride for ICE to contribute significantly to this process, since most of the technical information required for the declaration of the corridor came from the studies it carried out for the offset.

Important efforts have been made to identify representative high conservation value rivers (National Strategy of Biodiversity Conservation, InBIO, 2016–2025). However, as in most countries, there is no dedicated PA category for rivers, and hence they are not specifically protected through the PA system. Their protection is largely ad hoc or a by-product of terrestrial PAs. In principle, two instruments could be used to protect rivers more systematically: catchment and wetland protections.

Protection Areas as defined in the Forest Law (No. 7575) are dedicated to the protection of small catchments and riparian vegetation, and trees in these areas may only be removed for activities declared to be in the national interest. However, these areas have also been historically under-managed and have only recently become subject to a new policy effort (MINAE 2020). Wetland protections can be made under various PA categories, and in the case of the most valuable wetlands, they can also be designated as Ramsar Sites. A National Wetlands Policy was launched in 2017, with the aim of updating wetland inventories, which currently include more than 300 sites (30% of which are protected), and improving their management (MINAE 2017). However, as in most other countries, Costa Rica's wetland protections are not focused on rivers but on other types of aquatic ecosystems: most of the country's 12 Ramsar Sites are coastal wetlands.

Two special cases in Costa Rica's Ramsar network relate to hydropower. Cuenca de Arenal was designated in 2000 and includes the largest reservoir in the country, as well as seven PAs in its surrounding catchment. Turberas de Talamanca, which includes the Tapantí National Park and the Reserva Forestal Rio Macho, was designated in 2003 and is partly protected because of its hydrological services for downstream users – including water supply to the metropolitan area of San José, and hydropower generation.

The exclusion of HPPs in PAs also extends to transmission lines, access roads and other components, except those built before the declaration of PAs, as in the case of Tapantí and Macizo de la Muerte. The only component of the country's power system where discussions about the compatibility with PAs are still ongoing is geothermal development (Guido-Sequeira 2010). Most high-temperature geothermal fields are at least partly within national parks, and some of the existing geothermal plants are directly on their boundaries. Several legal initiatives have tried, so far unsuccessfully, to introduce exceptions to allow geothermal plants in PAs. Some of the resources may be accessible through directional drilling, without affecting surface areas. But geothermal development will ultimately be limited if the legal principle of 'no regression', as applied to PAs, is upheld.

Even siting renewables in the vicinity of PAs may raise concerns over potential off-site impacts. The Guanacaste Conservation Area, one of Costa Rica's World Heritage Sites, has both wind farms and geothermal projects in the vicinity. There has been a long-standing discussion and cooperation between ICE and the management of the Guanacaste Conservation Area, to minimise impacts on PAs. The World Heritage Committee has requested the government to ensure that no renewables projects are located within the site, and that a strategic environmental assessment is conducted "*to identify the best means to harmonize renewable energy initiatives and biodiversity conservation objectives, considering the multiple existing and proposed projects and development pressures near the property*".[6]

4.5 Lessons learnt

With perfect foresight, both the HPP and the PA systems in Costa Rica would probably have been developed differently. Some HPPs might have been built in different sites, and some PAs might have covered different areas. Nevertheless, both systems provide essential services that underpin Costa Rica's very high environmental performance, and there are no major conflicts between the policy objectives and stakeholders behind renewable energy on the one side, and nature conservation on the other. From a practical point of view, at this stage, when most of the HPPs and PAs that will ever be developed in Costa Rica already exist, there can only be gradual adjustments to both systems over time.

Some of the lessons learnt can be applied through such adjustments, while others may be useful for other countries that are at an earlier stage of development:

- **Cooperate constructively**: The relevant Costa Rican organisations have largely cooperated in a transparent, constructive and solution-oriented manner, all motivated by a recognition that both PAs and low-carbon energy are necessary for sustainable development, and they are willing to apply lessons learnt and new approaches.
- **Manage cumulative impacts**: Evaluation and management of HPP impacts was traditionally done on a one-to-one basis, looking at the impact of one HPP on one PA. Cumulative impacts have only been considered more recently, for example in the preparation of the Reventazón HPP which is part of a cascade, and also the geothermal projects around the National Park Rincón de la Vieja (ICE/ERM 2015). Cumulative impacts have not been systematically considered in the planning for smaller HPPs, many of which are concentrated in a few basins such as the Sarapiquí and San Carlos in the north of Costa Rica (Anderson et al. 2006).
- **Emphasise aquatic ecosystems**: While the PA system has good representation of terrestrial ecosystems and species, little emphasis has been placed on aquatic ecosystems. Even for those aquatic ecosystems that have been protected (such as coastal wetlands), there has been little consideration of the cumulative impacts of upstream HPP developments (e.g. through changes to water flows and quality, sediment, endemic species habitat, or connectivity for migratory species). However, understanding is growing of how PAs are embedded in wider landscapes, and some initial initiatives to extend this understanding to river protections. Examples are the Bobo Fish Route corridor and the Reventazón HPP's adaptative monitoring programme for sediments and water quality, with the aim of adjusting plant operations depending on their downstream impacts, such as on Tortuguero National Park.
- **Improve protection mechanisms**: There is a good understanding of hydrological ecosystem services and a variety of mechanisms (including basin management, PAs and PES) to protect catchments of HPPs, but there is still potential to improve the targeting and effectiveness of such mechanisms.
- **Mainstream effective and appropriate compensation measures**: New initiatives such as biodiversity offsets and cumulative impact mitigation have been promoted by multilateral financial institutions, but may remain limited to projects financed by these banks unless they are fully integrated into national regulations and practices.
- **Manage existing HPPs adaptively**: As few new HPPs are built and the average age of Costa Rica's HPP fleet increases, the value of adaptive management also increases. Monitoring of individual and cumulative impacts can reveal opportunities for improvement, and proposals have already been made to substantially improve the monitoring of fish and other biological indicators (SINAC 2015). Climate change may also cause considerable changes to hydrology, impacting both PAs and water users downstream (SINAC 2013). The original environmental management plans may have become outdated as new PAs were created in the vicinity. In some cases, the original designs and operational rules should be reconsidered.

Chapter 4 has shown the complexity of managing the interactions between the hydropower and conservation sectors in one country. Although Costa Rica has already simplified this task by disallowing new HPPs inside PAs, a significant number of issues remain to be managed. Building on these experiences, as well as the overview of potential impacts in Chapter 3, the following chapter will now describe a systematic framework and priority measures for applying the mitigation hierarchy to HPPs that affect PAs.

