

# Riverscope

A new geospatial tool for investors,  
policy makers, and developers to  
assess hydropower projects

## General Summary

TMP Systems | August 2021



INTERNATIONAL  
**RIVERS**  
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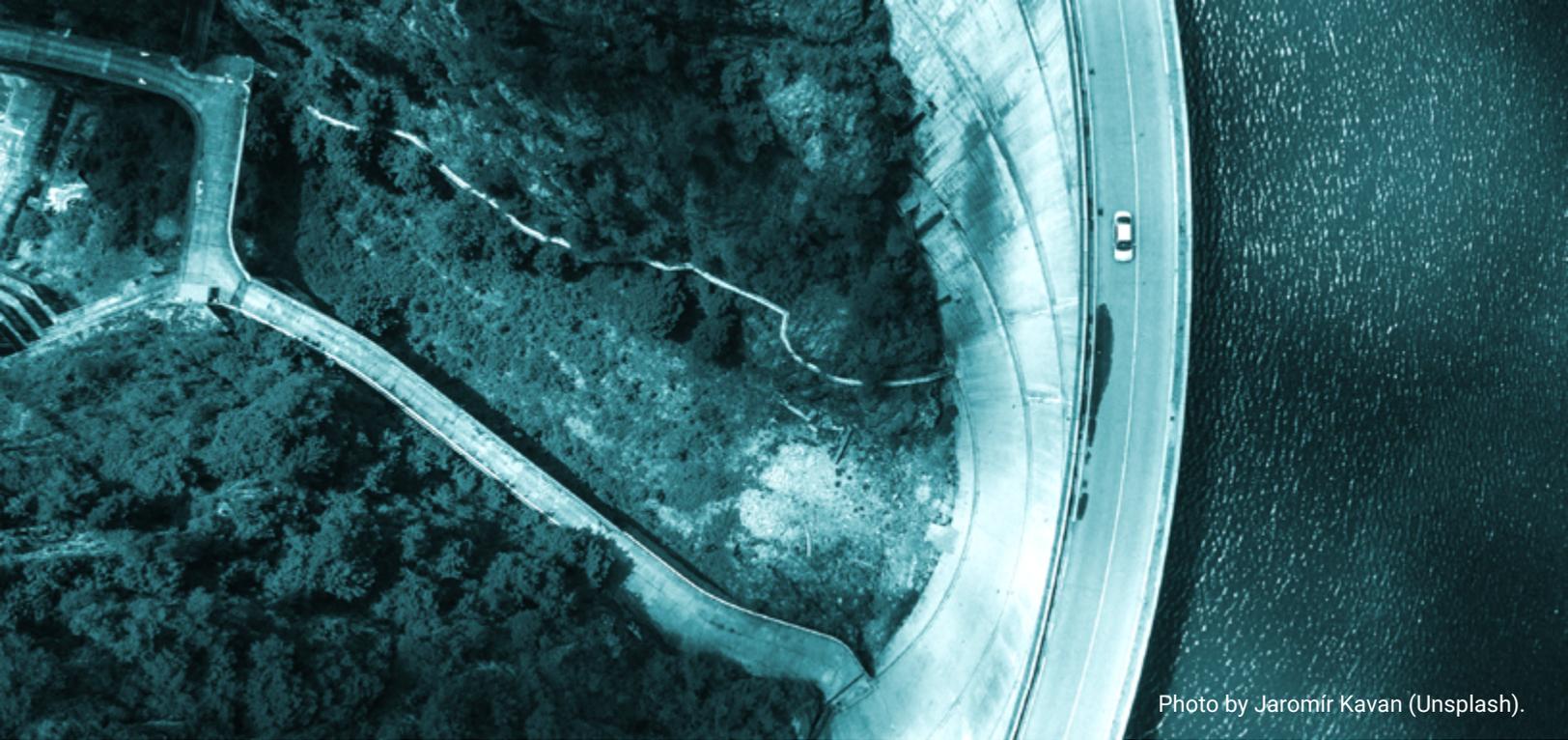


Photo by Jaromír Kavan (Unsplash).

## 1. OVERVIEW & BACKGROUND

The electricity produced by large-scale hydropower is expensive in commercial, social, and environmental terms. Dams have significant and irreversible impacts on societies and ecosystems while being exposed to huge operational and financial risks. Yet the way that these projects are assessed systematically underestimates these impacts and risks, meaning that investors, developers, and regulators often make the wrong decisions based on incomplete information.

This document summarizes pilot applications of “Riverscope”, an assessment tool that offers a new way to assess large dams.

So far, a proper assessment of the risks for five pilot cases has found that:

- **Social and environmental challenges** contribute to an average Net Present Value (NPV)<sup>1</sup> of -40% across the five pilots, which should remove rationale for private investment.
- Large dams **regularly face long delays** of between 4 to 10 years, which creates difficulties for energy planning as well as investment.
- **Hydropower is often more expensive** than solar and wind. For example, one of the pilot dams is likely to be 77% more expensive than solar.

- **Local socio-economic impacts are severe** and on average, we found 52,755 people<sup>2</sup> would be locally affected and possibly displaced, with millions affected by cumulative impacts.

Social and environmental risks in the hydropower sector are necessarily commercially significant because they are so large. They can be managed, at substantial cost, but not completely avoided and they can be ignored or underplayed, which normally leads to even more serious problems for the project. Current assessment processes fail to adequately recognize the scale or complexity of these risks and so we typically see budget overruns and long delays. This is because these substantial additional costs and unanticipated disruptions, which are entirely predictable, have not been factored in.

