Working Paper on Economic, Environmental and Social Impacts of Hydropower Development in the Lower Mekong Basin

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OXFAM

Natural Resources and Environmental Management Research and Training Center

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Acknowledgements

This working paper is a revised, condensed version of the report 'Planning Approaches for Water Resources Development in the Lower Mekong Basin' by Portland State University, Oregon and Mae Fah Luang University, Chiang Rai (Robert Costanza et al. 2011) which is hereafter referred to as the 'Costanza report'. We thank the authors for their consent to use this paper. We also thank Oxfam for their sponsorship of this paper.

Disclaimer

This working paper is based on data from the Costanza report, the Strategic Environmental Assessment of Hydropower on the Mekong Mainstream (SEA) written by the International Center for Environmental Management, Australia (ICEM) published in October 2010 and the Mekong River Commission (MRC) Assessment of Basin-wide Development Scenarios – Basin Development Plan Programme, Phase 2 (BDP2) published in November 2011.
Any views expressed in this paper are those of the authors. They do not necessarily represent the views of Robert Costanza et al., Mae Fah Luang University, ICEM, MRC or Oxfam.

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1. SUMMARY

The proposed hydropower projects on the Mekong River and its tributaries would block fish migration routes, change flood areas, change sediment/nutrient flows and reduce the catch from the largest freshwater fishery in the world. The Costanza report showed that by changing some key assumptions in the MRC Basin Development Plan BDP2 (discount rates for natural resources; fish value) the economic feasibility of the planned hydropower projects would change from positive (as in BDP2) to negative in terms of Net Present Value (NPV). This working paper is a revised, condensed version of the Costanza report. It focuses on a **Revised Case** (plausible set of key assumptions) and the NPV calculations are summarised below.

		BDP2 Scenario 6 Dams	BDP2 Scenario 11 Dams
		NPV ($ millions)	NPV ($ millions)
BDP2	Hydropower	25,000	32,800
10% Discount Rate	Capture fisheries	-1,000	-1,900
	Others (details in text)	2,700	2,500
	Total Economic Impact	26,700	33,400
Revised Case	Hydropower	25,000	32,800
3% Discount Rate	Capture fisheries	-27,000	-54,900
for natural resources	Others (details in text)	-400	300
	Total Economic Impact	-2,400	-21,800

The above table shows that the negative NPV for the capture fisheries loss (using 3% discount rate for natural resources) is much larger than the positive NPV for hydropower generated. A sensitivity analysis (fish loss, fish value, discount rate) was also carried out. It is concluded that the proposed mainstream hydropower projects would not have a net economic benefit in both the 6 dams and 11 dams scenarios. Furthermore, we have queried some inconsistencies in BDP2 (hydropower NPVs) and challenged a key BDP2 assumption that hydropower profits would accrue to the country where they would be built – this resulted in Lao PDR being the main beneficiary. We have assumed a profit split of 30% for the host country and 70% for the country funding the project and importing the electricity over the concession period (typically 25 years). This results in Thailand and Lao PDR being the beneficiaries whereas Cambodia and Vietnam would bear the main cost of hydropower developments. It is also clear that project developers and electricity importers would benefit but poor, rural farming and fishing communities would suffer.

It is recognised that there are uncertainties in the impact costs and some factors (social/cultural costs, lost capture fisheries, reduced sediment and nutrient flows) may be understated and the hydropower benefits considerably overstated. Further working papers to firm up these NPV values are proposed and it is expected that the negative economic impact of the proposed hydropower projects will increase.

The above conclusions fully support the Costanza report and SEA recommendations for a moratorium on mainstream dams in order to carry out further studies of the social impacts and project risk.

2. BACKGROUND

The Mekong River is the largest freshwater fishery in the world (estimated fish catch 2.1 to 2.5 million tons/year) and the third most bio-diverse river system (with approximately 800 fish species) after the Amazon and the Congo. The estimated fish catch does not include 0.5 – 0.7 million/tons year coastal fish production (as reported by SEA) which is dependent on Mekong River sediment/nutrient outflow and about 0.5 million tons/year of other aquatic animals (OAA) such as shrimps, crabs, molluscs and frogs. The annual fluctuation (water levels and flows) of the Mekong River is the main driver of the high productivity of the river and associated wetlands. However, this would change drastically if all proposed hydropower projects are constructed as fish migration routes would be blocked. Little is known about designing appropriate fish ladders for the diversity and size of the fishery (Dugan et al. 2010). The proposed hydropower projects are described in BDP2 and SEA. Many studies of potential adverse social and environmental impacts, from the planned dams, have been carried out. This paper focuses on potential economic consequences and is based on the Costanza report which in turn used much of the data, assumptions and projections reported in BDP2 and SEA. The main differences between the Costanza report and BDP2 were the estimated fish value, valuation of ecosystem services and discount rates for natural capital such as capture fisheries and wetlands.

