

# Hydropower's Impact on Waterways: A Sustainable Challenge

## Introduction

Hydropower is a key [renewable energy](#) source, providing reliable electricity with low [carbon emissions](#). However, hydropower's impact on waterways is significant, altering natural river systems, and affecting [ecosystems](#), sediment flow, and water quality. Balancing the benefits of clean energy with the need to protect vital waterways is crucial. By adopting a thrivable approach, we can go beyond sustainability, ensuring that hydropower projects contribute to flourishing ecosystems and thriving communities.

## Overview of Hydropower's Role in Renewable Energy

[Hydropower](#) has long been a cornerstone of the global transition to [renewable energy](#), playing a crucial role in providing clean, [reliable electricity](#) while reducing dependence on fossil fuels. As the world shifts towards more [sustainable energy solutions](#), hydropower stands out for its capacity to generate substantial amounts of power with relatively low carbon emissions. However, despite its advantages, hydropower projects—particularly large-scale dams—have significant and complex impacts on [waterway ecosystems](#). Understanding these effects is crucial for developing balanced approaches to energy production that safeguard environmental and social well-being.

## What is Hydropower and How does It Work?

[Hydropower](#) works by converting the kinetic energy of flowing water into electricity, primarily by constructing [dams](#) that control river flow. Hydropower

plants harness the potential energy stored in water to drive electricity-generating machinery by trapping water in reservoirs and releasing it through turbines. This process is effective in generating consistent, [renewable power](#), but it comes with substantial environmental trade-offs, particularly concerning river ecosystems.

## Hydropower's Impacts on Waterways

### Changes to Natural Water Flow

Dams alter the natural flow of rivers, disrupting both the physical and biological processes that sustain aquatic [ecosystems](#). Where rivers once flowed freely, providing essential nutrients and habitats, hydropower plants manipulate the flow for energy production, which can have far-reaching consequences. For example, fish species and aquatic plants that rely on seasonal water patterns are particularly affected. The controlled release of water often disrupts the dynamic balance of river [ecosystems](#), causing fluctuations in water levels and altering the availability of critical [resources](#).



How Dams Slow Rivers

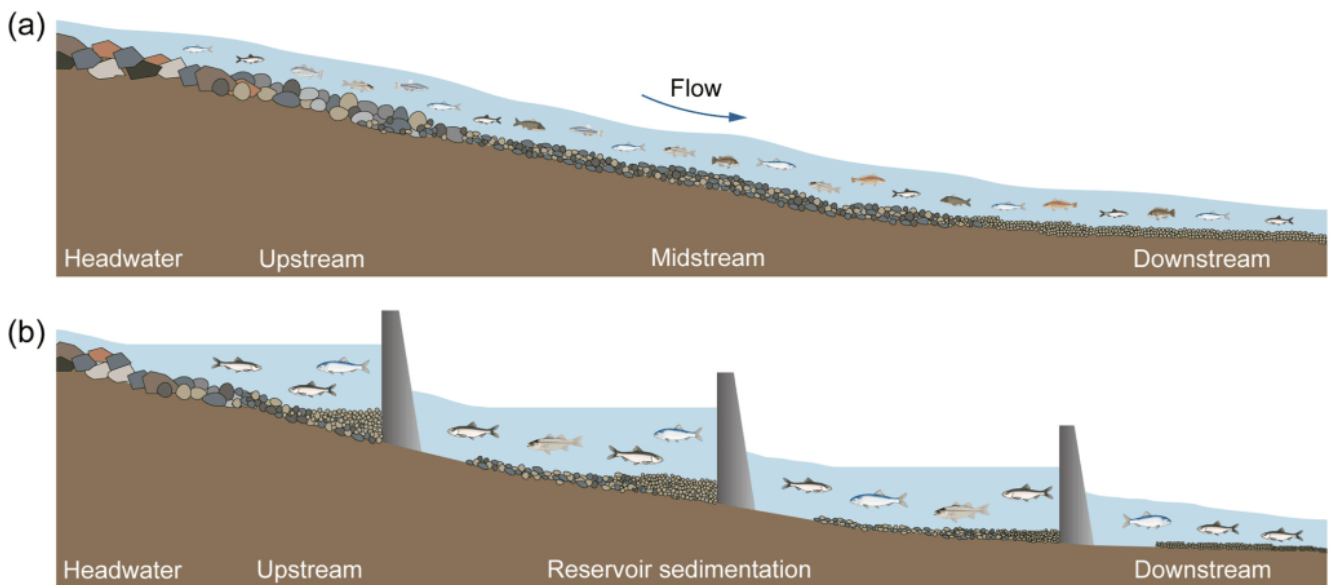
Source: [American Rivers](#)

# Impact on Aquatic Ecosystems

One of the most significant ecological impacts of hydropower is the obstruction of [\\*fish migration](#). Many species, such as salmon and eels, rely on long migrations to reach their spawning grounds. Dams create physical barriers, preventing these species from completing their life cycles. While some solutions, like [fish ladders](#), are implemented to mitigate these issues, they are not always effective in maintaining healthy fish populations.

In addition to migration barriers, hydropower reservoirs often lead to temperature stratification in the water, where layers of water at different temperatures form in the reservoir ([Guo et al., 2023](#)). The release of water from these layers—especially colder, oxygen-poor water from the bottom—can negatively impact the biodiversity of downstream ecosystems by creating conditions that are hostile to aquatic life.