Riverscope uses a combination of geospatial analysis, expert investigation, and financial modelling to produce a multidimensional assessment of hydropower projects (see below for further detail of our methodology). Riverscope is unique in that it presents a commercial comparison between hydropower, solar and wind, alongside a rapid but wide-reaching environmental and social risk analysis. As such, it provides relevant information and analysis for governments, investors, and the third sector.

Over the last year, TMP implemented Riverscope on five planned hydropower projects<sup>3</sup> (see map below). For every project, the business case for hydropower investment was extremely weak, due in part to elevated social and environmental risks. These projects are each quite complex and, partly as a result, they have been slow and expensive to implement. In all cases, delays are already measured in years but may easily reach into decades. These long timelines have been extended even further by COVID-19 disruptions.

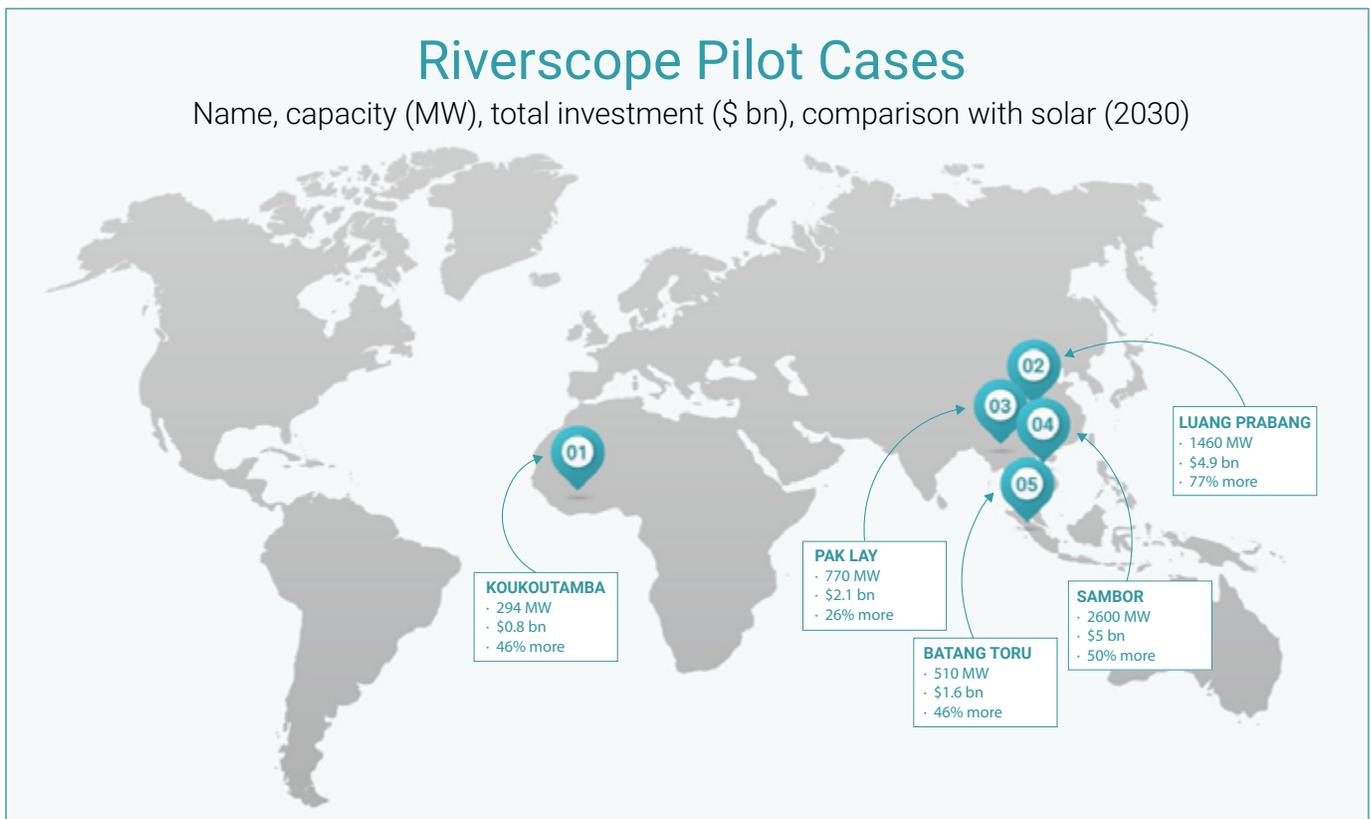
By the time these dams reach operation and eventual cashflow, they are competing in a very different energy market than had been expected many years prior. Current assessment processes have largely overlooked this serious financial risk. Today, solar and wind are becoming cheaper and more flexible as hydropower is becoming more complex and expensive. Meanwhile demand projections are wavering, particularly in the wake of the pandemic and, in the face of such uncertainty, it is vital that large hydropower assessment processes improve.

The Riverscope pilot presents assessments that together call into question the role of large hydropower in current and future energy planning.

These assessments suggest that hydropower has been systematically misunderstood by formal assessment processes. Attempts to manage social and environmental risks appear to be insufficient and fail to prevent significant adverse impacts.

The Riverscope pilots also demonstrate serious risks at a national or even regional level that have been underplayed because most assessments do not pay sufficient attention to the cumulative impacts of several dams developed within a single river system. As a result, hydropower development in places like the Mekong threatens food, water, and energy security across continental Southeast Asia, to point to just one example.

