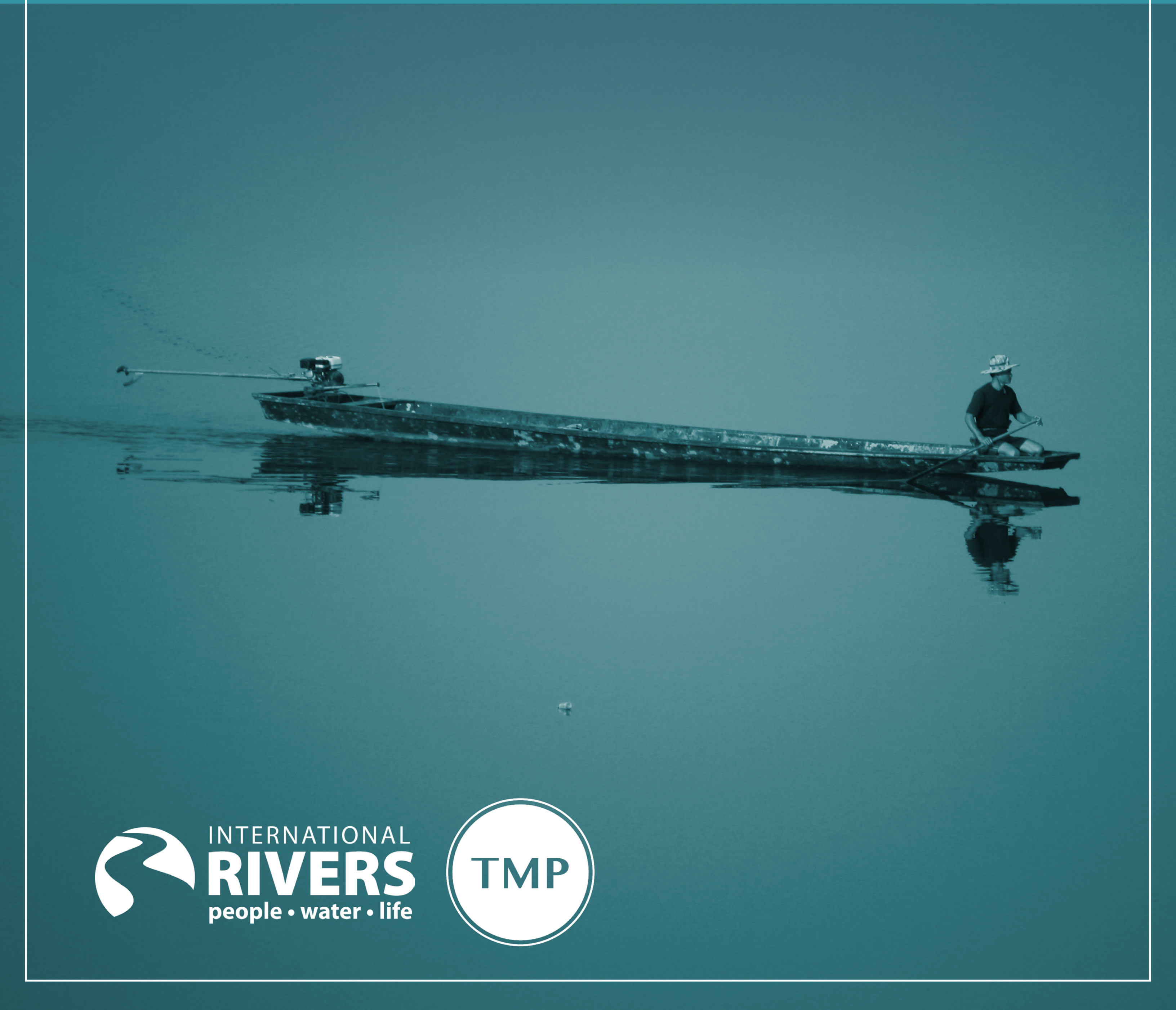
Riverscope:

Mekong Regional Assessment

July 2024



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A rapid and clean energy transition in the Mekong region is imperative for regional development, climate resilience and decarbonization. This report shows that hydropower may be a barrier rather than a contributor to this kind of transition because projects are slow to come online and likely to underperform relative to expectations or alternatives.

We have assessed 42 large hydropower assets in the Mekong region (11 planned, 11 under construction, 16 operating and 4 on hold) using a geospatial risk assessment tool called Riverscope. Riverscope quantifies social and environmental risks in financial terms using a robust and transparent methodology. Our quantitative assessment of asset-level risk and its drivers is complemented by analysis of key challenges for hydropower in the region, including climate exposure, debt accumulation and impacts on food security.

Our analysis finds that current hydropower ambitions are driving substantial risks for regional food security, climate resilience and fiscal stability. At the same time, environmental and social impacts of planned dams threaten to be severe for communities and ecosystems. At worst, unchanged hydropower plans could catalyze and exacerbate national and regional crises.

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Riverscope is a collaboration between TMP Public and International Rivers

Luang Prabang, Laos.
Photo by Thai Mekong People's Network.

1. INTRODUCTION

A rapid and clean energy transition in the Mekong region is imperative for people and planet. Naturally, the immense hydropower potential that is offered by one of the longest rivers in the world is attractive for local energy planners. Indeed, hydropower capacity has more than doubled in the Lower Mekong Basin (LMB) since 2010, from almost 5,000MW to over 12,000MW.[1] Another 44 projects, at least, are in planning or construction phases.[2]

This is concerning because new hydropower rarely delivers energy rapidly or cleanly in practice. Dams are highly exposed to delays, financial losses and climate impacts. Indeed, hydropower expansion in the Mekong has already led to a host of disputes, adverse environmental and social impacts and unfulfilled promises.

For this report, we have assessed 42 existing and planned hydropower assets[3] in the Mekong region, using a geospatial risk assessment tool called Riverscope. Riverscope quantifies social and environmental risks in financial terms, generating a single overall risk score for each asset.

Our scoring is complemented by further research and analysis into key challenges linked to hydropower development in the region, which include climate exposure, debt accumulation and impacts on food security. In general, we have found that planned projects in the Mekong have unusually high risks and are likely to be delivered both late and overbudget.

The analysis is delivered in five parts:

1. **METHODOLOGY:** A brief description of how Riverscope works and why we believe it provides a robust means of understanding both the risk-adjusted costs of planned hydropower and the drivers of this risk.
2. **RIVERSCOPE RESULTS:** This section provides the results of our Riverscope analysis, first for the entire set of 42 assets and then for three "subsets" – in Cambodia, Laos and the Lower Mekong mainstream. These quantitative results show that hydropower in the region is exceptionally risky.
3. **CLIMATE EXPOSURE AND ENERGY SECURITY:** Climate change threatens to reduce hydropower output through more frequent and severe drought. This section analyses the impact that these shortfalls might have for energy security, particularly in countries heavily reliant on hydropower.
4. **FOOD SECURITY AND SEDIMENT FLOWS:** Hydropower development endangers fish stocks and could seriously damage downstream agriculture because of reduced sediment flows. This section looks at the potentially devastating impacts of these changes for food security in the region.
5. **DEBT BURDEN AND HYDROPOWER RELIANCE:** Laos, in particular, is accruing enormous public debts to fund its hydropower plans. This story has the hallmarks of a debt trap, particularly given that the country is currently selling most hydroelectricity at an effective loss.[4] This section considers the risk that Laos may be forced to default on debts predominantly held by Chinese companies and institutions.

Our analysis concludes with a summary that ties together key findings, including the following headlines:

- **Our 42 assets had an average Riverscope risk score of 80,** which is exceptionally high. This score can translate into delays as long as 13 years, with an average Net Present Value (NPV) impact of $258 million per project. From a financial perspective, these assets are not investable.
- **Climate impacts will further reduce hydropower output and financial viability.** They will also threaten energy security at a national and regional level, which could have outsized economic impacts. In our view, these climate risks merit far greater consideration because we expect them to land in the next few years (i.e., before most planned assets are complete).
- Countries like Laos that are accruing a large debt burden to finance hydropower rollout are at **increasing fiscal risk** because of the risks described above. Under current arrangements, our analysis suggests that a debt trap and/or default are highly likely, not least because energy is already being sold at an effective loss.
- **The scale of hydropower development in the region poses severe risks to food security,** both through reduced fish stocks and reduced agricultural production. Unless Mekong countries pull back decisively from planned projects in the Lower Mekong Basin, the costs and impacts of food security crises could be enormous.
- In aggregate, **planned dams will negatively and directly impact large numbers of people**. On average, 30,489 people were directly exposed to physical and/or economic displacement from the projects assessed. Another average 69,749 people lived downstream in areas that are likely to be impacted.

All-in-all, hydropower could drive or contribute to overlapping social, economic, and environmental crises that threaten the entire region. The risks at a micro- and macro-level are substantial and should provoke a major overhaul of energy plans in the region (and in any other region in a similar hydropower-dependent situation). A strategy that better recognizes climate risks, food security challenges and of course the cost of rapid energy development is sorely needed.

2. METHODOLOGY

This assessment draws on a combination of quantitative approaches developed by TMP (Riverscope[5] and the Mission Climate Project[6]) as well as existing qualitative research and analysis.

Social, environmental and climate risks are often externalized, and not properly factored into financial and energy planning decisions. Combining these approaches helps to demonstrate the way that these contextual factors can have very real financial and material consequences.

This methodology can be helpful to decision-makers and energy planners because it provides them with a blueprint for making risk-adjusted price and cost projections. In particular, this can help them to understand where there are arguments for altering planned hydropower or for replacing it with alternatives like solar and wind.

2.1. RIVERSCOPE

Riverscope[7] is a geospatial system that quantifies key social and environmental risks of hydropower assets at a project-level. It then links this risk exposure to potential delays and financial losses. Riverscope is designed to enable rapid, comparable, and material assessments of hydropower projects.

Riverscope provides a risk score from 0-100 by drawing on 17 subnational level social and environmental indicators that are statistically correlated with delays for hydropower projects. These 17 social and environmental indicators were selected from a longlist of 300 following a robust statistical analysis based on two distinct sets of existing hydropower projects: a Test set with projects reported to have experienced problems and delays, and a Control set that did not have reported problems.

Comparing geospatial data for Test and Control sets allowed us to identify characteristics that were statistically associated with increased material risk. Using these 17 indicators, Riverscope provides an overall risk score for a given hydropower asset's location, which indicates whether the underlying local conditions are more or less similar to those found in the Test set. Higher scores indicate increased risk.

Riverscope's overall risk score is then correlated with TMP's expected delay model to provide a range of potential delays for a given hydropower asset. The delay model was developed by examining 49 existing hydropower assets that have experienced delay, then using this set to create a distribution of delays from several days to decades. The Riverscope score helps us to pick out where on this distribution a project might lie i.e., how long delays might be.

Expected delays are then fed into a discounted cashflow model. The financial modelling process draws on publicly available financial assumptions about hydropower projects alongside the potential delays to a project's Net Present Value (NPV) under different cost and delay scenarios.

Using this rapid assessment approach on multiple assets within a given country or region (e.g., the Mekong) provides a macro-level view of the risk factors that are common at a country and regional level. This view can be strengthened through another component of the overall Riverscope approach: additional layers of quantitative and/or qualitative analysis.

Naturally, some risks and challenges are not fully captured by the Riverscope quantitative assessment. These kinds of issues (e.g., food security and corruption) may be better approached through a qualitative investigation. For example, understanding the role of fish migrations and sediment flows for regional food security can provide a more informed view of the way that people are likely to respond when these relationships are disrupted.

2.2. THE MISSION CLIMATE PROJECT

For our Mekong analysis, we wanted to add a layer of analysis that captures near-term climate risk using models from the Mission Climate Project (MCP).[8] Riverscope provides a view based on the historical performance of hydropower assets, but we also want a forward-looking view that links climate challenges and opportunities to broader socio-economic and political impacts in the near-term (i.e., over the next ten years).

