9. CONCLUSIONS AND RECOMMENDATIONS

9.1 A Dynamic Baseline: the Present Situation

The Sekong Basin has undergone environmental and social changes in recent years because of hydropower, other infrastructure developments, and population growth. It is a dynamic situation even in the absence of further renewable energy development that is proposed over the next decade. In 2010, the Sekong Basin had a virtually undisturbed river system with no barriers to fish migration and very little flow regulation. The Houay Ho hydropower plant (HPP) was the only one in the entire basin. Substantial hydropower development has taken place during the past decade, and several projects are under construction, including the Xe Pian–Xe Namnoy, Nam Kong 1, and Nam Kong 3.

The present situation can be summarized as follows:

- The Sekong mainstream provides a long distance of unrestricted river flow that makes it accessible to long-distance Mekong migratory fish.
- The Sekong mainstream has no reservoirs, which enables sediment transport downstream to the Sekong floodplain and further to the Mekong.
- Since the impoundment of the Lower Sesan 2 dam and reservoir in Cambodia, sediment transport has been interrupted from the other two rivers (Sesan and Srepok) of the Sekong, Sesan, and Srepok (3S) basin. The two rivers no longer make significant contributions to the Mekong.
- Apart from the trans-catchment water transfer from the A Luoi dam to the Bo River in Vietnam, no hydropower dams or reservoirs affected the mainstream Sekong River and its northern tributaries.
- Construction of four dams and a large reservoir providing seasonal regulation of the flows passing down the Xe Kaman has heavily altered the Xe Kaman tributary basin. This has also interrupted sediment flows, with only a reduced fine silt fraction passing downstream of the Xe Kaman–Sanxay Dam, although it is still possible for migrating fish from the Sekong and the Mekong to reach the Xe Xou and Nam Pa tributaries, whereas construction of several dams in cascade has fragmented the Xe Kaman mainstream and Nam Kong River.
- The Xe Pian and Xe Nam Noy tributaries have had their flows radically altered and water transferred directly to the Sekong River through new power plants. Flows along the natural courses of these tributaries have been reduced substantially, perhaps most noticeably by reduced frequency and magnitude of floods because of the high regulating volume of the Xe Namnoy and Houay Ho reservoirs.
- New roads have been constructed to the uppermost dam site, Nam Kong 3, and to the various dam sites along the Xe Kaman. Roads to the new dams and diversion dams on the Bolaven Plateau have opened access to its resources, but road access north along the main Sekong River remains difficult, especially in the wet season.
- The Houay Lamphan Gnai HPP is the only Sekong Basin power project providing power exclusively to the local grid. Most existing hydropower projects are export orientated. Transmission lines have been constructed from hydropower projects in the Xe Kaman and Nam Kong sub-basins to the Vietnam border. A 220-kilovolt transmission line runs from the Xe Pian–Xe Namnoy project to Thailand.
- Forests face multiple pressures, including hydropower, new roads, agriculture, and mining. Mining is concentrated in the Xe Kaman sub-basin (Map 3.6), but exploration permits have been issued covering most of the basin, so mining may significantly affect land use change in the future.
- The basin has no wind or solar energy projects.

9.2 Alternative Development Pathways

This study has assessed three alternative development pathways:

- *Full development pathway*, with 23 additional projects operational by 2030
- *Conservative development pathway*, with 18 additional projects by 2030
- *Intermediate development pathway*, with 23 additional projects by 2030

Table 9.1 summarizes the characteristics of the three development pathways assessed in this report, including some key parameters relevant to assessment of cumulative impacts. Figure 9.1 illustrates the difference in power-generating capacity of each development pathway.

9.3 Power Generation and Revenue Forecasts

The conservative development pathway would generate approximately 9.7 terawatt-hours (TWh) of power annually (57 percent more than the present situation) (Figure 9.1), the intermediate development pathway would generate 11.9 TWh (94 percent more annually), and the full development pathway would generate 14 TWh (129 percent more) a year.

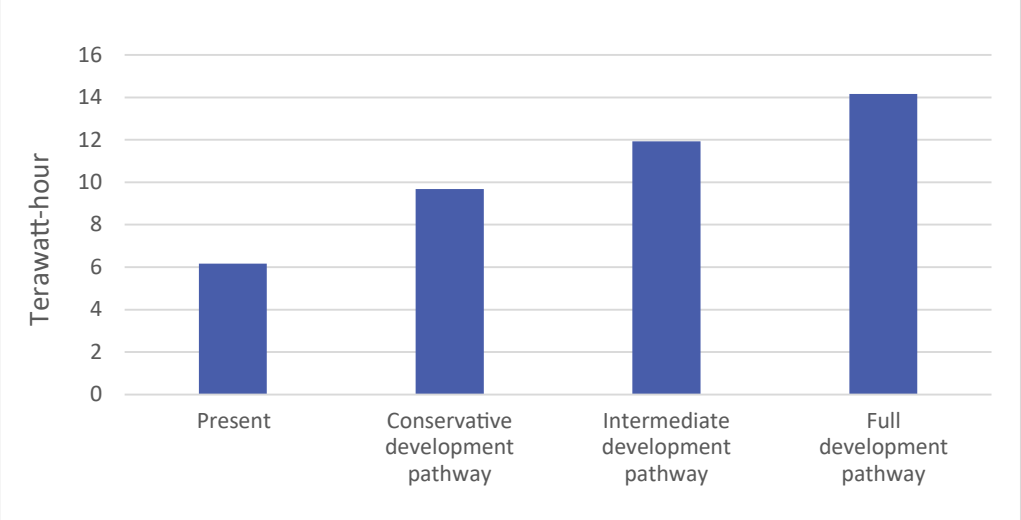
Table 9.1: Summary of Characteristics of Alternative Pathways