To date, governments and investors have been misled about the costs and benefits of large hydropower projects, leading to bad decisions. Riverscope provides a transparent and practical means for stakeholders to re-evaluate these decisions and to make better ones in the future. Energy developers, planners, and financiers can avoid wasted time, cost overruns and reputational issues, and instead focus on projects with the strongest business case and with much lower environmental and social risks.



## 1.1 THE RIVERSCOPE METHODOLOGY

Riverscope delivers a comprehensive, data-driven and repeatable assessment of social, environmental, and commercial risks by an expert third party that can be applied at any stage in a dam's development. The basis of the methodology is quantitative and built on the same foundations as a tool that TMP developed called [Landscape](#).<sup>4</sup> Any shortcomings in quantitative assessment are then addressed in a second, qualitative investigation. The full methodology is available at [www.riverscope.org](http://www.riverscope.org).

The quantitative assessment scores each hydropower project against a set of social and environmental indicators that are statistically correlated with common ESG issues in the hydropower sector. We established this set of 17 indicators by thoroughly analyzing 91 cases with reported problems and comparing them to 190 cases where we did not find reported problems.

Riverscope then uses previous analysis of delays in hydropower to estimate, at any given level of risk, how long the delay might be if there were problems. The final quantitative step involves converting these projected delays into financial terms. We use a bespoke discounted cashflow model to show how slippage reduces the Net Present Value (NPV) and so increases the likely Levelized Cost of Electricity (LCOE). Hydropower can be reasonably compared with alternatives like solar and wind based on these metrics.

This quantitative approach delivers an assessment that balances social, environmental, and commercial considerations. But it can be further improved with the application of qualitative investigation and analysis. This can help us to understand the trade-offs that hydropower offers for challenges like food security, involuntary resettlement and biodiversity. It can also help us to confirm all-important delay projections and provide further evidence for why some projects may experience very significant delays.

## 2. CASE STUDIES

### 2.1 OVERVIEW

So far, we have applied Riverscope to five projects (see map on page 3) which share some characteristics that are typical in the sector: these are large projects (on average \$3 billion investments) with substantial social and environmental risks; they are all dependent on concessional finance; they all face uncertain offtake arrangements; and they are all planned in locations where the negative impacts of hydropower projects are already significant.

We also needed some variety to test Riverscope's flexibility. Some of our cases have attracted some interest from private investors (Luang Prabang, Pak Lay) while others are purely public players; some have the full support of government (Luang Prabang, Pak Lay, Koukoutamba) while others are more controversial (Sambor, Batang Toru); finally, most intend to export their energy, but some are focused on domestic offtakers and markets (Batang Toru).

Through Riverscope, we have been able to analyse and quantify the costs and benefits of hydropower projects. These cases demonstrate some common features of large hydropower projects:

1. Large dams are often poor investments from a commercial perspective. All of the cases will be severely delayed, and, in all cases, they will be more expensive than solar by the date of expected operation (by 49% on average). The five cases are likely to be delayed by 2-4 years and we would expect them to reach the market between 2027-2039, perhaps considerably later.<sup>5</sup>
2. Large dams have serious negative socio-economic impacts for those living near or downstream from them. On average, we found 52,755 people would be directly affected.<sup>6</sup> But in many instances, indirect social impacts are far-reaching. For example, in the Mekong, dams threaten regional food security and stability through their impact on fisheries and some of the region's most productive agricultural lands.



Nam Theun 1 dam under construction, Laos.  
Photo by Shutterstock.

3. For each project we examined, hydropower threatened biodiversity and the local environment. Individual projects can represent extinction level events for some species. The five cases we looked at could lead to the extinction of species such as the Tapanuli orangutan and giant catfish, among others. These costs appear unacceptably high.
4. Tropical dams either drive climate change (catchment)<sup>7</sup> or are highly exposed to changing water regimes (run-of-river). Many schemes are now run-of-river and will be less productive because of climate impacts. Their capacity factors are uncertain and likely lower than stated, while many will not operate year-round.

Projects that have to negotiate this kind of opposition and complexity are often so severely delayed that, by the time they come online, the market in which they are competing will have changed dramatically in ways that are nearly impossible to predict over these sorts of timeframes. Major disruptions such as the COVID-19 pandemic and extreme weather events have made accurate projections even more difficult. The cases also show that alternatives like solar and wind regularly offer a cheaper way to deliver better local impact while driving more rapid and robust economic growth at a macro scale.

## 2.2 KEY FINDINGS

The rest of this section is split over three parts: first, we describe our key commercial findings before moving on to our conclusions about the social and environmental risks associated with dams. Finally, we provide some insights into our comparison with alternative technologies. Overall, our analysis suggests that alternatives are preferable for every major stakeholder group: government, investors, local people and NGOs.