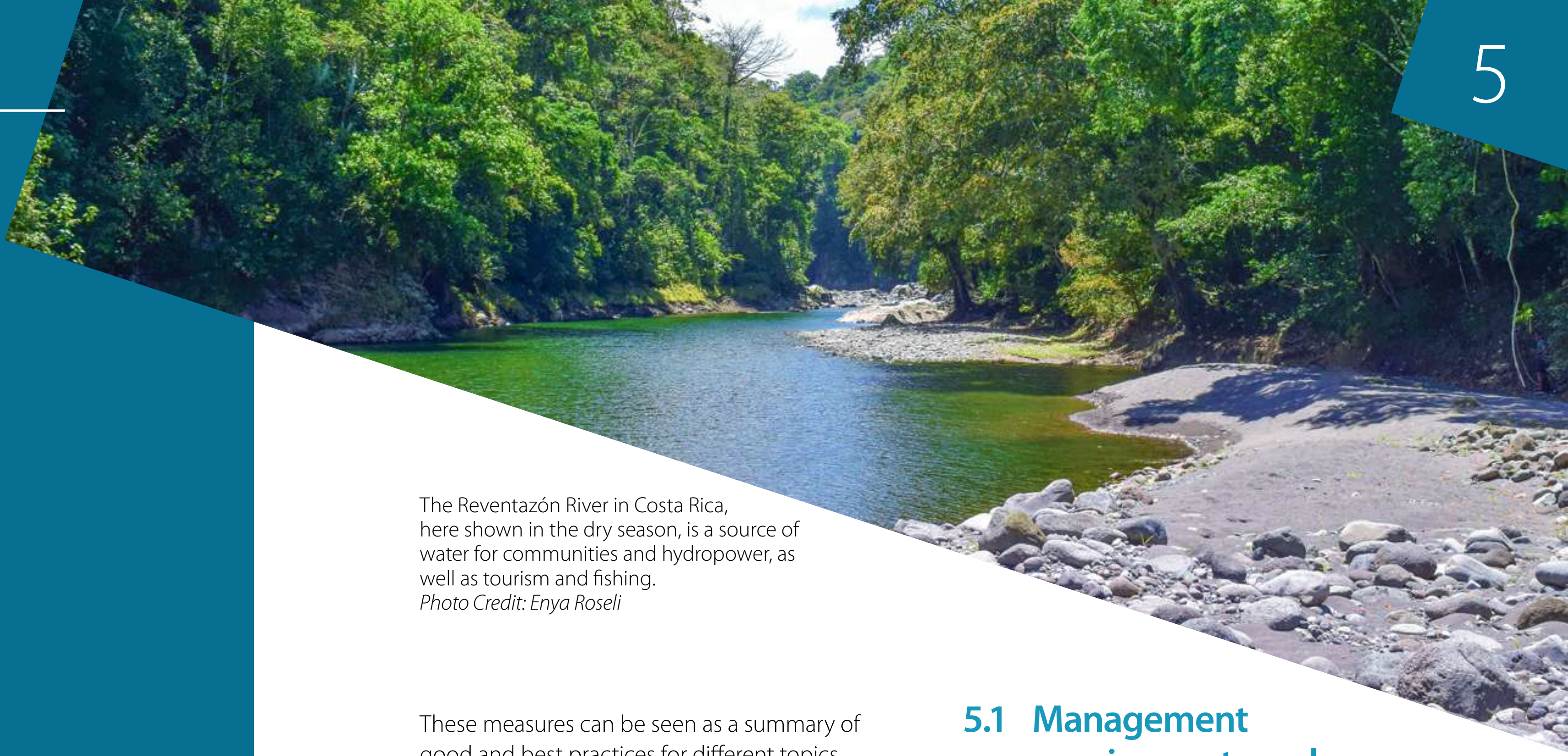
6 https://whc.unesco.org/en/decisions/7488/

5 Practical measures to avoid, minimise, mitigate, compensate, and enhance impacts

Arenal hydroelectric plant reservoir. In the background Arenal Volcano National Park.
Photo Credit: Instituto Costarricense de Electricidad

Practical measures to avoid, minimise, mitigate, compensate, and enhance

The following sections are structured according to project life-cycle stages and the mitigation hierarchy. Section 5.1 shows the evolution of key tasks over time, while measures to avoid negative impacts are covered in Section 5.2, measures to minimise, mitigate and compensate for negative impacts are described in Section 5.3, and measures to enhance positive impacts are explained in Section 5.4.



The Reventazón River in Costa Rica, here shown in the dry season, is a source of water for communities and hydropower, as well as tourism and fishing.
Photo Credit: Enya Roseli

These measures can be seen as a summary of good and best practices for different topics and issues covered in detail in the Hydropower Sustainability Tools. What is distinct in the case of HPPs in or near PAs, is that the stakes are higher: the special value that has already been established corresponds to a special duty of care.

It should be emphasised that some of the issues described in this guide cannot be fully resolved at the project level. They may have to be addressed by higher-level government agencies and power system managers. Costa Rica's experience, described in the previous chapter, showed a number of achievements, but also challenges: these include cooperating constructively, managing cumulative impacts, protecting aquatic ecosystems, improving the targeting of protection mechanisms, mainstreaming innovative approaches, and adaptively managing existing HPP fleets. Individual HPP and PA managers need to keep these issues in mind, and can make contributions towards their resolution, but cannot be expected to resolve them successfully without the support of a conducive larger framework.

5.1 Management requirements and responsibilities throughout the life cycle

Both HPPs and PAs go through a life cycle, from the early or identification stage (when multiple options are still considered), through specific preparation (until a decision is made to invest in a particular HPP or to declare a particular PA), implementation (the period when a HPP is built, or a PA created on the ground), and operation. The life cycle of either the HPP or the PA may start earlier, but at least for some period they will be existing in parallel. Major events during the operational stage – such as changes in management objectives or categories for PAs, declaration of a new PA or de-gazetting of a PA, planning for new HPPs, or relicensing, rehabilitation, re-operation and removal of HPPs – will be opportunities for a re-evaluation and recalibration of interactions.

Neither ideas for new HPPs nor for new PAs will automatically come to fruition. Ideas need to be analysed for their costs, benefits and impacts. Ideas that are not feasible may not progress to the next stage of the life cycle. In some cases, the life cycle of an HPP or a PA will come to an end, although that is relatively rare and not included in the chart below.

The overall objective during hydropower development is to identify and implement a balanced solution that is, at a minimum, compatible with the management objectives of all potentially affected

Figure 12. Requirements through the life cycle

Hydropower Project	Project Life Cycle Stage	Protected Area
• As part of the initial risk screening or sensitivity mapping process, identify existing or potential PAs as an indicator of elevated conservation value, potential permitting problems, and stakeholder conflicts • Consider high-level options to avoid, minimize, and mitigate impacts, and potentially improve outcomes for PAs • Recognize value of existing and potential PAs in upstream catchments	Early Stage	• During consideration of new PAs, take their potential positive impact on other stakeholders (including HPPs, primarily through watershed protection) as well as potential constraints they might impose on these stakeholders into account
• Ensure that any potential impacts of preparatory activities (such as geotechnical investigations) on PAs are well managed • Identify all existing and candidate PAs that could be affected by construction and operation, their management objectives, and legal and regulatory constraints • Analyze potential positive and negative impacts (including cumulative impacts) on PA resources and objectives in detail, and establish their significance • Identify mitigation options across the whole spectrum of the mitigation hierarchy, from avoidance, minimization, mitigation to compensation	Preparation	• Make decisions on boundaries, zoning, objectives and management measures, with a good understanding of threats and opportunities from existing and planned HPPs in the area • Expand the PA system to strengthen the conservation of particular ecosystems affected by HPPs (as offsets) and of areas delivering ecosystem services to HPPs
• Manage construction to minimize negative impacts on PAs, through appropriate provisions in contracts (e.g., regarding sourcing of materials) and supervision of work sites and camps • Prepare for the beginning of the operation period, for example by preparing the reservoir areas for first filling and by advancing plans for compensation actions, such as support for neighboring PA's infrastructure and management	Implementation	• Demarcate new PA and develop management structure
• Monitor and manage adaptively • Remain in contact with nearby PAs to understand any emerging issues	Operation	• Monitor and manage adaptively • Remain in contact with nearby HPPs to understand any emerging issues

