

# 7. CUMULATIVE IMPACT ASSESSMENT OF ALTERNATIVE DEVELOPMENT PATHWAYS

## 7.1 Aquatic Biodiversity and Ecosystems

### 7.1.1 Impact of Flow Regime Changes

Flow regime change because of hydropower and the effect on aquatic ecosystems have been calculated quantitatively for each development pathway using hydrological modeling and climate change models developed for this cumulative impact assessment (CIA). The assessment considered three key indicators of flow regime change—magnitude, duration, and frequency—that are ecologically relevant and sensitive to hydropower development. Magnitude refers to the amount of water under average flow, very low flow, and very high flow conditions. Duration is the length of time that low flow and high flow conditions occur. Frequency is how often there are very low and very high flow conditions. Scores for flow regime change have been calculated as percentage variation from the present situation for each of the three development pathways.

Some flow-related stressors associated with hydropower development include the following: reduced high flows (during the wet season) with effects on fish species that depend on connectivity between river channels and floodplains; greater low flows (during the dry season), which will affect fish habitats; and a delay in the flood pulse (start of wet season), which provides signals for fish migration. These stressors interact and have cumulative impacts. Studies show that any change in the three flow indicators can decrease the abundance and diversity of fish species (Poff and Zimmerman 2010).

Water extraction in the Sekong Basin affects flow regime change less than hydropower does, but the expansion of the agriculture sector together with increased domestic and industrial use of water could put pressure on water resources, particularly dry season flows.

Climate change is an additional pressure affecting the flow regime. Climate change projections for the Sekong Basin are for a slight increase in flow during the wet season and a larger decrease during the dry season (see Appendix B).

Analyses were conducted for seven indicator species present in the Sekong Basin, selected according to ecological characteristics (super-endemic, endangered, and migratory) and socio-economic characteristics (important as a source of food or otherwise important for local communities). The analyses found that dam construction will harm all fish species, with the largest effects occurring under the full development pathway and the least under the conservative development pathway. The full development pathway would most severely affect the fish species *Sphaerobelum bolavensis*, which is super-endemic and important for food.

### 7.1.2 Impact of Habitat Fragmentation and Reduced Connectivity

Aquatic habitat connectivity is important for many species of fish that require access to different riparian habitats at different stages of the lifecycle. Dams can reduce connectivity and increase habitat fragmentation by physically blocking a river, changing habit conditions from lentic (flowing water) to lotic (standing water), and reducing wet season flows, which prevents aquatic creatures from accessing floodplains and channels. A large reduction in connectivity and an increase in fragmentation pose a risk to fish populations supported by affected habitats.

Habitat fragmentation was calculated quantitatively for each development pathway for the seven indicator species using several indicators: longest length of continuous river providing a habitat for each species, number of habitat segments created by hydropower projects, and length of river transformed from lentic to lotic conditions. Details of the method of calculating fragmentation and connectivity are given in Appendix F. Impacts are greatest under the full development pathway (because of construction of seven mainstream projects) and less under the intermediate development pathway (with only two mainstream projects). Under the conservative development pathway, because additional hydropower development is in tributaries and sub-basins that already have dams, there would be only minor changes from the present situation.

Changes in rivers under all development pathways are illustrated in maps in Appendix F. The colors show the degree of change assessed as a combined score of average changes to flow regime, sediment transport, and fish connectivity.

### 7.1.3 Mitigation Options

#### 7.1.3.1 Environmental Flows

Setting appropriate environmental flows (EFlows) for hydropower projects throughout the basin would be an important way to mitigate cumulative effects on aquatic biodiversity and ecosystem services under all three development pathways. An integrated, basin-wide approach is required, taking into account existing and planned projects. Industry good practice guidance advises that, for the Sekong Basin, this should be a detailed, high-resolution assessment because of the presence of cascading and peaking operations, habitats of high conservation value, and natural resources important for local livelihoods. The assessment would involve collection and analysis of empirical data and a consultative process involving stakeholders. The outcome would be an EFlow regime with variations between sub-basins and river sections consistent with differing environmental and social values.

Hydropower operators in the basin should be encouraged to jointly formulate and implement EFlows for several practical reasons. For example, a downstream dam without a reservoir might be unable to maintain minimum flow releases important for floodplain connectivity if an upstream storage dam were to temporarily stop discharging for maintenance or other reasons. Sediment flushing and sluicing require coordination among dams in a cascade to ensure efficient sediment transport from one dam to the next. Coordinated releases are also important to provide hydrological triggers for fish migration. A basin-scale EFlow assessment can be beneficial to project developers because it can obviate the need for such an assessment as part of the project environmental impact assessment (EIA). Global experience is that EFlows can achieve good ecological and social outcomes with little or no production losses.

EFlow requirements will vary under each of the development pathways studied. Although a detailed assessment is beyond the scope of this study, the EFlow regime for the full development pathway would need to be particularly rigorous and well-coordinated because of the higher concentration of hydropower projects in the basin

and the existence of a cascade of seven dams on the Sekong mainstem. Under the intermediate development pathway, operational coordination between Sekong 5 and Sekong 4B would be a priority given the high storage capacity of these upper catchment dams. Under the conservative development pathway (and likewise the other two pathways), coordinated EFlows would be important for hydropower operations in the Bolaven, Nam Kong, and Xe Kaman sub-basins.

#### 7.1.3.2 Sediment Flushing and Sluicing

The feasibility of sediment flushing depends on a number of factors, including the shape and size of the reservoir. Section 6.2 discusses flushing opportunities. In general, efficient sediment flushing is feasible only for very small reservoirs, with volumes up to approximately 2 percent of annual inflow. For medium-sized reservoirs, with volumes up to 20 percent of annual inflow, sediment sluicing may be feasible during periods with high sediment concentration. For larger reservoirs, sediments can be removed only using mechanical means, such as dredging. This study assessed potential for flushing and sluicing in five reservoirs with volumes up to 5 percent of annual inflow: Sekong Downstream A and B, Sekong 3A and 3B, and Nam Kong 2. The degree of sediment trapping was modeled to be 67 percent without flushing and 62 percent with flushing (see Appendix E).

Many of the proposed Sekong Basin dams have large reservoirs (for example, Sekong 4B and 5), as do several existing dams (for example, Xe Kaman 1, Nam Kong 3, Houay Ho, and Xe Pian–Xe Namnoy). Sediment sluicing or flushing will not be effective for these dams.