The MCP blends inputs from existing general circulation and regional climate data models into a broader framework TMP designed to understand how climate impacts social and political stability. More specifically, the models[9] show which areas are more likely to experience extreme shifts in climate behaviour related to temperature and precipitation (e.g., increases in extreme temperatures; annual dry days; consecutive wet days, etc.) between 1°C and 1.5°C[10] of global warming.

Then, social, political and demographic conditions are considered alongside qualitative research and evidence to better understand what the implications of these extreme climate events might be. In many scenarios, we can envisage that the social, political and economic repercussions of these climate shocks are just as problematic as the initial climate impacts themselves, particularly for planners and large projects.

MCP's near-term focus is unique in that it provides information that is relevant to planning decisions now. Often the timeframe for climate modelling is concerned with 2050, 2070 or even 2100 as the window of impact. But MCP's models indicate that climate extremes are likely to create problems over the coming decade already, with increasing evidence that we will breach the 1.5°C level sooner than anticipated (perhaps as soon as 2026).[11]

This near-term climate view complements Riverscope by providing a clearer understanding of the ways in which climate extremes could create financial and material problems for projects in different stages of development. For example, an indication of extreme flooding helps to understand the risk of added costs and delays to projects under construction, while extreme drought exposure helps to understand the risk of potential revenue disruptions for projects in operation.

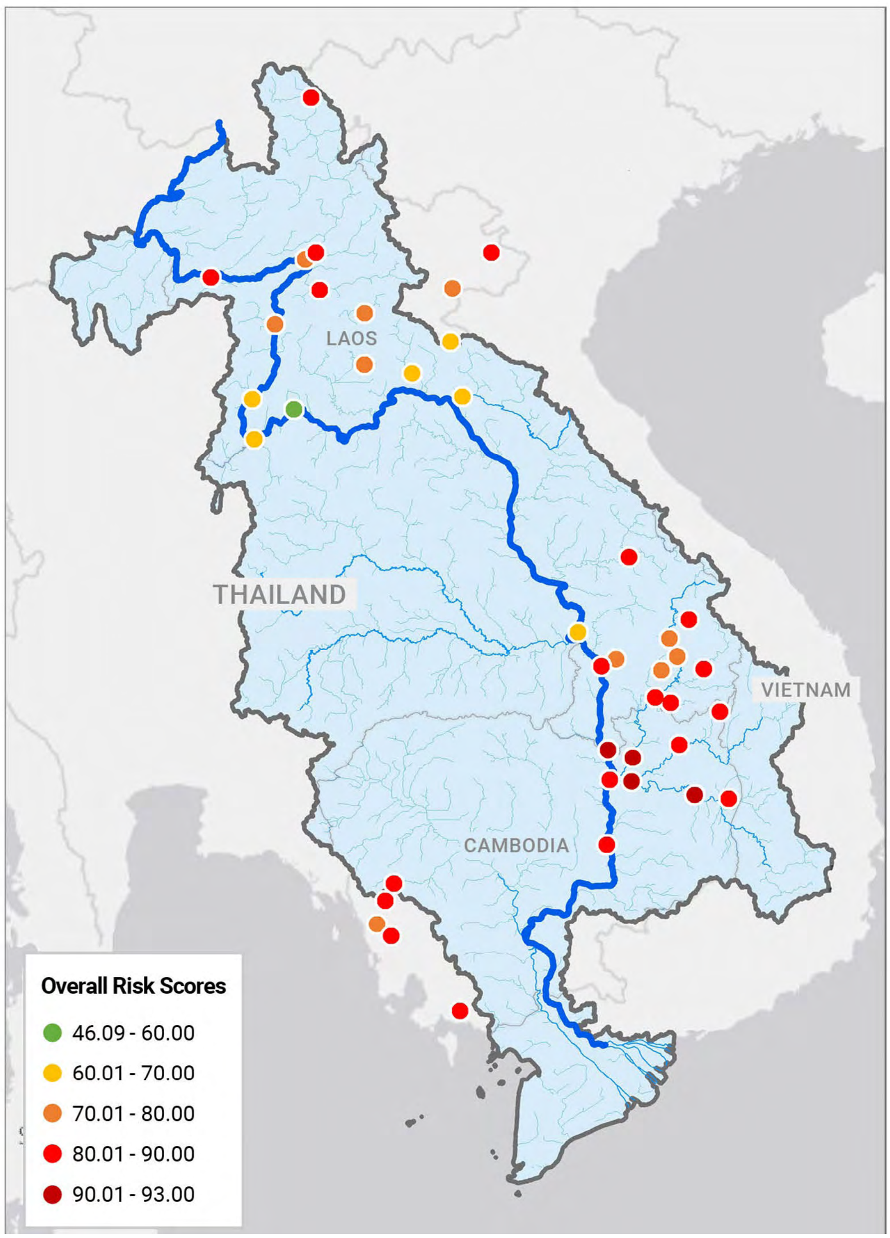
At a macro-level, the MCP provides Riverscope with a broader view of near-term climate exposure for a country or region, particularly regarding problems like reduced output or safety concerns. This macro-context helps to inform understanding on broader issues around energy security and regional stability, alongside further qualitative investigation into these issues.

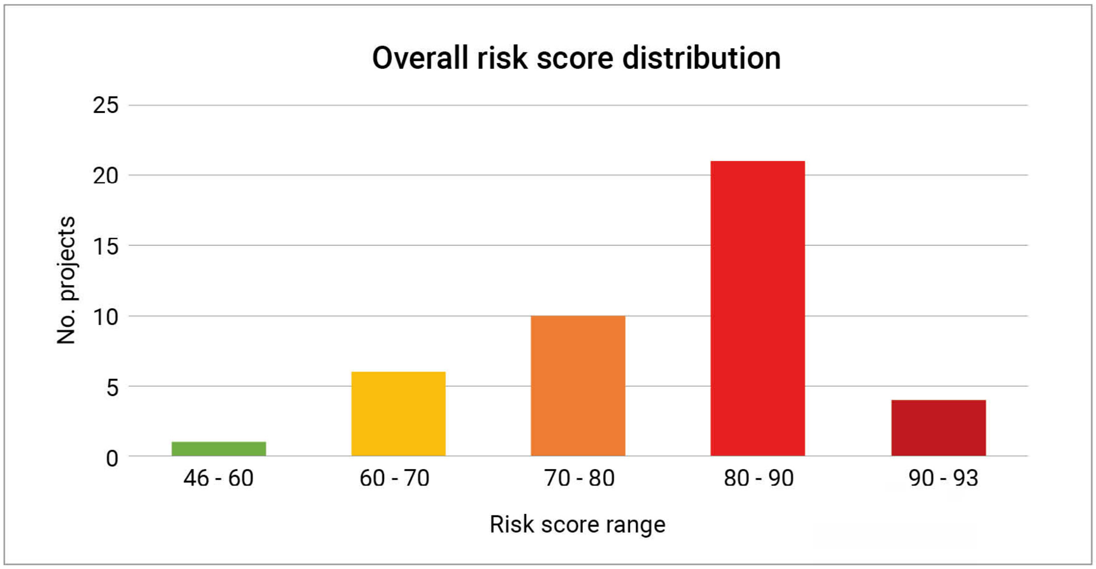
3. RIVERSCOPE MEKONG REGIONAL ASSESSMENT

3.1. OVERALL ASSESSMENT

Overall, the Riverscope assessment covered 42 large hydropower assets[12] (see figure to right) from Laos, Cambodia and the Lower Mekong mainstream, with some bordering Thailand. The projects were primarily selected from the Stimson Center's Mekong Infrastructure Tracker,[13] alongside Power Development Plans and other publicly available resources. The aim was to select a representative sample of large projects of various sizes and across different stages of development (i.e., in planning, under construction and operational).

Riverscope shows that most projects in the Mekong are highly exposed to social and environmental risks, with 60% of projects scoring above 80 (see figure on following page), translating into expected delays of between 2.4 – 2.7 years, or in worst cases between 13.3 – 15.2 years.





These results are exceptionally bad when compared to Riverscope assessments in other countries and regions, which suggests that many of these projects will experience serious problems. We would expect most of these projects to be significant loss-leaders that have a range of negative impacts at local, national and even regional levels. Their predominance suggests that the region needs more robust and data-driven due diligence processes early in hydropower and energy planning.

Our results show that projects in Cambodia are generally more exposed than those in Laos. Cambodia's planned Lower Sekong project scored the highest overall (93), but there is little publicly available information about the project.

A closer look shows that it is in a remote area along the lower Sekong River, where local people lack access to basic services and typically do not trust outsiders proposing large, highly disruptive projects. Project proponents will need to ensure that it does not threaten already vulnerable livelihoods, or risk opposition, which is extremely difficult given the known impacts of hydropower on natural resources (e.g., on fish and fresh water).

Indeed, the Sekong River is a crucial spawning tributary for migratory fish. One estimate suggests that blocking it could reduce total fish production in the Mekong by as much as 20%.[14] This exposes the project to both local and regional backlash over concerns for biodiversity and fisheries production. The upstream 86MW Lower Sekong A project in Laos has already been exposed to such backlash.[15]

Overall, the analysis identifies three key risk drivers that were common across all the projects assessed. These relate to dispute over displacement and livelihood disruption, impacts on biodiversity and fragile ecosystems and hydropower production exposure to severe drought conditions.

3.1.1. SOCIAL RISK: DISPLACEMENT DRIVES DISPUTE

First, most projects assessed are in areas where people lack access to basic services like schooling, sanitation, and clean drinking water. These remote areas pose greater risks because it is often harder to identify legitimate stakeholders and to communicate with local communities. People in these areas often have pre-existing grievances which makes trust-building even harder, especially where a project involves displacement.

TMP's dataset of hydropower disputes indicates that displacement is the most common driver of dispute (for 57% of cases). For people living without access to basic services, displacement can have disproportionate negative impacts on their lives, increasing their vulnerability to climate impacts and reducing overall climate resilience. This risk of dispute and impact is even more acute in a context of poor resettlement processes, which are common in the Mekong.

The 400MW Lower Sesan 2 project is one example from Cambodia. The project is in an area with poor access to key social services. Roughly 5,000 people were displaced during construction, despite local opposition to loss of livelihoods and cultural traditions.[16] The project has since negatively affected the income and livelihoods of displaced communities, as well as people living outside of the resettlement area.[17]

Our analysis found 11,467 people living within 20km from Lower Sesan 2 and another 8,283 people downstream.[18] This suggests that at least 19,750 people are exposed to physical and/or economic displacement, which includes loss of natural resources like fish or fresh water. Compensation could amount to ~$140 million under conservative estimates,[19] almost triple the $50 million estimated for resettlement and compensation in the project's EIA.[20]

3.1.2. ENVIRONMENTAL RISK: THREATS TO BIODIVERSITY AND ECOSYSTEMS

The second major risk factor relates to the increase in global attention on protecting biodiversity and fragile ecosystems, which is often in contradiction with the way that hydropower projects are sited. Notably, environmental impacts are the second most common driver of dispute (25% of cases) in our dispute database. This is important because just one of the projects assessed scored below 95 for the IUCN species richness indicator, while the average Protected Areas score was 91.

While these high biodiversity risks may be explained by the exceptionally high levels of biodiversity found in the Mekong,[21] some projects are sited within protected areas, which strongly indicates poor environmental due diligence. For example, the proposed Ban Koum/Salavanh[22] project (bordering Laos and Thailand) was proposed between two national parks,[23] while Nam Theun 1 is located directly within the Nam Kading National Protected Area.

This kind of disregard for sensitive environmental areas can bring national and even international focus to a project that might otherwise only create problems at a local level.