A thrivable approach emphasizes proactive measures like advanced fish passage systems and adaptive water management techniques to ensure aquatic ecosystems can recover and thrive alongside hydropower operations.



Impacts of Dams on River Bed Sediment

Source: [AGU](#)

## Sediment Transport and Water Quality Issues

Another major impact of dam construction is the retention of sediment that rivers naturally carry downstream. Sediment is crucial for maintaining riverbeds,

forming habitats, and supporting coastal ecosystems. When dams trap this sediment, it leads to downstream erosion, the loss of habitats, and a reduction in the nutrient-rich materials that sustain plant and animal life. Over time, this can severely degrade river ecosystems.

Water quality is also affected by the build up of organic material and nutrients in reservoirs. This accumulation can lead to eutrophication, where excessive nutrients promote algal blooms that deplete oxygen levels in the water, creating “dead zones” where most aquatic life cannot survive ([Moutinho et al., 2021](#)). These changes in water quality not only affect ecosystems but also have consequences for nearby human communities that rely on rivers for drinking water, agriculture, and recreation.

## **Social and Economic Impact**

The social and economic impacts of hydropower projects are often as significant as their environmental effects. Dam construction frequently forces the relocation of entire communities, disrupting their way of life and economic activities. The loss of homes, farms, and cultural sites can lead to long-term social and economic instability for affected populations.

Hydropower also regulates water flow, which can affect water availability in downstream areas, particularly during drought periods. This can have a direct impact on agriculture and water supply, intensifying competition for limited resources and leading to conflicts between communities, industries, and governments.

## **Why Focus on Hydropower's Impact on Waterways?**

Understanding the impact of hydropower on waterways is essential for achieving sustainable development. Rivers are not just sources of water and energy; they are lifelines for ecosystems and human communities alike. When hydropower projects are poorly planned or managed, they can cause irreparable damage to these vital resources. However, by applying scientific planning and innovative measures, we can mitigate the negative impacts of hydropower development and maintain the balance and [health of ecosystems](#). Ensuring sustainable energy

production while protecting [water resources](#) is a key challenge for future [hydropower](#) projects.

To align with thriving, hydropower projects must incorporate innovative solutions, such as flow restoration strategies, that maintain dynamic river systems while supporting energy production. Hydropower projects often disrupt local communities, but adopting a [thrivable perspective](#) ensures that social capital is not sacrificed for economic gain. By integrating community engagement and equitable resource management into project planning, hydropower can foster thriving communities while delivering clean energy.

## **Link to the United Nations Sustainable Development Goals (SDGs)**

Hydropower plays an important role in meeting several of the United Nations Sustainable Development Goals (SDGs), but it must be managed carefully to ensure that its environmental and social impacts do not undermine these objectives.

### **SDG6: Clean Water and Sanitation**

Hydropower projects must ensure that water quality is preserved, and ecosystems are protected, so that [clean and safe water](#) remain available for all. This involves preventing [waterway pollution](#) and managing sediment transport to avoid ecological degradation.

### **SDG7: Affordable and Clean Energy**

As a [renewable energy](#) source, hydropower provides clean, reliable, and affordable electricity. However, to truly contribute to [sustainability](#), hydropower must balance its ecological impacts on waterways with its role in reducing reliance on fossil fuels.

### **SDG13: Climate Action**

Hydropower helps mitigate [climate change](#) by providing low-carbon energy, but it is essential to ensure that these projects do not cause undue harm to the



ecosystems they depend on. Protecting natural ecosystems while reducing emissions is critical for long-term climate resilience.

## **SDG15: Life on Land**

Hydropower development must take into account the preservation of [biodiversity](#) and ecosystems. By implementing measures that protect terrestrial and aquatic species, we can reduce the negative impacts of dam construction and operation on surrounding environments.

## **SDG17: Partnerships for the Goals**

Achieving sustainable hydropower development requires collaboration among governments, businesses, communities, and environmental groups. Through [partnerships](#), we can develop strategies that minimise ecological damage while maximising the benefits of renewable energy.

# **A Thrivable Framework for Hydropower**

To ensure that hydropower development contributes to a sustainable and thriving future, the THRIVE Framework offers a comprehensive approach:

[Materiality](#): Understanding the impacts of hydropower on waterway health under the certain context is essential for ensuring the sustainable use and protection of water resources and ecosystems.

[Systems Thinking](#): Applying systems thinking allows us to see the broader picture of how hydropower affects everything from water resource management to community livelihoods and biodiversity.

[Strong Sustainability](#): Hydropower projects must go beyond reducing harm and instead aim to maintain or enhance the health of water ecosystems. This ensures that natural capital is preserved for future generations.

[Regenerative Economy](#): A regenerative approach to hydropower development involves promoting ecosystem restoration alongside energy production. By protecting waterways, we can create a future where energy generation and ecological health go hand in hand.

[Multi-Capital](#): Hydropower projects must assess their impact not only on natural capital (waterway ecosystems) but also on social capital (community well-being) and economic capital (clean energy supply). Balancing these different forms of capital is key to achieving sustainable outcomes.

At [THRIVE](#), our mission is to go beyond sustainability and foster thriving, where both human societies and natural systems can flourish together. To learn more about how THRIVE supports innovative solutions in renewable energy and ecosystem protection, visit our [blogs](#), subscribe to our [newsletter](#), and join our live [webinars](#). Stay connected with our blog and [podcast](#) series for insights into building a future that truly thrives.