Can Hydropower Drive Sustainable Growth in Laos

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Content

Abstract

This paper looks at the effects of investment in hydropower in Lao PDR and considers the question: Can hydropower drive sustainable economic growth in Laos? We divided sustainability down into its three pillars (environmental, social, and economic) and expanded on key pros and cons in each category, which were based on points made in reviewed literature. We found that although the economic benefits are large, the social and environmental costs are equally, if not more, large. In addition, hydropower dams disproportionately, negatively impacts people in rural areas, who must be involuntary resettled and/or whose livelihoods depend on the river's resources. In conclusion, hydropower currently should not be deemed "sustainable development" in Laos, considering the net economic impact of planned Mekong hydropower projects is negative and, therefore, not economically feasible.

1. Introduction

Lao People's Democratic Republic or Lao PDR is a landlocked country with around 7 million people and approximately 6.5% GDP growth in 2018 (reported by Asian Development Bank). Laos PDR is located in the center of Southeast Asia and it is bordered by Thailand, the southern part of China, Myanmar, Vietnam and the northern part of Cambodia. Almost half of Lao PDR's topography is mountainous, which extents mostly in the northern part of the country. Lao PDR is well known as a natural resource-rich country especially its rivers which are Mekong river and Mekong tributaries such as Nam Theun, Nam Ngum or Nam Leuk. With the benefit of having lots of rivers, Lao PDR has a good potential in the hydropower industry or being a big exporter of electricity from hydroelectricity plants.

From the Economic Research Institute for ASEAN and East Asia, they report that hydroelectricity is one of the top 5 sectors that contribute the highest volume to Lao PDR's GDP, which is calculated equal to 6% of GDP. In recent years, Lao PDR has invested and allowed foreign investors to invest heavily in the hydropower plants which can be seen from Figure 1 that from 2005 to 2017, hydropower plants number increase from 9 to 46 plants raising electricity capacity to 6,444 megawatts. The government also has a plan to increase the hydroelectricity plant to 100 plants in 2020 with 28,000 megawatt of generating electricity capacity. Lao PDR invests and allows many FDIs they plan to be the "Battery of South-East Asia" by exporting to many countries such as Thailand,Vietnam, Cambodia and also Singapore and China.

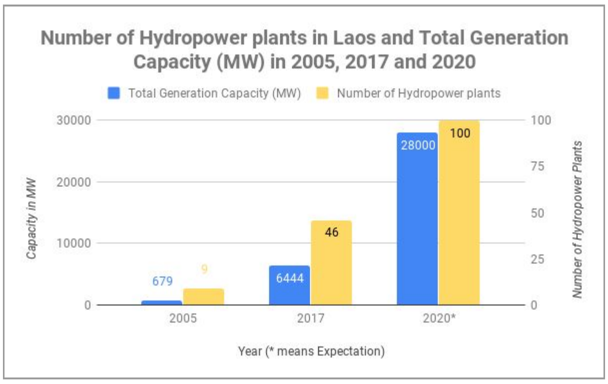


Figure 1 : Number of Hydropower plants in Laos and total generation capacity (MW) in 2005, 2017 and 2020

There are many benefits from hydropower. With a higher number of hydropower plants, access to electricity in Laos PDR has also increased which can be seen from figure 2. From 2000 to 2017 the percentage of electrification in Lao PDR had increased from 43% to 93% which was a double of the year 2000. In 2018, the percentage of Lao PDR's population access to electricity is almost 100% of the Lao PDR's population. With the increased electrification in Laos, it can be assumed that people's well being has also improved.

Moreover, there are many hydropower projects that are successful for example, Nam Theun 2 (NT2) project or Nam Leuk project which can generate high revenue to Laos government. From this, Laos government can use the revenue to develop the country and reduce some problems such as poverty in Laos PDR.

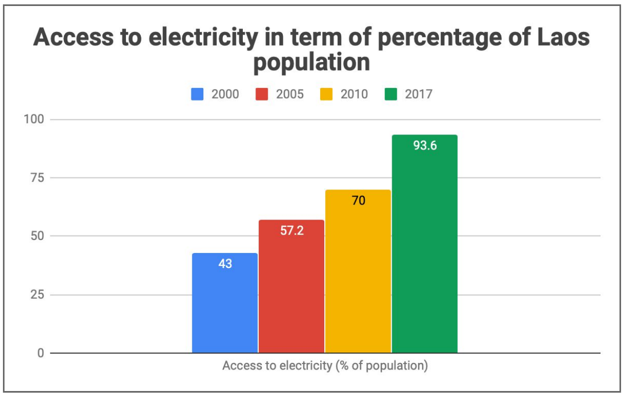


Figure 2 : Access to electricity in terms of Lao PDR's population from World Bank

Hydropower is also considered to be a sustainable energy since it is one of the renewable energy sources (which are Hydropower, Geothermal energy, Wind energy and etc). Being a renewable energy source means that this energy source (hydropower) will not be depleted, and Laos people will have electricity to use and consume benefit from this sector such as revenue for a long time. Therefore, investing in hydropower could potentially be seen sustainable development.

Even though Hydropower is one of the most successful sectors in terms of generating high revenue (which is about 6% of Lao PDR's GDP) and that revenue can be used to reduce poverty in Lao PDR , there are still some problems from this sector. For example, around five years ago, there were three dams that had collapsed: the Xekaman Dam in 2016, the Nam Ao Dam in 2017, and Xe-Pian Xe Namnoy Dam in 2018. From there event of dam collapsed, there were many people died, and also many houses or environment had been destroyed from this event which can be seen in figure 3.

Figure 3 : The damage from the Nam Ao dam collapse in 2017 (left picture) and Xe-Pian Xe Namnoy Dam in 2018 (right picture)

There are not only dam collapsed but there are also some problems from the dam construction such as pollution or damage natural habitation of animals. The recent project in Laos is Xayaburi Dam which is located in the northern part of Laos and owned by Xayaburi Power Company Limited. Xayaburi dam seem to have many environmental and social concerns such that the Xayaburi dam can make Me Kong drought. When the Mekong river drought, it affects those people whose income is from fishery since no fish can not survive.

Figure 4 : Damage on environment and habitats around the Mekong River from Xayaburi Dam

From these consequences of hydropower sector, it leads to our goals that we would like to analyze about costs and benefits of hydroelectric in Lao PDR in both construction and electricity generation parts. Moreover, this paper will suggest some recommendations to ensure that all hydropower projects in the future will be economic, environmental and social sustainable.

2. Literature Review

In doing our research for the sustainability of hydroelectric power generation in Laos, we came across six relevant papers. Four papers are case studies specifically about hydropower in Laos, or at least the Lower Mekong Basin, while the other two papers are about the sustainability of hydropower in general.

