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Key Findings of NHI's Sambor Hydropower Dam Alternatives Assessment

The Sambor Hydropower Dam Alternatives Assessment was conducted by an international team of experts directed by the Natural Heritage Institute (NHI) under a formal agreement (Memorandum of Understanding) with the Ministry of Mines and Energy of the Royal Government of Cambodia (RGC), executed on October 20, 2014. The MoU charged the NHI Team to assess siting, design and operational alternatives to the originally proposed Sambor Hydropower Dam on the mainstream of the Mekong River and also a no-dam alternative for power generation. The 2600 MW project would be the largest hydropower dam constructed on the Lower Mekong and it would create a complete barrier to migratory fish that are a valuable source of protein and income to people in Cambodia, and block sediment that replenishes the Mekong Delta and nourishes the food chain of the Tonle Sap Great Lake. This exacerbates climate change impacts, such as sea-level rise, and reduces the region's ability to build resiliency. NHI's Sambor Alternatives Assessment developed a set of environmental performance standards (e.g. max fish survival and sediment passage) selected to maintain the natural functions of the Mekong river system, and then considered how a major hydropower facility could be sited, designed and operated to achieve those standards while maximizing power production and maintaining economic viability.

This document summarizes the process behind and the key findings of the Sambor Alternatives Assessment. The full report can be downloaded from the links provided on page 6.

Background

- The Mekong River is the most productive fishery in the world, producing a harvest valued at $1.7 billion per year. Over 60 million people depend on this natural bounty for their food security, livelihoods and cultural enrichment. It is also the second most biodiverse river in the world (after the Amazon), with some 1200 species. The Sambor dam site (see Figure 1) is in the reach of the Mekong River that annually experiences the largest migration of fish in the world. The Sambor reach is the worst possible place to build a major dam; such a structure could literally kill the river, unless sited, designed and operated sustainably.

- The original Sambor Dam would be 2600MW, twice as large as any other dam constructed or planned for the mainstream of the Lower Mekong. It would be 18 kilometers wide, 33 meters high (from tailwater to maximum storage level) and create a reservoir 82 kilometers long. The dam and the reservoir would create a barrier that would be devastating for the migratory fish stocks that move from the Tonle Sap Great Lake to the spawning grounds upstream and in the "3-S" (Se San, Sre Pok and Se Kong) tributaries. The reservoir would disrupt the reproductive cycle because the eggs, larvae and frys would not be able to drift back downstream through this long static pool. Furthermore, fish passes are ineffective on dams higher than 30 meters. At least 86 species are long-range migratory species in the Cambodia part of the Mekong River, and all would become endangered by a Sambor dam. Irrawaddy river dolphins, which are critically endangered, also use the Sambor corridor for refuge and breeding grounds. Dam construction at or near Sambor places the remaining 80 dolphins at high risk of extinction.