For the full development pathway, joint, coordinated flushing and sluicing of the four lowermost mainstream dams (Sekong Downstream A and B, Sekong 3A and B) to promote sediment transport will be important to support floodplain geomorphology and aquatic habitats.

Under the conservative development pathway, joint, coordinated cascade flushing and sluicing should be implemented in smaller reservoirs in the Xe Kaman, Bolaven, and Nam Kong sub-basins to maintain river geomorphology and aquatic habitats in these tributaries. Specifically, in the Bolaven sub-basin, flushing and sluicing should be considered for the planned Xe Katam hydropower plant (HPP), and design modifications should be explored to enable flushing and sluicing of the already commissioned Xe Namnoy 1 and 6

and Xe Namnoy 2–Xe Katam 1. Flushing and sluicing are also relevant for the Lower Xe Pian HPP. Flushing and sluicing of Nam Kong 2 and 3 are not relevant because the Nam Kong 1, already under construction downstream, will trap the majority of sediment (flushing is not feasible because of the large reservoir size). In the Xe Kaman cluster, flushing and sluicing are not feasible for the larger Xe Kaman 1 and the smaller Xe Kaman–Sanxay, although flushing and sluicing are feasible for the Xe Kaman 2A, 2B, and 4 cascade, albeit only with local and tributary sediment transport benefits.

### 7.1.3.3 Fish Passages

The efficacy of fish passages for mitigating the impacts of hydropower development on fish and other aquatic organisms is unproven in the Mekong region. It is likely that only some migratory fish species would benefit even if mechanisms for fish passage were optimally designed with provisions for upstream passage of fish and downstream passage of eggs, spawn, and juvenile fish. Fish passages, therefore, offer the potential for only partial mitigation of adverse impacts on fisheries, habitat fragmentation, and lack of connectivity caused by hydropower development.

Field research is needed to investigate designs, costs, and efficiencies of fish passages optimized for various endemic migratory fish species in the Sekong Basin. Engineered solutions may include fish ladders, fish locks and lifts, fish-friendly turbines, and truck and transport, although fish ladders are generally not considered economically or technically feasible for dams with an elevation greater than 40 meters. Because of this fundamental height restriction on fish passages, opportunities are limited to lower-head dams in the Sekong Basin.

Under the full development pathway, the priority would be to maximize connectivity and minimize fragmentation of the Sekong mainstream by installing fish passages on the lowest four mainstream dams (Sekong 4A and 3 and Sekong Downstream A and B). Truck and transport of fish might be an option for the large upper mainstream dams (Sekong 4B and 5) and other tributary dams, but this approach is untested in Lao PDR.

There may also be value in installing fish passages on Sekong tributaries, even on those fully developed for hydropower. Again, this would depend on researching a suitable design and would apply only to dams with lower heights,

such as Lower Xe Pian, Xe Katam, Xe Namnoy 1 and 6, Xe Namnoy 2–Xe Katam 1, and the dams upstream of Xe Kaman 1 in the Xe Kaman cluster.

### 7.1.3.4 Fish Conservation Zones

The Sekong Basin has a high concentration of fish conservation zones that planned hydropower reservoirs will inundate (see Map 3.2, Chapter 3). It may be possible to establish new fish conservation zones in suitable river reaches, especially free-flowing reaches. These could serve as viable important—albeit altered—ecosystems to support aquatic biodiversity and local livelihoods that depend on fisheries. The focus should be on native and endemic fish species rather than introduced species that may be invasive. Consultative approaches with active participation of local communities in managing fish conservation zones would be important to achieve conservation targets. Also vital would be monitoring and enforcement to prevent illegal fishing methods and harvesting of endangered species.

## 7.2 Terrestrial Biodiversity and Ecosystems

Impacts on terrestrial valued environmental components (VECs) have been assessed for each development pathway, with a focus on key conservation areas within the Sekong Basin and with reference to several indicator species selected on the basis of conservation status (for example, threatened or endangered), species uniqueness, habitat requirements, and importance to local communities. The methodology is described in detail in Appendix C.

Five key conservation areas within the Sekong Basin (see Map 3.3, Chapter 3) have been assessed in this CIA:

- Dong Ampham National Protected Area (NPA)
- Nam Kong National Protected Forest (NFP)
- Xe Pian National Protected Area
- Xe Sap National Protected Area
- Bolaven National Protected Forest

Forest cover, density, and quality in the Sekong Basin have declined in recent decades partly because of hydropower but also logging, mining, and conversion to agriculture.

The future impact of hydropower on key conservation areas and forests has been estimated for each of the three development pathways, ranging from an extra 3,290 hectares of additional land acquisition under the conservative development pathway to an extra 11,196 hectares under the full development pathway. Construction of the proposed Sekong 5 HPP, which features in the intermediate and full development pathways, will result in 1,567 hectares of direct impact in the Xe Sap NPA. This is significant considering its current undisturbed condition and high biodiversity.

Hydropower development can affect key conservation areas and forest directly through land acquisition (because of reservoir inundation and construction of associated infrastructure) and indirectly through fragmentation (because of the reservoir, transmission lines, and access roads). Moreover, illicit hunting and harvesting of forest resources often increases within reservoir catchments because project roads increase access by vehicles and reservoirs improve access by boat. Resettlement of villages can increase pressure on forest resources at the resettlement site.

To capture this complexity, a composite index for key conservation areas was applied to each of the three development pathways, taking the following into consideration:

- The proportion of each conservation area directly affected (percent)
- The proximity of hydropower projects to conservation areas (kilometers)
- The degree of fragmentation because of transmission lines and access roads (percent)
- The number of globally threatened species in the conservation area

According to this analysis, the cumulative impact of hydropower development on key conservation areas is already substantial for the Dong Amphan NPA and Nam Kong and Bolaven NPFs. Further hydropower development as envisaged under the full development pathway will have only a small additional cumulative impact on most conservation areas within the Sekong Basin, except for the Xe Sap NPA (Table 7.1), where the impact will rise from none (presently) to high (intermediate and full development pathways).

The forests of the Upper Sekong Basin are largely undisturbed and relatively intact. The Xe Xap NPA forms a substantial part of these forests, but the forest is relatively undisturbed outside of the NPA as well. This is a biodiversity-rich terrestrial ecosystem that provides habitats for rare flora and fauna, possibly including the critically endangered Saola (Asian unicorn), which is found only in the Annamite Mountains of Vietnam and Lao PDR.