### 2.2.1 COMMERCIAL FINDINGS

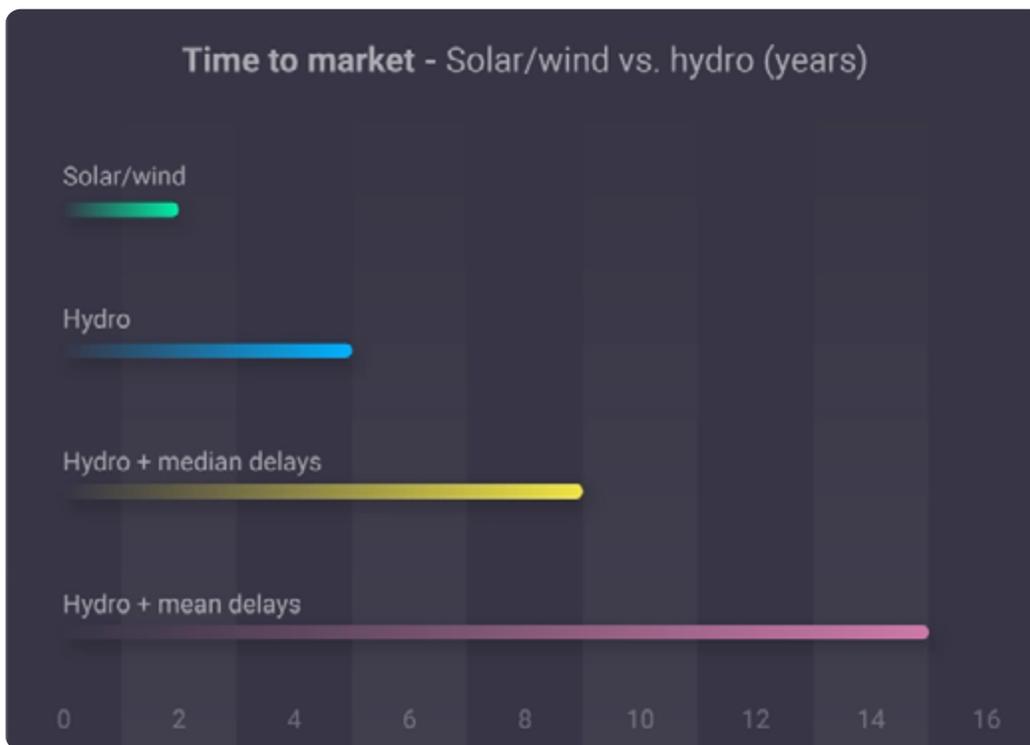
Projects that are delayed by years or decades will struggle to turn a profit. Each hydropower project is, essentially, different, with its own complexities and challenges. Some of these challenges can be avoided, others mitigated, but all of this takes time and money which together reduce the overall value of the project. As a result, the electricity that would be produced by our five pilot dams would be relatively expensive, should they become operational. Finally, such large capacity additions may be hard for energy planners in the context of soft and uncertain demand in the wake of COVID-19.

#### DELAYS, SLIPPAGE AND FALLING VALUE (NPV)

Across the 49 cases we examined in the development of Riverscope,<sup>8</sup> the median delay was

4 years, but this masks the fact that some dams experience very long delays, making the mean delay over 10 years. Across the five pilot cases we looked at, we modelled likely delays of between 2-3 years—less than these averages. But we also found that delays could reach into decades, on top of already lengthy planning and construction processes. By contrast, alternatives like solar and onshore wind

investors would be likely to lose money. Most investors will avoid a neutral NPV, but we found an average NPV of -40% across our five pilots. In the most extreme cases and circumstances, NPV could be -195%.<sup>11</sup> In short, the commercial cases for our pilots were extremely weak because inherently complex projects lead to almost inevitable and long delays.



Graph 1. Created by TMP Public

can take just two years to reach the market (i.e. planning, development and construction), as shown in the graph 1.<sup>9</sup>

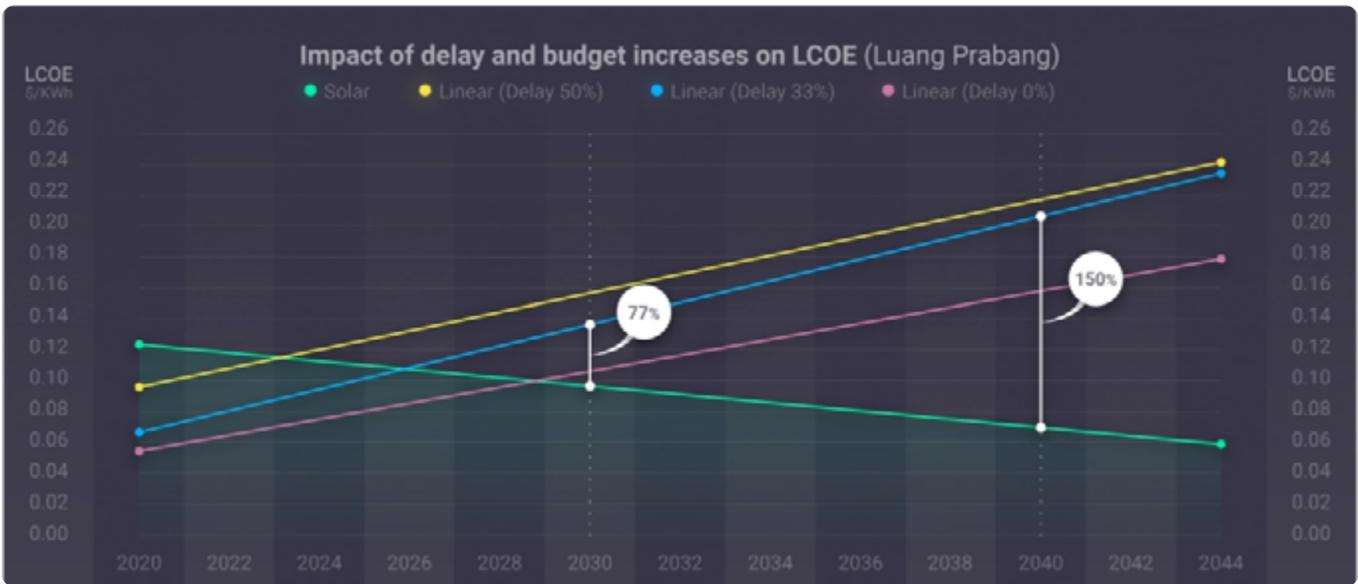
Since our case studies are all in planning or very early construction phases, it was not possible for us to establish whether these delays led to significant increases in budget. Relying on previous research, we found that, on average, hydropower projects in emerging markets come in around 33% over budget.<sup>10</sup> This figure appears conservative based on our investigations of historical cases but is useful for the purpose of financial modelling.