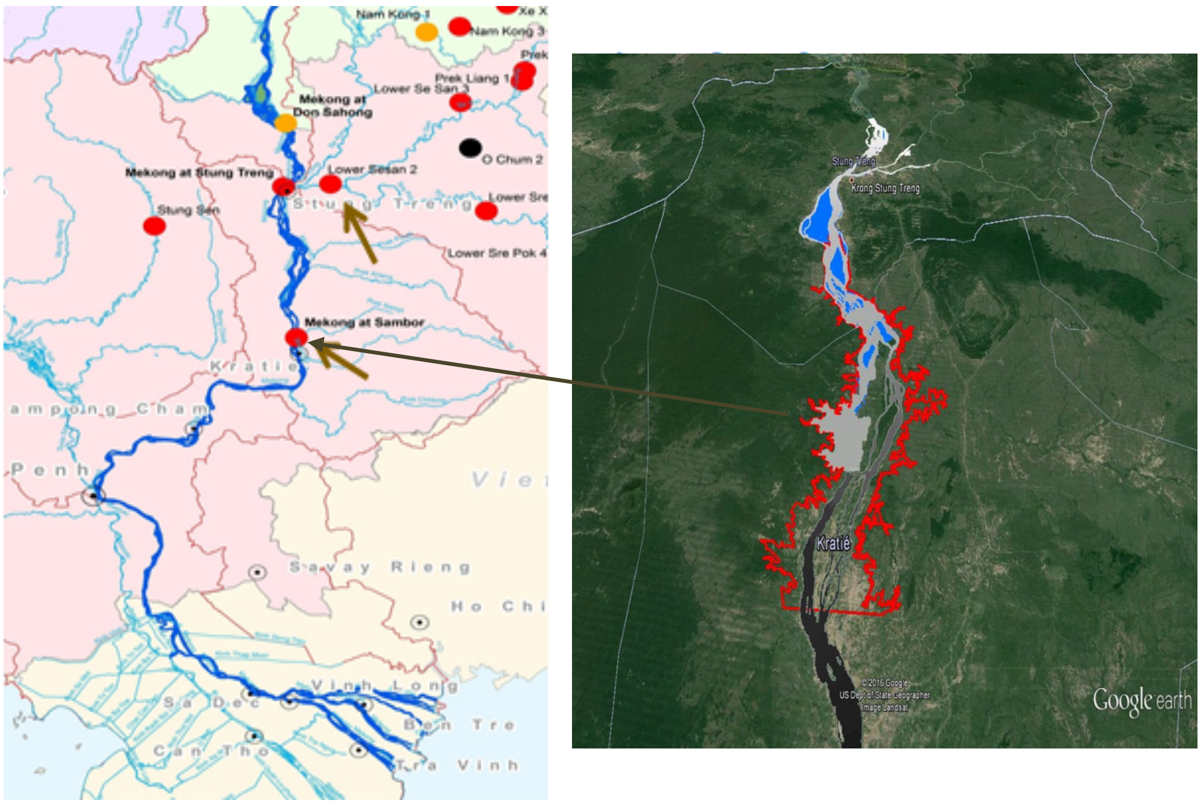

Figure 1: Left image shows the locations of Sambor and Lower Sesan 2 hydropower projects in the Lower Mekong Basin. The right-side image shows the foot print (red outline) of the original proposed Sambor compared with NHI's alternatives 7 and 6A (blue)

- A Sambor dam would capture all of the bedload and 60% of the suspended sediments that are needed to maintain and replenish the Mekong Delta in Vietnam, which according to the IPCC is one of the three major delta systems in the world most vulnerable to sea level rise, with its attendant storm surges and salinization. The resilience of the delta to the effects of climate change depends directly on this annual replenishment of sediment. This delta is home to 18 million people, produces half of the rice harvest for Vietnam, the world's second largest rice exporter, and the epicenter of fish harvesting and biodiversity. It also nourishes the food chain in the Tonle Sap Great Lake.

NHI's Alternatives Assessment

- In view of these unacceptably large impacts, the NHI studied 10 alternatives sites, designs and operations. The starting point involved reversing the usual process (Text Box 1) for conducting hydropower dam pre-feasibility studies in which the first step is optimizing power output at a particular site, and then assessing impacts and adopting mitigation measures. In that sequence, the mitigations measures are intended to accommodate the power production. In the NHI method, the team first established a set of standards to preserve the health of the natural and social systems, and then considered how a major hydropower facility could be sited, designed and operated to achieve those standards.