The planned Sekong 4B and 5 hydropower projects on the Sekong River mainstream and the planned developments on the Nam Emoun tributary will affect these unique, biodiversity-rich forested areas in the Upper Sekong Basin directly because of reservoir inundation and indirectly because of habitat fragmentation, increased hunting, and unsustainable harvesting of timber and forest products.

The species threatened most from renewable energy development projects under the full development pathway (hydropower, wind, and solar) in the Sekong Basin include the Asian elephant and gibbon.

A final composite rating for terrestrial VECs (key conservation areas, habitats, and terrestrial species) indicates that the incremental cumulative impact of the full development pathway will

**Table 7.1: Cumulative Impacts on Key Conservation Areas under Full Development Pathway**

Key conservation area	Number of proposed projects	Area affected (hectares)
Dong Amphan NPA	6	625
Nam Kong NPF	2	111
Xe Xap NPA	1	1,567
Bolaven Upstream NPF	4	498

Note: NPA = National Protected Area; NPF = National Protected Forest.



be moderate and slight to moderate under the intermediate and conservative development pathways, respectively. It is likely that other stressors such as mining, plantations, transmission line and road development, hunting, and forest resource extraction will have a similar impact.

Impacts of hydropower on terrestrial biodiversity and ecosystems are closely correlated with the number of projects and the size of the project footprints. Accordingly, impacts could be reduced by opting not to develop certain projects or through design modifications that reduce reservoir sizes.

For a given development pathway, the following measures would be most effective if coordinated among power developers on a basin scale.

- Catchment management protection measures, including reforestation of already degraded forestlands, especially for Sekong 5, Nam Khong 1, Nam Emoun, and Xe Kaman 2A where forest loss is greatest
- Shared transmission lines—to cut the number of transmission lines required and so reduce disturbance of forests and fragmentation of habitats
- Biological corridors—to enable wildlife migration between key conservation areas and avoid fragmentation of important habitats
- Patrols and enforcement in conservation areas—to reduce illicit logging, hunting, and harvesting of non-timber forest products (NTFPs) in conservation areas
- Community management of protected areas—to encourage sustainable resource use by local villages
- Domestic energy supply—affordable electricity and fuel-efficient wood stoves to reduce demand for fuel wood in local communities

These measures alone are unlikely to fully mitigate the impacts of hydropower development on terrestrial biodiversity and ecosystems in the Sekong Basin under the full development pathway. In particular, construction of the Sekong 5 and 4B HPPs will affect the Xe Sap NPA and surrounding area in a way that will be challenging to mitigate. There is potential to protect terrestrial habitats and ecosystems elsewhere (inside and outside of the Sekong Basin) as a means of offsetting these impacts.

## 7.3 Natural Resource-Dependent Livelihoods

### 7.3.1 Fisheries

River fisheries are critically important for the livelihoods of much of the population of the Sekong Basin, as described in Section 3.6.5. Impacts on riparian fisheries have been assessed quantitatively as far as possible (fish catch tons per year) using information in project environmental and social impact assessment (ESIA) reports and qualitatively, relying on experiences from other hydropower development projects in Lao PDR. The loss of river fisheries because of hydropower development has been compared to the potential productivity of reservoir fisheries based on experiences elsewhere in Lao PDR.

With the construction of tributary and mainstream dams in the Sekong Basin and the migration obstruction this represents, the species composition of the river system will change. Non-migratory species that can adapt to the ecological conditions in a lake (lacustrine or lentic ecosystem) will flourish at the expense of the migratory species that depend on the ecological conditions of a flowing river (lotic ecosystem). After the establishment of a reservoir, one can normally expect a sharp increase in the population and total biomass of lacustrine fish species such as common carp (*Cyprinus carpio*) and tilapia (*Oreochromis spp.*), which are introduced aquaculture species, and hampala barb (*Hampala macrolepidota*), which is a species commonly found in Southeast Asia that can tolerate flowing river and lake conditions.

Reservoirs may thus become a source of food and income for the surrounding population. How sustainable this resource can be depends to a large degree on how it is managed and on the presence of good areas for regeneration and spawning in the reservoir. There is often an initial sharp increase in lacustrine fish populations in newly impounded reservoirs because submerged vegetation provides an abundant source of aquatic food. Fish populations level off after impoundment and stabilize at a lower level if managed properly with regulated fishing and sanctuaries for spawning.

In general, the productivity of reservoir fisheries can be anticipated to be less than the existing river fisheries because there are fewer shallow fishing

grounds and fish migration is obstructed. In river stretches downstream of dams, flow regulation leads to loss of diversity of habitats, fish species, and aquatic flora and invertebrates because deep pools tend to fill up, and riverbanks tend to be less productive.

The productivity of reservoirs varies greatly according to their depth and shape, with shallow reservoirs tending to be the most productive. Deep reservoirs act as nutrient sinks, and drawdowns in shallow reservoirs allow vegetation growth that serves as food for fish when the water rises again. To take one example, the Nam Ngum reservoir, which was completed in 1971, yielded 133 kilograms per hectare per year in 2007 (McCartney, Funge-Smith, and Kura 2018). This is well above the average of 74 kilograms per hectare per year of other reservoirs in the region (Kolding and van Zwieten 2006) probably because of the Nam Ngum reservoir’s large drawdown zones and favorable spawning area. Because of the likely depth and shape of future Sekong Basin reservoirs, they will generally have lower fish productivity. Assuming a productivity of 100 kilograms of fish per hectare per year for future reservoirs in the Sekong Basin and multiplying this by total reservoir area for the full development pathway (15,489 hectares), the result is an estimated future reservoir productivity of 1,550 tons per year, mostly associated with Sekong mainstream projects (reservoir area 12,190 hectares, fish productivity 1,219 tons per year). Comparing these figures with the estimated current fish consumption data indicates the impacts on fish productivity and consumption that can be expected with a hydropower development following the full development pathway.

Published data on fish catches and consumption in the Sekong Basin varies. Hortle (2007) combines multiple studies and arrives at an estimate of fish consumption of 17.1 kilogram per person per year for Sekong Province. The total population

of the five Sekong riparian districts (Kalum, Laman, Xaisettha, Samakkhixai, and Sanamxai) is 124,138 people, and the population of the whole Sekong Basin is estimated to be 241,670 people (Meynell 2014). Using these figures to calculate total consumption in the riparian districts and the whole basin and comparing them with reservoir productivity, one arrives at the results presented in Table 7.2.