PAs, and ideally contributes to their management objectives. This requires environmental and social teams to work in an integrated manner with technical and commercial experts to select appropriate siting, design and operational options, as well as other mitigation measures. These then need to be well documented and consistently described in all project documents, such as environmental management plans, licence conditions, tender documents for construction, power purchase agreements and others. They also need to be implemented, monitored, enforced, and adapted over time. This is an iterative process, during which managers of individual PAs, as well as the responsible PA agency, relevant NGOs, landowners within and around the PAs, and other stakeholders should be engaged.

5.2 Project selection and siting

In an ideal world, a proactive, integrated and comprehensive spatial planning process would de-conflict PAs and HPPs by assigning them different locations, and facilitate positive interrelationships – for example, through PAs in HPP catchments to protect upstream landcover. However, in the real world:

- separate planning processes exist for PAs and for HPPs;
- these planning processes are often not well articulated (for example, where governments leave project selection to private HPP developers, who then cherry-pick projects without concern for their overall strategic fit);
- there are locations of high value for both uses: conservation and power generation;
- many PAs and HPPs already exist, so planning can never start from a blank slate; and
- interactions are much more complex and nuanced than simply overlapping site requirements.

Because of these difficulties, in most countries PAs and HPPs are not fully de-conflicted, and the selection of sites for new HPPs is the most obvious opportunity to avoid impacts on PAs. Planners and developers should keep in mind existing PAs, potential future PAs, corridors between PAs, and longer-distance impacts (e.g. on PAs along downstream river reaches) when identifying potential HPP sites. Siting needs to be based on both desk- and field-based evaluation of biodiversity, ecosystem services, technical potential, and other relevant factors. Selection of appropriate sites is the most important step towards sustainability. Inappropriate sites almost inevitably lead to conflicts, delays, and impacts that are difficult or impossible to mitigate. The planning process should therefore distinguish between high-risk, medium-risk, and low-risk types of sites (Figure 13).

A number of other siting considerations may be applicable depending on the spatial configuration of PAs and HPPs. For example, from the viewpoint of HPP development, sites downstream of existing PAs – or where there is a significant chance that a PA may be created – should be given preference, because of the higher probability of stable inflows and reduced reservoir sedimentation over the long term. From the point of view of the PA's integrity, this will require resolving any upstream migration issues.

Depending on the regulatory frameworks in different countries, HPP site selection may be the responsibility of public or private entities. This should not affect the overall imperative of taking PAs into consideration. PA system planners also have responsibilities in this regard, by making their plans easily available and by minimising the constraints these plans impose on other land and water uses, such as HPPs.

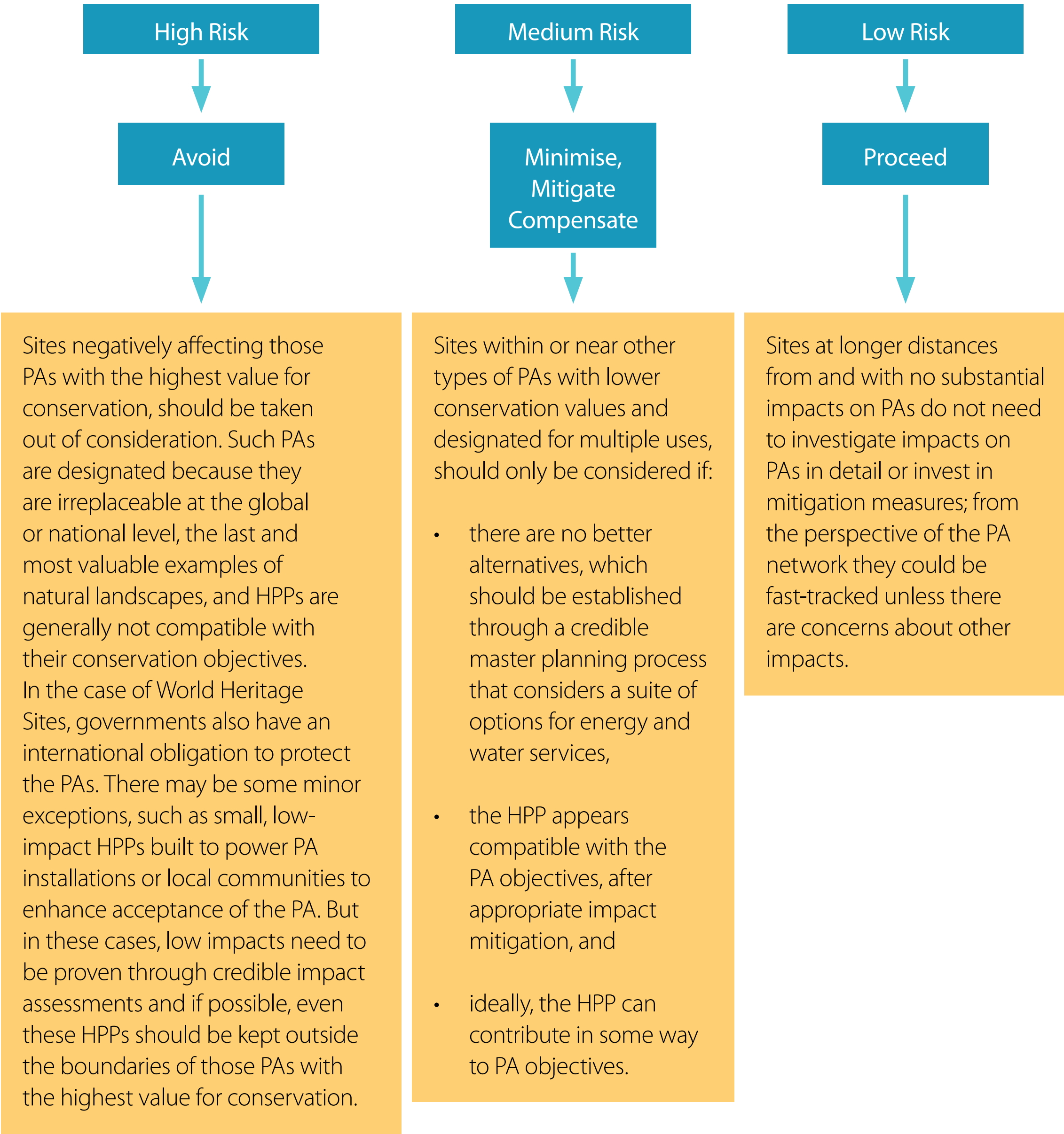
Once a project site is selected, any impacts on PAs at that site need to be well managed. The remaining sections of Chapter 5 describe practical approaches to reduce negative and enhance positive impacts.