To start off, the most dated paper was published in 2010 and called *Hydropower and sustainable development: a case study of Lao PDR*. It breaks up the sustainability of the hydropower sector in Lao PDR into two parts: the environmental and social aspects of sustainability and the economic aspects of sustainability. Overall, with respect to the environmental and social aspects, the Government of Laos has already developed quite comprehensive domestic legislation to deal with environmental conservation issues. For instance, "According to the Environmental Protection Law of 1999, and Environmental Assessment Regulations 1770 of 2000, all large hydropower projects must produce a full Environmental Impact Assessment (EIA) report and Environmental Management Plan (EMP). The Electricity Law (1997) stipulates that investors in electricity production have the obligation to protect the environment, namely to assess the impact on the natural environment, on the ecosystem, to limit the impact on society and wildlife habitat" (Jusi, 2010, p. 203). However, it is important to note that the social and environmental safeguards of multilateral development banks (i.e. Asian Development Bank, World Bank) have enhanced the implementation process of many hydropower projects in Laos, which lack human, technical, and financial resources (Jusi, 2010, p. 203). With respect to the economic aspect of sustainability, considering the large capital and resource requirements of hydropower, the financial vacuum left by the withdrawal of big development agencies has resulted in relying on financiers that lack policies on environmental and social issues and do not adhere to internally accepted guidelines (Jusi, 2010, p. 205). In summary, although there has been substantial improvements in policies, legal requirements, and assessment guidelines, there are still major problems like insufficient quality of environmental and social assessments, ineffective regulatory framework, lack of transparency, and failure to conduct comprehensive consultations with all stakeholders (Jusi, 2010, p. 199).

In Matthijs Smits' 2012 paper, *Hydropower and the Green Economy in Laos: Sustainable Developments?* he discusses the benefits, the social and environmental costs, and the equity of hydropower. The benefits in monetary terms are large. The Nam Theun 2 hydropower project is expected to generate \$80 million annual and \$2 billion over its lifetime, and other hydropower projects are expected to provide similar proportional benefits as well (114). The government even claims that the share of hydropower (and mining) to Laos's GDP will increase from 4% in 2010 to 20% in 2020 (115). The social and environmental impacts of dams includes involuntary resettlement, loss of fisheries, emission of greenhouse gases, and disruption of livelihoods and ecosystems in general (115). A shortcoming of this paper, that we will address in the conclusion, is the lack of quantifying the social and environmental costs. Another concern is the distribution of benefits, which are "likely to be accumulated by the urban elite and middle class, while the majority of the social and environmental costs will be carried by the people in dam-affected rural areas" (115). It concludes by suggesting that large hydropower may actually negatively impact poor people by jeopardising their land use, fisheries, and other forms of livelihood.

This third paper, *The People and their River, the World Bank and its Dam: Revisiting the Xe Bang Fai River in Laos*, was published in 2015 and specifies how the livelihoods of people dependent on the river's resources are negatively affected. Downstream impacts include severe decline in diversity and quantity of fish in XBF, declines in wet season rice cultivation and riverside vegetable gardening, and degradation of water quality (1089-92). The research concluded that, "It tends to be the poorest and most vulnerable communities, families and individuals who are most dependent on communal natural resources, such as rivers and related aquatic resources, which have been the most severely impacted" (1093). In addition, the NT2 concession agreement obliged NTPC to allocate \$16 million for a Downstream Programme (DSP) intended to assist people negatively impacted by the project. However, the authors' findings suggest "neither the DSP's approach to compensation nor its specific project components have adequately addressed the cumulative impacts to livelihoods that are the most serious negative legacy of NT2 in the XBF basin" (1093).

The most recent paper we found of hydropower in Lao PDR, *Tradeoff analysis between electricity generation and ecosystem services in the Lower Mekong Basin*, was published in 2018 and was a joint effort by Thai and Australian scholars. Direct and indirect benefits costs and benefits of hydropower development were quantified and internalized to net present values (NPVs) and compared it to the Mekong River Commission (MRC) conclusions. There were many economic calculations based on many assumptions with varying degrees of certainty but they claimed to have used best case scenario of conservative data to assess the three main important factors, which have the largest economic impacts: hydropower generation benefits, capture fisheries loss, and sediment/nutrients loss (29-30). This study also estimated social mitigation costs, which MRC excluded, and revised environmental mitigation costs, which MRC underestimated in their economic assessment. This paper's key takeaway was that the forecast loss of capture fisheries, sediment/nutrients and social mitigation costs are greater than the benefits from electricity generation, improved irrigation and flood control. The paper also forecasts huge negative economic impacts for Cambodia and Vietnam in contrast to previous MRC conclusions that all countries will benefit from hydropower development.

Frans Koch's chapter, *Hydropower - Internalised Costs and Externalised Benefits*, details the benefits of hydropower with respect to the environment. The benefits of hydropower consists of the minimal level of noxious and greenhouse gas emissions, its energy security from political instability, and its renewable, non-depletable nature. On the other hand, the costs of hydropower consist of negative effects on the river ecosystem and of social changes in communities in the vicinity of large projects. All of these aspects will be detailed in our upcoming analysis.

Lastly, the final paper, *Hydropower for Sustainable Energy Development*, discusses how hydropower is characterized as a renewable energy source due to the fact that it uses the energy of flowing water, without consuming it, to generate electricity; therefore, all hydropower projects – small or large, run-of-river or storage – meet the explanation of being renewable (3). Hydropower creates fewer pollution and climate problems than fossil fuels. In addition, hydroelectric projects are the energy source with the lowest greenhouse gas emissions compared to thermal coal, thermal natural gas, solar, wind, and nuclear. Contrary to what this paper claims, however, hydropower does pollute water it uses to generate power. On the other hand, it acknowledges that revenues generated through electricity sales can finance essential infrastructure for human welfare like drinking water supply systems, irrigation schemes, infrastructure enhancing navigation, recreational facilities, and ecotourism.

3. Framework

Sustainable energy refers to the energy used in ways that support sustainable development in all dimensions. In essence, something is sustainable if doing so is not at the expense of the future generation. There are negative and positive aspects in many regards when it comes to hydropower as sustainable energy development in Lao PDR. *Considering how sustainability is a multifaceted concept, we found that the simplest way to frame our report is by dividing sustainability into its three pillars: environmental, social, and economic then summarizing each aspect's positive and negative impacts*. One thing to keep in mind is that many impacts often fall into more than one category, but for organisational purposes, we placed certain impacts where we thought they would fit best, despite having association with another/other pillar(s).