Under the full development pathway, there is a large negative difference between reservoir productivity and fish consumption for the riparian districts and the whole Sekong River Basin. This indicates that future reservoir fisheries will be insufficient to meet present levels of fish consumption. Regulation and fragmentation of the Sekong mainstream and tributaries will significantly reduce fish catches as a source of food and earnings for the basin population. Although reservoir fisheries can make up for some of the loss of river fisheries, the total impact on food security and nutrition is likely to be negative.

Under the intermediate development pathway, impacts are slightly lower but still substantial because of blockage of fish migration in the upper reaches of the Sekong mainstream (because of Sekong 4B and 5) and full development of tributaries throughout the basin.

The conservative development pathway will keep the mainstream open for fish migration up from the Mekong and in that way maintain the potential for continued mainstream river fisheries that communities along the Sekong depend on for their livelihoods. Although new hydropower projects will affect some tributaries in the Sekong Basin under the conservative development pathway, the majority of these—including the Xe Kaman, Xe Namnoy, Nam Kong, and Xe Pian tributaries—already have commissioned dams that obstruct fish migration.

**Table 7.2: Reservoir Productivity and Calculated Fish Consumption**

Area	Population	Reservoir productivity	Calculated fish consumption	Difference
Riparian communities	124,138	1,219,000	2,122,760	- 903,760
Sekong River Basin	241,670	1,550,000	4,132,557	- 2,582,557

## 7.3.2 Agriculture

Construction and operation of multiple hydropower projects in the Sekong Basin will result in the loss of important agricultural and forest areas that local people use for their livelihoods. Reservoirs inundate agricultural land and leave areas in the catchment unavailable for community use. Downstream of hydropower projects—especially during peaking operations—rapid fluctuations in river levels can cause erosion that affects riverbank gardens in riparian villages. Dams also decrease downstream sediment loads, resulting in loss of nutrient-rich sediment deposits important for subsistent agriculture.

Loss of agricultural production has been quantified (Table 7.3) using information from ESIA reports and geographic information system mapping. Where ESIA data are not available, loss of agricultural land has been estimated to be 5 percent of reservoir area. The impact on livelihoods of losing agricultural land depends on the amount of remaining land available to villages experiencing partial land loss and provision of adequate land for villagers who are resettled.

One type of agricultural land that is of crucial importance for the livelihoods of people living along tributaries and the Sekong mainstream is riverbank gardens, where important food crops are cultivated.

**Table 7.3: Estimated Loss of Agricultural Land**

Project name	Conservative development	Intermediate development	Full development	Total agricultural land (hectares)
Nam Kong 1	X	X	X	174
Nam Bi 1	X	X	X	n.a.
Nam Bi 2	X	X	X	n.a.
Nam Bi 3	X	X	X	n.a.
Nam Ang	X	X	X	0.2
Nam Emoun	X	X	X	84
Nam Pangou	X	X	X	n.a.
Xe Pian-Houaysoy	X	X	X	n.a.
Xe Katam	X	X	X	4
Xe Kaman 2A	X	X	X	12
Xe Kaman 2B	X	X	X	43
Xe Kaman 1	X	X	X	0
Xe Namnoy 5	X	X	X	n.a.
Sekong 5		X	X	0
Sekong 4B		X	X	65
Sekong 4A			X	1,023
Sekong 3A			X	59
Sekong 3B			X	92
Sekong Downstream A			X	70
Sekong Downstream B			X	45
<b>Total</b>	<b>317</b>	<b>382</b>	<b>1,671</b>	<b>1,671.2</b>

Note: n.a. = data not available in project documentation and cannot be estimated as reservoir area is unknown. If no Xs, the plant is not part of the respective scenario.

One example is the Sekong Downstream B project, for which the ESIA reports 394 affected households, of which 312 households lose riverbank gardens. The loss of riverbank gardens will mostly affect local production of vegetables for household consumption and, to a smaller degree, income from the sale of riverbank garden produce. The effect on people's livelihoods is likely to be significant.

Agricultural land loss varies between the development pathways, ranging from less than 400 hectares under the conservative and intermediate development pathways to 1,671.2 hectares under the full development pathway; this additional impact is associated with five proposed Sekong mainstream dams that are in densely populated lowland areas.

### 7.3.3 Timber and Forest Products

The Sekong River Basin population depends greatly on harvesting forest products, particularly NTFPs, for income and consumption. In research conducted for the CGIAR Challenge Program on Food and Water (CGIAR 2014), 11 villages that hydropower projects had affected or were expected to affect (Xe Kaman 1, Xe Kaman–Sansay, Sekong 3A) were studied and surveyed. The study results indicated that more than 95 percent of the households collected NTFPs, which constitute a substantial source of carbohydrates and green leafy vegetables. NTFPs are particularly important during rice shortages that normally occur in the rainy season. Sale of NTFPs such as bamboo shoots and rattan is also an important source of cash income for women.

NTFPs are under pressure in the Sekong Basin, and the resource base has declined in recent decades. The CGIAR study reported that women in areas affected by hydropower development

are finding it increasingly difficult to collect NTFPs because of forest depletion, and as a result they have to walk further and spend more time harvesting NTFPs. District and provincial consultations in the Sekong River Basin conducted in September 2019 confirmed the same pattern of diminishing access to NTFPs.

Further hydropower development in the Sekong Basin will affect NTFP resource availability because of loss of relatively intact forest. The estimated loss of the different forest types in the present situation and under the full development pathway is shown in Table 7.4.

The greatest forest loss will occur under the full development pathway, with 11,196 hectares (about 112 square kilometers) of forested land affected, half of which is production forest, almost one-quarter is conservation forest (including areas of the Xe Sap and Dong Amphan NPAs), and the remainder is predominantly regeneration and protection forest (Table 7.5). Forest resources will be moderately affected under the intermediate development pathway and slightly affected under the conservative development pathway.

For communities, different categories of forest have different livelihood uses. Fallow swidden fields can be a rich source of NTFPs and bamboo. Production forest (forest designated for future commercial timber extraction) is also a source of NTFPs, construction timber, and fuel wood for communities.