In addition to BDP2, the MRC have issued extensive reports on many aspects related to development of water resources in the Lower Mekong Basin (LMB) and they have formulated and assessed a wide range of basin-wide development scenarios. The Costanza report is also a very comprehensive document (83 pages with 3 page executive summary) which focussed on the Definite Future, 6 mainstream dams and 11 mainstream dams scenarios. The Costanza report highlights the environmental/social risks and economic uncertainties of mainstream dams (and recommends further studies to quantify adverse impacts) but does not strongly emphasise the huge potential economic losses if all proposed mainstream dams are constructed. The Costanza report reinforces the importance of how LMB governments balance hydropower development with sustainable rural livelihoods.

Since the Costanza report was published, there have been several developments (on planning of Mekong hydropower projects) which were discussed at the Stimson MFU Workshop held in 2014 at Mae Fah Luang University, Chiang Rai, Thailand:

- The main negative impact on capture fisheries is expected to be in Cambodia and the Vietnam Mekong delta where 30 million people would be adversely affected. This is not consistent with the Costanza report which forecasts the largest decrease in capture fisheries for the 11 dams case to be in Thailand.
- Current estimate of Mekong Basin capture fisheries is 2.1 - 2.5 million tons/year and forecast fisheries loss, if all dams are constructed, is higher than previous estimates.
- Lao PDR decision to proceed with the Xayaburi project even though a transboundary EIA has not been carried out. This sets a precedent for mainstream Mekong dams.
- Social/cultural impacts of existing hydropower projects have been underestimated and mitigation costs to offset impacts have not been included in development costs.

3. ECONOMIC MODEL AND DISCOUNT RATES

This study focuses on mainstream hydropower projects and two of the three main BDP2 scenarios evaluated in the Costanza report:

(i) LMB 20 Year Plan Scenario with six mainstream dams in Northern Lao P.D.R. This scenario also includes 30 planned tributary dams and is referred to as the ‘6 dams scenario’

(ii) LMB 20 Year Plan Scenario with Climate Change. This scenario includes 11 planned mainstream dams and 30 planned tributary dams and is referred to as the '11 dams scenario'

The costs and benefits of planned hydropower project were evaluated in BDP2 in terms of Net Present Values (NPV) over a 50 year evaluation period (see Box below). The NPV calculations were based on a 10% discount factor which is typically used to evaluate major infrastructure projects. However, the Costanza report argued that this NPV calculation method is inappropriate for natural resources (such as capture fisheries, reservoir fisheries and wetland areas) and used lower discount rates (1% and 3%) and an Infinite Time Horizon for natural resources. For other items in the evaluation, the Costanza report also used NPV(10) with a 50 year evaluation period.

The Net Present Value (NPV) of a project is the sum of all future project discounted cash flows (investment, revenues, costs, loans) over the project evaluation period. The future cash flows are converted to a base time (usually today) by discount factors related to interest rates. A 10% discount rate is typically used for project evaluations. If the project NPV(10) is positive, then the project is considered viable; if the project NPV(10) is negative, then it is not viable.

This paper follows the methodology in the Costanza report but only used a 3% discount factor for natural resources as a 1% discount factor would not change any conclusions but would just result in a much higher negative economic impact for the loss in capture fisheries. A sensitivity calculation was carried out for 4% discount rate which is considered at the high end for discount rates used for natural resources (Stiglitz 1994**).** To be consistent with BDP2 and the Costanza report, NPVs were calculated without inflation.

Table 1. Calculation methods and Discount Rates

	Calculation Method	**Discount Rate**
Hydropower	NPV - 50 year time period	10%
Aquaculture	NPV - 50 year time period	10%
Reservoir fisheries	NPV - Infinite Time Horizon	3%
Capture fisheries	NPV - Infinite Time Horizon	3%
Wetlands	NPV - Infinite Time Horizon	3%
Sediment/Nutrients	NPV - Infinite Time Horizon	3%
Others (see Note below)	NPV - 50 year time period	10%

Note: The NPV values used in this paper for **Others** (which are Irrigated agricultural production, Reduction in eco-hotspot/biodiversity, Forest area reduction, Recession rice, Flood damage mitigation, Mitigation of salinity affected areas, Losses in bank erosion areas and Navigation) are the same as those in the Costanza report and BDP2 which are based on 10% discount rate and 50 year evaluation period.