Development pathway	Active reservoir volume (hm^3)	Installed capacity (MW)	Annual generation (TWh)[a]	Total reservoir area (km^2)	Population resettled persons	Sediment load into Cambodia (tons/y)	2006 peak flood into Cambodia (m^3/s)	Number of dams on Sekong mainstem	Km of free run to headwater of Sekong
Present	3,928	1,554	6.16	224	14,500	3.7	3,453	0	410
Conservative	4,985	2,470	9.68	260	16,700	3.7	3,380	0	410
Intermediate	6,310	2,975	11.93	306	18,000	2.9	3,130	2	306
Full	6,881	3,512	14.13	382	26,900	1.7	3,084	7	68

Note: hm^3 = million cubic meters; MW = megawatts; TWh = terawatt-hours; km^2 = square kilometers; tons/y = tons per year; m^3/s = cubic meters per second; km = kilometer.

[a] The full development, conservative, and intermediate pathways also include an estimated additional 3.0 TWh per year of solar and wind energy.

Figure 9.1: Annual Electricity Generation Under Different Development Pathways



In Lao PDR, most hydropower projects are private investments built on a 30-year build-operate-transfer model, after which project ownership is transferred to the state. In the longer term, Sekong Basin hydropower projects will become valuable assets for the Lao PDR government and continue to generate revenue for their operational life. In the short term, projects contribute to government revenue through royalties on electricity sales, taxes, and government equity shares.

9.4 Cumulative Impacts

The three pathways will have different degrees of environmental and social impacts and risks.

The full development pathway will have large impacts on certain valued environmental components (VECs), especially fish, livelihoods that rely on river fisheries and agriculture, or are affected by resettlement. Bank and bed erosion may increase in alluvial parts of the river, and less variability in river levels and smaller loads of nutrient-rich silt will restrict vegetable horticulture. Harvests from floodplain fisheries will probably fall, with some years seeing no floodplain inundation at all. The full development pathway is likely to come at the cost of loss of unique, highly valued biodiversity. Social costs will be in the form of resettlement of several thousand people.

The conservative development pathway, which excludes the seven mainstream projects, will entail hydropower development on a smaller scale and at a slower pace but will still provide a significant boost to the local and national economy. Assessment of the conservative development pathway indicates few notable additional impacts from the present situation, especially with regard to the Sekong mainstream, although local impacts will be experienced in the tributaries.

The intermediate development pathway will have more impacts on some VECs, especially as a result of development of Sekong 4B and 5. Overall, impacts will be less than under the full development pathway but greater than the conservative development pathway. Table 9.2 synthesizes the cumulative impacts on VECs under alternative pathways.

Table 9.2: Summary of Cumulative Impacts on Valued Environmental Components for Each Pathway

VEC	Full development	Intermediate development	Conservative development
Aquatic habitats and biodiversity	Large reduction in aquatic biodiversity due to disruption of migratory routes and inundation of riparian habitats important for spawning and feeding	Moderate impact on aquatic biodiversity because of fragmentation of Sekong tributaries; fish migration to and from the Mekong supports continued connectivity along most of the Sekong mainstem	Little impact on aquatic biodiversity because connectivity is maintained along the full length of the Sekong mainstem and several tributaries to support fish migration to and from the Mekong
Terrestrial habitats and biodiversity	Moderate impact on terrestrial biodiversity because of impacts on forests and protected areas	Moderate impact on terrestrial biodiversity due to impacts on forests and protected areas	Little impact on terrestrial habitats and biodiversity—important protected areas avoided
Natural resource–dependent livelihoods	Large adverse impact on livelihoods, particularly agriculture, fisheries, and resettlement	Moderate impact on livelihoods, particularly resettlement	Little impact on livelihoods overall but significant for directly affected communities
Society and culture	Moderate impact on culture and heritage, particularly because of resettlement	Mixed impact on culture and heritage—adverse and beneficial	Mixed impact on culture and heritage—adverse and beneficial

9.5 Mitigation

Mitigation measures discussed here refer to future hydropower projects rather than projects already built. There is generally limited scope to modify hydropower projects after they have been built or even after detailed designs have been completed; the technical challenges and financial costs involved tend to be prohibitive.