Our group tried to aggregate as much relevant and useful information as we could, but there are still aspects of sustainability assessment that were left unsaid because they were too difficult to quantify such as rare endangered species concerns, community acceptance, effectiveness of ongoing compensatory benefits, savings on greenhouse gas emissions, and more.

4. Analysis

For the analysis, there will be three parts according to the three pillars of sustainability which are Environmental, Social and Economic parts. Those three parts will also divided into positive effects and negative effects with supporting evidence for each effects.

4.1. Environmental Aspect

4.1.1. Positive impacts (Environmental Aspect)

First positive impact of hydropower is that hydropower is a renewable energy. From many researches such as paper from OECD or NREL reported that all renewable energy sources (Hydropower, Geothermal energy, Wind energy and etc) are better for the environment than those non-renewable energy sources (Natural Gas, Oil or Coal) in terms of creating lower pollution such as water pollution or air pollution (ex. greenhouse gases) in the process of electricity generation.

Most of the research evidence are about the air pollution which is Greenhouse gases. The reason that Greenhouse gases are air pollution is because Greenhouse gases causes a Greenhouse effect which means those gases trap heat in the atmosphere. Greenhouse gases make the average world temperature increase leading to Global Warming.

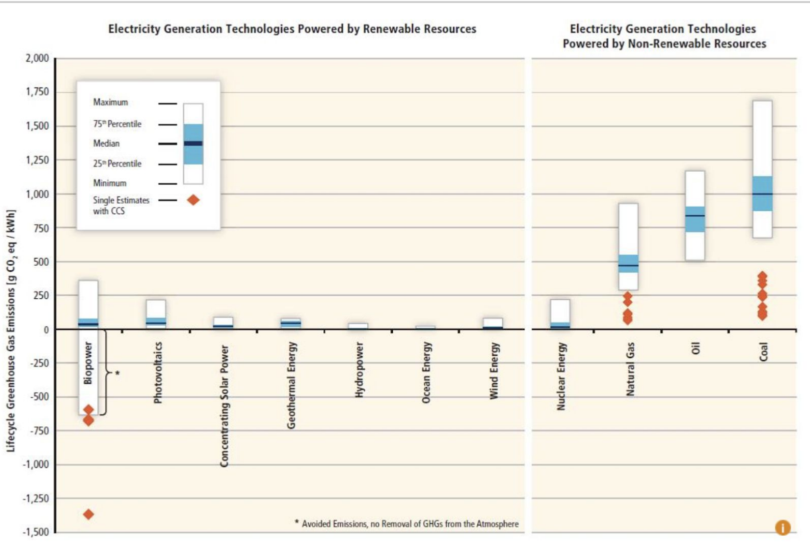
From the research by OECD, it reported that hydropower creates very minimal amount of noxious and greenhouse gases. This research used Life Cycle Assessment (LCA) methodology to find that within 1 kWh of electricity generation for each energy source, how much greenhouse gases and particulate matter have been produced. There are 7 energy sources for this research which are Hydropower, Coal, Nuclear, Natural Gas, Biomass, Wind and Solar photovoltaic. Hydropower, Biomass, Wind and Solar photovoltaic are renewable energy sources while Coal, Nuclear, and Natural Gas are non-renewable energy sources. The result is shown in figure 5 that that the amount of noxious emissions (SO2, NOx, NMVOC –

non methane volatile organic compounds, and particulate matter) and greenhouse gas emissions are much less for hydropower. The range of each emission is dependent on the size of the plant.

Generation option	Greenhouse gas emissions gm equiv CO_2/kWh	SO_2 emissions milligram /kWh	NO_x emissions milligram /kWh	NMVOC milligram /kWh	Particulate matter milligram /kWh
Hydropower	2-48	5-60	3-42	0	5
Coal – modern plant	790-1 182	700-32 321+	700–5 273+	18-29	30-663+
Nuclear	2–59	3-50	2-100	0	2
Natural Gas (combined cycle)	389–511	4-15 000+[4]	13+-1500	72-164	1-10+
Biomass forestry waste combustion	15–101	12-140	701-1950	0	217-320
Wind	7–124	21-87	14-50	0	5-35
Solar photovoltaic	13–731	24-490	16-340	70	12-190

Figure 5 : Emissions produced by 1 kWh of electricity based on life cycle analysis by OECD

Another research which supports that hydropower as a renewable energy, it is better for the environment and produce less pollution, is from National Renewable Energy Laboratory (NREL). This research finded the lifecycle greenhouse gas emissions per 1 kWh of each energy sources which classified into renewable energy sources (Biopower, Photovoltaics, Concentration Solar Power, Geothermal Energy, Hydropower, Ocean Energy and Wind Energy) and non-renewable energy sources (Nuclear Energy, Natural Gas, Oil and Coal). The result is that hydropower creates the second lowest greenhouse gas and the first is ocean energy which is shown in figure 6.



Different sources of energy produce different amounts of heat-trapping gases. As shown in this chart, renewable energies tend to have much lower emissions than other sources, such as natural gas or coal.

Figure 6 : The lifecycle greenhouse gas emissions per 1 kWh of each energy sources

Second advantage from hydroelectricity sector is that Lao PDR can use revenue from this sector to reinvest in environmental management. Most of the modern hydropower projects nowadays have to do an environmental and social management plan in order to get an approval from the government.

Lao PDR also has a law for this management as well. According to the Environmental Protection Law (1999), and Decree on Environment and Social Impact Assessment No. 112 (2010), hydropower projects with an installed capacity of more than 15 MW must report an Environment and Social Impact Assessment (ESIA) and an Environmental Management Plan (EMP). With these laws, many hydropower projects ,that invested in Laos, have to report an Environment and Social Impact Assessment and an Environmental Management Plan since most of them have capacity more than 15 MW. For example, the Nam Leuk Hydropower plant reported that they used their revenue for building a Phou Khao Khouay National park in 2003. Another example is Nam Theun 2 (NT2) which is the biggest and the most successful hydropower project in Lao PDR. Nam Theun 2 project also used the revenue to build a national park in Nakai - Nam Theun called Nakai - Nam Theun National Biodiversity Conservation Area (2019). Those two national park are shown in figure 7. From this management, it can be used to compensate those forests that had been cut down and increase green area in Lao PDR.