5.3 Reducing negative impacts

5.3.1 Temporary construction impacts

In many ways, techniques for the minimisation and mitigation of construction impacts are well known. For example, disposing of excavated material in well-defined, stabilised and revegetated spoil areas that will not erode and impact water quality, is not particularly difficult – it simply requires sufficient

Figure 13. Approaches for high-, medium- and low-risk sites



attention to detail and adequate resources. Most environmental management plans of HPPs are already focused on construction stage impacts. Potential impacts, and options to reduce them, are not substantially different from those of other large construction projects, inside and outside PAs. However, extra efforts must be made in the design and execution of works inside and near PAs, because of the high value of surrounding areas and their sensitivity to impacts. All parties involved – from the site manager to the individual worker, whether they work for the main developer, contractors, suppliers or service providers – need to understand that they have a special duty of care, when allowed to operate in or near a special place. This also entails dedicated education, supervision and enforcement.

Because of the site-specificity of PAs and HPPs, and their interactions, it is impossible to detail all the precautions that might be necessary. As an example, a range of precautions applying to terrestrial wildlife must be considered. PAs typically have an abundance and a large variety of wildlife, some of which may be endangered. Individual animals need food, water, shelter and space to

survive in the short term, and populations need habitats for long-term reproductive success, which may include recolonising areas affected by HPP construction. In this example, mitigation measures for terrestrial wildlife may include the following:

- Identify and retain vital habitats and landscape features, such as nesting and feeding sites, migratory corridors, trees providing shade and cover, etc., for vulnerable species.
- Build tunnels, overpasses, bypasses or other features for wildlife movements.
- Avoid pollution (e.g. dispersal of plastic bags, oil spills) affecting wildlife, through proper solid waste and wastewater management.
- Control workers' activities, including wildlife harassment, hunting, or starting of fires, through environmental education and by restricting workers' movement outside camps and work fronts, and providing sufficient food, entertainment, etc., within camps.
- Control invasive species that may colonise disturbed sites and displace native species.
- Time noise-producing activities, such as aggregate crushing or blasting, to minimise disturbance of species of concern.
- Minimise light disturbance by ensuring that lights are not directed outside the site.
- Deter animals from entering dangerous areas.
- Rescue individual animals and relocate them to ecologically suitable habitats within the range of that population, which are not yet at their carrying capacity.
- Control traffic speeds to reduce collision and mortality risks for wildlife.
- Control access of third parties along construction roads.
- Minimise site footprint and control site demarcation.
- Rehabilitate disturbed land and create patches of habitats within the project site, with features attractive to species of concern.
- Support wildlife and PA agencies in their work (through equipment, funding, data exchange, etc.) if they face additional workloads as a result of construction.

Measures need to be systematically planned and documented within the ESIA/ESMP process, grounded in wildlife science, well understood and accepted by all parties, supervised and enforced, and monitored in their effectiveness, to enable adaptive management. This is important because some measures are likely to be futile (e.g. rescuing individual animals when essential habitat is permanently lost), not cost-effective (e.g. some reforestation programmes, compared to natural revegetation), or even counterproductive (e.g. breeding programmes that risk introducing non-native species or diseases, or changing the genetic profile of a population).

Good practices for minimising biodiversity impacts are described in detail in the How-to Guide on Hydropower Biodiversity and Invasive Species (IHA 2021).

The overriding principle during construction should be to maintain healthy recruitment populations and habitats that can be recolonised after temporary disturbances are over. Similar principles should apply to other PA objectives. For example, in terms of recreation and tourism, construction design and management should minimise damages to the recreational value of the area during construction, and prepare the area for a resurgence in recreational use.

5.3.2 Permanent loss of area

Minimising the footprint of an HPP can be achieved through a variety of measures, such as:

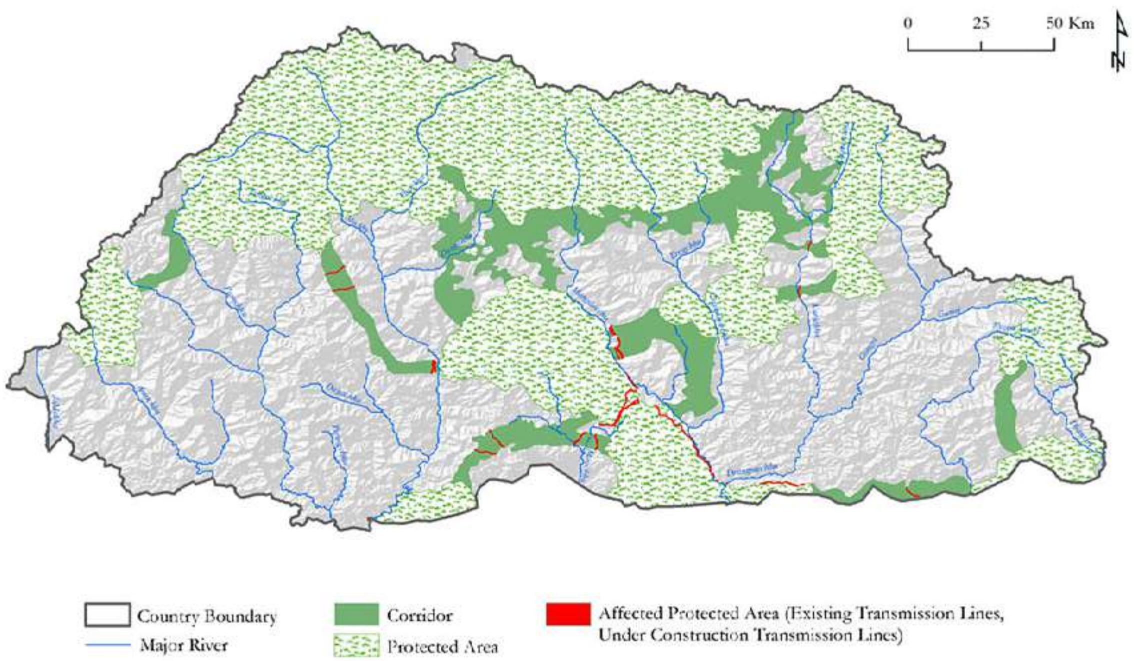
- co-locating new incremental hydropower with existing water infrastructure (such as multi-purpose reservoirs, canals and conduits, upgrades to existing HPPs);

- hybridising technologies to reduce the reservoir size (e.g. HPP/battery and HPP/floating solar PV combinations);
- lowering dam height, thus creating a smaller reservoir;
- reducing the length of the bypass stretch;
- implementing underground options for some project components, such as powerhouses, waterways and transmission lines;
- designing compact, low-visibility structures for above-ground works;
- co-locating transmission lines in existing corridors for linear infrastructure, such as other lines, roads and pipelines;
- raising the height of transmission towers, which may avoid the need to clear vegetation along the right of way (if compatible with visual integrity objectives);
- using existing roads, quarries, industrial areas, etc. for construction;
- locating temporary infrastructure such as camps, workshops, spoil dumps, etc. in the future reservoir area; and
- locating some HPP components outside the PA boundaries, or at least in buffer zones (if these exist) instead of the core zone.