3.1.3. CLIMATE RISK: DROUGHT UNDERMINES HYDRO PRODUCTION

Finally, 95% of projects assessed showed high exposure to drought risk, with an average score of 89. This high drought exposure may be explained by the Mekong's annual monsoon which naturally results in annual wet and dry seasons. But climate change is likely to increase the extremity of this already high drought exposure.

Riverscope's drought risk indicator, which uses a historical methodology, is complemented by TMP's Mission Climate Project (MCP), using a forward-looking climate model that, unusually, focuses exclusively on the next decade.[24] This MCP data suggests that multiple climate impacts (e.g., extreme temperature, drought and flooding) are more likely in the Mekong in the near-term.

In other words, extreme climate events could start creating problems even before planned projects are expected to come online, as well as once they are operational. As such, climate impacts should be considered in project lead times and costs, which could be inflated substantially by the climate disruption that MCP predicts.

A recent 3-year drought[25] illustrated the way that climate change might affect natural climate cycles, with the potential to undermine the reliability of projects across the region. Cambodian hydro production dropped by 30% (or 18% of national capacity), which led to rolling blackouts in Phnom Penh.[26] Similarly, EDL Generation Public Company (EdL-Gen)[27] fell 25% short of its power generation targets in 2019 due to extended drought.[28] More recently, 11 hydropower projects were shut down in Northern Vietnam because of water shortages, reducing grid capacity by approximately 5,000 MW and resulting in power cuts to northern provinces.[29]

But droughts are not the only climate risk relevant to hydropower, as evidenced by a 2021 flooding event in Nepal, which damaged 16 projects under construction and another 10 in operation.[30] Indeed, our modelling indicates that more extreme droughts will be coupled with extreme precipitation and flooding events. While bouts of extreme precipitation could certainly increase production, they clearly pose a safety risk to dams, both during construction (which can take 5-7 years) and in operation.[31]

3.2. SUBSET ASSESSMENTS

We have broken our set of assets into a series of "subsets" that focus in on parts of the Mekong. The subsets include 14 projects from Cambodia, 19 in Laos and 11 mainstream projects in the LMB.

These subsets reflect key areas for proposed hydropower development, and we wanted to understand the dynamics of each in more detail. As such, the following subsections pick out some key risk drivers and projects in each area to underline similarities and differences.

3.2.1. CAMBODIA ASSESSMENT

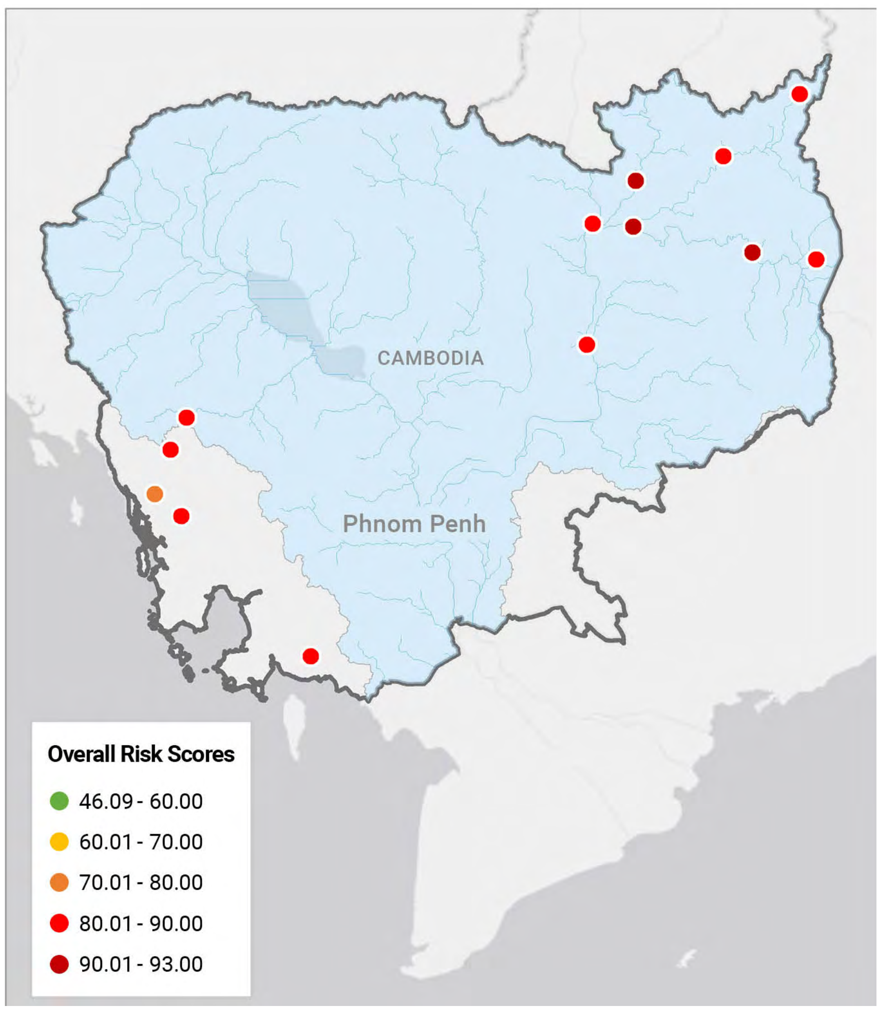
Cambodia's energy mix is dominated by hydropower and fossil fuels, with hydropower making up the largest share at 38%, followed by coal, fuel oil and solar PV.[32] Recent Power Development Plans indicate continued reliance on hydropower through 2040, with an increase of 124% from a 1,330MW base.[33]

In 2020, the Cambodian government announced a moratorium on the two proposed mainstream hydropower projects in Cambodia over environmental and social concerns.[34] But Cambodia plans to significantly increase their Laos import capacity from 440MW to 3,095MW by 2030,[35] and have already indirectly supported mainstream hydropower in Laos through imports from the Don Sahong dam.[36]

While energy plans are important for energy security considerations, they are also a crucial factor in ensuring regional food security because of direct impacts between hydropower development and fisheries and agricultural production. Critically, Cambodia's Tonle Sap Lake, the largest freshwater lake in Southeast Asia, supports anywhere between 1 and 4 million people,[37] but is reliant on natural water and sediment flows from upstream. Hydropower has started to disrupt these relations.[38]

The Cambodian subset was the highest overall scoring set of the three, with an average overall risk score of 88. This translates into an average delay of 2.6 years, and an average NPV loss of 29% (or $254 million)[39] for each project. In the worst case, each project could be delayed by 14.3 years.

Perhaps unsurprisingly, the highest scoring half of the subset includes the two postponed mainstream hydropower projects, Sambor and Stung Treng, whereas the remaining projects are primarily in very early stages of development (with planned operation



DAM	CAPACITY (MW)	STATUS	OVERALL RISK SCORE
LOWER SEKONG	190	PLANNED	93
LOWER SREPOK 3	330	PLANNED	91
LOWER SESAN 2	400	OPERATIONAL	90
SAMBOR	2600	ON HOLD	90
LOWER SESAN 3	260	PLANNED	90
LOWER SREPOK 4	48	PLANNED	89
STUNG TRENG	980	ON HOLD	89
STUNG TATAY	246	OPERATIONAL	88
STUNG TATAI LEU	150	CONSTRUCTION	87
STUNG PURSAT I	80	CONSTRUCTION	87
STUNG ATAY	120	OPERATIONAL	85
PREK LIANG 2	128	PLANNED	85
KAMCHAY	193	OPERATIONAL	85
LOWER STUNG RUSSEI CHRUM	132	OPERATION	78

dates between 2033-2039). This suggests that there is still time to carry out thorough due diligence on these highly exposed projects, as well as to investigate potential alternatives.

A closer look at the highest scoring project in the subset (and overall), Lower Sekong, reveals that it is planned just 130km downstream from the controversial Lower Sekong A project in Laos (more on this project in the next subsection).[40] Lower Sekong is only expected to come online in 2037, which may explain why it has received less attention than the Laos project. But opposition to Lower Sekong A could spread to the Lower Sekong project and potentially gain traction between countries, should it take off.

Riverscope found that projects in Cambodia were generally more exposed to social risks than projects in Laos, as supported by Multidimensional Poverty Index (MPI) data.[41] Projects in Cambodia were more likely to be in areas where people lack access to basic services like sanitation (average scores from 93-96) and drinking water (averages scores from 83-86).

These social conditions reflect a higher vulnerability to shocks and stresses from development or climate impacts on factors like food security, fisheries production and access to fresh water. International financial institutions have similarly recognized the threats that climate change and dam construction pose for Cambodia's fisheries, and by extent, the livelihoods and nourishment of vulnerable communities.[42] This means that greater effort will be needed to ensure these social impacts are mitigated effectively (e.g., through robust social engagement and grievance reporting systems), which could add delays and additional costs to development.

3.2.2. LAOS ASSESSMENT

Laos aims to become the so-called "battery of Southeast Asia" and is already the largest hydropower producer and exporter in the LMB. In 2021, it had an installed hydropower capacity of over 8,910MW,[43] while it exported 73% (38,737GWh) of total country energy produced in 2020, with plans to increase exports to 83% (124,400GWh) of production by 2030.[44]

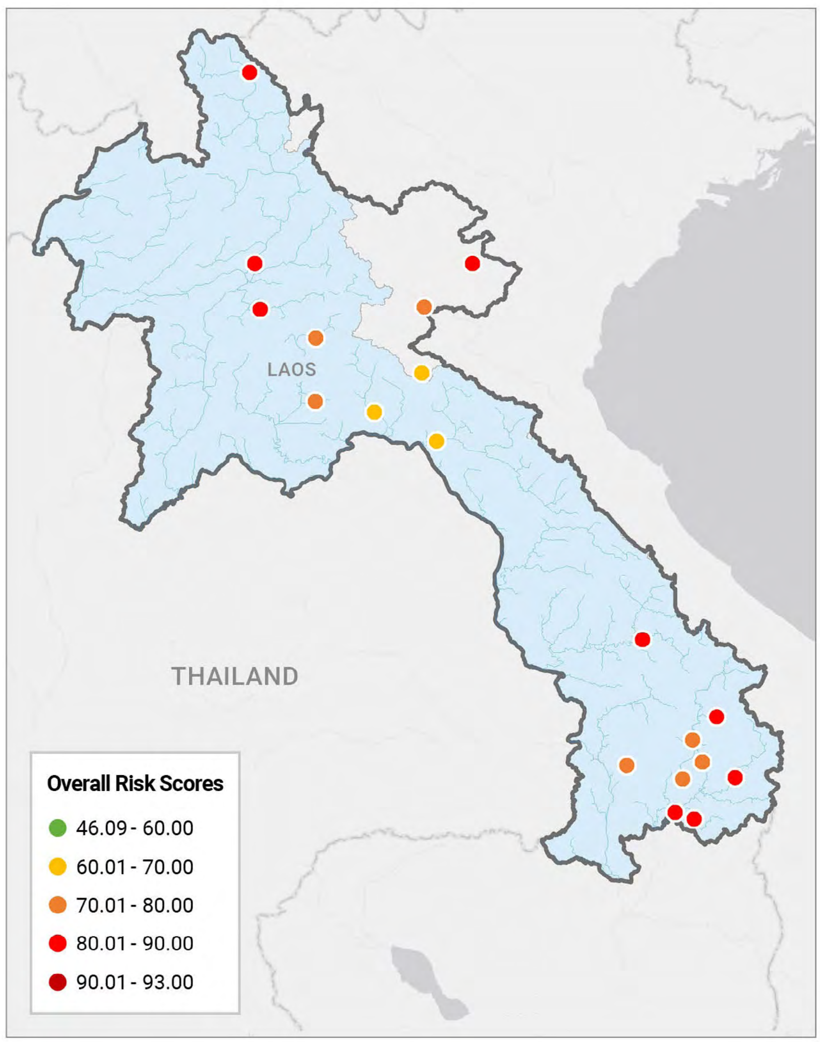
Laos has taken on high and perhaps unsustainable levels of debt to finance this growth. This is a major concern because many dams will take a long time to come online before they can deliver revenue,[45] and once they do, revenue collection is likely to be hindered by the various tax exemptions in place to attract foreign investment for large projects, like hydropower.[46] We expect this position to erode rather than improve with time, because social risks and climate impacts threaten to hobble hydropower construction and operation.