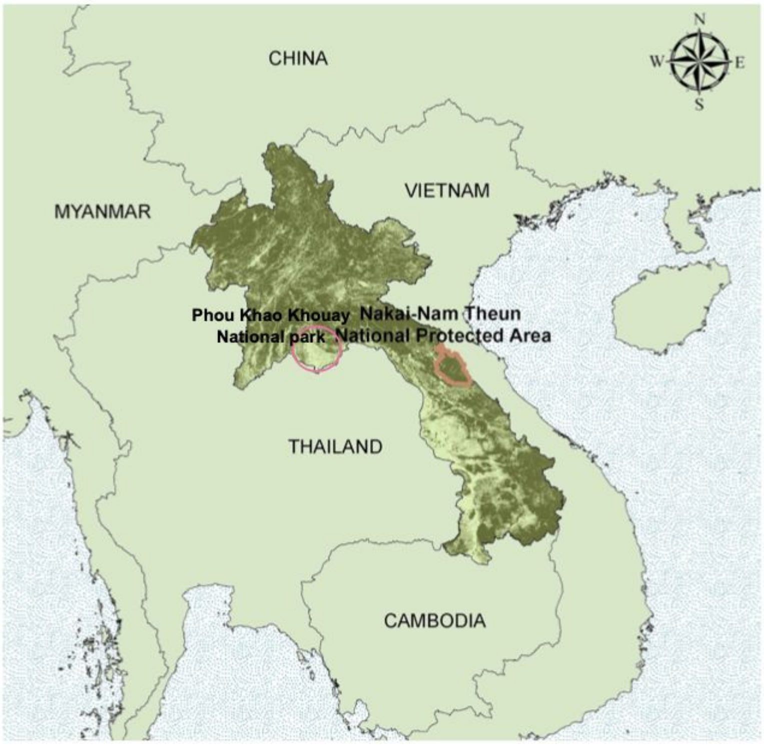


Figure 7 : A map shows Phou Khao Khouay National Park and Nakai-Nam Theun National Protected Area

4.1.2. Negative impacts (Environmental Aspect)

Undoubtedly, there are negative impacts on the environment associated with developing hydropower facilities. Firstly, the degradation in the quality of water originates from a direct and indirect effect, the direct effect is from the dam construction which is a part of the hydropower facility. The dam holds back sediments which is necessary for maintaining the downstream ecosystem as it contributes to the improvement of habitat quality. The indirect effect is from the reservoir which results in oxygen stratification, eutrophication and thermal pollution.

Oxygen stratification refers to the process where the water is separated into layers, the higher concentrations at the top and the lower concentrations at the bottom. This causes a reduction in the overall oxygen level which is problematic to the ecosystem. Eutrophication is the process where water is enriched with chemical nutrients such as nitrogen and phosphorus which leads to excessive algal growth, this catches too much oxygen and leaves little room for other organisms to grow. Thermal pollution occurs when thermal energy is accumulated in the top layers of the reservoir and this excess heat, which is an indirect pollutant, could strongly affect freshwater communities. Figure 7 depicts the water quality scenario of Bengbu floodgate in China, it can be seen that the ammonium (NH3–N) level is higher with dams than without dams and Chemical Oxygen Demand (CODMn) depends on the season.

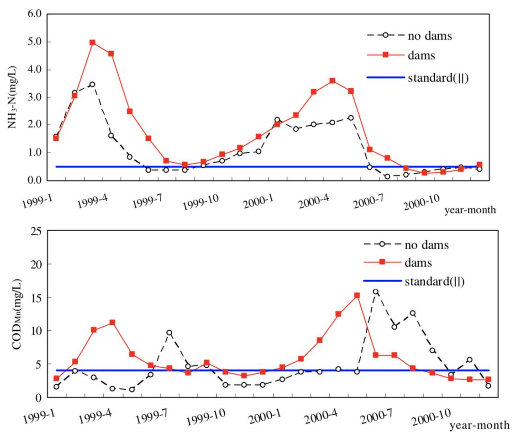


Fig. 8 NH_3–N and COD_{Mn} concentration of Bengbu floodgate in the having dams scenario (11) and non-dam scenario (01)

Figure 8: Case study of water quality in Bengbu floodgate

There are many ways that the hydropower infrastructure could be harmful to habitats. A dam with a reservoir could obstruct fish from migrating which some species only mate in certain areas of the river so this could lead to an extinction of some fish species. Moreover, hydropower turbines and the high voltage power lines that are part of the dam structure could kill or injure fish and birds that passes through. The construction of the dam with a reservoir requires a large plot of land which means reduction in forest and wetland area. From Figure

8, it can Laos' forest area has been declining since 1990 at approximately a rate of 134,000 hectares per year.

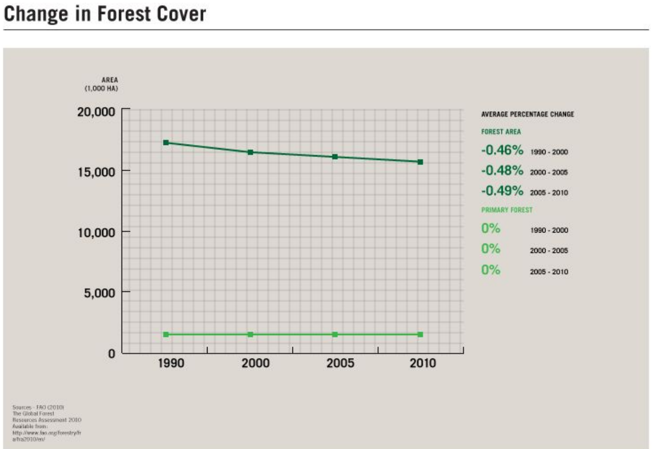


Figure 9 : Laos’ change in forest cover from 1990

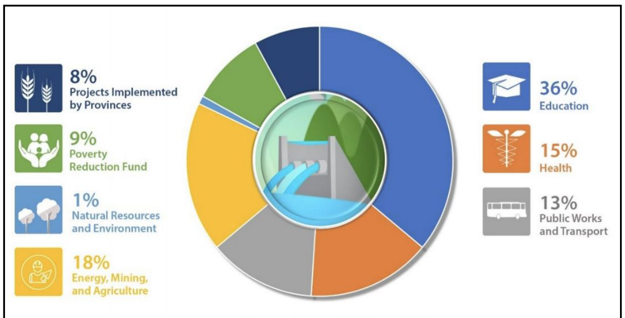
However, deforestation and forest degradation are not the only factors that contribute to the emission of greenhouse gases. During the construction process of hydropower dams, some materials may be created with equipment that produce emissions and those may be associated with fossil fuels. In addition, carbon dioxide and methane may also form in the reservoirs and be emitted into the atmosphere.