We used a discounted cashflow model (DCF) to establish the impact that these delays and budget increases might have on our pilot cases. In every instance, our modelling showed that the project had a negative Net Present Value (NPV), meaning

## THE COST OF ELECTRICITY AND STRENGTH OF DEMAND

Dams might make sense, despite their environmental and social costs, if they can produce urgently needed and cheap electricity. But in fact, our analysis shows that hydroelectricity is likely to be much more expensive than alternatives and that, in many cases, the energy they deliver may not be needed. On average, we found that our pilots would be 49% more expensive than solar at the time that electricity is first delivered to offtakers, but in some cases this rose to as much as 77% more (see graph 2 overleaf). We got similar results in our comparison with wind.

This may come as a surprise because hydropower is, at present, often a cheaper option. However, this is based on a weak and incomplete assessment



Graph 2: Created by TMP Public

of hydropower which fails to recognize the rate at which solar and wind are becoming cheaper, while in fact hydropower is becoming ever-more expensive.<sup>12</sup> Graph 2 above plots out some of the results for our cases to demonstrate that this trend will only become stronger over time. It takes so long for dams to get to market that the market has fundamentally changed by the time they enter.

Changes in expected energy demand underline the problem as clearly as rising costs and falling project values. Even before the pandemic, some of the projects we examined targeted energy markets that did not really exist.<sup>13</sup> COVID-19 has led to significant reductions in the energy that will be needed and has injected further uncertainty into electricity markets. These changes in forecasted demand reduces the need for each of the projects we examined, as well as increasing the risks for them.

In the context of such uncertainty, most energy planners would prefer a gradual rollout of smaller capacity additions linked to certain increases in demand, rather than a large addition at some uncertain but quite distant point in the future. Alternatives like solar and wind offer such incremental supply options, which would also help them to avoid long and expensive transmission lines that are exposed to similar delay risks and reputational problems as the dams themselves (see next section).

## 2.2.2 ENVIRONMENTAL AND SOCIAL FINDINGS

Riverscope shows that social and environmental risks weaken the commercial case for hydropower. Where project stakeholders attempt to minimise added costs and time spent on high social and environmental standards, the resulting project impacts are often severe enough to provoke opposition, which contribute to delays from which hydropower projects regularly suffer. Even with these measures, our analysis found that social and environmental impacts across our five cases were severe and often overwhelmingly negative.

Given the severity of these adverse impacts, it is important to question the role of public finance from concessional sources in hydropower. Dams are typically heavily dependent on such capital since they require large sums over long periods for, as we have seen, little to no return. But, like government support for hydropower over alternative technologies, this preference for hydropower seems to ignore the public goods argument laid out across this section.

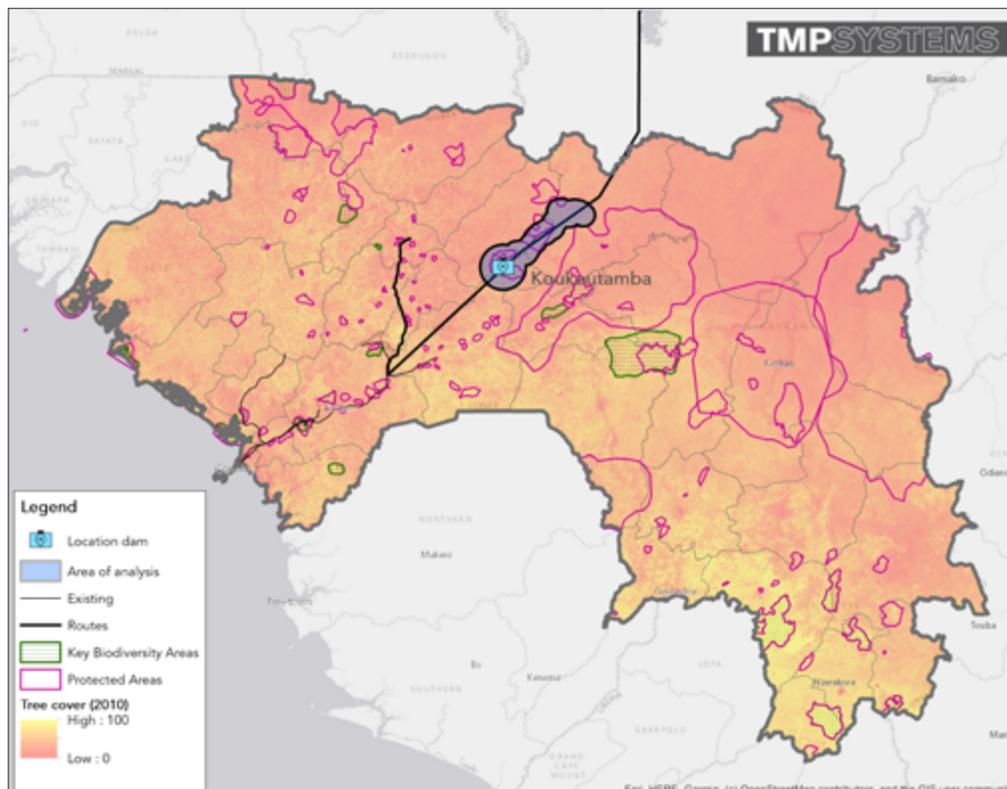
## BIODIVERSITY

Large dams, even with mitigation measures, routinely prompt significant declines in local biodiversity by driving large-scale land use change, opening remote areas to predatory activities like poaching and logging, and devastating aquatic ecosystems and migratory species. Single dams can alone be disastrous, yet these impacts are compounded with every additional project. Such cumulative impacts can rapidly reach the macro-level, which is particularly severe for aquatic biodiversity: by 2040, tributary and particularly mainstream dams along the Mekong will disrupt migration routes of 30-40% of fish species found in the river, with an estimated 40-80% loss of total biomass.<sup>14</sup> The fish passages installed for these dams are known to be ineffective, with less than a 55% survival rate.<sup>15</sup>