The Laos subset of projects was the second highest scoring set of the three, with an average overall score of 78. This translates into an average delay of 2.3 years, and an average NPV loss of 25% (or $139 million) for each project. In the worst case, each project could be delayed by 12.8 years because of social and environmental factors.

The highest scoring project of the subset, the Lower Sekong A (88), has faced criticism from international environmental groups.[47] The project would block a tributary that has seen increasing fish migration and spawning activity since the development of Lower Sesan 2.[48] This could have considerable negative impacts on regional fish stocks. Other food security concerns were raised over the potential impacts on agricultural production in the Mekong Delta downstream.

Overall, Riverscope shows that projects in Laos are generally developed in areas where people are highly vulnerable to poverty (with an average score of 81), but not necessarily always living in absolute poverty.

This higher vulnerability to poverty is concerning given regional experience with displacement and poor or no compensation. Xe Lanong 1 (the second highest scoring project in the subset) is one recent example. It relocated 88 families without compensation to resettlement villages that were incomplete and lacking basic services.[49] These poor development practices can lead to delays and added costs.



DAM	CAPACITY (MW)	STATUS	OVERALL RISK SCORE
LOWER SEKONG A	86	CONSTRUCTION	88
XE LANONG 1	60	OPERATIONAL	88
NAM KONG 1	160	OPERATIONAL	85
NAM OU 7	210	OPERATIONAL	85
NAM SAM	156	CONSTRUCTION	85
NAM EMOUN	129	CONSTRUCTION	83
NAM OU 1	180	OPERATIONAL	82
NAM KHAN 2	130	OPERATIONAL	82
XEKAMAN 1	290	OPERATIONAL	81
XEKONG 3B	146	CONSTRUCTION	79
XEKONG 4B	165	CONSTRUCTION	79
XE PIAN-XE NAMNOY	410	OPERATIONAL	74
NAM NEUN 1	124	PLANNED	74
NAM NGUM 4	240	CONSTRUCTION	73
NAM BAK 1	160	PLANNED	72
NAM PAK	150	CONSTRUCTION	70
NAM MO 2	120	CONSTRUCTION	67
NAM NGIEP 1	290	OPERATIONAL	66
NAM THEUN 1	670	OPERATIONAL	61

3.2.3. MAINSTREAM ASSESSMENT

The Mekong mainstream (or Lancang in China) has undergone considerable hydropower development since the first large project in 1995. Since then, another 12 mainstream projects were commissioned between China and Laos,[50] while 20 more are planned between China, Laos, Thailand and Cambodia, with a cumulative capacity of 21,393MW.[51]

Such rapid hydropower development has the potential to provide energy supply under favorable climate conditions, but would come at considerable financial, social and ecological cost. An estimated 52 million people depend on the health of the Lower

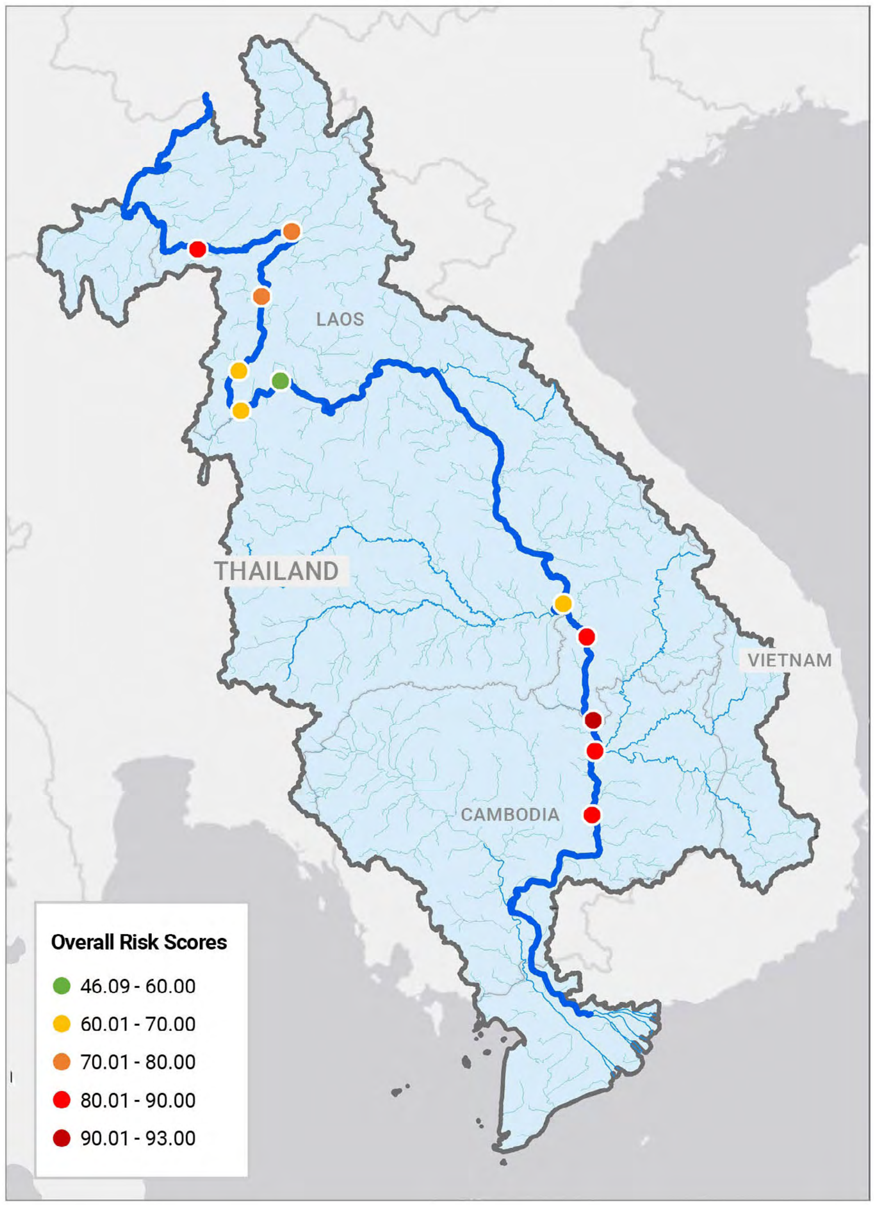
Mekong Basin (LMB) for natural resources (e.g., fish and farming) and livelihood security,[52] which is likely to come under increasing pressure with continued development of hydropower in the Lower Mekong mainstream and tributaries.[53]

Where people in the LMB rely on a healthy river system for food and livelihood security, large hydropower relies on favorable climate conditions to support energy security. Climate change could undermine both underlying relationships and indeed exacerbate the negative impacts of large hydropower development on the region.

On average, the mainstream subset of projects was the lowest scoring of the three, with an average overall score of 76,[54] compared to 78 for Laos and 88 for Cambodia. But this is still a very high average score: 76 translates into an average expected delay of 2.2 years, and an average NPV loss of 28% (or $645 million) for each project. In the worst case, each project could be delayed by 12.5 years.

The average score of 76 is strongly influenced by Pak Chom, the overall lowest scoring project (46).[55] A closer look at the project suggests that this low score may be explained by its location roughly 50km upstream from Laos' capital city, Vientiane. People in this area generally have access to key services like sanitation and drinking water, which lowers social risks for the project.

However, Pak Chom is located on the Thai-Lao border and is still highly exposed to biodiversity risks. In early 2022, the governors of Thailand's Loei and Ubon Ratchathani provinces called for the suspension of a feasibility study for the Pak Chom and Ban Khoum dams.[56] This means that four of the proposed mainstream dams – Pak Chom and Ban Khoum on the Thai-Lao border, and Sambor and Stung Treng in Cambodia – are effectively on hold.




Xayaburi dam, Lower Mekong River.
Photo by International Rivers.

DAM	COUNTRY	CAPACITY (MW)	STATUS	OVERALL RISK SCORE
DON SAHONG	LAOS	325	OPERATIONAL	91
SAMBOR	CAMBODIA	2600	ON HOLD	90
STUNG TRENG	CAMBODIA	980	ON HOLD	89
PAK BENG	LAOS	912	PLANNED	82
PHOU NGOY	LAOS	728	PLANNED	81
XAYABURI	LAOS	1285	OPERATIONAL	80
LUANG PRABANG	LAOS	1460	CONSTRUCTION	80
PAK LAY	LAOS	770	PLANNED	68
BAN KOUM	THAILAND-LAOS	1872	ON HOLD	68
SANAKHAM	LAOS	700	PLANNED	63
PAK CHOM	THAILAND-LAOS	1076	ON HOLD	46

Sediment flows for the mainstream subset have average scores of 97-98 (compared to 68 for Laos and 74 for Cambodia). The mainstream transports nutrients to downstream wetlands and farming areas (e.g., Tonle Sap Lake and Mekong Delta) supporting soils, crops and fisheries.[57] Hydropower has decimated these flows,[58] and models forecast that under a scenario of continued dam development, just 3% of pre-dam sediment will reach the Delta by 2040.[59]

Drought exposure is another key risk factor for the mainstream subset, with an average score of 94.

This is especially concerning given the cumulative capacity (12,643MW) that is exposed, which could have considerable implications for regional energy security (more on this in the next section).

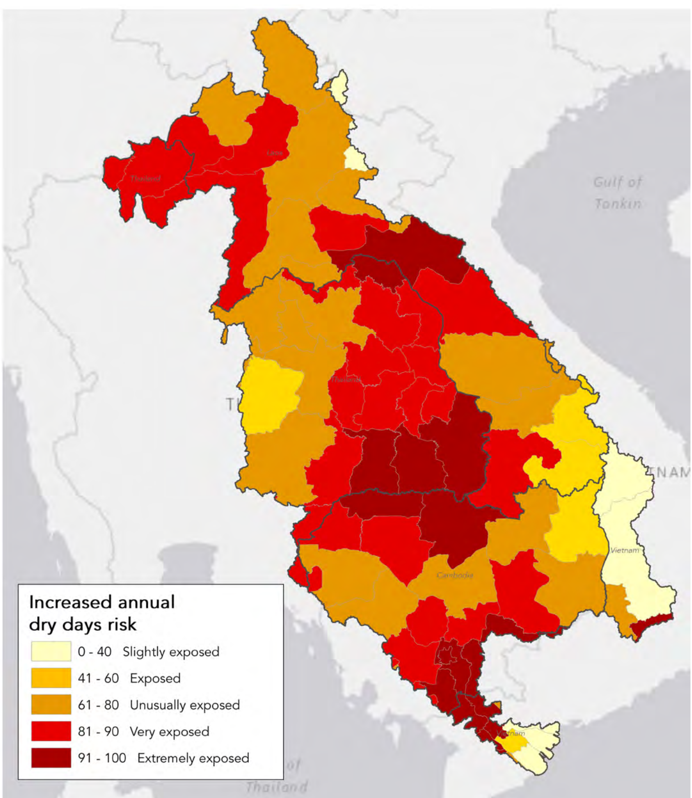
Altogether, the Riverscope assessment helped to draw out three broader issues related to hydropower in the Mekong region. These include climate risks to energy security, food security and sediment flow disruptions and the risk of large debt linked to rapid hydropower development. These three themes are explored further in the following three sections.