4. KEY ASSUMPTIONS

4.1. Hydropower Generation

According to BDP2 and SEA, the planned hydropower generation capacity would be 25,000 MW for the 11 dams scenario and 18,000 MW for the 6 dams scenario. A capital investment of $ 52 billion would be required for the 11 dams scenario and this would generate a NPV of 33 billion. Nine proposed mainstream dams would be built in Lao PDR and two in Cambodia but 90% of the hydropower would be purchased by Thailand and Vietnam. The hydropower generation from the 11 proposed mainstream dams would provide 6-8% of the forecast LMB power demand for 2025.

The economic evaluation of hydropower in BDP2 assumed that the host country would be the project owner and that hydropower benefits would accrue to the host country but this seems unlikely for Lao PDR in view of the huge funding requirement. The BDP2 evaluation assumed that the electricity export price would be 85% of replacement value in the importing country. This seems high and results in a large electricity trading benefit (NPV about $ 10 billion) for Lao PDR according to the BDP2 report. Furthermore, the capital investment data in the BDP2 Technical Notes seem to be low which would also overstate the hydropower benefit NPV numbers. However, the scope of this study did not allow for a detailed analysis of hydropower which will be carried out in a further paper.

Therefore, the **Revised Case** still uses the same total NPV numbers ($ 25 billion for 6 dams scenario and $ 32.8 for 11 dams scenario) for hydropower generation as in BDP2 and the Costanza report. The allocation of hydropower costs and benefits were reassessed in the **Revised Case** and a split 30% for host country (i.e. country where the dam will be built) and 70% for the country funding the project and importing the electricity was assumed. This is based on existing large scale hydropower projects where the project owner is 80% Thailand / 20% Lao PDR and 90% of the electricity will be exported to Thailand. This assumption results in a split of the NPV of $ 25 billion for the 6 dams scenario into 28% Lao PDR; 56% Thailand, 4% Cambodia and 12% Vietnam; the NPV of $ 32.8 billion for the 11 dams scenario is split into 22% Lao PDR; 46% Thailand, 11% Cambodia and 21% Vietnam.

4.2. Reservoir Fisheries

The capacity and storage area of hydropower reservoirs along the Mekong River would increase considerably with more dams and this would result in both a change in water quality and an increase in reservoir fish catch. Where biomass is submerged, there is development of anaerobic conditions leading to loss of aquatic life. Stagnant waters also contribute to low oxygen conditions. This paper uses the same increase in catch for reservoir fisheries as BDP2 (64,000 tons/year for 11 dams) but assumes a fish value of $ 2.50/kg as discussed in Section 4.4. This paper also corrects an input error in the Costanza report for the 11 dams scenario.

4.3. Aquaculture

Aquaculture production has expanded enormously throughout the Mekong Basin and current fish production is estimated to be about 2.4 million tons/year mainly from Thailand and Vietnam (Hortle 2015). Additional aquaculture production would mitigate some lost capture fisheries but the largest increase is expected to be in Vietnam which would mainly be for export to countries outside the LMB. The SEA reported that replacement of capture fisheries loss by aquaculture production is not realistic for two main reasons. Firstly, a large proportion of aquaculture production depends on capture fisheries for feed. Secondly, producing aquaculture is more costly than capturing wild fish.
The **Revised Case** uses a fish value of $ 2.50/kg and the same assumption as the Costanza report for the increase in aquaculture production (increase equivalent to 10% of fish catch loss). However, the **Revised Case** calculated the aquaculture benefit using NPV(10) with 50 year time period as aquaculture requires capital investment, operating and maintenance costs unlike natural resources.

4.4. Capture Fisheries

It is difficult to estimate the annual Mekong River fish catch from the four LMB countries as government fish catch data do not cover small scale fishers and commercial fishers tend to under report. It is more difficult to estimate the loss in capture fisheries if dams were built on the Mekong River due to many different fish species with different migration habits. A wide range of fish catch estimates are listed in Appendix 2. The economic impact (NPV values) estimated in BDP2 seems to be based on the low end of these ranges. The Costanza report assumed 2.3 million tons/year capture fisheries and a reduction of 58% in each country if all 11 dams were built. This resulted in high economic losses for Thailand whereas BDP2 and SEA expected that the main loss of capture fisheries would be in Cambodia and Vietnam.