4.2. Social Aspect

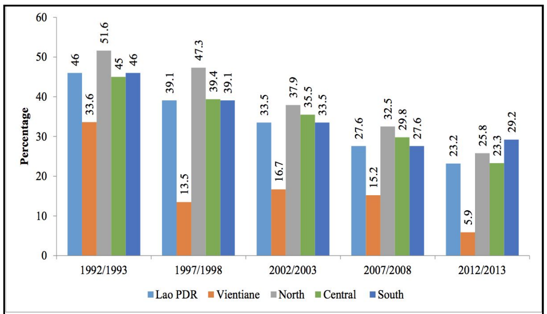
4.2.1. Positive impacts (Social Aspect)

There are alternative development and poverty reduction options for Laos, a number of which are already being studied and implemented by Lao government agencies in cooperation with donors and non-governmental organizations.These approaches would improve the ability of lowland and upland farmers to adapt to change, safeguard their natural resources, and help them take advantage of new income-generating opportunities.

The Revenue Management Program (RMP) is a key dimension of the Nam Theun 2 Hydropower Project (NT2), the objective of which is to assist the Government of Lao PDR to implement priority poverty reduction and environmental programs using revenues from the Nam Theun 2 Hydroelectric Power facility. Net revenues from the Nam Theun 2 project come from royalties, dividends, profit taxes, and dividend taxes. The Government of Lao PDR then identifies eligible programs and projects in the national budget, which comply with the RMP criteria (poverty alleviation or environmental management) for budget allocation. Eligible projects/programs selected by the Ministry of Planning and Investment and implemented by ministries such as Education, Health, Energy and Mining.



Source: SAO Audits FY 2009/10-2014/15



Source: Pimhidzai et al. (2014); UNDP (2009).

Also, the highest priority of Laos Government is to rapidly electrify all households in the country. The electrification increased from 36% in 2000 to almost 67% in 2010. The target established by the government is to increase network coverage to serve 80% of households by 2015 and 90% of households by 2020. Meet the rapidly increasing demand and grid integration. A result of the government's strong electrification program will be a substantial increase in electricity demand in the years to come.

However, in the future hydropower in Laos won't have the same level of account of transparency, considering high corruption is one of the biggest problems in Laos. According from the 2017 transparency international corruption perception index, Lao PDR ranked the country at number 132 out of 180 and scored only 29 out of 100.

4.2.2. Negative impacts (Social Aspect)

Although the hydropower can generate revenue to Laos which seem to be good for the country, the dam also creates negative effects in part of a social aspect to Laos as well. There are around 70,000 Laotian people who suffer from the resettlement due to the hydropower project. Most of the villages are forced to change their culture, religious, social, and economic terms. Even if there is a new place prepared for the resettled villagers, some of them still suffer from a lack of good facilities in order to spend the same livelihood.

The resettled villagers are difficult to achieve a stable livelihood and it seems to spend at least 5 years to gain stability. Most of the resettled villagers are agriculturist and fisher and the new town cause the villager to loss of access to the familiar environment that they use for their livelihoods such as grazing land, river, or forest which make them hard to their old work or old culture. There is the case of the Houay Ho dam project that displaces over 2,500 people from 12 villages that lead to the majority livelihood of them which is coffee farmer has changed due to the newly prepared farmland isn't suitable to grow coffee making the framer lose their productivity and they're profitable. In terms of fishery part, the dam causes altered water flow regime which directly affects most of the species of fish in the river up and downstream. Since the habitation of fish was change environment, this leads to the reduction of the number of fish caught and fish is one of the main foods of the villager's consumption.

Furthermore, the new flow system also makes it increasingly difficult for small craft to navigate the river safely for fisher as well.

Moreover, the dam creates safety and security risk to the community up and downstream. If the dam collapses, it will cost a lot of damage in many parts of the country. In July 2018, according to a report from the BBC news, the Xe-Pian Xe- Namnoy dam collapsed (Figure 10) due to heavy rainfall. This accident affected the downstream village which caused flash flooding through 6 villages. Over 6,000 Laotian people became homeless but it was not strongly as around 30 people who died. The overall impact of the accident affected over 10,000 people. The overall cost was estimated by the World Bank which include damages, losses cost, recovery cost, and the other cost at around 520 million USD.

Figure 10 : Direction of flooding to downstream communities

Also, the health care problem is one of the problems that Laotian people should concern. Although no evidence shows the number of Laotian people who suffer from this problem due to the hydropower project, in another country faces this problem. For example, the Samuel dam in Brazil causes a reservoir that becomes a breeding ground for disease vectors such as the anopheline mosquitoes. These mosquitoes can transmit malaria to humans.

4.3. Economic Aspect

4.3.1. Positive impacts (Economic Aspect)

There are three main economic advantages of hydropower generation in Laos: government revenues, reliability of export value, and mutually beneficial increases in GDP (for Laos and Thailand). These three “pros” were determined based on reasoning from either the multiple aforementioned papers or research we found to be a compelling argument.

A significant benefit is the revenue, specifically government revenue, hydropower brings in from its exports. Specifically government revenue was mentioned because in some cases, the Government of Laos (GoL) will not receive revenue if the project is completely owned by foreign entities that are investing in hydropower projects in Laos. Nonetheless, let us take a look at Nam Theun 2 (NT2), the most notable hydropower dam in Laos. Laos exports more than 90% of NT2’s generated electricity to Thailand, in return, the GoL received revenue through taxes, royalties and dividends (ADB). Like many other hydroelectric projects, NT2 is structured as a build-own-operate-transfer, which a concession of 31 years, of which the operating period is 25 years. After the concession period (by 2033), investors/developers should have fully recouped their investment and the ownership will be transferred to GoL free of charge and they will receive full share of revenues as opposed to just 25%. With help from developers like ADB and World Bank. the project tried to set the standards for the construction of ‘good dams’ - those that address environmental and social impacts, and steer revenue toward the country’s neediest people. Its goals are poverty reduction, environmental conservation, development through infrastructure investment, and sustainable economic growth (ADB). Between 2010 and 2017 alone, over $170 million in revenues were received by the Lao treasure in income from NT2. It is expected that over the 25-year operating period, NT2 will earn $1.9 billion in foreign exchange (ADB). These impacts spill over into social and environmental because, in keeping with the project’s legal agreements, all government revenues from NT2 have and will be allocated to projects and programs contributing to poverty alleviation and environmental management.

General Prayut Chan-o-cha (Thailand PM) and Mr. Thongloun Sisoulith (Laos PM) witnessed signing of MOU between Electricity Generating Authority of Thailand (EGAT) and Électricité du Laos (EDL) for new PPA of Nam Ngum 1 and Say-sed. 2018.

