QnAs with Emilio F. Moran

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Globally, hydropower provided 71% of renewable energy in 2016 (1). In the United States, however, large hydropower dams fell out of favor in the 1970s (2). Emilio F. Moran, an environmental social scientist at Michigan State University, has explored the reasons for this shift and future outlook for hydropower. Elected to the National Academy of Sciences in 2010, Moran has spent his career at the crossroads of natural and social sciences, examining the relationships between humans and the environment. In his Inaugural Article (3), Moran et al. discuss the environmental, social, and political impacts of large hydropower dams, the construction of which is on the rise in developing countries, and propose more sustainable alternatives.

PNAS: You argue that building large, hydropower dams in the developing world is detrimental. Why?

Moran: Large hydroelectric dams are not sustainable for the long term, first of all, because they have a fixed lifespan, estimated to be 50 years. A second problem in dams' nonsustainability is that they don't produce as much energy because there's less water volume and less energy stored in the reservoir as it fills up with sediment.

The biggest problem that stopped big dams in North America and Europe was the recognition that they had huge environmental negative outcomes for biodiversity and the ecology of our rivers. Diversity declines because only a few fish species are able to adapt to the conditions created by a dammed river. In North America and Europe, that's bad enough, but when you go to the tropics, you can have 500–2,000 fish species that will be affected.

A lot of people are forcibly resettled by large dams, and they almost never end up with the equal or better life that they were promised when the dam's benefits were explained to them. Compensation for people downstream from a dam is almost never provided, and those upstream suffer social, cultural, and economic losses that are also rarely compensated or even taken into account.

PNAS: In addition to other environmental effects, like deforestation and disruption of the river ecosystem,

you note that dams release greenhouse gases. Can you explain?

Moran: The greenhouse gases come from decomposition in the reservoir. There is a lot of CO₂ and methane emitted after a dam is built. Especially in tropical areas, there is a poor record of removing the tree biomass in the reservoir area, so they largely get left there, the area gets flooded, and there is a very slow decay of this organic material resulting in emissions.

PNAS: So large dams contribute to climate change. What effect does climate change have on dams?

Moran: If you have declining rainfall, as is predicted and already occurring in many areas of the tropics, then the promised amount of energy that was going to be produced to justify the dam turns out to be a huge and costly miscalculation. The ones I've been studying in the Amazon are producing, even within 4–5 years of completion, 60% or less of what was promised when they were approved, and that's only going to get worse with continuing climate change. If large dams are to be built, there's a need to be more transparent about the real costs and benefits, because there is a tendency to overestimate the benefits and underestimate the costs in hydropower development.

PNAS: A global analysis of 245 large dams built between 1934 and 2007 found that actual costs averaged 96% higher than predicted costs (4). Why?

Moran: There is quite a bit of corruption that accounts at least in part for this inflation of costs, and government approvals [are obtained] on the promise of all that energy for economic development. Civil society

Emilio F. Moran. Image courtesy of the Trustees of Indiana University.

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and the people affected by dams are rarely consulted adequately. Large infrastructure projects seem susceptible to influence buying and to the ills we know are associated with crony capitalism.

PNAS: What does sustainable hydropower look like?

Moran: We are working on rethinking the entire hydropower industry. I tell our engineering team that the turbine design has to have one, fundamental requirement: You must make a turbine that will not harm fish and biodiversity, that this is just as important as energy production. I think it is possible to do both, but it requires thinking about both from the start. This is a new approach to engineering design.

In our paper (3), we suggest that if you are going to have hydropower that is sustainable, you need to move in a different direction from building large dams. You need to produce hydropower with small turbines in the river to provide energy to local

communities, which, by the way, are currently bypassed by large hydro projects. Microhydropower is an effort to produce smaller amounts of energy without blocking the river.

We're going to try and have a prototype ready in a couple of years. The goal is not to get the most efficient turbine in the world but one that makes a sustainable contribution to the food, water, and energy needs of local communities. There are social and ecological requirements that must inform the design. We think of this as a new engineering for the 21st century.

I think it's a very exciting area to rethink the entire energy matrix and how to reconceive it and reduce the vulnerability of the system. Dependence on hydropower makes countries' energy vulnerable to climate change. Decentralized energy makes it easier to address vulnerability if it's not on the scale of a whole country. Small hydro has a role to play, along with solar, wind, and others, in meeting the needs of all citizens.

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- 1 Rex W, Foster V, Lyon K, Bucknall J, Liden R (2014) Supporting hydropower: An overview of the World Bank Group's engagement. *Live Wire* 2014/36 (World Bank Group, Washington, DC).
 - 2 O'Connor JE, Duda JJ, Grant GE (2015) Ecology. 1000 dams down and counting. *Science* 348:496–497.
 - 3 Moran EF, Lopez MC, Moore N, Müller N, Hyndman DW (2018) Sustainable hydropower in the 21st century. *Proc Natl Acad Sci USA* 115:11891–11898.
 - 4 Latrubesse EM, et al. (2017) Damming the rivers of the Amazon basin. *Nature* 546:363–369.