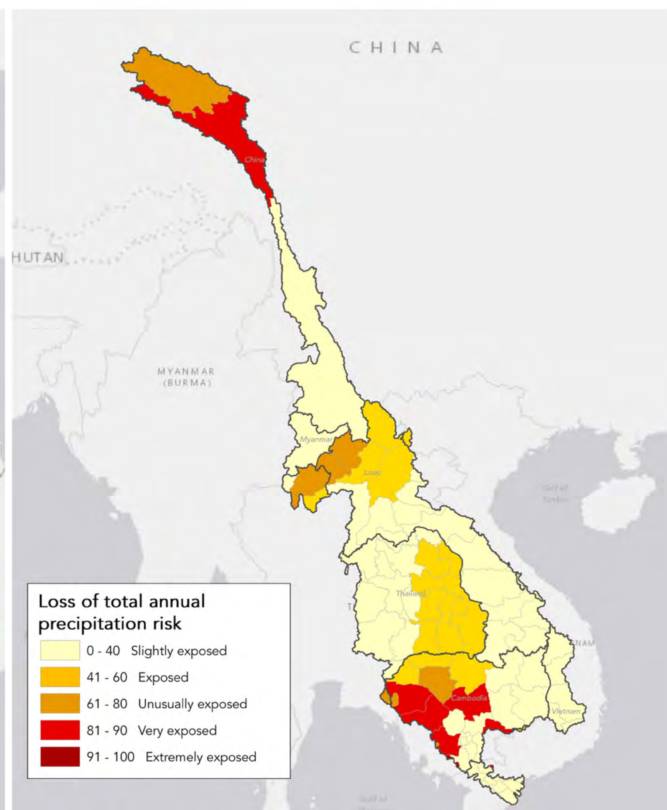
4. CLIMATE EXPOSURE AND ENERGY SECURITY

This section provides a regional view of climate risk for energy security with a focus on Laos. This Laos focus was largely driven by its unusually high share of hydropower in the country energy mix (double that of Cambodia), alongside its considerable contribution to regional energy exports.[60] This concentration of hydro production and exports suggests that climate impacts in Laos could have ripple effects on regional energy security.

The MCP's models[61] indicate that in the near-term (i.e., between now and 2030), large parts of the region are exposed to increasing drought conditions. In particular, the lower Mekong is significantly exposed to an increasing number of annual dry days (see left figure below). Similarly, some areas in the broader basin (e.g., at the top of the basin in China, in northern Thailand and Laos, as well as parts of Cambodia) are exposed to an overall loss in annual precipitation (right figure below). Meanwhile most of the upper and lower reaches of the Mekong are also exposed to shifts in extreme temperatures[62] (e.g., most of China, large areas of Cambodia and parts of Vietnam, see figure overleaf).

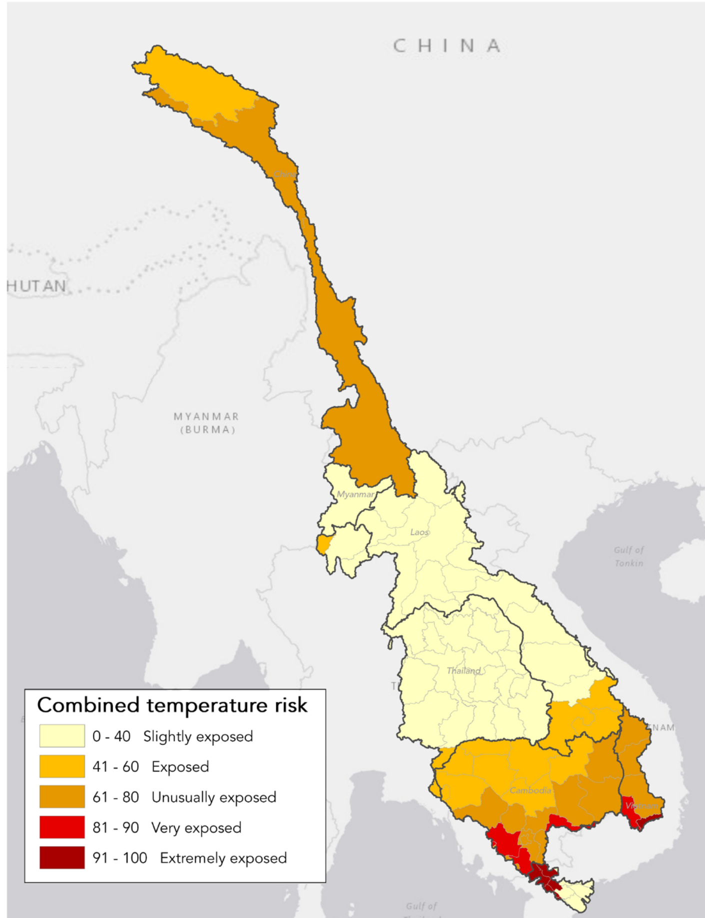
These results are concerning because the region is already heavily reliant on hydropower, and because high temperatures and drought have already been linked to reduced hydropower output in the region. China's Yunnan Province (which borders Myanmar, Laos and Vietnam) saw a near 30% reduction in hydro production in the first 5 months of 2020.[63] Similarly, Cambodian hydropower was reduced by 30% in the previous year.[64]



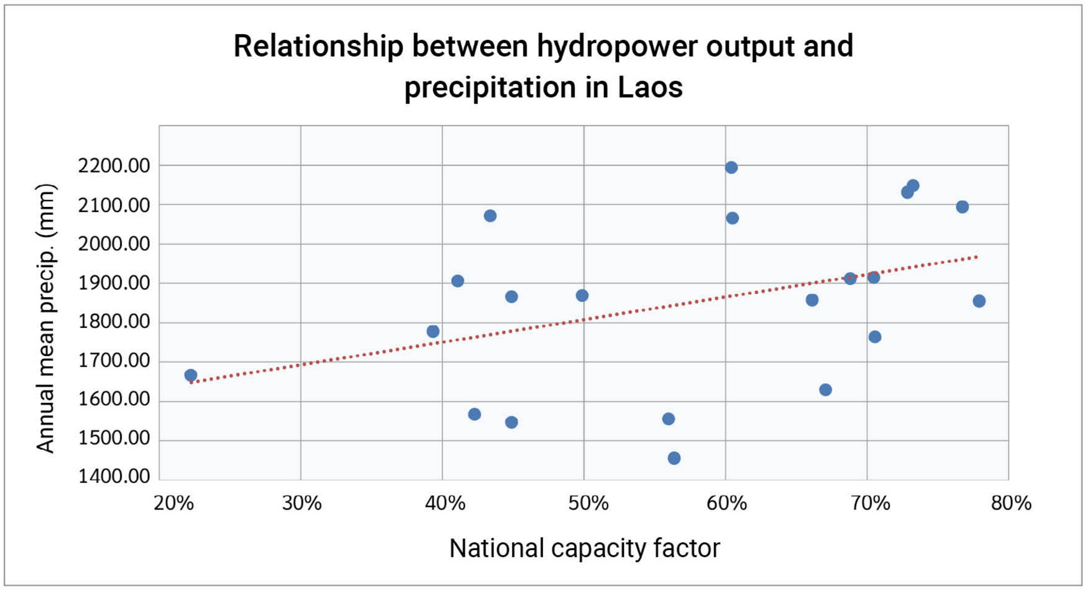


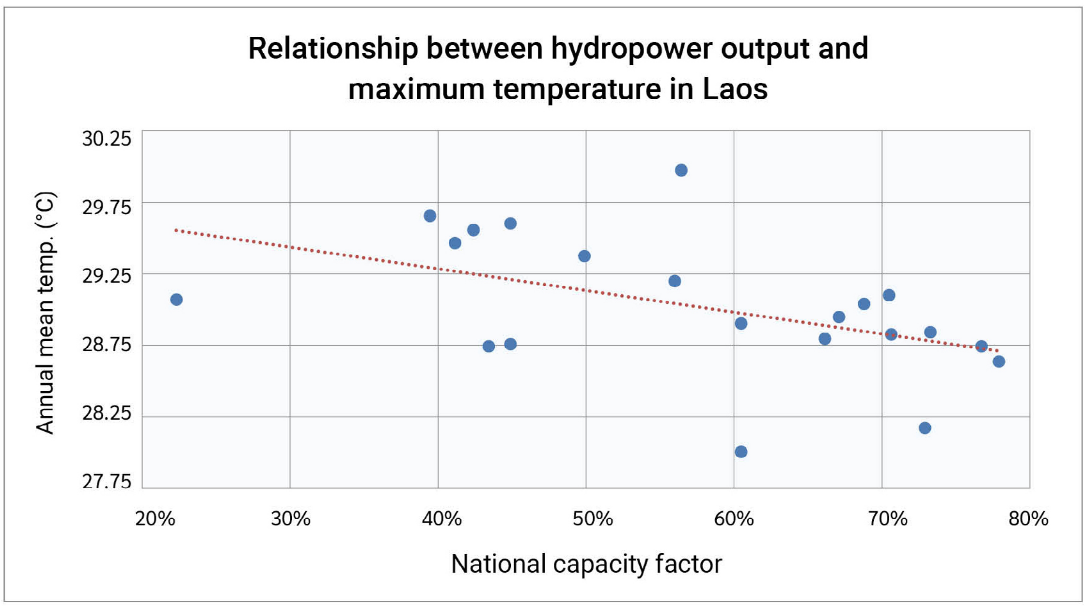
To further illustrate these links, we compared available data on national hydropower output in Laos[65] with annual mean precipitation and annual mean maximum temperatures.[66] By using figures for installed hydropower capacity and actual hydropower output at a national level, we calculated a national capacity factor for each year between 2000-2020, which was then compared with the two climate metrics.

The results (on following page) are intuitive, showing a positive relationship between annual mean precipitation and hydropower output, and a negative relationship with annual mean temperature. Although the relationship does not appear very strong in this analysis,[67] the results do support international evidence of hydropower taking strain under unusually hot and dry climate conditions.[68]




Mekong, Don Sahong, Laos.
Photo by International Rivers.

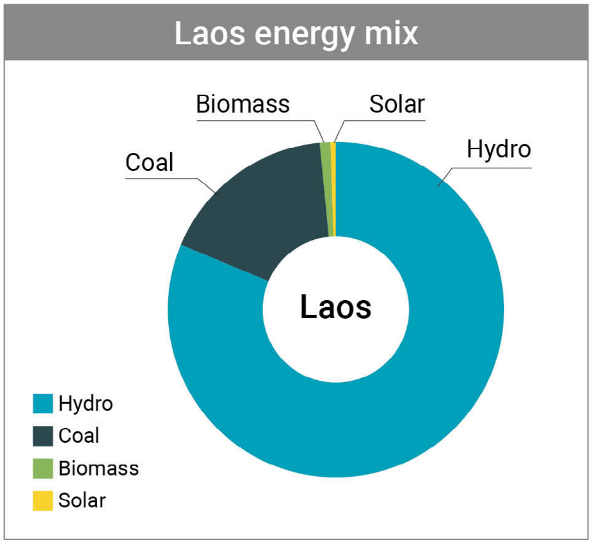


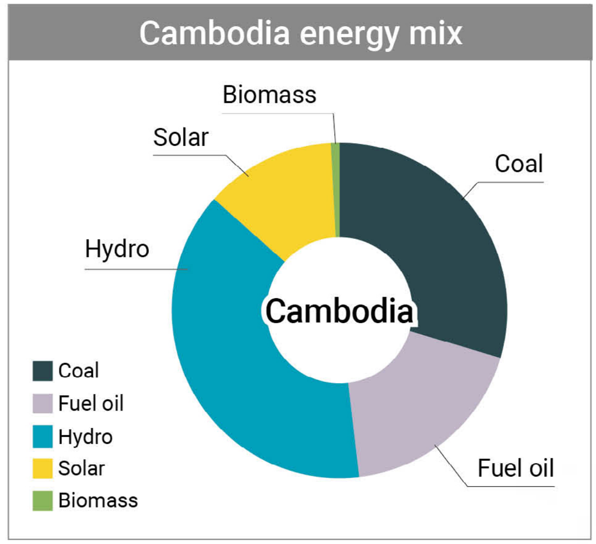


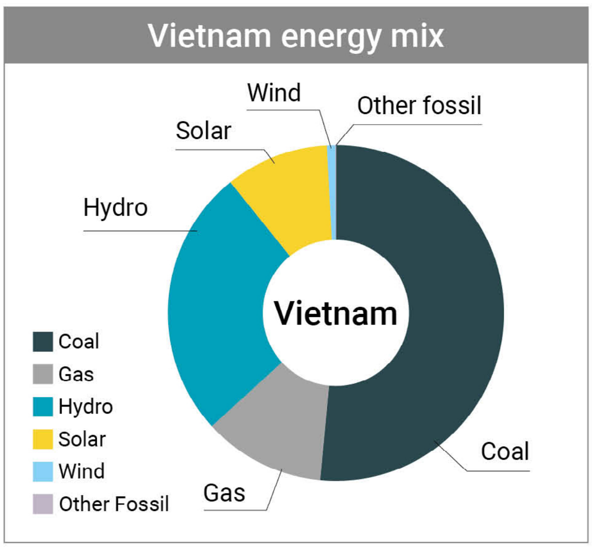
From an emissions perspective, this vulnerability to periods of low flow could trigger increased reliance on backup fossil fuel power sources. Reduced hydropower output during droughts will need to be made up through other generation options, or risk blackouts.