The second economic advantage is Laos's reliability of export volume. There is a trend of significantly increasing demand in Thailand indicated by the extension of a memorandum of understanding (MOU) for increasing electricity from Laos. Laos has secured several and is projected to secure more power purchase agreements (PPAs) with Thailand, and these agreements usually last 20-30 years (EGAT, 2018). In Figure 11 below, notice that there are currently 4 private hydropower plants in Laos supplying commercial electricity to Thailand, and 2 projects under construction that have already been committed to a contract with EGAT, scheduled for commercial operation in 2019. It is safe to say that we should expect to see continued renewals of PPAs considering Thailand and Laos excellent relations, exemplified in the photos above. The Prime Ministers of Thailand and Laos are not only shaking hands to commemorate the agreement, but also, if you notice the background, to celebrate "50 Years of Thai-Lao Stable Energy Relations" (EGAT, 2018). In addition, we should expect increased electricity exports to other Asian countries like Vietnam, Singapore, and Myanmar, and China (Jusi, 2010, p. 206).

Figure 11: Hydroelectric Dams in Lao PDR and Generation Capacity

Station	MW	Station	MW
Nam Nhone	3	Nam Ngiep 2	180
Nam Leuk	60	Nam Ngiep 1	290
Nam Lik	100	Theun-Hinboun	550
Nam Ngum 5	120	Nam Ngum 2	615
Houay Ho	152	Nam Theun 2	1075
Nam Ngum 1	155	Xayaburi	1285

The third economic advantage is how Thailand increasing their import of Lao electricity would lead to a mutually beneficial increase in their GDPs. This conclusion was reached through a simulation ran in *Export Supply of Electricity from Laos to Thailand: An Econometric Analysis*. The study analyzes the effects on two economies simultaneously, therefore the change in the exogenous variable not only affects one economy but also affects another economy at the same time. Table 3 is broken down into 3 periods, "Post-Reform Adjustment Period," "Asian Crisis Period," and "Sustained Growth and Foreign Capital Inflows Period" to see the effect on different periods of the economy. The table shows that a 10% decrease in the import of electricity in Laos affects Thai economy by reduction of electricity consumption in the first (1987- 1996), second (1997-1999), and third (2000-2010) period by 3.1540, 3.3306, and 3.3036 million USD, respectively (Lamphayphan, et al., 2015, p. 456). Since consumption of electricity is a component of total consumption, when it decreases the whole consumption also decreases. The decrease in consumption then leads to the large decrease in GDP of Thailand by 10.2730, 10.7666, and 10.7545 million USD in the first, second, and third period respectively. A 10% increase in the import of electricity shows the exact opposite as the decrease (reductions in GDP become additions). The proportion of change is the same, a table of the increase-simulation was omitted. Therefore, "increase in Thailand's electricity import from Laos, not only has positive effect on Thai economy in terms of increasing consumption of electricity stimulating economic activities in Thailand, but it also has positive effect on Lao economy simultaneously in terms of increasing income from electricity export" (Lamphayphan, et al., 2015, p. 458).

Table 3: Estimation result of decreasing the import of electricity from Laos to Thailand (Unit: Million USD)

Country	10% Decrease in IME_T^L			
	Variable	1987-1996	1997-1999	2000-2010
Laos	CE_L	−0.0962	−0.1008	−0.1008
	EXE_L^T	−2.7613	−2.8930	−2.8933
	GDP_L	−3.5830	−3.7540	−3.7542
	I_L	−1.4709	−1.5411	−1.5412
Thailand	CE_T	−3.1540	−3.3066	−3.3036
	IME_T^L	−2.7613	−2.8930	−2.8933
	GDP_T	−10.2730	−10.7666	−10.7545
	IT	−2.8260	−2.9633	−2.9654

Source: Lamphayphan, T., Toyoda, T., Czerkawski, C., & Kyophilavong, P. (2015).

Appendix 2: All variables in the model

Variable	Meaning	Unit
Laos		
$CAPE_L$	Installed capacity of electricity	Kw
C_L	Consumption	USD
CE_L	Consumption of electricity	USD
CEN_L	Consumption of non-electricity products	USD
EP_L	Electricity production	USD
EX_L	Export	USD
EXE_L	Export of electricity	USD
EXE_L^T	Export of electricity to Thailand	USD
$EXEN_L$	Export of non-electricity	USD
EXE_L^{TN}	Export of electricity to non-Thailand countries	USD
G_L	Government expenditure	USD
GDP_L	Gross domestic product	USD
I_L	Investment	USD
IM_L	Import	USD
IME_L	Import of electricity	USD
$IMEN_L$	Import of non-electricity products	USD
ThaiLand		
C_T	Consumption	USD
CE_T	Consumption of electricity	USD
CEN_T	Consumption of non-electricity products	USD
EX_T	Export	USD
G_T	Government expenditure	USD
GDP_T	Gross domestic product	USD
I_T	Investment	USD
IM_T	Import	USD
$IMEN_T$	Import of energy	USD
$IMEN_T^L$	Import of energy from Laos	USD
$IMEN_T^{LN}$	Import of energy from non-Laos countries	USD
$IMENN_T$	Import of non-energy products	USD

Source: Authors

4.3.2. Negative impacts (Economic Aspect)

There are three significant disadvantages to the development of hydropower in Laos: loss of income, Dutch Disease, and its opportunity cost.

To those reliant on the Mekong River and its tributaries, the plan to build 11 large hydropower dams on the Lower Mekong Basin (LMB), such massive disruption threatens their homes, way of life and livelihood. The river feeds the rice fields in Vietnam's delta and provides around a quarter of all the world's caught freshwater fish, thus it is crucial as the region's food supply but also as a major source of income for those who live alongside it (Newman, n.d.). Hydrologist, Mark Goichot, reports that the dams have reduced silt transportation downstream, allowing the incursion of sea water into the Mekong delta. According to BBC News, salt water intrusion destroyed more than 23 sq km of rice fields in 2014. In addition to destroying rice fields, the intrusion causes species loss, tree loss, and would adversely decrease agriculture production in the Mekong floodplains (Newman, n.d.). Taking a look at Table 2, the total economic impact of the estimated sedimentation loss due to the 11 planned hydropower projects (excluding loss from Vietnam inland fisheries) is $450 million a year.

Table 2. Estimated Sedimentation loss due to planned hydropower projects

	Loss in tons/year	Loss in $ million/year
Vietnam inland fisheries	(included in capture fisheries loss)	
Vietnam rice production	550,000	220 (rice value $ 400/ton)
Cambodia rice production	200,000	80 (rice value $ 400/ton)
Vietnam coastal fisheries	50,000	150

Source: Economic Evaluation of Hydropower Projects in the Lower Mekong Basin, (2017).