Text Box 1: Sustainable Hydropower by Design: a new paradigm

Conventional Approach

- Select Dam Site
  - Maximize Energy Production
  - Design Hydropower Facility
- Identify Impacts
- Develop Mitigation Measures
- Result
  - Mitigation inadequate for sustainability standard
  - Risk of Knowledge Gaps not explained

New Approach

- Identify requirements for health of natural and social systems
  - 95% fish survival for both upstream and downstream fish passage
  - Larval drift – flow velocity of water ≥ 0.3m/s
  - Minimize barotrauma potential at spillway and power house
  - Minimize turbine mortality
  - ~95% of suspended sediment annually through the reservoir
  - Maintain reservoir storage over the long term
  - Minimize # of people relocated
- Design Facility to meet these requirements
- Result
  - Optimized Solution that concurrently integrates
    - Site Selection
    - Energy Production
    - Fish Passage
    - Sediment Passage
    - Relocation Needs
  - Communicate Risk of Knowledge Gaps

- The results of the Sambor Alternatives Summary, including a no-dam option are presented in **Table 2**. In terms of hydropower projects, the one most able to attain the performance standards in Text Box 1 is called Sambor Alt_7 in the Report. This would be the most fully mitigated major dam project ever conceived—no current hydropower dam operating today could meet its specifications. The site would be 13 km upstream of the original Sambor dam in an area with multiple channels, which would allow others to be free-flowing for passage of fish and sediment, and potentially also the Irrawaddy river dolphins. The dam would include three fish passage facilities, gates to periodically flush sediment and utilize the most advanced turbines currently under development to avoid fish baurotrauma. It would be operated to maintain a constant minimum flow sufficient to keep the eggs, larvae and frys in suspension all the way through the reservoir to the point of discharge at the powerhouse or spillway during all times of the year. This analysis defined the permissible size of the project and its power output. The installed capacity would decrease from 2600MW for the original Sambor dam to 1240MW for NHI Alternative 7.

- Even this alternative poses substantial risks to the extraordinary resources of the Mekong due to the large remaining uncertainties regarding the function of the migratory fishery (all with distinct lifecycles and behaviors), and the untested performance of these advanced mitigation measures. The NHI team also assessed the consequences for fish yield in the event that these measures fall short of the 95% survival aiming point. The results show that a level of performance that reflects the historic global experience would devastate the fishery! For this reason, the NHI team sought and obtained from the chief Minister for Hydropower Development a modification to the MoU to authorize a comparative study of a no-dam alternative, based on solar power, that promises to outperform the Sambor Dam alternative with respect to power output, cost, reliability and avoidance of financial risks.

Table 1: Key results of NHI Sambor Alternatives Assessment.

Alternative	Result	Reason
1. Small dam on side channel (Alt. 6A)	Not **financially** feasible	Dam backs up water into main channel so not enough water goes through turbines
2. Large dam on main channel (Alt 7A) with all mitigation measures including fish screens	Not **financially** feasible	Large costs of the fish screens
3. Large dam on main channel (Alt. 7A) with all mitigation measures except fish screens	Not **economically** defensible	Large damage costs to migratory fishery
4. Floating solar PV at Lower Se San 2	**Outperforms** dam options on every criteria including cost	Sharp decline in costs relative to hydro, no impacts on fishery

No-Dam Alternative

- The concept devised by the NHI team is to augment the power output of existing hydropower facilities instead of building a new one at the Sambor site. The project most promising for that is Cambodia's largest existing hydropower facility, the Lower Se San 2 (LSS2), which is owned and operated by the same investors interested in the Sambor project. This 400 MW project is located (see Figure 1) at the confluence of two of the 3-S tributaries, the Se San and the Sre Pok, and was commissioned in November, 2017. The concept involves siting floating solar photovoltaic panel on the LSS2 reservoir and integrating them into the operations of the hydropower project itself, so that they would operate as a single, hybrid facility.

- To assess whether the increase in power could be viewed as an alternative to the Sambor dam, the NHI team considered whether it could be comparable or superior to even the most fully-mitigated Sambor Alternatives (Sambor Alt_7) with respect to the primary consideration factors from the vantage point of the national government, the investors and the grid operators (which are the power customers). These factors, and the conclusions of the comparative assessment, are as follows:

  - **Reliability of power output:** this and the cost are the primary concerns of the grid operators. Hydropower at LSS2 is very reliable on a daily basis (because it can store a day of inflow), but extremely variable on a seasonal basis (because of vast difference in inflows between the wet and dry seasons). Solar power is quite variable over the course of a day (because it only generates power when the sun is shining), but surprisingly uniform over the course of a year. Consequently, there is a happy complementarity when the two components are combined. Indeed, a hybrid facility at LSS2 would be more reliable than the Sambor dam alternatives, which makes it attractive to the grid operators.