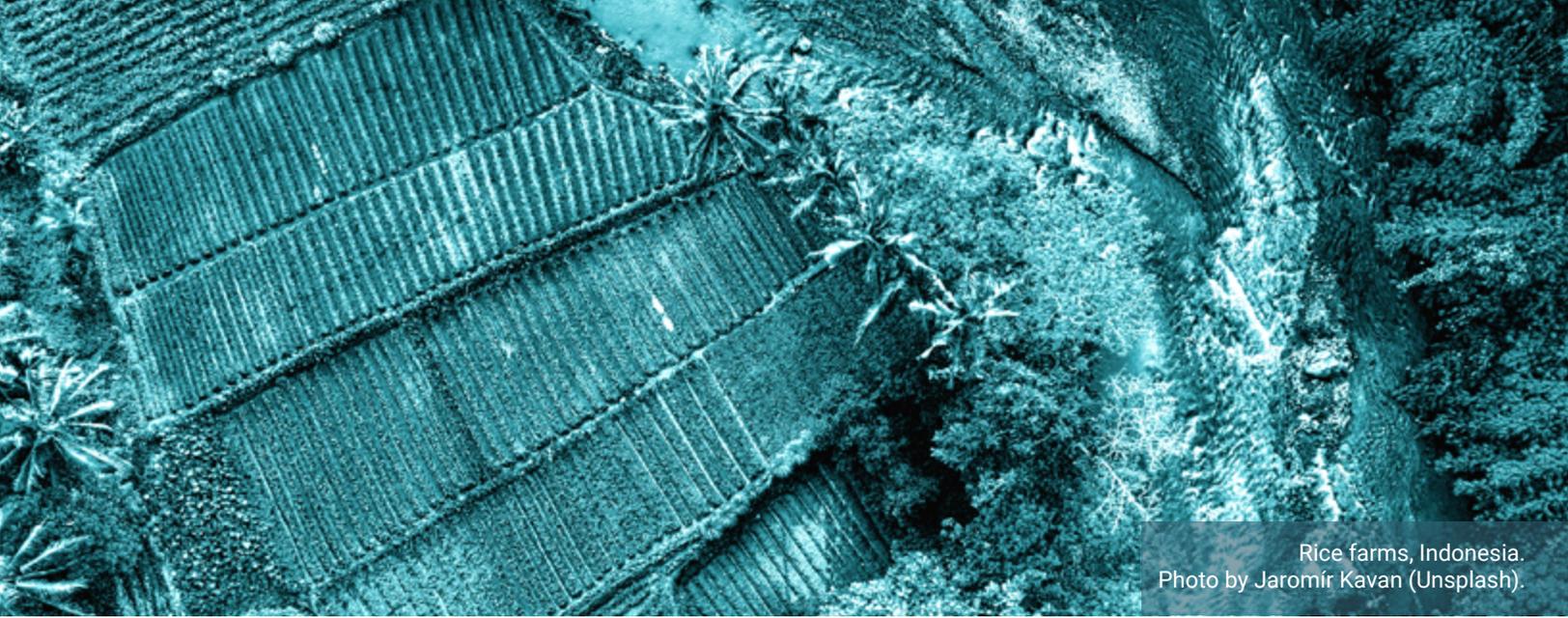
Koukoutamba and Batang Toru illustrate another type of biodiversity impact: in very remote locations, presumably chosen to keep displacement low (see later subsection), there is a high chance that dams will impact threatened and already marginalized

species. The graphic below shows how these local threats are also often compounded by the need to develop hundreds of kilometres of transmission lines in similarly sensitive areas (which also drives further displacement, and potentially, conflict). In the case of Batang Toru, this would result in an extinction level threat to the Tapanuli orangutan, while Koukoutamba would lead to a considerable decline in the critically endangered Western Chimpanzee population.

From the perspective of project backers, these environmental risks are particularly problematic because they can stir local and international opposition to large dams and associated transmission infrastructure. In the case of Batang Toru, for example, the Bank of China withdrew financial support in light of advocacy against the project's biodiversity impacts and COVID-19. At a local level, communities increasingly recognize that biodiversity impacts can affect food security, ecotourism opportunities and traditional livelihoods. In this way, social and environmental risks for dams are becoming inextricable.



Map created by TMP Public



Rice farms, Indonesia.  
Photo by Jaromír Kavan (Unsplash).

## FOOD, ENERGY AND WATER SECURITY

Large dams alter water systems, even where they are “run-of-river” designs or when they operate on a seasonal basis to protect traditional and variable flow regimes. Across the cases we examined, we could see that large dams offer greater risk than benefit for water management and are likely to be highly exposed to the impacts of climate change on water regimes. More plainly, in most cases we expect hydropower to be both exposed to increasing risk of drought and climate uncertainty, while it may also compound the impact of droughts and water shortages downstream.