The largest contributor to forest loss of proposed HPPs is Sekong 4A, which will affect 4,699 hectares (about 47 square kilometers) of forest largely classified as production forest (Table 7.5). The second-largest area of forest loss is associated with Sekong 5, with 1,981 hectares (20 square kilometers) of forest loss, mainly within the Xe Sap NPA.

**Table 7.4: Summary of Forest Loss for Each Development Pathway**

Development pathway	Production forest	Conservation forest and natural protected area	Protection forest	Regeneration forest	Total forest loss
Hectares					
Full	5,843	2,324	860	1,743	11,196
Intermediate	651	2,192	500	1,928	5,271
Conservative	651	625	86	1,928	3,290



**Table 7.5: Area of Forest Impacted by Existing and Proposed Hydropower Projects**

Project Name	Conservative development	Intermediate development	Full development	Production forest (ha)	Conservation forest and natural protected area (ha)	Protection forest (ha)	Regeneration forest (ha)	Total forest (ha)
Nam Kong 1	X	X	X	293	0	0	1,481	1,774
Nam Bi 1	X	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Nam Bi 2	X	X	X	54	48	0	51	153
Nam Bi	X	X	X	0	29	0	0	29
Nam Ang	X	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Nam Emoun	X	X	X	137	0	0	289	426
Xe Pian-Houaysoy	X	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Xe Katam	X	X	X	16	0	16	0	32
Xe Kaman 2A	X	X	X	148	548	0	104	800
Xe Kaman 2B	X	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Xe Kaman 4	X	X	X	3	0	70	3	76
Xe Namnoy 5	X	X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Sekong 5		X	X	0	1,567	414	0	1,981
Sekong 4B		X	X	n.a.	n.a.	n.a.	n.a.	n.a.
Sekong 4A			X	4,473	51	71	104	4,699
Sekong 3A			X	356	23	188		567
Sekong 3B			X		58			58
Sekong Downstream A			X	0	0	101	0	101
Sekong Downstream B			X	500	0	0	0	500
<b>Total</b>				<b>5,980</b>	<b>2,324</b>	<b>860</b>	<b>2,032</b>	<b>11,196</b>

Note: ha = hectare; n.a. = data not available; If no Xs, the plant is not part of the respective scenario.

Hydropower development is only one cause of forest loss and thereby of diminishing timber and NTFP resources in the Sekong River Basin. Logging and conversion of forest to agriculture and for timber plantations also play significant roles. If proposed mining concessions in the basin are approved, large areas of forest will be affected.

### 7-3-4 Mitigation Options

The impacts of hydropower on natural resource-dependent livelihoods are closely correlated with the number of projects and size of project

footprints. Accordingly, impacts could be reduced by opting not to develop certain projects or through design modifications that reduce reservoir sizes. In the context of a given development pathway, the following measures would be most effective if coordinated among power developers on a basin scale.

- *Reservoir fisheries*: support community-managed capture and farmed fisheries in reservoirs, with exclusive focus on native species
- *Replacement agricultural land*: ensure adequate land for affected communities for agriculture and harvesting of NTFPs

- *Boost productivity*: capacity building (farmer training), infrastructure (for example, irrigation and roads), and access to finance (saving and loans) to increase productivity and access to markets
- *Alternative livelihoods*: support of off-farm income-generating activities to supplement agriculture and harvesting of forest products
- *Community forest management*: to promote sustainable use of fuel wood, timber, and NTFPs
- *Domestic energy supply*: affordable electricity and fuel-efficient wood stoves to reduce demand for fuel wood

Industry experience is that impacts of hydropower development on local livelihoods are difficult to fully mitigate. Even well-resourced HPPs in Lao PDR have struggled to meet livelihood restoration targets for resettled communities. Considering the intensity of hydropower development being planned for the Sekong Basin, the impact on livelihoods can be expected to be significant. This is especially true for the full development pathway but also for the intermediate development pathway; both include construction of Sekong 4A, which will affect approximately 47 square kilometers of forest and 10 square kilometers of agricultural land.

## 7.4 Community and Culture

### 7.4.1 Resettlement

Hydropower projects often necessitate resettlement of villages from within the project footprint to make way for the reservoir, dam, and powerhouse. Resettlement may also be required for project access roads, electricity transmission lines, and watershed management plans. Even where resettlement does not occur, villages may experience partial loss of community forest, agricultural land, and housing, with impacts on livelihoods.

Riparian communities immediately downstream from dams may need to be resettled for community health and safety reasons. For example, if water released from a dam has a strong odor that affects community well-being, or dam discharge causes rapid fluctuations in the river level that pose a hazard for fishers and other river users, riverside communities may be resettled. Flood risks from extreme weather and other events causing uncontrolled releases or dam breaches must also be assessed, which may lead

to a decision to resettle communities away from the danger zone. Communities situated below a cascade of dams may be particularly vulnerable. Even if resettlement is not required, emergency preparedness plans need to be put in place.

Project-induced resettlement generally involves relocating villages to new purpose-built village settlements. This has the potential to significantly affect social cohesion and cultural integrity because it breaks traditional ties to land and place and disrupts social structures. Resettlement sites tend to be close to main roads and large towns, which can accelerate cultural integration of ethnic groups into the dominant Lao culture, which affects ethnic minority languages, customs, beliefs, and social norms. Such factors are typically considered as part of the EIA for individual projects, resulting in project-specific resettlement and social development plans designed not only to mitigate impacts but also to enhance social outcomes. The efficacy of such measures is project specific, but some residual unmitigated impacts can generally be expected. Cumulatively, development of hydropower in the Sekong Basin will amplify the effects of individual projects.

Existing hydropower development in the Sekong Basin has resulted in substantial resettlement, mostly within the past decade. At least 13,800 people have been resettled because of seven completed hydropower projects (69 percent from one project: the Xe Pian–Xe Namnoy HPP). Data are not available for five projects, so the true total is likely to be higher.

The full development pathway will lead to resettlement of an additional 12,600 people, and because data for some projects are not available, the total may be higher. Almost half of the total resettlement required for the full development pathway is associated with two Sekong mainstream projects: Downstream A and B (about 5,000 people displaced). These two projects also have the highest ratio of resettled people to gigawatt-hours of power generation (7:1 and 11:1, respectively). In comparison, the Sekong 5 HPP, which has the largest reservoir, displaces less than one person per megawatt.

