Reforming Hydroelectric Power Infrastructure to Promote Ecological Preservation

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The ancient Greeks were one of the first civilizations to use water as a source of energy, using an early form of the water wheel. Since the time of the ancient Greeks, a world leaning more toward renewable energy sources has rediscovered the efficiency, productivity, and sustainability of hydropower; however, only 3% of the U.S' 80,000 dams actually produce energy. Most dams are used for irrigation purposes and shipping and navigation services. (1) While renewable energy sources, such as hydropower, are more environmentally friendly than traditional extractive sources, they are not necessarily more ecosystem friendly than that of coal or natural gas, for example. The scientific journal 'Nature' mapped 12 million kilometers of rivers globally and concluded that only 37% of rivers longer than 1,000 kilometers remain free-flowing over their entire length. (2) Dams were the leading cause of river disruption. The infrastructure that is required to support a dam does support green energy initiatives, but dams simultaneously degrade the surrounding ecosystem, which is why creating measures that stabilize or remove hydropower production and protect ecosystems is imperative.

Across the world freshwater fish species have experienced an 83% decline in population since 1970. (3) This decrease is mainly attributed to dams causing aquatic ecosystems to be broken up and preventing fish migration, which negatively impacts millions of people who depend on freshwater fish for both food and the fishing industry for income. (4) The Yangtze River was home to the now extinct Chinese paddlefish. Dams along the river significantly contributed to the species extinction. Similarly, dams in North America essentially erased the salmonid population. (5) Dams are not only detrimental to the aquatic ecosystem, but also to the surrounding terrestrial wildlife. For instance, the construction of energy producing dams in the jaguar-populated Neotropics and tiger-populated Paleotropics, have led to a population decrease

in both of these species. Flooding destroyed terrestrial habitats and led to declines in local density rates. Because these mammals are apex predators, they have low population rates and require large amounts of land, therefore these species are more vulnerable to habitat loss. (6) Additionally, the Balbina Dam in northern Brazil has caused irreparable damage to the local ecosystem. Flooding from the dam created an artificial archipelago within the Amazon Rainforest. Approximately 3,546 islands now exist where a once continuous forest stood. This ecological reshaping led to a mass decline in the vertebrate population. (7) When dams cause flooding, such as in northern Brazil, the direct effect is the loss of biodiversity.

Hydropower technologies are effective in producing green energy; however, the efficacy of these dams relies heavily on the topography of the dam's location. For example, rivers in Colorado are on steeper slopes, so there is no need for large dams. In contrast, the Balbina Dam is located on low ground, so raising the water level needed to provide the energy-producing cascades requires extensive infrastructure. (8) Provided, understanding that flooding created by dams gets more significant as the surrounding land gets flatter, ecosystems on low land (near dams) are more at risk of destruction.

In 2016, 71% of the world's renewable energy was produced by hydroelectric power. The market for dams has shifted largely from first world countries to developing countries. In 2018, an estimated 3,700 dams in the developing world were in various construction periods. (9) Some of the largest hydropower dams are built on the Amazon River Basin in Brazil, the Congo River Basin in western Africa, and the Mekong River Basin in Cambodia. (10) These developing areas are also susceptible to major climate changes, effects of which include extreme droughts and floods, because they all lie below the equator. When either of these events occur, a dam's ability to generate electricity is significantly weakened, because the system is either under or

overwhelmed, which weakens the overall efficiency of large dams, and reinforces the potential advantages of switching from hydropower to other forms of green energy. (11) It should be noted, in the context of eco-social justice, it might not be viable for a developing country to make this switch because of expenses. The initiative to make this change should rest largely on the shoulders of first world countries who have already benefited from destructive practices.

While the effects of large dams seem more significant, the impact of smaller reservoirs on proportionally smaller ecosystems is just as important. A study conducted on the effect of hydroelectric power (HEP) on ecosystems of small freshwater animals (macroinvertebrates) located in England and Wales found a "statistically significant reduction in the proportion of invertebrates of different families… after HEP [plants] were built", (12) which demonstrates small ecosystems are still negatively impacted by the effects of dams. In addition, smaller dams' impacts on the environment are equal to their larger counterparts. Effects of dams alter key aspects of river ecosystems such as the aforementioned reduction and extinction of various fish species, flooding, biodiversity loss, and terrestrial habitat loss, in addition to the changing of flow regimes, channel shape, water temperature, and sediment transport. The magnitude of these effects is likely to depend on watershed and surrounding land characteristics, but the size of a dam does not matter in regards to the harmful effects the dam creates. (13)

Despite these consequences, there are multiple solutions to help protect a river's fragile ecosystem from a dam's harmful effects. One way to assess these solutions is to use the index mortality rate of fish, to establish where they are most impacted by dams and then introducing regulations that protect fish populations. Decreasing this index for a river can be accomplished by addressing problems caused by the generating turbines of hydroelectric dams. First, protecting fish from the turbines of dams would have a significant positive impact on this index. A study

done in Germany found multiple solutions to making turbines safer for fish to swim through. These methods included using racks of curved bars and electric anodes which both direct fish away from the center of the turbine. If implemented, these solutions would be successful because they rely on working with natural fish behaviors. (14)

Second, many fish migrate during their life. For anadromous fish, like salmon, migrating downstream happens early in life, and migrating upstream to spawning areas occurs during adult life. The opposite is true for catadromous fish, like eels, who eventually go to the sea to spawn. Dams severely limit fish migration by creating an obstacle in the river. A remedy to the barrier would be to implement fish ladders to provide a detour route for fish so they do not have to swim through the turbines in the first place. Fish ladders work essentially the same as wildlife overpasses: Both intend to protect animals by creating animal-only routes over possibly dangerous human infrastructure. These structures work by connecting a system of pools that fish jump through until they reach the other side of the dam. (15) Ladders provide an alternative path for fish to thrive, therefore creating a commensalism relationship where humans benefit from the energy produced by dams, and fish carry on with their natural life processes without interruption. These processes include migrating to reproduce. The reproduction of fish is important because spawning stabilizes the population and gives both marine and terrestrial predators a consistent food source; therefore, the local food chain remains intact and preserves the ecosystem the chain lies in.

Third, making small changes to a dam itself and the surrounding river can be effective in preserving an ecosystem. The Hydropower Reform Coalition recommends that dam operators stabilize lake levels, water temperature, and oxygen levels to both protect river banks from erosion, and improve water quality. Furthermore, replacing outdated equipment can protect

marine life while simultaneously generating more electricity by using less water. (16) These small tweaks are cost-efficient but also have a positive impact on the surrounding ecosystem. Terrestrial animals who live on river banks will not face habitual loss due to erosion, and aquatic life populations will not decrease because the water is cleaner and dam technologies are safer.

Finally, the most practical solution to preserve river ecosystems is removing dams and replacing their energy output with other renewable sources such as wind and/or solar power, which have a relatively lower ecological impact. Solar panel and wind turbine prices have decreased since being introduced to the international market, and will continue to do so because of their growing economic viability. Meanwhile, aging infrastructure, exorbitant costs, and biological dangers associated with dams will continue to persist, even if all of the aforementioned measures are implemented. Hydroelectric dams very rarely maximize their full potential, and they continue to be a destructive force in the ecosystem they are put in. As our global society becomes more conscious of our collective human impact on the environment, the most reasonable conclusion is that hydroelectric infrastructure should be removed to preserve ecosystems across the world.

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