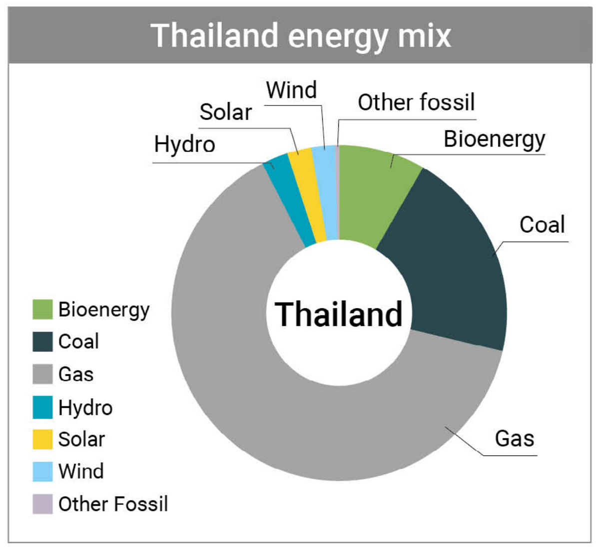
High concentrations of fossil fuels in the regional energy mix (see below)[69] could increase regional emissions when hydropower is unable to perform.[70]

In fact, coal was introduced into Laos' energy mix to provide backup power during the Mekong dry season.[71] Alternatively Laos has also been importing electricity from neighboring countries during the dry season, when electricity demand is typically higher. However, the cost of this imported electricity is often higher than the price it gets for its exports, which has contributed to the debt burden of Laos' state utility, EDL.[72]









While backup thermal power may be needed more frequently under climate change, which risks undermining national decarbonization targets, thermal power itself is exposed to throttling, or even complete shutdowns during periods of drought and extreme heat.[73] This means that a dual reliance on hydro and thermal power could limit supply right when energy is needed the most (e.g., for cooling systems and irrigation).

All the above suggests that Laos is already exposed to the impacts of climate change. Expanding hydropower capacity would only further expose the country to potential energy supply challenges and could put further pressure on Laos' current debt burden (see more in section 6). These climate impacts would likely have regional ramifications too because Laos exports the bulk of electricity produced to its neighbors.

Finally, it bears noting that the approach we have taken here is indicative.[74] This can be largely attributed to a lack of long-term, project-level production data available in the public domain. While we understand that hydropower companies and governments often prefer to keep this information private, it does raise a broader concern about the obstacles in the way of producing independent climate analysis for a sector that is clearly climate exposed.

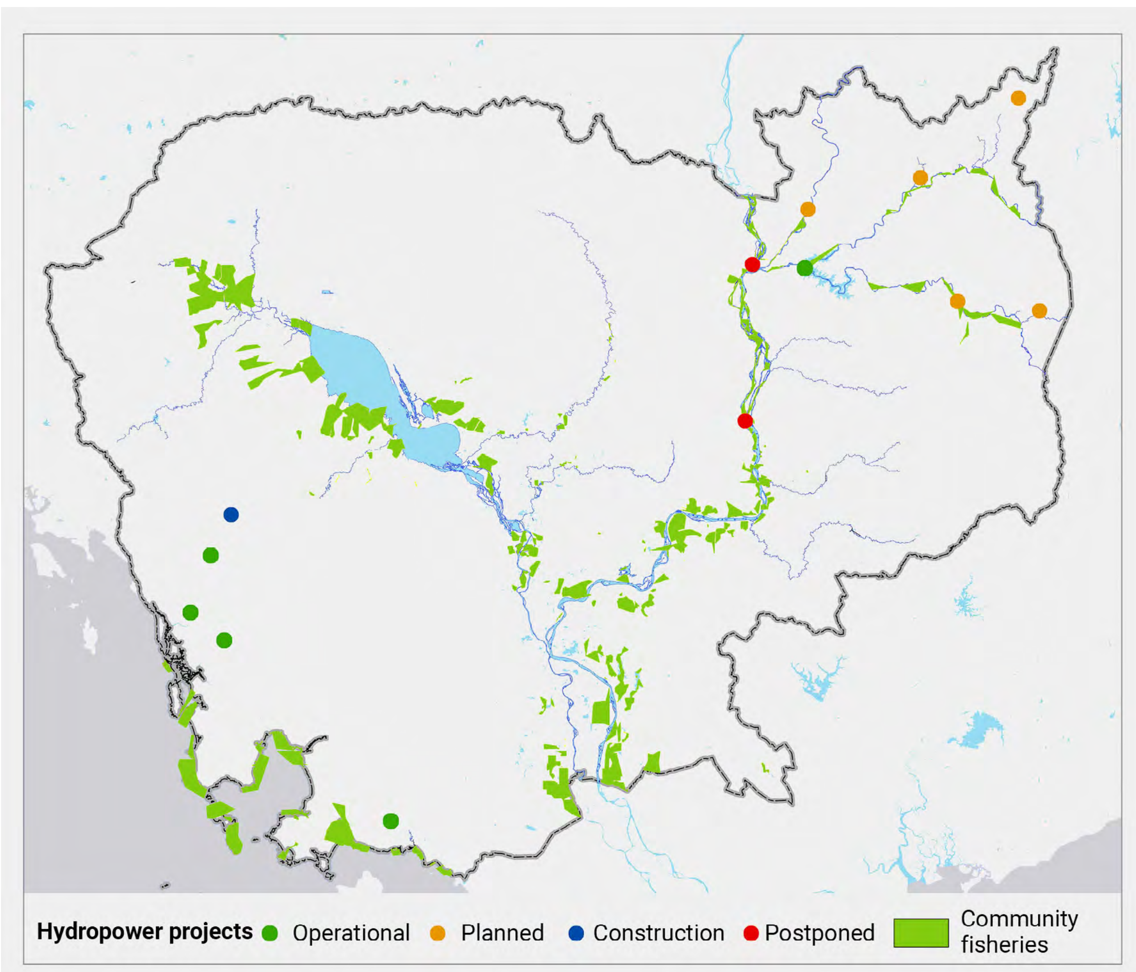
5. FOOD SECURITY AND SEDIMENT FLOWS

The agricultural and fisheries sectors play a crucial role in supporting food and livelihood security in the Mekong region, with production figures that are globally significant. The LMB produces 2.3 million tonnes of wild fish per year (valued at $11.2 billion),[75] which amounts to almost 20% of global inland fisheries production.[76] Similarly, agriculture extends over 5.7 million hectares (most of which is in Vietnam[77]), with a production value of $7.7 billion.[78]

Critically, these sectors are integrated with the seasonal flows and nutrient-rich sediments from the Mekong River.[79] But these natural processes are disrupted by hydropower development, which necessarily fragments the river and moderates flows according to electricity production regimes.[80] This is evidenced by an observed reduction in wet season flows and an increase in dry season flows since hydropower development.[81]

While these more indirect impacts can be considerable for fisheries and agricultural production, there is also evidence of negative impacts to fish and larvae passing through hydropower projects.[82] This is particularly concerning for migratory fish, which make up a significant portion (roughly 40%) of fish catch[83] in the Mekong.

To better understand which projects in the Cambodian subset may have more significant impacts on existing community fisheries, we carried out a geospatial analysis to identify those projects that are located near to existing community fisheries (see figure below)[84]. The analysis shows that at least half of the projects in the subset are located within 20km of community fishery areas.



Those projects nearest to community fisheries were mostly in early planning phases (or postponed, in the case of Sambor and Stung Treng) and were the highest scoring projects according to the Riverscope assessment. This proximity to community fisheries further exposes these projects to local backlash, as evidenced by the already operational Lower Sesan 2 project which faced considerable local opposition during development.

Measures to mitigate the impacts of hydropower projects on fisheries (e.g., fish ladders, passages, lifts)[85] can be especially costly for large projects[86] and are seldom (if ever) 100% effective. This particularly matters in the Mekong because of the multiple large projects that are planned and already operational, and because of the sheer number of fish species, and fish stocks, that rely on migration.[87]

Because of these dynamics, the scale of impact of continued hydropower production in the LMB would be extreme. Estimates suggest that continued hydropower development along tributaries and the mainstream could reduce fisheries production by as much as 40-80% by 2040.[88] This would have significant food security impacts at a local and regional level given the integral role of fisheries production across Mekong countries.

We then expect that climate change will exacerbate these risks in the coming decade through more erratic and extreme weather events. These could limit alternative food sources, like rice production, or further undermine already vulnerable fisheries. Such regional impacts would contribute to global food security challenges because of its significance to global production (e.g., rice and fish), and because of the likely impacts that climate will have on food security and prices throughout the rest of the world.