While some of these measures may cost more or reduce generation potential, this may be the price to pay to make an HPP acceptable in this setting.

As an example, Bhutan is a country with a very extensive PA network, and an active HPP development programme. Figure 14 shows that planners have largely succeeded in de-conflicting both land uses, although since the PA network crosses the entire country from north to south, even with optimal alignments it is impossible to prevent some transmission lines from crossing PAs and their corridors. The existing and under-construction HPPs affect 24 km^2 or 0.1% of the PA network, and transmission lines 10 km^2 or 0.04% (World Bank 2016).

Figure 14. Existing and under-construction transmission lines and PAs in Bhutan
Source: https://documents1.worldbank.org/curated/en/254821470402939614/pdf/107462-REVISED-PUBLIC-HydropowerforBhutanWebCORRECTED.pdf



5.3.3 Loss of terrestrial connectivity

If terrestrial connectivity is a significant issue, reducing the length and width of the reservoir may be the most effective mitigation approach, as it allows easier circumvention or crossing of the reservoir. Reducing the area is typically accomplished by adjusting the design with a lower dam, but it may also be achieved by changing operations, for example by lowering reservoir levels during migration season. People also may need bridges or ferry services to cross a reservoir.

Linear infrastructure barriers can be designed for easier crossings, such as with under-, over- and bypasses; reducing the width of corridors; avoiding fencing, paving and clear-cuts; or control of traffic speeds. In addition, as mentioned above, connectivity impacts may be reduced through judicious alignment of linear infrastructure – where possible, outside PAs.

5.3.4 Loss of aquatic connectivity

Upstream and downstream connectivity losses along a river can be mitigated by limiting the height of the dam and length of the reservoir, and ensuring it has sufficient flow velocity, by installing fish passages with appropriate designs for target species and flow rates, and by ensuring sufficient flows in any bypass reaches. Connectivity is also related to downstream flow regimes and sediment management, as described below in Section 5.3.6.

5.3.5 Increased access

Access is restricted and controlled in many PAs, and some areas are purposely left roadless. Access roads to HPPs should not undermine the protection that these restrictions provide. Increased access, which could be more intense but temporary during construction, and perhaps less intense but permanent during operations, can be controlled and largely avoided with appropriate measures.

The number of access roads can be kept to a minimum to reduce the points of entry that need to be controlled. Some can be dismantled and rehabilitated when they are no longer needed, while others can be managed as private roads that only authorised HPP staff and visitors are allowed to use. Workers can be housed in camps outside the PA and bused to work sites. Some exploration and construction activities can even be conducted with alternative transport modes, including boats, cable cars, rail, and if necessary, helicopters. In the Brazilian Amazon, after increasing opposition to traditional HPP approaches, this so-called 'platform' approach has been considered to eliminate the need for access roads.

Where roads need to be built, they can be designed to the least intrusive standards. Access can be monitored by staffed gates, remotely operated cameras, and aerial and satellite images to detect encroachment and other illegal resource uses. Resources for access control and monitoring need to be secured, for example through regular contributions to PA budgets. Controlled access can also be useful to enhance the recreational value of a PA (see also Section 5.4.1).

5.3.6 Downstream impacts

Good practices for minimising downstream impacts are described in detail in the How-to Guides on Downstream Flow Regimes (IHA 2020) and Sedimentation and Erosion (IHA 2019a).

Flow alterations can be kept to a minimum if HPPs are operated in an instantaneous run-of-river mode, where inflows equal outflows. If a storage project is not operated in run-of-river mode, at least key components of the flow regime that are important for downstream values need to be maintained, such as floods of a certain magnitude, minimum flows, and maximum flow rate changes. Diversion projects need to maintain adequate flows in the bypass stretch. Inter-basin diversion projects need to provide adequate flow regimes both in the river from which flows are diverted, and the one into which flows are diverted.

Similarly, alterations of sediment transport can be kept to a minimum if reservoirs are sufficiently small and fast-flowing not to trap sediments, and any accumulated sediment is regularly flushed.

Environmental flows and sediment transport studies need to meet particularly high standards if PA objectives could be affected. They need to be fully integrated into dam and reservoir design and into operational studies, so that constraints from downstream values are taken into consideration at an early stage.

In practice, not all negative impacts covered in Section 5.3 can be effectively avoided, minimised and mitigated by all HPPs. Wherever possible, any residual negative impacts should be compensated. Compensation or offset measures are intended to make positive contributions, for example by replacing a lost hiking trail with a similar or better new trail. They are typically oriented towards similar objectives and are difficult to separate from enhancement measures. Thus, categorising a measure as compensation or enhancement may depend on its outcomes, i.e. whether a net benefit will result (a better performance of a PA with than without the impacts from the HPP). For simplification, the following Section 5.4 should be understood as also covering many compensation measures.

5.4 Enhancing positive impacts

5.4.1 Support for existing protected areas

As described earlier, many 'paper parks' lack effective management due to insufficient funding. Even countries that prioritise conservation, such as Peru, are hampered by inadequate resources. In 2016, each PA ranger in the Peruvian Amazon, perhaps the most biologically diverse region on Earth, was responsible for an average area of 369 km^2.[7] Some medium-sized HPPs can have the same number of staff, and often with much better equipment, than the park service of an entire country. Therefore, even a small share of the revenues from HPPs can make a significant difference to the budgets and the effectiveness of nearby PAs.

One example is the support from Nam Theun II HPP in Laos for the Nakai-Nam Theun National Park in its catchment area. This is one of the most important PAs in south-east Asia, with the HPP making an annual contribution of USD 1 million to the PA over the 25-year concession period.

Donors, such as HPPs, often want to earmark their contributions for specific investments, to enhance visibility and recognition, or in some cases to track the use of funds or to comply with compensation conditions. However, general budget contributions that PA managers can allocate to their priorities can be the most useful ones, filling critical gaps for personnel, fuel and basic equipment.

In some cases, HPPs make contributions in kind, which support PAs with donations of land, infrastructure, vehicles, power supply, or special projects such as biological research and environmental education. Funding and in-kind contributions should be additional to government efforts, rather than replacing them. In the Chaglla HPP in Peru, in-kind contributions for biodiversity included support for the closest National Park (Tingo Maria) to carry out a species inventory, book publication, maintenance of park infrastructure, and a study on the potential of carbon credits. In Yellowstone National Park in the US, a 230 kW hydropower turbine supplies about one-third of the electricity needed for the park headquarters.