This study reviewed the data on migratory fish catch shown in Appendix 2 and assumed that all the migratory fish would not survive in the 11 dams scenario based on SEA and BDP2 assessments that 11 dams would be a near total barrier to fish migration along most of the mainstream . The fish catch loss data in the table are based on conservative BDP2 estimates prepared by Hortle (2009).

Table 2. Estimated Fish Catch loss due to proposed hydropower projects

		6 Dams Scenario	**11 Dams Scenario**
	Current Fish Catch (tons/year)	**Forecast Fish Catch Loss** (tons/year)	**Forecast Fish Catch Loss** (tons/year)
Lao PDR	220,000	40,000	50,000
Thailand	840,000	50,000	50,000
Cambodia	700,000	140,000	340,000
Vietnam	340,000	60,000	140,000
Total	2,100,000	290,000	580,000

The above estimated fish catch does not include 0.5 – 0.7 million/tons year coastal fish production (as reported by SEA) which is dependent on Mekong River sediment/nutrient outflow and about 0.5 million/tons year of other aquatic animals (OAA).

This paper assumes a fish value of $ 2.5/kg for aquaculture/reservoir fish and $ 3.5/kg for capture fisheries which seem conservative compared to today’s market prices. Furthermore, this fish value does not include related economic activity such as fishing nets, processing and selling of fish. The fish values are derived from a market survey conducted by Thailand fishery department in 2014 with validation from some Vietnamese data. In Thailand and Vietnam, the market fish price for farmed black fish (Snakehead, Clarias, Pangasius Catfish, Catfish, Climbing Perch) and for farmed white fish (Carps, Silver Barb, Tilapia) is in the range of $2-3/kg, whereas the wild white fish (Silver Barbs, Carps, Red Tail Tinfoil, Wild Pangasius Catfish) are in the range of $5-10/kg (Personal communication, 2015).

4.5. Wetlands

Studies have shown that about 25% of the LMB land is classified as wetland area (McCartney 2015). This consists of forests, marshes, and grasslands which are flooded during the rainy season. According to the Assessment of Basin-wide Development Scenarios (MRC 2011), all types of wetland areas will decrease for the 6 dam scenario as the 6 mainstream dams are located in higher elevation areas of Lao PDR and their storage reservoirs will hold back waters that normally flood lower level areas. For the 11 dams’ scenario however the additional mainstream dams are in low level areas of Lao PDR and Cambodia and thus will substantially increase flooded wetland areas.

The Costanza report assumed different values for each type of wetland based on wetland values derived from the Mississippi Delta Study (Batker et al. 2008). The average value was about $3,000/ha/year. In this paper, the wetland values are derived from a Thailand survey of 780 local households in Bung Khong Long—the largest freshwater lake in Northeast Thailand (Chaikumbung 2013). The average value found was almost $1,300/ha/year, and this figure represents local values and ability to pay. This figure is believed to be minimal because these households have low income and low ability to pay for such services. The **Revised Case** study used a value of $1,500/ha/year for forest wetlands, $1,200/ha/year for marshes, and $1,000/ha/year for grassland wetlands. These figures are conservative when compared to other world figures. De Groot et al. (2012) reported the total economic value of ecosystem services provided by wetlands to range from $3,300 to 25,680/ha/year.

5. ECONOMIC CALCULATIONS

The revised NPV calculations for the **Revised Case** are summarised in Tables 3-6 below and detailed in Appendix 3. The changes from the Costanza report are listed below:

(i) The loss of capture fisheries is shown in Section 4.4. whereas the Costanza report assumed a fish catch of 2.3 million tons/year and 58% fish catch loss for each country.
(ii) Fish value changed from $ 3/kg to $ 2.5/kg for farm fish and $ 3.5 for wild fish
(iii) The value of Wetlands is based on recent studies in LMB countries.
(iv) A data input error for Reservoir Fisheries was corrected.
(v) The economic impacts of changes in capture fisheries, reservoir fisheries, aquaculture and wetlands are phased over 15 years from the starting date of first dam construction.
(vi) The aquaculture value is calculated using NPV(10) with a 50 year time period.
(vii) The NPV numbers for hydropower generation are split 30% for the host country and 70% for the country funding the project and importing the bulk of the electricity.
(viii) Estimated NPV values added for Social/Cultural Impacts and Sediment/Nutrient Flows.