For countries that are heavily dependent on hydropower, changing water regimes and the unpredictable nature of cumulative hydropower impacts create real threats for energy security. This is apparent in Southeast Asia and in our Mekong cases. But there are also plenty of precedents from Latin America (particularly Brazil), Southern Africa and South Asia. Unfortunately, these drops in energy production from hydropower generally come when the energy is needed most.

The most severe impact on the food-energy-water (FEW) nexus may, however, be on food security and nutrition. Hydropower directly threatens the health of freshwater fisheries as well as surrounding croplands. The Mekong provides a striking example: the cases we look at could jeopardize the food security for the estimated 65 million people living in the Lower Mekong Basin.<sup>16</sup> Again, this reflects the way in which environmental impacts of hydropower can be directly linked to social issues.

## DISPLACEMENT

Large hydropower typically involves extensive displacement of local communities. Tens of thousands of people are expected to be physically displaced across the 5 cases, with Sambor alone estimated to displace almost 20,000 people. An even larger number will be economically displaced or at least severely affected. Our rapid geospatial analysis suggests as many as 706,193 people in total will be affected across the cases, with an average of 141,238.<sup>17</sup>

Forced displacement with inadequate support—which is the rule rather than the exception in emerging markets—creates severe and enduring socio-economic and cultural problems, including increased conflict. Research shows that 46% of disputes over investments in emerging markets are driven by displacement.<sup>18</sup> Uprooted communities are often moved away from established croplands and traditional lands, which directly threatens their livelihoods and cultures.

In short, hydropower projects are closely linked to the impoverishment of local communities, a scenario that is proven nearly impossible to avoid in project design. These human rights violations can drive and consolidate local and international opposition to dams, which in turn makes them harder and more expensive to design and operate. These concerns should certainly disqualify most projects from access to public finance.

Along with other severe social and environmental impacts, displacement should make hydropower

unattractive to a wide variety of stakeholders, who will generally see better outcomes from alternative energy options.

### 2.2.3 COMPARISON WITH SOLAR AND WIND

Riverscope found, across all five cases, that there were commercially viable alternatives to hydropower that delivered greater benefit with much lower negative impacts. According to our analysis, these alternatives should be preferable to all key stakeholders: government, investors, local people, NGOs, and offtakers. For our analysis we only looked in detail at solar and wind; however, different places are best served by different and often distinctive combinations of technologies.

As demonstrated above, solar and wind will be cheaper than hydropower projects that are currently in the planning phases, often by a very considerable margin. Lower capital expenditure requirements, greater flexibility and high rates of return make these alternatives attractive for private investors, which increases the speed and efficiency of energy rollout while freeing up public finance for more urgent development needs. This energy will come to the market sooner, in a much more predictable fashion and at a much lower rate, which also makes these technologies attractive to offtakers.

The common refrain for solar and wind is that variable energy sources create problems. Most planned hydropower projects are variable, however, and, in most instances, storage could be procured for solar or wind to make them more consistent than hydropower at a lower price. In addition, most new dams require long and challenging transmission lines that drive up costs and risk exposure. Energy planners may also struggle with large hydropower

because it promises a huge injection of capacity at some quite uncertain point in the medium-term. In contrast, solar and wind can be developed incrementally.

The superiority of solar and wind is most clear when considering its impact on local stakeholders and on the environment. These technologies have much lower spatial requirements, significantly reducing displacement, and they generally have little-to-no impact on aquatic biodiversity or water regimes. Alternatives can be sited quite flexibly, including through co-location models like floating solar, avoiding sensitive locations and the need for long transmission lines, which in turn reduces drivers of deforestation, poaching and biodiversity loss. Solar and wind technologies can come into competition for land with agriculture and indeed with conservation; but compared to hydro, these environmental risks can be managed more cheaply and easily.

Similarly, alternatives like solar and wind do not pose the same social risks as hydropower and are likely to be far more effective in delivering cheap energy and driving economic development. Solar has demonstrated its significant job creation potential by creating almost double the job years as hydropower in 2019.<sup>19</sup> The decentralised renewable energy sector can be developed rapidly within or close to communities, meeting energy demand as and where it is needed. Moreover, decentralised renewable systems offer more directed economic stimulus and ownership to underserved areas.

All told, the superiority of solar and wind is significant in almost every dimension once we use effective assessment processes. This strongly suggests that there are serious problems with the way that most decisions for large hydropower are made.



Solar farm.  
Photo by Shutterstock.

### 3. KEY TAKEAWAYS & RECOMMENDATIONS

Our Riverscope pilots strongly suggest that assessment processes for hydropower are in urgent need of improvement. Failure to recognize the inherent complexity of large hydropower projects or the inextricable linkage of social, environmental and commercial risks has led to consistently poor decision-making. Much more extensive efforts are needed to exhaust alternative options before dams are developed and much better monitoring and regulatory systems are needed to avoid the worst cumulative impacts of hydropower. On the basis of our pilot project, we recommend:

- **The hydropower sector should not receive concessional finance** because it cannot make the commercial, environmental or social case for it, particularly when compared to alternatives. When hydropower is proposed, alternative options should be fully exhausted before it can proceed. Governments and international financial institutions can help foster an enabling environment for solar and wind by offering them the same sort of concessional finance currently awarded to hydropower.
- Where large hydropower projects are pushed forward, **high social and environmental standards are needed to improve impact and mitigate risk**. The cost of designing and implementing such high standards should be factored into the planning process.
- Environmental, social, and commercial risks are systematically underestimated by hydropower developers and financiers; therefore, any **investment into hydropower should be reviewed via a new feasibility study**. Riverscope provides a way for investors and project backers to do this in collaboration and with consideration of transmission line development.
- Demand growth and distribution has been directly affected by COVID-19. Many emerging markets now need less energy than predicted previously, with quite uncertain demand profiles in the future. **A more gradual approach to energy roll out**, facilitated by alternatives, is urgently needed.