By contrast, the intermediate development pathway will require resettlement of approximately 3,700 people and the conservative development pathway approximately 2,500 people. These development pathways have lower resettlement impacts because they omit some or all planned mainstream Sekong River dams, particularly in the lower reaches, where population density is higher.

In summary, the full development pathway will require the greatest resettlement, the intermediate pathway will require moderate resettlement, and

the conservative pathway will require a small amount of resettlement (Tables 7.6 and 7.7).

**Table 7.6: Resettled Persons per Unit of Power Generation**

Pathway	Installed capacity (MW)	Reservoir area (km <sup>2</sup> )	Resettled persons	Resettled persons per annual GWh
Present situation	1,554	147	13,844	2.2
Conservative development	2,470	257	16,330	1.7
Intermediate development	2,975	303	17,578	1.5
Full development	3,512	379	26,499	1.9

Note: MW = megawatt; km<sup>2</sup> = square kilometer; GWh = gigawatt-hour.

**Table 7.7: Project-Induced Resettlement in Each Development Pathway**

Project Name	Present situation	Conservative development	Intermediate development	Full development	Installed capacity (MW)	Reservoir area (km <sup>2</sup> )	Resettled persons	Resettled persons/annual GWh
A Luoi	X	X	X	X	170	8	872	1.3
Houay Ho	X	X	X	X	152	37	1,920	4.3
Xe Kaman 3	X	X	X	X	250	9	0	0
Xe Namnoy 6	X	X	X	X	5	n.a.	n.a.	n.a.
Xe Namnoy 1	X	X	X	X	15	0	n.a.	n.a.
Houay Lamphan Gnai	X	X	X	X	88	7	1,398	3.1
Xe Kaman 1	X	X	X	X	290	n.a.	n.a.	n.a.
Xe Kaman–Sanxay	X	X	X	X	32	1	n.a.	n.a.
Nam Kong 2	X	X	X	X	66	4	0	0
Xe Katam 1 Xe Namnoy 2	X	X	X	X	22	0	92	0.3
Xe Pian Xe Namnoy	X	X	X	X	410	49	9,458	5.3
Nam Kong 3	X	X	X	X	54	32	104	0.5
Dakchaliou 1		X	X	X	11	0	n.a.	n.a.
Dakchaliou 2		X	X	X	13	0	n.a.	n.a.
Nam Kong 1		X	X	X	150	22	1,612	2.9
Nam Bi 1		X	X	X	68	n.a.	n.a.	n.a.
Nam Bi 2		X	X	X	50	n.a.	n.a.	n.a.
Nam Bi 3		X	X	X	12	n.a.	n.a.	n.a.
Nam Ang		X	X	X	55	0	n.a.	n.a.
Nam Emoun		X	X	X	129	n.a.	n.a.	n.a.
Nam Pangou		X	X	X	33	n.a.	n.a.	n.a.

Xe Pian–Houysoy		X	X	X	45	n.a.	n.a.	n.a.
Lower Xe Pian		X	X	X	15	0	n.a.	n.a.
Xe Katam		X	X	X	81	0	n.a.	n.a.
Xe Kaman 2A		X	X	X	64	82	342	0.3
Xe Kaman 2B		X	X	X	100	1	98	0.3
Xe Kaman 4		X	X	X	70	5	342	1.2
Xe Namnoy 5		X	X	X	20	0	92	1
Sekong 5			X	X	330	33	440	0.3
Sekong 4B			X	X	175	13	808	1.1
Sekong 4A				X	165	23	2,494	3.2
Sekong 3A				X	114	12	1,080	2.3
Sekong 3B				X	122	18	240	0.6
Sekong Downstream A				X	86	14	2,764	7.3
Sekong Downstream B				X	50	9	2,343	11.2
<b>Total</b>					<b>3,512</b>	<b>379</b>	<b>26,499</b>	<b>1.9</b>
<b>Average</b>					<b>100</b>	<b>14</b>	<b>1,325</b>	<b>2.3</b>

Note: MW = megawatt; km<sup>2</sup> = square kilometer; GWh = gigawatt-hour; n.a. = data not available; If no Xs, the plant is not part of the respective scenario.

## 7.4.2 Ethnic Customs and Language and Religious Beliefs

Renewable energy development is likely to affect traditional customs, languages, belief systems, and other cultural elements associated with ethnic groups in the Sekong Basin (see Section 3.6.1) through diverse and diffuse processes. Based on stakeholder consultations for this study and experiences of recent hydropower projects in other parts of Lao PDR, the impacts are likely to be positive, negative, and sometimes mixed.

- During construction and operation of hydropower projects, there will be interactions between locals and non-locals attached to the project (workers, camp followers, and economic migrants), resulting in exchanges of knowledge and experience that may enhance or erode traditional values.
- It is common for hydropower projects to resettle ethnic groups living in homogenous communities into heterogeneous communities. This can be expected to accelerate ongoing integration and assimilation of smaller ethnic

groups into mainstream lowland culture. There is a potential for loss of tradition but also a chance to benefit from new ideas and practices.

- Social development programs that hydropower projects sponsor as part of resettlement plans typically aim to improve education and health services for local communities. They can therefore help raise the socio-economic situation of ethnic groups previously lacking access to public services, utilities, and markets. Social development programs typically benefit girls and women and thus may narrow the gender gap that is common in Mon-Khmer communities.
- Employment and other economic growth associated with project development may provide new opportunities for women, leading to a more equal role in household decision making.

Impacts on ethnicity and culture are required to be assessed as part of EIAs for individual projects and mitigated through social development plans or ethnic minority development plans.

The effectiveness of these plans varies by project, but residual unmitigated impacts can be expected. Hydropower development in the Sekong Basin overall will amplify the effects of individual projects.

Hydropower development in the Sekong Basin will particularly affect communities belonging to the Mon-Khmer ethnolinguistic family (see

Section 3.6.1) because most project sites are located in the upper watershed near Mon-Khmer villages (Map 7.1). Impacts on Mon-Khmer communities in terms of resettlement (both positive and negative) and economic integration (probably positive overall) are assessed as substantial and similar under all three pathways because all three include intense development of tributaries where Mon-Khmer people live.

**Map 7.1: Distribution of Ethnic Groups and Hydropower Projects in the Sekong Basin**





Under the full development pathway, construction of the Sekong mainstream cascade will result in substantial resettlement of ethnic Lao communities in the lowlands. Notwithstanding the challenges associated with resettlement, relocation will probably not significantly affect customs and traditional beliefs for these communities because they are already a part of the mainstream society and economy.