Table 3. Summary of NPV calculations for 6 dams scenario

	BDP2 NPV ($ millions)	**Costanza Report** NPV ($ millions)	**Revised Case** NPV ($ millions)
Hydropower	25,000	25,000	25,000*
Reservoir fisheries	100	4,000	2,700
Aquaculture	1,300	800	400
Capture fisheries	-1,000	-28,500	-27,000
Wetlands	-200	-4,500	-1,500
Social/Cultural	0	0	-800
Sediment/Nutrient	0	0	-2,700
Others	1,500	1,500	1,500
Total	26,700	-1,700	-2,400

* Hydropower NPV is taken from BDP2 but may be overstated – see Section 4.1.

Table 4. Country cost/benefit split for 6 dams scenario

	BDP2 NPV ($ millions)	Costanza Report NPV ($ millions)	Revised Case NPV ($ millions)
Lao PDR	17,600	16,600	4,600
Thailand	3,900	-1,400	10,300
Cambodia	1,400	-15,000	-13,200
Vietnam	3,800	-1,900	-4,100
Total	26,700	-1,700	-2,400

Table 5. Summary of NPV calculations for 11 dams scenario

	BDP2 NPV ($ millions)	Costanza Report NPV ($ millions)	Revised Case NPV ($ millions)
Hydropower	32,800	32,800	32,800*
Reservoir fisheries	200	26,100	4,300
Aquaculture	1,300	4,000	800
Capture fisheries	-1,900	-133,600	-54,900
Wetlands	100	3,500	1,100
Social/Cultural	0	0	-1,500
Sediment/Nutrient	0	0	-5,400
Others	900	900	900
Total	33,400	-66,300	-21,800

*Hydropower NPV is taken from BDP2 but may be overstated – see Section 4.1.

Table 6. Country cost/benefit split for 11 dams scenario

	BDP2 NPV ($ millions)	Costanza Report NPV ($ millions)	Revised Case NPV ($ millions)
Lao PDR	22,600	20,400	3,400
Thailand	4,500	-39,100	11,000
Cambodia	2,600	-33,700	-26,400
Vietnam	3,700	-13,900	-9,800
Total	33,400	-66,300	-21,800

Tables 3 and 5 clearly show that the economic impact of the loss of capture fisheries (based on migratory fish) is much larger than the hydropower benefit for both the 6 dams and 11 dams scenarios. Tables 4 and 6 show that Thailand and Lao PDR are the beneficiaries of the proposed hydropower projects whereas Cambodia and Vietnam would both have large negative impacts. This result is significantly different to the BDP2 and Costanza reports which indicated that Lao PDR would be the main beneficiary in all scenarios and that Thailand would have a large negative impact in the 11 dams scenario.

5.1. Sensitivity calculations

The summary of the total economic impact of sensitivity calculations (compared to above tables) is shown below:

	BDP2 Scenario 6 Dams	BDP2 Scenario 11 Dams
	NPV ($ millions)	NPV ($ millions)
Revised Case	-2,400	-21,800
Fish loss increased to BDP2 worst case	-37,500	-57,800
Fish value decreased to $ 2/kg and $ 3/kg	800	-15,000
Fish value increased to $ 3/kg and $ 4/kg	-5,700	-28,600
Discount rate 4% for natural resources	6,100	-5,500

Clearly, an increase in fish loss or fish value will considerably increase the negative NPV numbers. It is noted that the NPV numbers for natural resources are very sensitive to the selected discount rate but even with 4% discount rate (considered to be high for natural resources) the net economic impact is negative for the 11 dams scenario.

6. ENVIRONMENTAL AND SOCIAL IMPACTS

6.1. Ecosystem

Mekong River ecosystem services include provisioning services (fisheries, aquatic animals and plants, fresh water for cleaning, bathing, and irrigation), regulating (erosion control, riverbank stabilization), supporting (soil formation, nutrient cycling, provisioning of habitat), and cultural services (sense of place, income generation for cultural events, etc.). Ecosystem services need to be evaluated and made explicit in order to reach a socially optimal balance and an efficient allocation of public goods. Wetlands provide many crucial ecosystem products and services as well (availability of food, clean water, fibre and fuel).