- **Further analysis is needed on the impacts and risks of climate change for the hydropower sector**. Hydropower is both a contributor to, and is vulnerable to, the impacts of climate change. Indirectly hydropower contributes to climate change through deforestation, while directly, hydropower reservoirs are known for their considerable GHG emissions, particularly in tropical regions. Yet increasingly unpredictable climate impacts can directly affect the output of hydropower plants during periods of drought.
- Large hydropower projects can create regional political tensions over their impacts on transboundary river systems. These disputes are likely to escalate as the impacts of climate change take hold. There is an increasing need **to better understand the cumulative and transboundary impacts of hydropower** so these can be factored into regional-level energy planning.
- Large hydropower is often developed with the intention of bulk energy exports. But high risks and implementation challenges often make hydropower a driver of bad debt rather than development. **The lender or debtor would be better served by considering alternative energy technologies that pose lower investment risk.**

#### 3.1 NEXT STEPS / WAY FORWARD

- Having tried and tested Riverscope on five real world cases, it is important that our findings presented here be taken into account when evaluating future energy development.
- Our website, at [www.riverscope.org](http://www.riverscope.org), provides further details on these projects, including the full reports and methodologies. Here you can also find information about how you can get involved by attending our events or get in contact for further information.
- We are also in the process of developing an Alternative Energy tool which will provide quantitative geospatial assessments into potential alternative energy investments and business opportunities. This will form part of our next steps towards implementing our findings into practice.



Solar farm, Vietnam.  
Photo by Nguyen Quang Ngoc Tonkin (Shutterstock).

## ENDNOTES

1. According to Investopedia: Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyse the profitability of a projected investment or project ([www.investopedia.com/terms/n/npv.asp](http://www.investopedia.com/terms/n/npv.asp)).
2. This analysis was based on data from Gridded Population of the World, v10.
3. Koukoutamba (Guinea), Batang Toru (Indonesia), Pak Lay (Laos), Luang Prabang (Laos), and Sambor (Cambodia).
4. Landscape was developed by TMP together with development finance institutions (DFIs), NGOs, private investors, international companies and government expertise. It has hundreds of regular users and features on Bloomberg's Terminal product. It has been tested thoroughly by comparing its results with real world experience and with the outputs of fieldwork. This process has benefitted significantly from DFI support including testing across thousands of assets and dozens of portfolios.
5. In extreme cases, these delays extended to between 9 and 14 years due to environmental and social risks. Given that the mean delay from an analysis of 49 cases was 10 years, these higher figures are certainly possible.
6. This analysis was based on data from Gridded Population of the World, v10.
7. <https://cordis.europa.eu/article/id/418240-tropical-dams-an-underestimated-source-of-greenhouse-gas-emissions>.
8. Initially 91 cases were reviewed for delays. This was narrowed down to 49 cases as the data from 42 of the cases was not considered to be credible.
9. Initial figures for solar/wind and hydro (excluding delays) were based on minimum figures from [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA\\_Renewable-Power-Generations-Costs-in-2018.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf).
10. <https://www.tandfonline.com/doi/full/10.1080/07900627.2019.1568232>.
11. This figure is for Luang Prabang with a 9 year delay and 50% budget increase.
12. [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA\\_Power\\_Generation\\_Costs\\_2019.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf).
13. See, for example, the excellent analysis of Batang Toru by Brown and Brown: [https://www.mightyearth.org/wp-content/uploads/Batang\\_Toru\\_Analysis\\_English-final.pdf](https://www.mightyearth.org/wp-content/uploads/Batang_Toru_Analysis_English-final.pdf).
14. <https://www.mrcmekong.org/assets/Publications/Council-Study/Council-study-Reports-discipline/CS-Key-Messages-long-v9.pdf>.
15. [https://data.opendevelopmentmekong.net/dataset/4f1bb5fd-a564-4d37-878b-c288af460143/resource/a2dc0ce6-f0fd-4688-94ab-6996a801a239/download/volume-1\\_executive-summary.pdf](https://data.opendevelopmentmekong.net/dataset/4f1bb5fd-a564-4d37-878b-c288af460143/resource/a2dc0ce6-f0fd-4688-94ab-6996a801a239/download/volume-1_executive-summary.pdf).
16. [https://www.mrcmekong.org/assets/Publications/SOBR-v8\\_Final-for-web.pdf](https://www.mrcmekong.org/assets/Publications/SOBR-v8_Final-for-web.pdf).
17. This analysis was based on data from Gridded Population of the World, v10.
18. [https://rightsandresources.org/wp-content/uploads/RRI\\_IAN\\_Managing-Tenure-Risk.pdf](https://rightsandresources.org/wp-content/uploads/RRI_IAN_Managing-Tenure-Risk.pdf).
19. [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Sep/Key\\_Findings\\_Jobs\\_Review\\_2020\\_EN.pdf?la=en&hash=DCEBCE3272DC5AF77F18FFECD9DC5DA49F19C719](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Sep/Key_Findings_Jobs_Review_2020_EN.pdf?la=en&hash=DCEBCE3272DC5AF77F18FFECD9DC5DA49F19C719).