### 7.4.3 Gender

Cumulative effects of renewable energy development on gender have been evaluated with reference to gender assessments in ESIA reports (where available) and results of local government and village consultations.

Changes in gender roles in Lao PDR have been positively influenced by increased access to education, socio-economic development, and efforts of authorities and organizations to make gender relations more equitable. In this context, renewable energy development that offers employment and economic growth may provide opportunities for women, leading to a more equal role in household decision making. Social development programs that hydropower projects sponsor as part of village resettlement typically result in better education and health services for communities. It is likely that this will benefit girls and women, narrowing the gender gap that is common in Mon-Khmer communities. Power projects typically support the expansion of rural electricity networks to project-affected communities. Access to electricity in the home can help reduce some labor-intensive tasks (cooking, milling, and washing) that are performed mainly by women and girls. Conversely, renewable energy projects in rural areas may increase the risk of sexual or domestic violence for women and girls, especially if project construction draws in large numbers of migrant workers and camp followers. Nevertheless, the cumulative impact of hydropower development on gender equality is likely to be positive overall.

### 7.4.4 Mitigation Options

The impacts of hydropower on the aspects of community and culture reviewed are closely correlated with the number of projects and the size of project footprints. Accordingly, impacts could be reduced by opting not to develop certain projects or through design modifications that reduce reservoir sizes. In the context of a given development pathway, the following measures, which specific projects could apply, would be most effective if coordinated among power developers on a basin scale.

- Assess potential resettlement sites within the Sekong Basin—considering the need for land for housing, agriculture, and access to natural resources—to identify a maximum threshold for resettlement.
- Maintain community cohesion during resettlement—keep resettled villagers together; avoid combining different ethnic groups without consultation and consent.
- Establish funding arrangements and mechanisms to support cultural events and activities as part of resettlement and social developments plans.
- Integrate gender considerations into all resettlement and social development plans.

## 7.5 Summary of Impacts and Mitigation Measures for All Pathways

Tables 7.8, 7.9, and 7.10 summarize the impacts and mitigation measures for all three development pathways.

**Table 7.8: Full Development Pathway**

VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
<b>Aquatic habitats and biodiversity</b>				
Aquatic fauna and fish populations (flow regime change)	Decrease in floodplain connectivity because of reduction in high flows in wet season	Large	<p>Joint and coordinated EFlows especially for Sekong mainstream dams to trigger fish migration</p> <p>Joint coordinated flushing and sluicing of four lowermost Sekong mainstream dams to maintain floodplain geomorphology and aquatic habitats</p>	Creation of reservoirs will change the ecosystem structure from lotic to lentic. Flushing and sluicing will be only partially effective, so floodplain geomorphology and aquatic habitat structure will still change.
Habitat fragmentation and fish connectivity	Physical blockage of river by dams and changes in the aquatic habitat, especially under the full development pathway because of seven Sekong mainstream dams	Large	<p>Fish passages, especially on four lowermost mainstream dams if feasible</p> <p>For tributary and mainstream dams, research on the effectiveness, costs, and benefits of different types of fish passages (fish ladders, fish lifts, natural bypasses for dams up to 40 meters high, and truck and transport for higher dams)</p>	Fish passages are not 100 percent effective, so migration is still partially obstructed. Creation of reservoirs will affect upstream and downstream migration triggers.
<b>Terrestrial habitats and biodiversity</b>				
Key conservation areas	Inundation by reservoirs and habitat fragmentation by ancillary infrastructure (e.g., transmission lines and roads)	Moderate	Creation of biodiversity offsets for inundated areas (2,324 hectares) <sup>a</sup> and land taken for ancillary infrastructure to ensure no net loss in biodiversity if feasible (and net gain if possible)	Biodiversity offsets may not be able to replicate original conditions of lost conservation areas.
Terrestrial species	Habitat inundation by reservoirs and obstruction of migration routes	Moderate	Creation of biodiversity offsets and ensuring biological corridors for wildlife migrations	Biodiversity offsets may not be able to replicate original conditions of lost conservation areas.
<b>Natural resource-dependent livelihoods</b>				
Fisheries	Decrease in fish populations and species composition, especially along the Sekong mainstream	Severe	Community-managed reservoir fisheries programs and fish cage cultures (native species)	Reservoir fisheries are unlikely to match the productivity of unregulated rivers, so total availability of fish for consumption will decrease.
Agriculture	Loss of riverbank gardens and agricultural lands (1,670 hectares), especially along the Sekong mainstream <sup>b</sup>	Large	Development of replacement agricultural land with equivalent productivity	Forests near resettlement villages will decline because of conversion to agricultural land.

<sup>a</sup> Sekong 5 and Xekaman 2A account for more than 90 percent of this loss, at 2,115 hectares (1,567 and 548 hectares, respectively).

<sup>b</sup> Sekong 4A constitutes more than 60 percent of this loss (1,023 hectares).

VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
Forest and NTFP	Inundation of forests (11,196 hectares <sup>c</sup> ) containing NTFPs	Moderate	Catchment management protection measures, including reforestation of already degraded forestlands; biggest losses from Sekong 5, Nam Khong 1, Nam Emoun, and Xe Kaman 2A	Reforestation is challenging and unlikely to be effective in replacing lost conservation and protection forests.
Physical displacement and resettlement	11,498 people resettled, <sup>d</sup> especially in relation to Sekong mainstream dams	Large	Basin-wide strategy for resettlement identifying suitable areas for agriculture and housing	Livelihood restoration targets will be difficult to meet because of lack of resettlement sites with sufficient land for agriculture and forest-dependent livelihoods.
<b>Culture and heritage</b>				
Ethnic customs and language, religious beliefs	Positive and negative impacts because of resettlement of villages	Moderate	Maintain community cohesion during village resettlement  Support ethnic minority communities to maintain cultural identity through social development plans	There will be physical stress and impacts on resettled people in relation to loss of their original land.
Gender	Potential positive changes in gender roles because of socio-economic development, but some gender-related risks that have not been well studied	Slight	Community development planning that specifically addresses gender, including gender awareness training to mitigate harms and enhance benefits  Gender disaggregated monitoring of resettled communities	Potential for gender-based violence, trafficking and exploitation.