6.2. Sediment and Nutrient Flows

The load of suspended sediments in the Mekong River, previously estimated at 160-165 million tons/year, provides an equivalent of 26,000 tons/year of phosphate to the soils of the Mekong Delta. This sediment load and its nutrient value has already been reduced by some 50% to 80-82.5 million tons/year by the Upper Mekong Basin projects in China. Recent studies concluded that, with construction of all planned mainstream dams, the cumulative sediment reduction would amount to 56-84% (Kummu et al. 2010), 75% in the SEA (ICEM 2010), and up to 96% (Kondolf 2014), resulting in a huge change in the core ecology of the Mekong delta. The Mekong delta is crucially dependent on sustained sediment supplies to maintain its delta shoreline position and to balance subsidence. According to Anthony et al. (2015), erosion is affecting the 180 km-long muddy South China Sea coast nearly 90% of which is in retreat. This coastal erosion magnifies the vulnerability of the delta as it poses threats to the security and livelihood of subsistence farmers and fishermen.

It is estimated that the sediment loss is valued between $ 100 million to $1 billion/year and we have conservatively assumed $ 100 million/year for 6 dams scenario and $ 200 million/ year for 11 dams scenario. The country split of the economic impact of sediment loss is more difficult to estimate as all four countries will be affected by diminishing soil replenishment and erosion along river embankments, but the largest impact will be to the Vietnam delta. For this working paper, we assume 70% loss of sediments and nutrients to Vietnam and 10% loss to Cambodia, Lao PDR and Thailand. A further working paper needs to evaluate the costs of sediment and nutrient losses on the ecosystem and to downstream communities caused by the accumulative blockage by tributary and mainstream dams.

6.3. Social Impacts

Social/cultural impacts, similar to capture fisheries, have not been thoroughly evaluated in BDP2. Hydropower construction on the mainstream and tributaries of the Mekong River will pose potential threats to the food security and livelihoods of 30 million rural people in the LMB region. The understanding of the extent of which people's dependence on water resources and the river's ecosystem for their livelihoods, health, and wellbeing is still evolving. The livelihoods of the LMB people totally depend upon the integrity of the Mekong river ecosystem. How society manages the proposed hydropower projects for "modernizing" the region will define the future wellbeing of the LMB people. The economic impact of social/cultural issues are not accounted for in BDP2 but could result in mitigation costs of 5-12% capital investment based on 'best practices' implemented at existing Mekong hydropower projects. The **Revised Case** conservatively assumes mitigation costs of social/cultural impacts to be 5% capital investment.

7. RISK ASSESSMENT

Cost benefit analysis and NPV calculations are often used for investment decisions and are most useful when the economic input data are well defined, but unfortunately, this is not the case for the Mekong mainstream hydropower project proposals where considerable transboundary and cumulative impacts are projected. The SEA summarized the expected impacts and risks of the mainstream hydropower developments as shown below:

- Significant basin-wide effects on water flow regimes and sedimentation throughout the entire Mekong basin.
- The areas from Bo Gaeo to Luang Prabang and all reaches of the Mekong inundated by the mainstream reservoirs would no longer experience the ecologically important annual transition seasons, which trigger vital biological processes within riverine and floodplain habitats. All other reaches of the river would experience a reduction in the duration of these important transition seasons.
- The major reduction in the load of suspended sediments in the Mekong River will result in a huge change to the core ecology of the Vietnam delta.
- The LMB mainstream dams would fundamentally affect the integrity and productivity of the Mekong aquatic system by: permanently inundating most of the river's existing aquatic habitats; severing at the local level the crucial seasonal distinctions of the river's hydrology; and cutting transport of sediments and nutrients between upland areas and the floodplains.
- Habitat loss would induce primary production reduction of the Mekong River.
- Climate change will increase the likelihood of extreme events occurring during the life of the mainstream projects, including those that represent the threshold of safe dam design.
- Negative impacts will ensue to ecosystems of international importance, affecting many species that are endangered globally, leading perhaps to their extinction.
- The mainstream projects would fundamentally undermine the abundance, productivity and diversity of the Mekong fish resources.
- Due to inundation of agricultural lands and loss of riverbank gardens, despite expansion in irrigation associated with the project, agricultural productivity will be severely affected.