Instead of increasing PA resources to counter existing pressures, directly addressing those pressures on PAs can be even more effective. HPPs can help support alternative livelihoods, which do not depend on resource extraction, in many different ways. Examples include through preferential local hiring and contracting, direct livelihoods development programmes for affected people and other local communities, a reliable power supply that enhances local productivity, and taxes and royalties that strengthen local governments and infrastructure. Good practices are described in detail in the How-to Guide on Benefit Sharing (IHA 2019b). In the Virunga National Park and World Heritage Site in the DRC, which is severely affected by lack of security and illegal resource use, four small HPPs with a total of 30 MW are being developed to foster local development.[8]

Before embarking on such initiatives, a careful analysis of local socio-economic dynamics should be conducted to avoid unwanted consequences. In some situations, the consequences could be

7 Calculated from https://wwfgeftracks.com/sites/default/files/2018-08/WWF%20GEF%209374_Securing%20the%20Future%20of%20Peru%27s%20Protected%20Areas_ProDoc.pdf

8 https://virunga.org/alliance/

counterproductive for the PA: for example, if increased income enables people to buy more effective equipment for illegal resource extraction (e.g. trucks, chainsaws, boats with outboard motors, or hunting weapons), or if the new opportunities attract additional settlers.

5.4.2 Creation of new protected areas

In some cases, there are opportunities to enhance the PA system by creating new PAs or expanding and upgrading existing ones. This could be either to protect an HPP, to compensate for its impacts on PAs, or through new PAs on a reservoir or on surplus land that the HPP owns. Care must be taken to achieve community acceptance of any use restrictions, and in the case of Indigenous Peoples, their Free Prior and Informed Consent (FPIC) before a PA is declared.

Catchment protection can take many forms, including administrative restrictions on landowners (perhaps combined with compensatory payments for environmental services), acquisition of land by the HPP, and declaration of catchments as private or public PAs. To decide on the best approach, there should be a thorough analysis of current land and water use and likely future land and water-use trends, the implications for the HPP, and the areas within the catchment which provide the highest benefits from protection (e.g. cloud forests, steep slopes, riparian vegetation along upstream tributaries, a buffer zone around the reservoir). The declaration of a PA is likely to be the most effective option for protection when large areas of the catchment are in public or HPP ownership, and to pre-empt future pressure on resources.

For example, Fortuna Forest Reserve is one of the most valuable PAs in Panama, and the core area of La Amistad Biosphere Reserve. It was created in the catchment of the Fortuna HPP, Panama's largest HPP, and is managed through a cooperation of the hydropower operator with a Smithsonian research station. Combined with sustainable agricultural practices and erosion control on the reservoir banks, the PA contributes to limiting sediment delivery to the reservoir.

Despite efforts to avoid, minimise and mitigate HPP impacts on PAs, residual impacts on the size or quality of habitats may remain. The losses

Box 2: Lessons learnt from the Blue Energy Initiative

Over the past several years, a cooperation between Conservation International, The Nature Conservancy, a number of donor organizations, and hydropower companies have explored ways to operationalize catchment protection for HPPs, starting with pilot projects in Latin America.

The challenge is that most HPP operators cannot quantify the benefits their catchments provide without considerable efforts to model the land use, hydrology, and sediment transport in their catchment; inflows and sediment deposition in the reservoir; and implications for power generation over time. The Blue Energy Initiative developed and tested an interconnected set of models that allows HPPs to undertake this quantification and consider the business case for whether, when, where, and how to invest in catchment protection. Any intervention should be cost-effective, with the highest possible return on investment. The strongest business case is likely where erosion is high or flows very irregular, and power generation is already impacted or will be impacted soon as a result of inadequate catchment management. Such business cases have been developed for two HPPs in Colombia, and are now under review.

Possible interventions in a catchment include reforestation, protection of existing forests, or sediment traps such as small check dams, wetlands, or contour lines.

There are also multiple potential institutional and contractual frameworks to consider, including contracts with private landowners. The choice of framework depends on many factors including land ownership, types of investments that are most cost-effective, existing frameworks that can be used (such as an existing PES or PA agency), and co-benefits that interventions may have. For example, reforestation may also benefit biodiversity, carbon sequestration, and other water users downstream - all of which may contribute to catchment protection.

in biodiversity that are predicted through an environmental impact assessment should then be compensated (and ideally, overcompensated) with at least equivalent gains elsewhere. The overall outcome should be 'no net loss', or preferably a net gain in biodiversity, as measured by population size, species diversity, habitat size or other metrics.

Biodiversity specialists need to establish whether that can be done most effectively through new PAs, expansion of existing PAs, or improved management of existing PAs. In general, PAs are a preferred instrument for offsets because they are meant to be permanent, just as the impacts from the HPP are permanent. Ideally, adjacent land to the HPP site with similar characteristics can be found. In some cases, an HPP itself may have surplus land available, resulting from the acquisition of large parcels of land, that is not all needed for operations. Protecting and restoring this land permanently may qualify as an offset if it contains equivalent ecosystems to those that are being lost, or it may simply be a convenient way of managing the surplus land.

In the context of HPPs, offsetting the impacts on aquatic ecosystems is a particular challenge. Equivalent habitats may be hard to find and hard to protect effectively. In some cases, river restoration may be possible and can be undertaken directly by the developer. However, permanently protecting rivers from development will always require government commitments. (While the HPP developer may be able to acquire riparian land, that is unlikely to be sufficient to avoid future development.) Offsetting is also (by definition) not possible when unique values (such as endemic species with no other habitat) and sites are affected. This is typically the case for the OUV protected through the World Heritage Convention, as well as for many other PAs.

While the emphasis so far has been on offsetting through equivalent habitats (or 'like-for-like' offsetting), there are cases with opportunities for so-called 'like-for-better' offsetting. Instead of protecting a common ecosystem or species, a rare ecosystem or species could be protected, or a multiple-use PA could be replaced by a strict PA.

A special category of new PAs are those that protect new habitats resulting from an HPP, particularly reservoirs. In many regions, there are few natural lakes in good condition, and reservoirs can provide valuable aquatic habitats for many species. If a PA is declared, restrictions on operations (e.g. with regard to water-level fluctuations) or other management needs (e.g. regulating access for recreation or controlling invasive species) may become necessary.

Responsibility for the ownership and management of newly created PAs needs to be clarified. For privately owned PAs, options include keeping them under private ownership and management by the HPP; keeping the ownership but outsourcing management to a community, an NGO or the national PA agency; or handing over both ownership and management to a third party (typically the PA agency). Each model has advantages and disadvantages in terms of ongoing control and responsibilities.

5.4.3 Dam removal

Removal of obsolete HPPs can enhance the value of PAs, and while this is still rarely done, it will probably become more common as the average age of dams increases. Removal can restore valuable habitat, but is a complex undertaking. Most old dams still provide some valuable services, removal can be expensive, some landowners and recreational users in the area may be reluctant to see a reservoir disappear, and the process also causes new environmental impacts such as habitat loss, traffic, and disposal of building materials and sediment (some of which may be polluted).

Most dam removals are therefore either motivated by safety concerns or by clear ecological advantages, as in the case described in Section 3.2.3. In principle, removal could also be triggered by an offset mechanism.