6. DEBT BURDEN AND HYDROPOWER RELIANCE

In Laos' pursuit to become a major energy exporter through hydropower, it has taken on considerable amounts of debt, primarily from China, that it is struggling to pay off. According to the World Bank, "public and publicly guaranteed (PPG) debt has reached critical levels, undermining macroeconomic stability and development prospects."[89] Estimates suggest that total PPG debt increased from $13.3 billion (73% of GDP) in 2020 to $14.5 billion (89% of GDP) in 2021, and greater than 110% of GDP in 2022, which is much higher than its regional neighbors.[90]

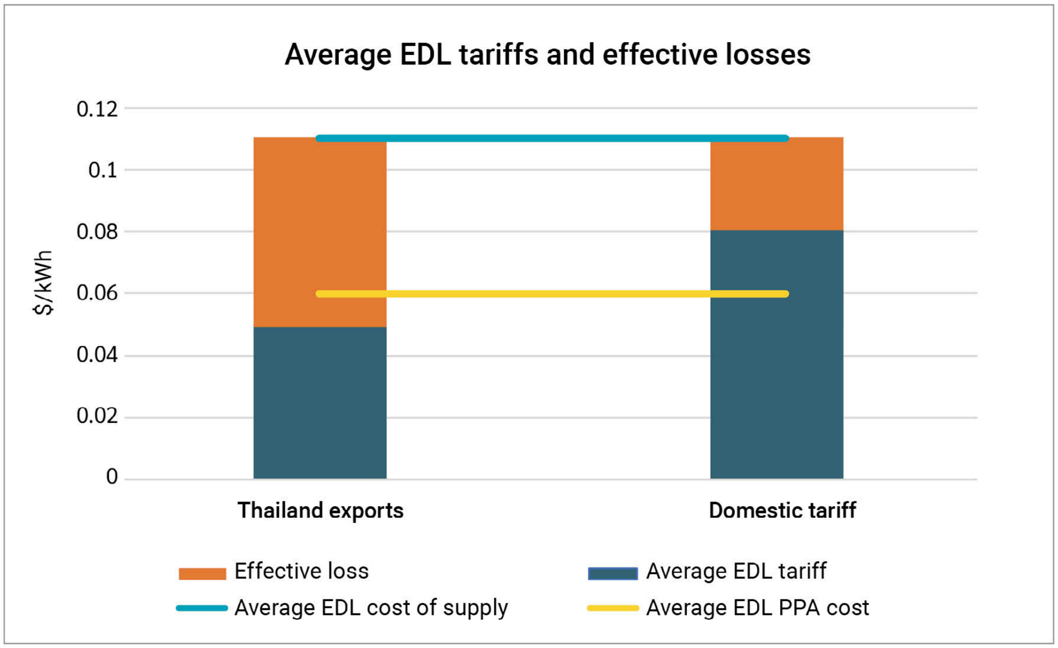
Indeed, the energy sector (primarily the national utility Électricité du Laos (EDL)) accounted for about 37% of PPG debt in 2021, while estimates suggest that EDL debt accounted for around half of the total increase in PPG debt between 2015 and 2020.[91] This overall debt burden translates into average public external debt repayments of more than $1.3 billion per year between 2023-2026.[92]

EDL's role in stacking up increasing debt can be partly explained by uncoordinated and poorly planned large hydropower investments, alongside an overburdened grid and unfavorable Power Purchase Agreements (PPAs).[93] Many domestic PPAs include 'take-or-pay' clauses that oblige EDL to purchase power, whether it is needed or not. As a result, preliminary estimates suggest roughly half of EDL's PPA costs can be attributed to unused capacity.[94]

A closer look at the pricing of PPAs for export projects shows that the average export tariff to Thailand (Laos' largest offtaker) is below the average price of electricity from domestic IPPs (see figure below)[95]. These lower export prices can be partly attributed to seasonal hydropower supply, with this lack of firm supply unfavorable to offtakers. Meanwhile, domestic tariffs are well below EDL's cost of supply recovery, which suggests that for every unit of electricity sold domestically, EDL incurs a loss.

A quick calculation shows that for every unit of IPP electricity sold domestically, instead of the seeming profit of 1.99USc/kWh, EDL actually incur a loss of 1.02USc/kWh. To put this into perspective, if we assume the two planned projects from the Laos subset both came online by 2025 and sold their electricity domestically, after just 5 years of operation this would amount to a loss of $67 million.

Another aspect of EDL's debt accumulation relates to its constrained energy grid. This is evidenced by difficulties linking projects in the far North of the country (e.g., the Nam Ou Cascade) to the capital,



Vientiane.[96] Similarly, some large hydropower projects have been unable to run at full capacity because of grid constraints.[97]

These grid challenges culminated in the formation of EDL-Transmission[98] in 2020, with a 90% share planned for sale to the Chinese state-owned enterprise, China Southern Power Grid (CSG).[99] CSG offer much-needed capital and expertise for Laos' transmission woes, but some researchers are characterizing the move as a "debt for equity swap" given Laos' indebtedness to China.[100] Agreement delays are now limiting new transmission investment with the risk of further deteriorating the grid.[101]

The next 5-10 years could bring some debt relief to Laos, with some government incentives for existing IPP projects coming to an end.[102] However, this would be undermined by the development of new projects. Laos has close to 12,000MW of hydropower in the pipeline, roughly half of which are likely to come online by 2030.[103] Riverscope indicates that at least 3,000MW of planned capacity is exposed to expected delays of over 2 years, which risk delaying revenue from these new projects and adding to Laos' debt burden.

7. SUMMARY AND RECOMMENDATIONS

Hydropower plans in the Mekong are driving extraordinary risks for food security, climate resilience and fiscal stability. At the same time, the impacts of planned dams will be severe for communities and ecosystems. From any angle, hydroelectricity in the region will come at a very high cost. At worst, hydropower plans could both catalyze and exacerbate national and regional crises.

Overall, we found that:

- Our 42 assets had an average Riverscope risk score of 80, which is exceptionally high. This score can translate into delays as long as 13 years, with an average NPV impact of $258 million per project. From a financial perspective, these assets are not investable.
- Climate impacts will further reduce hydropower output and financial viability. They will also threaten energy security at a national and regional level, which could have outsized economic impacts. In our view, these climate risks merit far greater consideration because we

expect them to land in the next few years (i.e., before most planned assets are complete).

- Countries like Laos that are accruing a large debt burden to finance hydropower rollout are at increasing fiscal risk because of the risks described above. Under current arrangements, our analysis suggests that a debt trap and/or default are highly likely, not least because energy is already being sold at a loss.
- The scale of hydropower development in the region poses severe risks to food security, both through reduced fish stocks and reduced agricultural production. Unless Mekong countries pull back decisively from planned projects, the costs and impacts of food security crises could be enormous.
- In aggregate, planned dams will negatively and directly impact large numbers of people. On average, 30,489 people were directly exposed to physical and/or economic displacement from the projects assessed. Another average 69,749 people lived downstream in areas that are very likely to be impacted.

The question then becomes whether these risks and impacts are merited for the benefits that hydropower can deliver. Our analysis suggests that they are not and that, in any case, hydropower will likely prove slow, expensive, and unreliable. Our assessment shows that the energy planners and investors in the region need to radically reassess current hydropower ambitions.

We are not suggesting any crude ban on the technology but rather we hope that a more rigorous and systematic approach to risk assessment can be taken first at an asset level and then with consideration of the cumulative impacts of current plans.

Better assessment and planning can deliver urgently needed energy more quickly and cheaply, leading to a more reliable and robust energy system that increases, rather than undermines, climate resilience and food security. There is no downside to a clearer and fuller appreciation of risk, it leads to better outcomes for people, governments and natural systems alike.

Zhaqu River (upper stem of the Lancang).
Photo by International Rivers.

ENDNOTES

1 https://www.mrcmekong.org/our-work/topics/hydropower/

2 https://portal.mrcmekong.org/hydropower/map

3 The projects were primary selected from Stimson's Mekong Infrastructure Tracker, alongside Power Development Plans and other publicly available resources. The aim was to select a representative sample of large projects in Laos, Cambodia and the Mekong mainstream, of various sizes and across different stages of development.

4 https://thedocs.worldbank.org/en/doc/e2126e24b45be8bbc35fdc6fc8374094-0360012022/original/Laos-CEM-Full-Report-ENG-Linking-Laos-Unlocking-Policies.pdf

5 https://riverscope.org/

6 https://mission.asktmp.com/

7 See the full methodology document at: https://riverscope.org/wp-content/uploads/2021/12/Riverscope-Rating-System-Methodology_final_15_12_2021.pdf

8 https://mission.asktmp.com/

9 The climate indicators underpinning the analysis draw on 20 CMIP6 climate models that are widely used by climate scientists around the world, including the IPCC, and were developed with our climate partners at the IBS Centre for Climate Physics, at Pusan National University in South Korea. We considered eight climate indicators, including increases in extreme temperature, unseasonably warm temperature, changes in annual precipitation, changes in annual dry days, unseasonably high rainfall, unseasonably low rainfall, changes in consecutive dry days, and changes in consecutive wet days.

10 We also have datasets for an increase from 1°C and 2°C

11 https://public.wmo.int/en/media/press-release/wmo-update-5050-chance-of-global-temperature-temporarily-reaching-15%C2%B0c-threshold

12 See Riverscope indicator scores for each project in the Appendix https://riverscope.org/wp-content/uploads/2024/07/Appendix_Mekong-Regional-Assessment-Riverscope-indicator-score-results_12JULY24.pdf

13 https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/

14 https://nhipcaudautu.vn/phong-cach-song/dap-se-kong-1-de-doa-dong-bang-song-cuu-long-3323435/

15 https://news.mongabay.com/2022/09/in-the-mekong-basin-an-unnecessary-dam-poses-an-outsized-threat/

16 https://www.phnompenhpost.com/national/villagers-activists-criticise-sesan-hydropower-project ; https://www.rfa.org/english/news/cambodia/dam-03022015173133.html

17 https://www.hrw.org/report/2021/08/10/underwater/human-rights-impacts-china-belt-and-road-project-cambodia ; https://www.cao-ombudsman.org/sites/default/files/downloads/CAO_Compliance%20Appraisal%20Report_Cambodia%20FI%2001-3_December%202022_EN.pdf

18 These figures are based on geospatial analysis which, respectively, counts the number of people within 20km from the Lower Sesan 2 dam site, and within 100km downstream of the dam site, with a 10km buffer on either side of the river (using the Gridded Population of the World [GPW v.4] dataset). This geospatial analysis is indicative and does not account for the unusual location of Lower Sesan 2 dam, which disconnects the Sesan and Srepok tributaries from the Mekong River and which is likely to affect a larger number of people, both upstream and downstream, as a result.

19 Assuming $7080 per person physically and economically displaced. The $7080 figure was derived from $6000/potentially affected person in 2022 dollar terms (+18%): https://rightsandresources.org/wp-content/uploads/Protecting-Liberias-Forest.pdf

20 https://data.opendevelopmentmekong.net/dataset/cd9d449d-f2ba-4d32-b692-2bb6df482652/resource/f528a095-f676-447b-ba87-90ff7f74a779/download/a5d8f560-6d7f-4fee-8886-259bb32cb2e3.pdf

21 The Mekong River is the second most biodiverse river in the world, with an estimated 1,148 fish species in the Mekong Basin. Crucially, this diversity is linked to the provision of ecosystem services that support regional food security. https://www.mrcmekong.org/assets/Publications/SOBR-v8_Final-for-web.pdf ; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9874365/

22 Ban Koum has reportedly been shelved following strong opposition in Thailand and a lack of cooperative framework between the two countries: https://www.internationalrivers.org/wp-content/uploads/sites/86/2020/06/mekongmainstreamdamsupdatejune2017_english.pdf ; https://www.bangkokpost.com/thailand/general/2265359/governor-shelves-dam-project

23 The Pha Team National Park on the Thai side, and the Phou Xiang Thong National Park on the Laos side

24 See Methodology section 2.2. for more information about the Mission Climate Project data

25 These 3 years produced the worst droughts on record and the lowest water levels in the last century: https://www.mrcmekong.org/assets/Publications/Mekong-low-flow-and-drought-conditions-2019-2021df.pdf

26 https://www.stimson.org/wp-content/uploads/2021/09/Stimson_Lower-Mekong-Energy-Developments_Final_May-2021.pdf

27 EDL-Gen is a subsidiary of Laos' state utility Electricite Du Laos, which wholly owns or has stakes in over 20 hydropower projects in Laos.