Many of these risks do not have mitigation measures which could lead to an enormous food shortage in the LMB. The Mekong delta is critical to the food security of Southeast Asia. It provides 50% of Vietnam's food, accounts for 90% of Vietnam's rice production, and 60% of its seafood, both with export values of several billion US$ per year. Thus loss of food security and loss of the protein for 30 million people would mean a mass relocation of local villagers and a potential social/cultural disaster.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. This study confirms the Costanza report assessment that, by changing some key assumptions in BDP2 (low discount rates for natural resources; fish value of $ 3/kg), the conclusions in BDP2 would be completely changed; the economic feasibility of the planned hydropower projects would change from positive (as in BDP2) to negative in terms of NPV.
8.2. The **revised case** in this study shows that the economic impact of the forecast loss of capture fisheries (based on migratory fish) is much larger than the hydropower benefit.
8.3. Assuming a split of 30% hydropower benefits for the host country and 70% for the country funding the project and importing the electricity, Thailand and Lao PDR are the beneficiaries of the proposed hydropower projects whereas Cambodia and Vietnam would bear the main cost. It is also clear that project developers and electricity importers would benefit but poor, rural fishing communities would suffer.
8.4. This study indicates that the capture fisheries NPV values in BDP2 are understated (loss in tons/year too low; fish value too low) and the hydropower benefit NPV values in BDP2 are overstated (capital investment too low; host country electricity trading benefit too high).
8.5. The economic impact of social/cultural issues are not accounted for in BDP2 but could result in mitigation costs of 5-12% capital investment which would adversely affect project viability.
8.6. If the mainstream projects are not pursued, there would be minimal risk for electricity security in the LMB countries and the forecast electricity demand could be supplied by alternative energy sources (e.g. solar, wind, biomass) and improved efficiency of energy use.
8.7. In the **revised case**, Lao PDR would have a positive NPV in both scenarios. It is proposed that Thailand, Cambodia and Vietnam should each make annual payments of about $100 million/year (total of $ 300 million/year) to Lao PDR for the next 30 years to compensate Lao PDR for not proceeding with mainstream hydropower development. This proposed payment scheme would be less than the forecast loss of capture fisheries in Cambodia and Vietnam. In addition, the international community could support all needed research activities to develop viable and acceptable mitigation measures during this period.

The following recommendations are proposed for further consideration:

1. Consider implementing a “payment for ecosystem services” to Lao PDR from other countries in the LMB as well as elsewhere.
2. Comprehensive risk assessment by requiring dam developers to post a recoverable assurance bond large enough to cover worse case damages.
3. A requirement that all hydropower development projects include the full cost and benefit of social and environmental conservation mitigation measures. Subsequently, the negotiated power purchase costs will reflect the true costs of hydropower development.

Further studies (hydropower evaluation, social and sediment/nutrient impact costs) are proposed to firm up the economic evaluation of mainstream hydropower development along the Mekong River. We request comments and suggestions from interested stakeholders throughout the GMS to clarify the scope of future studies.

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Appendix 1. List of existing and proposed Lower Mekong hydropower projects

	M/T *	**Location**	**Capacity** (MW)	**Project Developer**	**Status****
Pak Beng	M	Lao PDR	885	Hong Kong	MoU/FS
Luang Prabang	M	Lao PDR	1,410	Vietnam	MoU/FS
Xayaburi	M	Lao PDR	1,285	Thailand	Under construction
Pak Lay	M	Lao PDR	1,320	China	MoU/FS
Sanakham	M	Lao PDR	660	Hong Kong	MoU/FS
Pak Chom	M	Lao PDR	1,080	Thailand	?
Ban Khoum	M	Lao PDR	1,870	Thailand	MoU/FS
Lat Sua	M	Lao PDR	650	Thailand	MoU/FS
Don Sahong	M	Lao PDR	240	Malaysia	Preliminary work?
Stung Treng	M	Cambodia	980		MoU/FS
Sambor	M	Cambodia	2,600		MoU
Mainstream Total			12,980		
22 dams	T		3,300		In operation
18 dams	T		1,600		Committed
46 dams	T		5,600		Planned
Grand Total			23,480		

* M is Mainstream and T is Tributary

** MoU is Memorandum of Understanding; FS is ongoing Feasibility Study

Note 1. The 6 dams scenario includes Pak Beng, Luang Prabang, Xayaburi, Pak Lay, Sanakham, Pak Chom and 30 tributary dams

Note 2. The 11 dams scenario includes the dams in Note 1 and Ban Khoum, Lat Sua, Don Sahong, Stung Treng and Sambor

Note 3. The total capital investment is estimated to be US $ 52 billion for all hydropower projects in the 11 dams scenario and US $ 34 billion for the 6 dams scenario