All three development pathways require similar mitigation measures, although the magnitude of the interventions will vary in proportion to the intensity of the development. Key measures (as detailed in Section 7.5) include the following:

- Engineering design features, including gates at different levels and regulating ponds
- Joint and coordinated management of environmental flows (EFlows) and sediment flushing
- Incorporation of fish passages on main migration routes where technically feasible
- Reservoir fisheries programs (native species) that prioritize benefits for affected communities
- Catchment protection measures including reforestation and patrols to prevent illicit harvesting of forest products
- Creation of biodiversity offsets focused on support for protected areas with equivalent conservation values and biological corridors for wildlife migrations
- Carefully designed and fully resourced resettlement plans and community developments, considering risks and opportunities related to gender and ethnicity
- Livelihood restoration through the provision of replacement agricultural land and introduction of new income-generating activities, including off-farm activities

9.6 Recommendations

The findings of this study indicate the need for a Sekong Basin power development master plan incorporating renewable energy (hydropower, solar, and wind) as well as thermal power. Private sector interests have largely directed past developments in the basin on a first-come, first-served basis. The government should establish the trajectory of future development based on a strategic assessment of local and regional power demand and with consideration of the range of potential uses of natural resources in the basin. This approach would result in greater investment efficiency, a close match between power production and demand, and more opportunities to address adverse impacts through the full range of options available in the mitigation hierarchy. A master plan would be consistent with the 2017 Electricity Law, which requires power development planning on a five-year cycle, and the 2017 Law on Water Resources, which requires basin planning.

Important considerations for a Sekong Basin power development plan include the following:

- *Power demand*: up-to-date, realistic domestic and regional demand forecasts taking into account power development plans of neighboring countries, bilateral agreements (for example, memoranda of understanding), and a trend of rapid diversification of renewable energy solutions
- *Integrated water resources management*: incorporating integrated water resources management to ensure that needs and interests of multiple stakeholders in the basin are accommodated
- *Cumulative impacts*: environmental and social cumulative impacts as elaborated in this study
- *Avoidance by design*: reducing environmental and social impacts by modifying designs of particular projects (for example, Sekong 4A)
- *Trade-offs*: reaching a rational balance between economic benefits of power generation, adverse environmental and social impacts (particularly residual impacts and risks that cannot be fully mitigated), and opportunity costs of alternative natural resource uses foregone
- *Optimization*: achieving power generation enhancements and investment efficiencies by optimizing design and operating rules of hydropower cascades and in other circumstances where optimization benefits exist
- *Grid development*: shared transmission lines among power projects to reduce construction costs, improve grid efficiency, and reduce environmental and social impacts; co-funding by developers of transmission lines and cross-border interconnectors using this infrastructure
- *Integrating solar and wind*: identification of transmission grid and power supply and demand management improvements so that other renewable energy sources can

be absorbed into the power system while maintaining balance

This master plan would provide parameters within which individual projects would be designed, assessed, and approved. Project proponents would need to integrate mitigation measures identified in the master plan into feasibility studies and environmental and social impact assessments.

This study has identified several opportunities for coordination and collaboration during the operation of renewable energy projects. A simple, practical co-management platform should be established to promote coordination among hydropower operations and to implement collaborative measures to mitigate cumulative impacts. Examples of opportunities for coordination among power developers in the Sekong Basin include the following:

- *Coordinated environmental and social mitigation measures*: pooled funding and management arrangements for catchment protection, environmental offsets, and resettlement
- *Coordinated and joint operations*: information exchange and coordination among plant operators within the Sekong Basin, especially for dams in cascades on the same tributaries and within sub-basins to maintain EFlows and fish migration
- *Coordinated flood monitoring and warnings*: sharing hydrological data, collaborating on flood risk forecasting and preparedness, and establishing a warning system to notify local authorities and local communities of flood risks
- *Coordinated dam safety analyses*: cooperation of operators of cascading projects and pooling of resources to assess dam safety risks

Master planning and coordinated power operations will require that data and information gaps be addressed. Some priority areas for data, information, and analysis are summarized as follows:

Hydrological modeling

- Hydrological and meteorological monitoring data from existing hydropower projects should be collated and analyzed to enable precise calibration of the basin hydrological model developed for this study using satellite rainfall records.
- Meteorological and water gauging stations should be installed throughout the basin to provide a more complete set of measured data.
- Future climate change and hydrological models developed for the Sekong Basin should be made available to developers and government agencies responsible for planning, regulating, and monitoring hydropower development.

Sediment management

- The effectiveness of joint flushing and sluicing in cascades on the Sekong mainstream and tributaries should be further studied.
- Sediment load should be measured within the Sekong Basin to provide empirical data for the design of effective flushing, sluicing, and other management options.

Hydropower operating rules

- Hydropower modeling of the type conducted for this study can be refined with additional information about the operating rules of individual dams, improving the accuracy of the model, and enhancing the effectiveness and benefits of joint operation of cascades in the tributary systems.

Fish passages

- More empirical data on the efficacy of fish passages in the Lower Mekong Region are needed. Data will soon become available from the Xayaboury HPP on the Mekong mainstream, which incorporates several fish passage design features.

EFlows

- A study to determine an appropriate EFlow regime for the entire Sekong Basin is needed.