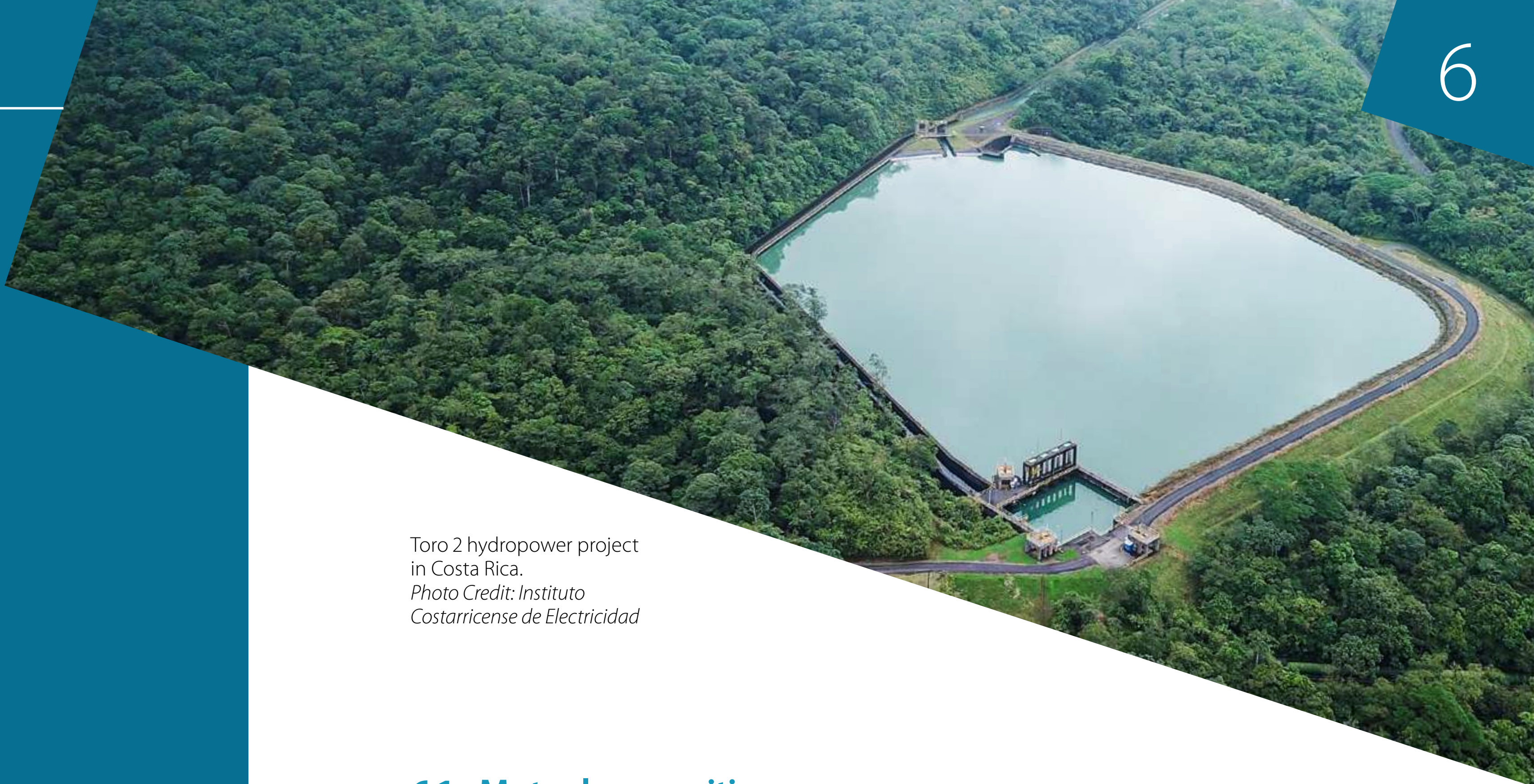
Because of the challenges described above, dam removal will remain highly selective in most countries for a considerable period of time. To assist with the selection process and target the highest-priority dams, with the best combination of removal costs and environmental net benefits, a 'reverse master-planning' process leading to a regional decommissioning plan can be advisable. This could include, for example, criteria such as the location of a dam in a PA, and its fragmentation effects on a river basin.


Reventazon hydropower station in Costa Rica.
Photo Credit: Instituto Costarricense de Electricidad

6 A way forward for hydropower and protected area stakeholders

A way forward for hydropower and protected area stakeholders

In a world with increasing scarcity of natural resources, there is an urgent need to make renewable energy development and conservation more compatible. Our conclusions outline options for stakeholders, to move towards universal adoption of the good practices described in this Guide.



Toro 2 hydropower project in Costa Rica.
Photo Credit: Instituto Costarricense de Electricidad

6.1 Mutual recognition, awareness and support

In most countries, the hydropower sector and the protected areas sector exist in parallel, with little interaction. The two sectors are driven by different agendas, respond to different government agencies, and intersect only in exceptional circumstances – for example, when a new HPP or a new PA interferes with the other sector's interests. In those situations, the interaction is often antagonistic, and the outcome is far more often that a new HPP displaces a PA, than the other way around. Ministries of Environment often have less political influence than Ministries of Energy, and PA managers may even be afraid to speak up, lest they be seen as undermining the government's development agenda. Transparency and an active civil society, including pro-conservation NGOs, can be a useful corrective to this imbalance.

As the example of Costa Rica showed, a basic precondition for a more productive engagement between the two sectors is that they both see each other as legitimate users of lands and rivers, supported by parallel government objectives and commitments. Both can contribute to sustainable, low-carbon development in different ways. To some extent, both have some flexibility in choosing sites and designs, to minimise constraints for the other sector. There are situations where they can directly support each other.

Beyond this mutual recognition, both sides need to be aware of the other's needs and plans. For a hydropower planner, this means taking time to learn about the region and its conservation priorities, existing and potential new PAs, and their management plans and resources, and taking these into account. Planning for hydropower expansion needs to be based on multiple criteria, beyond technical and commercial feasibility – for example, through the instrument of strategic environmental assessments. The terms of reference for ESIAs need to explicitly include analysis of potential impacts on PAs, and a discussion of avoidance, mitigation and compensation options. The terms of reference for a feasibility study need to explicitly ask for design and operational options that avoid or minimise impacts on PAs. In addition, the developer's corporate responsibility programme needs to consider including PAs in the scope of their activities.

Similarly, a PA planner needs to look beyond the boundaries of the PA and consider both impacts on the PA from the outside, and services that the PA can provide for external stakeholders. Both can inform management objectives and measures (including zoning), as well as required resources. In cases where an HPP is planned inside a PA or can significantly affect a PA, the environmental assessment and the investment decision need to be even more thorough than usual, considering the elevated values that are at stake, and PA policymakers and agency staff need to be closely involved in that process. They need to engage HPP planners in a constructive dialogue if they see siting, design or operations as incompatible with PA objectives, through explaining the risks and exploring alternatives.