  - **Cost:** Solar power would be slightly more expensive than the hydropower at LSS2, but the costs of solar systems have decreased rapidly over the past decade and further cost decreases are likely. Present costs of $1,000/kW for floating systems are likely to reduce to $900/kW over the next decade. When all economic costs and benefits are included, incorporating solar at LSS2 would provide a net economic benefit, whereas all of the Sambor alternatives would provide a net economic loss.

  - **Power output:** the solar power from LSS2 would not be as large as the power output from Sambor Alt_7 (400MW vs. 1240MW). But the question for the power sector planners in the RGC is not which facility can deliver more power at this time. The question at any discrete decision point is: what is the next least-cost alternative for meeting the next increment of power demand for domestic consumption of export. At this time, the answer to that question for Cambodia is unquestionably the solar augmentation alternative, not Sambor dam. Whether there will ever be a time when the best answer is Sambor dam depends on whether the cost of other renewables continues to decline year by year, which is widely predicted.

  - **Time for deployment:** solar photovoltaic systems can be deployed easily at the rate of 100MW per year. Indeed, a recent project in India constructed 648MW in just 10 months. By contrast, Sambor Alt_7 would require 5-6 years to construct after the financing and environmental impact assessment hurdles are completed.

  - **Avoidance of financial risks:** hydropower projects must be built to scale at the start. The long construction times mean that interest payments on loans accumulate for many years before the first revenue is generated, increasing the capital costs by around 20% Solar panels, by contrast, can be constructed in real time as the demand is experienced and can produce revenue for debt service very quickly. This vastly reduces the risks to investors. This factor alone makes the solar alternative much more competitive than the dam alternatives.

- **Avoidance of Impacts:** The LSS2 is already having negative repercussions since it was constructed and put into operation, but siting the solar alternative at LSS2 would imposes no further impacts to the Mekong fishery, nor contribute any additional sediment loss to the downstream system. No additional people would be displaced from their homes. An important added benefit is climate mitigation by reducing GHG emissions: a 280 MW facility can reduce as much as 357,000 tons per year.[1]

- The final recommendation to the RGC is that it should ***defer any commitment to a Sambor Dam while it pursues better alternatives, starting with the solar augmentation of existing reservoirs.*** Even the most fully mitigated alternative poses high risks. The solar alternative allows the RGC to defer making any commitment to a Sambor dam at this time. If, at some time in the future, Sambor Alt_7 emerges as the least cost alternative for meeting the next increment of demand, it can be reconsidered. However, if all costs and benefits, including the risks to natural resources are weighed in the balance, and if the cost of solar and other renewables continues to decline as expected, that day may never come.

EACH OF THE 4 VOLUMES OF THE FINAL REPORT CAN BE DOWNLOADED FROM THE FOLLOWING LINK: https://drive.google.com/open?id=1IdxGigFOids-UUk1bkpTQdh2YvZd2HOa. ***ALTERNATIVELY, YOU MAY SEND A REQUEST FOR THE DOCUMENTS TO JESSICA P. NAGTALON AT NHI:*** *jessnagtalon@n-h-i.org*

Volume 1: Executive Summary with Key Findings and Conclusions

Volume 2: Sambor Dam Alternatives

Volume 3: Solar Alternative to Sambor Dam

Volume 4: Technical Appendices

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Further information about NHI's projects can be found on the NHI website: www.n-h-i.org

[1] Source: solarmango.com. Assumes that reduction of CO2 emission per 1 kWh of solar power = 1 kg of CO2. Please note that the above calculation considers only the reduction in CO2 emissions for the electricity generated from a solar power plant vs. a coal plant and does not take into account CO2 from other parts of the value chain.