28 https://edlgen.com.la/uploads/credit-rating/2020/en/EDL-Gen_TRIS_Rating_Report_15_05_2020_(EN).pdf

29 https://e.vnexpress.net/news/business/economy/11-hydropower-plants-shut-down-due-to-water-shortage-4615445.html

30 https://myrepublica.nagariknetwork.com/news/floods-and-landslides-damages-26-hydropower-projects-multiple-road-sections/

31 https://www.firstpost.com/india/tragedy-at-tapovan-vishnugad-hydel-project-understanding-hydrology-geology-of-himalayas-is-need-of-the-hour-8689901.html ; https://www.diva-portal.org/smash/get/diva2:1471284/FULLTEXT01.pdf

32 https://eac.gov.kh/uploads/salient_feature/english/salient_feature_2022_en.pdf

33 Cambodia Power Development Masterplan 2022-2040, Cambodian Ministry of Mines and Energy, September 2022.

34 https://www.theguardian.com/world/2020/mar/20/cambodia-scraps-plans-for-mekong-hydropower-dams

35 Cambodia Power Development Masterplan 2022-2040, Cambodian Ministry of Mines and Energy, September 2022.

36 https://www.reuters.com/article/mekong-river-cambodia-idUSL4N29D3JC

37 https://thediplomat.com/2022/03/abby-seiff-on-the-slow-death-of-cambodias-tonle-sap-lake/

38 https://ui.adsabs.harvard.edu/abs/2021AGUFM.H31E..01D/abstract

39 NPV loss figures throughout the report assume a budget overrun of 33% which is common for large hydropower projects since 2000: https://www.tandfonline.com/doi/abs/10.1080/07900627.2019.1568232

40 https://www.iucn.org/news/viet-nam/202205/sekong-a-dam-lao-pdr-and-mekong-delta-a-moment-decision-viet-nam ; https://news.mongabay.com/2022/09/in-the-mekong-basin-an-unnecessary-dam-poses-an-outsized-threat/

41 Oxford University's MPI has three dimensions and 10 indicators, with the dimensions covering health, education and standard of living: https://ophi.org.uk/wp-content/uploads/CB_KHM_2022.pdf

42 https://www.adb.org/sites/default/files/publication/722236/climate-risk-country-profile-cambodia.pdf

43 https://edlgen.com.la/uploads/webcast/en/EDL-Gen_Opportunity_Day_PPT_2022.pdf

44 https://www.greatermekong.org/sites/default/files/rptcc28/4%20-%20Country%20Presentation_%20Lao%20PDR.pdf

45 We assessed 49 projects with delays and found the median delay was 4 years and the mean was 10 years.

46 https://documents1.worldbank.org/curated/en/525331657067519545/pdf/Lao-Peoples-Democratic-Republic-Systematic-Country-Diagnostic-Update.pdf

47 https://www.iucn.org/news/viet-nam/202205/sekong-a-dam-lao-pdr-and-mekong-delta-a-moment-decision-viet-nam ; https://news.mongabay.com/2022/09/in-the-mekong-basin-an-unnecessary-dam-poses-an-outsized-threat/

48 The Lower Sesan 2 blocks the Sesan and Srepok tributaries. Together the Sekong, Sesan and Srepok make up the 3S River Basin, which contributes about 20% of the water flow and 15-40% of sediment to the Mekong. These are particularly important for supporting the Tonle Sap and Mekong Delta areas downstream: https://www.mrcmekong.org/news-and-events/news/3s-basins-take-another-step-towards-shared-long-term-trans-boundary-vision/

49 The resettlement village did not have suitable land to grow rice and other common crops and the village itself did not have running water, sanitation, a school or a health center. It is unclear if or when the families received compensation, but they had not been compensated at the time of reporting: https://www.rfa.org/english/news/laos/laos-xe-la-nong-1-dam-02252020153728.html

50 10 were commissioned in China, while 2 were commissioned in Laos in 2019.

51 11 of which are planned in China, with the remaining 9 planned between Laos, Thailand and Cambodia.

52 https://www.mrcmekong.org/about/mekong-basin/

53 https://www.mrcmekong.org/assets/Publications/Council-Study/Key-messages-of-the-Council-Study-reports_26-Nov-18_revised-4-Jan-19.pdf ; https://www.mdpi.com/2073-4441/13/3/265

54 The lack of correlation between the size of the project and the overall risk score is noteworthy. This is one area where the Riverscope assessment methodology could be improved. However, it is worth emphasizing that Riverscope's quantitative methodology was designed to assess the contextual risks that environmental and social factors pose to dams in a standard and comparable way, rather than the risks that dams create in environmental and social terms. During design, we found that hydropower's design-driven risks would be better assessed and understood on a case-by-case basis, and that a deep dive approach is more appropriate here as a result.

55 Excluding Pak Chom from the subset increases the average score to 79, similar to the Laos subset.

56 https://www.bangkokpost.com/thailand/general/2265359/governor-shelves-dam-project

57 https://mediamanager.sei.org/documents/Publications/Bangkok/SEI_2017_Report_Mekong_sediment_LoRes.pdf

58 https://portal.mrcmekong.org/assets/v1/documents/Report-workshop/Technical-Report_DSMP/DSMP-Report-2009_13-Final-Report-July-2014.pdf ; https://www.sciencedirect.com/science/article/abs/pii/S0169555X19305021

59 https://www.mrcmekong.org/assets/Publications/Council-Study/Key-messages-of-the-Council-Study-reports_26-Nov-18_revised-4-Jan-19.pdf

60 Laos exported 73% (38,737GWh) of energy produced in 2020, with plans to increase exports to 83% (124,400GWh) of production by 2030: https://www.greatermekong.org/sites/default/files/rptcc28/4%20-%20Country%20Presentation_%20Lao%20PDR.pdf

61 We use a relative scoring system here, where the exposure of an area to a given climate risk indicator (e.g., increase in the number of annual dry days) is compared to the rest of the world and then given a percentile rank from 0-100, where a score of 0 is the least exposed area in the world, and a score of 100 is the most exposed area in the world. E.g., areas scoring above 50 are more exposed than 50% of the world. The "areas" in this case are L1 administrative areas, based on GADM data.

62 The map combines two temperature indicators, including increases in extreme temperature and increases in unseasonably hot temperatures.

63 https://www.reuters.com/business/sustainable-business/inconvenient-truth-droughts-shrink-hydropower-pose-risk-global-push-clean-energy-2021-08-13/

64 https://www.stimson.org/wp-content/uploads/2021/09/Stimson_Lower-Mekong-Energy-Developments_Final_May-2021.pdf

65 National data from IRENA's annual renewable energy statistics reports: https://pxweb.irena.org/pxweb/en/IRENASTAT

66 Historical climate data from: https://climateknowledgeportal.worldbank.org/country/lao-pdr/climate-data-historical

67 This can be attributed to the granularity of the data being at national level. Long-term project-level production data was unavailable.

68 https://www.bloomberg.com/news/features/2022-10-26/drought-from-china-to-us-hits-hydro-dams-slashing-the-top-clean-energy-source

69 Laos data: https://edlgen.com.la/uploads/webcast/en/EDL-Gen_Opportunity_Day_PPT_2022.pdf ; Cambodia data: https://eac.gov.kh/uploads/salient_feature/english/salient_feature_2022_en.pdf ; Thailand and Vietnam data: https://ember-climate.org/insights/research/global-electricity-review-2022/

70 https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EF001814

71 "The main reason we want to produce more electricity from coal-fired power is to minimize the amount of reimported power and address the electricity shortage in the dry season," - Lao Minister of Energy and Mines, Daovong Phonekeo: http://www.news.cn/english/2021-11/10/c_1310302206.htm

72 https://lao.mofa.go.kr/la-en/brd/m_1893/view.do?seq=419

73 For example, India's Farakka coal plant was shut down because of a lack of water: https://www.thehindubusinessline.com/todays-paper/tp-news/ntpc-plant-shutdown-hits-power-supply-in-5-states/article8353545.ece

74 While we acknowledge that we are not hydrological experts, we do understand the challenges associated with regional governance, as well as the inherent uncertainties associated with the double hydrological impacts of hydropower development and climate change.

75 https://www.mrcmekong.org/assets/Publications/SOBR-v8_Final-for-web.pdf

76 https://www.fao.org/3/ca9229en/ca9229en.pdf

77 The Vietnamese Mekong Delta produced 23,8 million tonnes of rice in 2020, or close to 5% of global rice production, most of which is exported: https://www.gso.gov.vn/en/px-web/?pxid=E0615&theme=Agriculture%2C%20Forestry%20and%20Fishing ; https://www.fao.org/3/cc3233en/cc3233en.pdf

78 https://www.mrcmekong.org/assets/Publications/SOBR-v8_Final-for-web.pdf

79 Flooding raises water levels to enable fish migration and spawning, while at the same time it soaks agricultural lands and replenishes soils with nutrient-rich sediments from upstream.

80 This is most acute for conventional impoundment dams, but run-of-river schemes have also proven to disrupt flows, as reflected downstream of Xayaburi: https://www.mrcmekong.org/assets/Publications/JEMPILOT2022.pdf

81 https://www.mrcmekong.org/assets/Publications/Mekong-low-flow-and-drought-conditions-2019-2021df.pdf

82 https://www.mdpi.com/2073-4441/15/3/421 ; https://www.publish.csiro.au/mf/pdf/MF18126 ; https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-020-0184-0 ; https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/cobi.13870

83 https://www.mrcmekong.org/assets/Publications/technical/tech-No48-Review-of-Existing-Research-on-Fish-Passage.pdf

84 Community fisheries data from: https://data.opendevelopmentcambodia.net/en/dataset/fishery

85 https://www.mrcmekong.org/assets/Publications/technical/tech-No48-Review-of-Existing-Research-on-Fish-Passage.pdf

86 Xayaburi Power Company spent over $300 million (or almost 10% of the estimated cost of Xayaburi) on a fish passage facility: https://www.frontiersin.org/articles/10.3389/fenvs.2020.566509/full

87 The annual migration from the Tonle Sap up the Mekong mainstream is widely considered one of the largest in the world: https://www.stimson.org/2022/testimony-of-stimson-center-southeast-asia-program-director-mr-brian-eyler/ ; https://www.nationalgeographic.com/animals/article/mekong-river-fish-migrations

88 https://www.mrcmekong.org/assets/Publications/Council-Study/Key-messages-of-the-Council-Study-reports_26-Nov-18_revised-4-Jan-19.pdf

89 https://thedocs.worldbank.org/en/doc/4d007846d90603cba830b0b2859cf9be-0070062023/original/LaoEconomicMonitorMay2023.pdf

90 https://documents1.worldbank.org/curated/en/099060923122518058/pdf/P17962811201b491164fc14b071a710122bc24998063.pdf

91 https://thedocs.worldbank.org/en/doc/e2126e24b45be8bbc35fdc6fc8374094-0360012022/original/Laos-CEM-Full-Report-ENG-Linking-Laos-Unlocking-Policies.pdf

92 https://thedocs.worldbank.org/en/doc/4d007846d90603cba830b0b2859cf9be-0070062023/original/LaoEconomicMonitorMay2023.pdf

93 https://thedocs.worldbank.org/en/doc/e2126e24b45be8bbc35fdc6fc8374094-0360012022/original/Laos-CEM-Full-Report-ENG-Linking-Laos-Unlocking-Policies.pdf

94 https://thedocs.worldbank.org/en/doc/e2126e24b45be8bbc35fdc6fc8374094-0360012022/original/Laos-CEM-Full-Report-ENG-Linking-Laos-Unlocking-Policies.pdf

95 Figure data from: https://thedocs.worldbank.org/en/doc/e2126e24b45be8bbc35fdc6fc8374094-0360012022/original/Laos-CEM-Full-Report-ENG-Linking-Laos-Unlocking-Policies.pdf

96 https://onlinelibrary.wiley.com/doi/full/10.1002/app5.318 ; https://www.greatermekong.org/sites/default/files/Attachment%209%20.LAO%20Master%20Plan.pdf (slide 8)

97 http://www.xinhuanet.com/english/2020-10/05/c_139420452.htm

98 EDL-T is a joint venture that was formed to take over ownership of all transmission assets of 230 kV and 500kV lines and substations from EDL

99 https://documents1.worldbank.org/curated/en/099400009222240962/pdf/P1784770ef99af0a0b20d03b632bedf0fe.pdf

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Cover Image: Fisherman in Nong Khai province, Thailand. Photo by International Rivers.