Legitimate conflicts of interest and differences of opinion may still exist, but if the good practices described in this guide are followed, there should be no need for antagonism. A good example of constructive engagement between HPP and PA stakeholders, even in a difficult environment, can be found in and around the Rwenzori Mountains National Park in Uganda. After review by IUCN, the government did not issue a permit for the original design of the small Kakaka HPP that would have been located just inside this World Heritage Site and would have affected its OUV. A number of other small HPPs have now been developed outside the boundary, benefiting from the regular flows from the park, and monitoring is being conducted on their possible effects on the park. There is also an ongoing dialogue on HPP developers' potential contributions to park funding, supported by a study that demonstrated the economic value of watershed services.[9]

In sensitive cases, where there may be significant negative or positive impacts of HPPs on PAs and a complex stakeholder situation, the Hydropower Sustainability Tools should be applied. A third-party sustainability assessment can document existing good and best practices, reveal opportunities for improvements, and provide a platform for stakeholder engagement, dialogue and compromise. This could be applied, where a PA is considered at risk from an HPP, in order to support the discussions between developers, host governments and financiers.

As the example of Costa Rica also showed, good practices and expectations for managing interactions between HPPs and PAs are evolving, and even advanced countries with a strong commitment to sustainable development have opportunities for improvement. Beyond preserving the integrity of individual PAs, Costa Rica and many other countries will also have to better manage cumulative impacts; protect aquatic ecosystems (which are often underrepresented in their PA systems, and strongly affected by HPPs); improve the targeting of protection mechanisms (making sure that the catchments of important HPPs are covered); mainstream innovative measures such as biodiversity offsets; and manage their ageing fleets of existing HPPs adaptively. These shared challenges at the level of entire landscapes and hydropower sectors will require significant efforts, including international cooperation and exchange of experiences.

6.2 Potential industry commitments

As described above, governments set the regulatory frameworks that define what is allowed in and around PAs, guided by the international agreements they have joined. They also make conservation commitments and set targets at the national and international level. However, they need to pursue multiple objectives in parallel, including making sure that electricity is available and affordable, and they constantly have to consider trade-offs. Where resources (such as lands, waters and budgets) are scarce, they have to make difficult decisions on priorities. Sometimes, these may impact PAs.

These decisions are not always well informed. There have been cases where governments have changed direction, ignored or tried to downplay impacts on PAs, and disregarded their own previous commitments to designate and protect PAs. Such decisions can be driven by narrow and short-sighted politics and could result in unnecessary HPPs that jeopardise conservation objectives, human rights, and the socio-economic benefits from PAs.

Governments are not always the only decision-makers. In cases of transboundary impacts, HPPs may also need the consent of their neighbours. In countries with constitutional checks and balances, they may also need the support of parliament and the courts. HPPs also need other partners, such as developers, commercial and development banks, power offtakers, suppliers, consultants and others. Unless these are owned by or directly controlled by the host government, they need to reach their own conclusions on whether to support a project with impacts on PAs.

Globally, there is growing awareness of the loss of natural values and the critical role of PAs. Private as well as public companies and banks incur increasing reputational risks if they are seen to be associated with projects affecting PAs. Such reputational risks can turn into material risks if HPPs are delayed or the conflicts around them result in a loss of other business opportunities, investors, customers or staff. As an example, in 2020, the world's largest sovereign wealth fund (Norway's Government Pension Fund) decided to sell off its shares in ElSewedy Electric Co, an Egyptian contractor, because of its involvement in the Julius Nyerere HPP in Tanzania (see Section 3.1.1). Conversely, making a public commitment to stay out of PAs can enhance the reputation of companies.

Staying away from projects affecting high-value PAs is thus not just the right thing to do, but also a strategy to mitigate business risks. It can be difficult for an individual company to take this decision, as it may be replaced by others. Nevertheless, some individual companies have taken such decisions, apparently considering that projects in World Heritage Sites were too few, too complex, and not worth the risk, with lost opportunities outweighed by reputational gains. But such decisions are easier when taken collectively, by a broader coalition of businesses that are interested in improving the reputation of a whole sector, and pledge not to undermine each other. This was part of the intention of the ICMM's or the insurance industry's collective commitment not to invest in World Heritage Sites. While there might still be non-member mining or insurance companies that ignore the commitment, the broader the coalition is, the more effective it will be in avoiding these risks. Similar considerations apply to the hydropower sector, which strongly depends on political and public goodwill.

Previous industry commitments have recognised the different values and visibilities of different PA categories. This is a practical and easily communicated approach to a differentiated commitment, as it would be unrealistic to make a commitment to stay away from all 240,000 existing and all potential future PAs. In some ways, this would even be counterproductive, as it would not recognise the potential value of PAs to HPPs, the compatibility of low-impact HPPs with some categories of PAs, and HPPs' potential contributions to PAs.

Any no-go commitment should be informed by an awareness of potential costs. While all countries have multiple options for power generation technologies and sites, there may be cases where a site in a PA is the most attractive site available, providing cheaper or more reliable power than all alternatives. Foregoing that site then carries a real opportunity cost. This cost can be well known when a country has an up-to-date, comprehensive power generation masterplan: it will show where attractive projects are located, and whether and by how much the cost of power might increase as a result of a no-go commitment. Most countries, however, do not have that type of information, and there will be some uncertainty over possible opportunity costs. The opportunity costs of foregoing sites may also be less than expected, when financial risks due to delays over conflictive sites and difficulties in accessing finance are considered. Clearly, the probability of foregoing an attractive project is larger when a no-go commitment is broad, than when it is more narrowly targeted. For example, World Heritage Sites cover about 1% of the Earth's land surface, while combined with IUCN category I and II PAs, they cover about 10% of the land surface. Excluding the entire 30% that are planned to be protected by 2030 would affect proportionately more potential HPPs.

Even with relatively large exclusions, recent cost and technological developments can reduce concerns about potential opportunity costs. While hydropower used to have clear cost advantages in many countries, the costs for different power generation sources have converged in recent years, and there are also more technologies available for integrating different power sources. Furthermore, siting is becoming less constrained, with some power generation sources very flexible in their site requirements, and becoming even more so with time (e.g. through closed-loop pumped storage, floating solar PV and wind, and directional exploration for geothermal power). It is therefore less likely that there is only one, clearly superior

9 Badman (n.d.) "World Heritage and Environmental Assessments: An IUCN perspective": https://onlinelibrary.wiley.com/doi/10.1111/aje.12823; https://africa.panda.org/food_footer/?uNewsID=32268; https://www.futurewater.nl/wp-content/uploads/2016/01/hunink_etal_2006_rwenzori_fw149.pdf.

solution for a country, which requires affecting a high-value PA.

Based on the outcomes of this guide and discussions with the multistakeholder Working Group on Protected Areas (see Foreword), the International Hydropower Association developed a progressive and forward-looking set of commitments for its members, officially published as part of the San Jose Declaration during the 2021 World Hydropower Congress:

No-go commitment: Not develop new hydropower projects in World Heritage Sites.

Duty of care commitment: Implement high standards of performance and transparency when affecting protected areas as well as candidate protected areas and corridors between protected areas, through a systematic application of the Hydropower Sustainability Tools or certification against the Hydropower Sustainability Standard.

Cooperation commitment: Cooperate with government, civil society organisations and communities to respect the strengthening of existing protected areas and the declaration of new protected areas.

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