Dutch Disease is a noteworthy economic danger for Laos if there is heavy government investment in hydropower. This whole idea could be discussed in the context of the "resource curse," where resource-rich countries tend to grow slower than resource-poor countries. The logic behind this hypothesis is a crowding-out in that natural resources crowd out activity *x*; activity *x* drives growth; therefore, natural resources harm growth (Taguchi & Khinsamone, 2018). This crowding-out logic can be applied to the Dutch Disease hypothesis by arguing that natural resources crowd out manufacturing activities (Taguchi & Khinsamone, 2018). Taguchi and Khinsamone's *Analysis of the 'Dutch Disease' Effect on the Selected Resource-Rich ASEAN Economies*, using a vector autoregression model, found that Laos seemed to have suffered from Dutch Disease from 1970 to 2015. Looking at Granger causality test below, it was in Lao PDR (and Myanmar) that the causality from mining and utility production (*mau)* to manufacturing-services ratio (*mos*) was identified at the conventionally significant level.

Table 4. Granger Causality Test

Null Hypothesis		Lags	Chi-sq
Indonesia	*mau* does not Granger Cause *mos*	1	0.000
Lao PDR	*mau* does not Granger Cause *mos*	1	6.122**
Malaysia	*mau* does not Granger Cause *mos*	1	2.510
Myanmar	*mau* does not Granger Cause *mos*	1	4.263**
Vietnam	*mau* does not Granger Cause *mos*	1	2.038

Note: ** denotes rejection of null hypothesis at the 95 per cent level of significance. PDR, People's Democratic Republic.

Source: (Taguchi & Khinsamone, 2018)

Hydropower plants have high upfront capital costs, therefore the opportunity cost of alternatives, like wind or solar energy, are also high. Construction of hydroelectric plants are costly for logistical reasons like topography, laying foundations under water, and the materials used to build them. The plants have to operate for a long time in order to recoup the investment injected in the construction. For instance, NT2 cost nearly $1.25 billion in construction and legal fees, and it will take nearly 25 years to gain an estimated $1.9 billion in foreign exchange earnings (ADB). On the plus side, the plants do not require much maintenance. It would be environmentally *and* economically advisable to consider diversifying Laos's energy mix with wind and solar. For one, overdependence on hydropower puts Laos at risk for energy shortages during drought conditions, which will become increasingly likely due to climate change. In addition, diversify would make good economic sense. Utility-scale (generating enough electricity to sell through PPAs) solar is nearly as cost-competitive as hydropower in Laos, and may even be a safer bet considering it avoids the social and environmental challenges (Vest, 2016). In fact, solar already plays an important role in electrifying some of Laos's rural communities. For example, solar company Sunlabob has pioneered low-cost solar home systems to provide basic electricity services like lighting and device charging to remote communities (Vest, 2016).

5. Policy recommendation

According to all the negative impacts mentioned, we have come up with policy recommendations that should be implemented to mitigate the problems in all three aspects. We believe that Laos does not need any more dams, as exemplified in Table 1 showing an excess of electricity to be exported. Laos should, however, ensure that the quality of its current dams are up to standard and will do more good than harm.

Table 1: Forecast of domestic electricity demand for the whole country (2012-2020)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Demand	786	1,021	1,165	1,419	2,083	3,180	3,290	3,401	3,403	3,488
Supply	579	786	859	1,161	2,349	6,851	7,342	8,298	8,473	8,737
Balance	−207	−235	−306	−258	266	3,670	4,052	4,897	5,070	5,249
		Need to import					Excess electricity to be exported			

Source: EDL (2012).

Table found in: ***Export Supply of Electricity from Laos to Thailand: An Econometric Analysis***

Issues	**Recommendations**
Economic Aspect	
The Opportunity Cost	Cost-benefit Analysis of Building Future Dams
The Dutch Disease	Reinvestment Plan 1) Reinvest in other sectors to increase productivity
Financial Safety	Emergency Funds 1) Capacity Funds
Environmental Aspect	
Harmful to habitats	Environmental Safeguards 1) Environmental and social impact assessment 2) Indicators and criteria
Emergency Drill	Emergency Funds 1) Funding mechanisms
Social Aspect	
Loss of livelihood	Resettlemt Plan 1) Compensation 2) Training programme 3) Consultation Reinvestment Plan 1) Revenue Management Program
Unskilled Labor	Meticulous Worker and Contingency Plans 1.) Improve overall knowledge 2.) Training on management, monitoring and reporting skills 3.) Arrange in-service courses 4.) Arrange workshops 5.) Equipment maintained

The first policy we have come up with is the ‘Cost-benefit Analysis of Building Future Dams,’ which quantifies the cost and benefit in monetary terms including all the items that the market does not provide a reasonable value, this deals with one of the economically negative impact. Some of the net benefits could be the revenue generated from hydropower and social benefits or other non-economic benefits, in comparison with other energy sector investment options. Other indicators such as the net present value of the project, or the economic costs per unit of capacity installed or power generated, may also be taken into consideration. As for the cost, the factors to be taken into consideration are estimation of the damage and resettlement issues of people affected by the project, the means to mitigate adverse impacts on the environment, animal habitats, biodiversity and expenses of restoration of etc.

Regarding the environmental impacts, we would suggest that ‘Environmental Safeguards’ must be taken into account which this refers to implementing plans to ensure impacts are properly managed and the hydropower project is sustainable. It is essential for every hydropower project to report environmental and social impact assessment, as mentioned in the *Environmental Protection Law (1999),* and *Decree on Environment and Social Impact Assessment No. 112 (2010)*, “ Hydropower projects with an installed capacity of more than 15 MW must report an Environment and Social Impact Assessment (ESIA) and an Environmental Management Plan (EMP)**.”** Following Environmental Management and Monitoring Plan (EMMP), this can be categorised into 11 main measures; noise abatement, air pollution abatement, water quality protection, handling fuels and explosive materials, disposal of spoils and solid waste, protection of terrestrial vegetation, protection of aquatic habitats and resources, protection against unexploded ordnance, protection against health impacts, safety measures and blasting for dam removal measures. Besides that, it is also important for the project developers to have frequent benchmarking and monitoring with clear system of indicators and criteria and arrangements for data analysis, with this we will be able to foresee signs of damage to the environment and be able to put in place actions and strategies to prevent ahead of time.

As for the social impacts, ‘Resettlement Plans’ will definitely need to be implemented to provide compensation to all forest, crops and non-removable assets that are destroyed during the whole process of hydropower projects. The details in the resettlement plan should include identification of those being settled, the measures to be implemented relating to resettlement assistance and livelihood support, the legal and compensation framework, budget allocation and financial management, timeframe and consultation to those affected. Special groups will also need to be set up to follow up and monitor process of the compensation to see if the impact is successfully mitigated or not and to ensure that those affected can restore and improve their livelihoods in the long run, some additional assistance may also be required, for example, training for their new occupations and teaching them how to adapt to new environment.