Note 4. The BDP2 report and the Costanza report assumed that the host country would be the project owner and that all hydropower benefits would accrue to the host country. This paper assumes that hydropower benefits would be split 30% to host country, 70% to the country funding the project and importing the bulk of the electricity

Appendix 2. Mekong River fish catch and fish loss data

Table 1. Estimated Mekong fish catch

FISH CATCH	**References**
Capture fishery plus OAAs 2.304 million tons /year - Lao 166,000 Thailand 861,000 Cambodia 558,000 Vietnam 719,000 tons/year	(Mekong River Commission 2010)
Total fish catch 2.64 million tons/year - Lao 182,700 Thailand 932,300 Cambodia 682,150 Vietnam 844,850 tons/year	(Van Zalinge et al. 2004)
Total fish consumption estimate 2.63 million tons/year	(Hortle 2007)
Total fish catch 2.3 million tons/year	(Mekong River Commission 2011)
Total fish catch 2.5 million tons/year	(An 2015)
Total fish catch 2.304 million tons/year. - Lao 166,000 Thailand 861,000 Cambodia 588,000 Vietnam 719,000	(Nam 2015)
Total fish catch 2.6 million tons/year	(Cowx et al. 2015)
Total estimate yield by guild for fish plus OAAs 2.55 million tons/year - Lao 208,450 Thailand 911,257 Cambodia 586,661 Vietnam 851,781 tons/year	(Halls 2010)
The estimated range of LMB yield is 1.3-2.7 million tons/year. The figure of 2.3 million tons per year is the best available estimate of capture fish plus OAAs.	(Hortle 2015)

Table 2. Estimated fish loss due to mainstream dams

LOSS OF FISH CATCH	**References**
The net loss to capture fisheries basin-wide estimated to be 295,000 – 964,000 tons/year	(Mekong River Commission 2011)
Loss estimated to be 270,000-600,000 for 6 dams 550,000 -880,000 for 11 dams	(ICEM 2010)
Loss of 280,000 tons/year for 6 dams 1,300,000 for 11 tons/year dams	(Costanza et al. 2011)
<u>For the mid case Scenario</u> 285,000 tons/year for 6 dams 579,000 tons/year for 11 dams	(Mekong River Commission 2011)
Migratory fish resources comprise 71% (or 1.32 million tons/year) of the fisheries yield at US$1.89 /kg Loss estimate 1,270,000 – 1,570,000 tons /year 20,000 tons /year for upper Mekong 500,000 – 600,000 tons/year for middle Mekong 750,000 – 950,000 tons/year for Cambodia and Vietnam	(Barlow et al. 2008)

Appendix 3. Economic Calculations

Table 3.1. Detailed summary of NPV calculations for 6 dams scenario.

	BDP2 NPV ($ millions)	**Costanza Report** NPV ($ millions)	**Revised Case.** NPV ($ millions)
Hydropower	25,002	25,002	25,002
Irrigated agriculture	1,659	1,659	1,659
Reservoir fisheries	132	3,961	2,707
Aquaculture	1,261	854	366
Capture fisheries	-952	-28,476	-27,001
Wetlands	-178	-4,520	-1,460
Social/Cultural Impact	0	0	-799
Sediment/Nutrient	0	0	-2,707
Eco-hotspot/biodiversity	-240	-240	-240
Forest area reduction	-228	-228	-228
Recession rice	-175	-175	-175
Flood mitigation	360	360	360
Salinity mitigation	23	23	23
Bank erosion losses	0	0	0
Navigation	64	64	64
Total	26,728	-1,716	-2,428

Table 3.2. Detailed summary of NPV calculations for 11 dams scenario.

	BDP2 NPV ($ millions)	**Costanza Report** NPV ($ millions)	**Revised Case.** NPV ($ millions)
Hydropower	32,823	32,823	32,823
Irrigated agriculture	1,659	1,659	1,659
Reservoir fisheries	215	26,058	4,331
Aquaculture	1,261	4,010	743
Capture fisheries	-1,936	-133,650	-54,854
Wetlands	101	3,536	1,114
Social/Cultural Impact	0	0	-1,494
Sediment/Nutrient	0	0	-5,414
Eco-hotspot/biodiversity	-415	-415	-415
Forest area reduction	-372	-372	-372
Recession rice	278	278	278
Flood mitigation	-273	-273	-273
Salinity mitigation	-2	-2	-2
Bank erosion losses	0	0	0
Navigation	64	64	64
Total	33,403	-66,284	-21,811