Furthermore, dam failures is a catastrophic type of failure characterized. There are emergency drill for situation of flood, abnormal flow, rapid change of dam body and etc, providing risk guarantee in case of dam burst. We are considering setting up a fund to cover the financial surprises life throws your way. These unexpected events can be stressful and costly. An emergency savings fund can help looking forward to the future without worrying about being unprepared for unexpected expenses and also can be used for capacity building to facilitate and speed up necessary training.

In terms of meticulous worker and contingency plans, we would like to offer the well trained and safety at workplace to ensure dam safety, public safety and workforce safety. basically, all the equipment would be properly maintained so the construction can go easily by plane. We will Arrange workshops for well-defined and limited topics and in-service courses with utilization of Internet based courses and tailor-made courses in cooperation with national and regional learning institutions. Training on management, monitoring and reporting skills for staff involved with monitoring and implementation of mitigation measures on central and province/district level.

According from the Nam Tueng2 project that was so successful by having The Revenue Management Program(RMP) as a key dimension. We would like to put this program into our 'Reinvestment Plan' to increase productivity in every sector and mitigating social and environmental impacts. On the other hand, the problem of corruption should also be solved. As we mentioned, the future hydropower in Laos would not have the same level of account or transparency which is not guaranteed because of the high corruption rates. We would recommend Laos PDR to build up the policies to prevent this problem such as the Anti-corruption team setting up to look into corruption complain, to instigate people and also departments. Open plan and government offices providing harder for people to do things unnoticed. Ensure money and things purchased are accounted for. Simply, there will be a record of every penny spent and what it was spent on. If the money has seemingly been spent but not accounted for, there should be an external investigation on it.

6. Conclusion

To conclude, we will be using Intrawalan et al.'s *Economic Evaluation of Hydropower Projects in the Lower Mekong Basin*, which was published in 2017. This paper shows that updated evaluations of the NPVs of the projected 11 dam scenario in LMB that take into account social and environmental costs. In Figure A, the first column shows calculation from 2011 by the MRC, whereas the second column was calculated in 2017 and includes estimated costs for social, environmental, and reduced sediment impacts, which were not taken into account by MRC. We can observe the *negative net economic impact*. This is mainly due to capture fisheries loss(-$13 billion) far exceeding hydropower benefits($6.6 billion), but also attributed to the inclusion of social impact costs(-$1.6 billion) and sediment/nutrient loss($2.3 billion). We can see that the MRC greatly overestimated the benefits, and the net economic impact is much lower than they estimated(33,400 vs. -7,300).

	BDP2 NPV(10) - $ million	**NREM Update NPV(10) - $ million**
Hydropower	32,800	6,600
Capture fisheries	-1,900	-13,000
Social Mitigation Costs	0	-1,600
Sediment & Nutrients Loss	0	-2,300
Others (details in text)	2,500	3,000
Total Economic Impact	33,400	-7,300

Figure A: Updated NPV for 11 dam scenario in LMB

Also, looking at the cost/benefit split by country in Figure B, notice how Laos and Thailand benefit(Thailand more than Laos), but Cambodia and Vietnam are negatively affected. This paper found that project developer, funders, and electricity importers would benefit but poor, farming and fishing communities in Lao PDR, Cambodia, and Vietnam would suffer.

Table 4. Country cost/benefit split for 11 dams scenario

	BDP2 NPV ($ million)	**Costanza Report NPV ($ million)**	**NREM Update NPV ($ million)**
Lao PDR	22,600	20,400	700
Thailand	4,500	-39,100	1,300
Cambodia	2,600	-33,700	-6,500
Vietnam	3,700	-13,900	-2,800
Total	33,400	-66,300	-7,300

Note. Numbers in BDP2 and NREM Update show NPV(10) whereas numbers in the Costanza report show NPV(3) for natural resources.

Figure B: Cost/benefit split by country

The economic impact for Laos from the mainstream projects is negative for most of the 25-year concession periods. As mentioned, most of Laos's benefit occurs after it gains project ownership. A similar forecast is expected for large tributary projects with foreign funding as well.

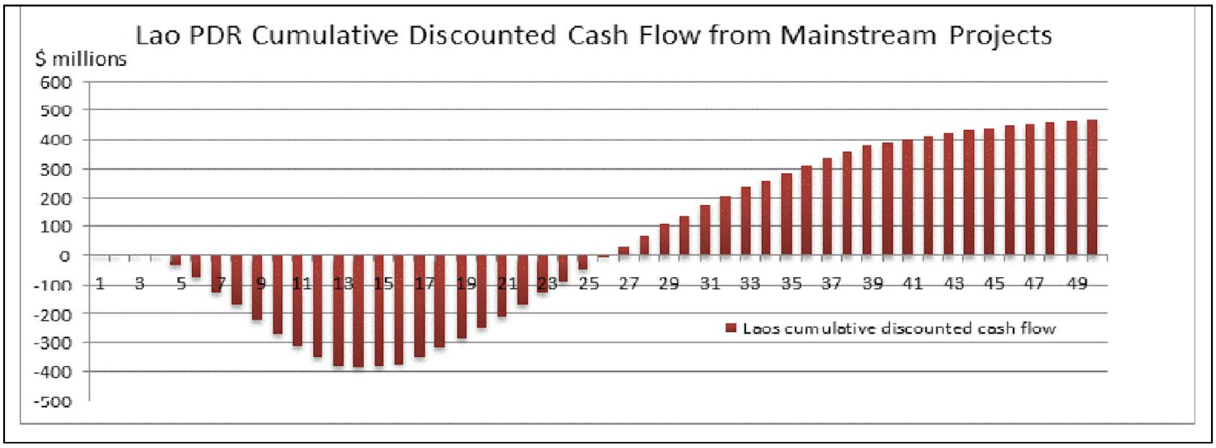


Figure C

Even from the start of this research assignment, we seemed to find no shortage of rhetoric about how export-oriented hydropower will help “kickstart development,” lead to “power progress,” or “alleviate poverty,” but had much more trouble finding examples of tangible links to *rural* electrification or improved livelihoods. It is now evident that hydropower development disproportionately affects people in rural areas, meanwhile the middle class and urban elite will likely accumulate its benefits (Smits, 2012).

In conclusion, we think that hydropower, in its current state and with respect to future projects, cannot be considered a sustainable development project for Lao PDR. To reinforce the idea further, the net economic impact of planned LMB hydropower projects is negative. Therefore, they must be considered *not economically feasible*. Only if costs can be mitigated through the aforementioned policy recommendations, do we think that hydropower could be sustainable for Laos.

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