<sup>c</sup> Sekong 4A, with total loss of 4,331 hectares of forest land, accounts for close to 40 percent of the loss, with 4,231 hectares being production forest. Sekong 5 stands at 1,981 hectares of total forest loss, with 1,567 hectares being conservation forest and 414 hectares of production forest.

<sup>d</sup> Sekong Downstream A and B constitute close to 45 percent of total, with more than 5,100 people resettled.

**Table 7.9: Intermediate Development Pathway**

VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
<b>Aquatic habitats and biodiversity</b>				
Aquatic fauna and fish populations (flow regime change)	Some decrease in floodplain connectivity because of reduction in high flows in wet season from development of only the two upper mainstream dams (Sekong 4B and 5)	Slight to moderate	After initial EFlow assessment, joint and coordinated EFlow releases especially for Sekong 4B and 5 to trigger migration; joint coordinated flushing and sluicing in smaller reservoirs in tributaries, where relevant, <sup>a</sup> to maintain river geomorphology and aquatic habitats	Creation of reservoirs will change the ecosystem structure from lotic to lentic. Flushing and sluicing will be only partially effective, so floodplain geomorphology and aquatic habitat structure will still change.
Habitat fragmentation and fish connectivity	Physical blockage of river by dams and changes in aquatic habitat	Moderate	Consider incorporation and design of fish passages along migration routes in tributary dams not higher than 40 meters (Lower Xe Pian, Xe Katam, Xe Namnoy 1 and 6, Xe Namnoy 2–Xe Katam 1, and dams upstream of Xe Kaman 1 in the Xe Kaman cluster); truck and transport for larger dams (Sekong 4B and 5) on mainstream and larger tributary dams; research effectiveness of above	Creation of Sekong 4B and 5 reservoirs will affect upstream and downstream migration in Upper Sekong.
<b>Terrestrial habitats and biodiversity</b>				
Key conservation areas	Inundation by reservoir and habitat fragmentation by ancillary infrastructure (e.g., transmission lines and roads); for this pathway, relates mainly to Sekong 5 inundation of the Xe Xap NPA	Slight to moderate	Creation of biodiversity offsets for inundated areas and land taken for ancillary infrastructure, especially for Sekong 5 (will inundate 1,567 hectares of the Xe Xap NPA)	Biodiversity offsets will not necessarily reflect original conditions of lost conservation areas, but purpose is to achieve no net loss in biodiversity if feasible (and net gain if possible).
Terrestrial species	Habitat inundation and obstruction of migration routes	Slight to moderate	Creation of biodiversity offsets and ensuring biological corridors for wildlife migration, especially for Sekong 5 ancillary infrastructure (e.g., transmission lines, roads)	Biodiversity offsets will not necessarily reflect original conditions of lost conservation areas, but purpose is to achieve no net loss in biodiversity if feasible (and net gain if possible).
<b>Natural resource–dependent livelihoods</b>				
Fisheries	Decrease in fish production and thus catches, as well as species composition, in Upper Sekong because of Sekong 4B and 5	Moderate to large	Enable reservoir fisheries programs and fish cage cultures (native species) in Sekong 4B and 5 reservoirs and relevant tributary reservoirs	Reservoir fisheries are unlikely to match the productivity of unregulated rivers, so availability of fish for consumption will decrease, especially in Upper Sekong mainstream, because of Sekong 4B and 5.

<sup>a</sup> In Bolaven, flushing and sluicing should be considered in the planned Xe Katam hydropower plant (HPP) if it is possible to redesign the already commissioned Xe Namnoy 1 and 6 and Xe Namnoy 2–Xe Katam 1. Flushing and sluicing are also relevant for the Lower Xe Pian HPP. Flushing and sluicing of Nam Kong 2 and 3 are not relevant because of the large Nam Kong 1 downstream already under construction. In the Xe Kaman cluster, the larger Xe Kaman 1 (and the smaller Xe Kaman–Sanxay) has been commissioned where flushing and sluicing are not feasible, but flushing and sluicing are feasible for the Xe Kaman 2A, 2B, and 4 cascade, albeit only with local and tributary sediment transport effects.

VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
Agriculture	Loss of riverbank gardens and agricultural lands (about 387 hectares), especially with Sekong 4B (65 hectares), Nam Kong 1 (174 hectares), Nam Emoun (84 hectares), and Xe Kaman 2A (43 hectares)	Slight to moderate	Development of new agricultural land, especially with Sekong 4B, but also planned tributary dams	Forests will decline because of conversion of agricultural land, although there will be less pressure on this along the Lower Sekong mainstream.
Forest and NTFP	Inundation of forest land (5,271 hectares total) including those with valuable NTFPs, especially along Sekong 5 (1,981 hectares)	Slight to moderate	Catchment management protection measures, including reforestation of already degraded forestlands, especially for Sekong 5, Nam Khong 1, Nam Emoun, and Xe Kaman 2A	Reforestation will not be fully effective, especially for lost conservation and protection forests.
Physical displacement and resettlement	Loss of settlements (3,300 people resettled) in inundated areas, with tributary dams constituting two-thirds of this and Sekong 4B and 5 constituting one-third	Moderate	Basin-wide guidelines for implementation of coordinated clearance of land for agriculture and building houses for resettled people to reduce residual cumulative impacts	There will be physical stress and impacts on resettled people in relation to loss of their original land.
<b>Culture and heritage</b>				
Ethnic customs, language, and religious beliefs	Different impacts on different ethnic groups because of development of only Sekong 4B and 5	Slight	Ensure ethnic groups are resettled to the same areas or villages; funding to support cultural events and activities as part of resettlement planning	There will be physical stress and impacts on resettled people in relation to loss of their original land.
Gender	Positive and negative impacts on gender because of exposure of ethnic minorities to mainstream society following resettlement	Slight	Community development planning that specifically addresses gender, including gender awareness training to mitigate harms and enhance benefits	Traditional gender customs will be lost (positive and negative).

Note: NPA = National Protected Area; NTFP = non-timber forest product.



**Table 7.10: Conservative Development Pathway**

VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
<b>Aquatic habitats and biodiversity</b>				
Aquatic fauna and fish populations (flow regime change)	Minor changes from present situation	Slight	After initial EFlow assessment, joint and coordinated EFlow releases in tributaries and joint coordinated flushing and sluicing in smaller reservoirs in tributaries, where relevant, <sup>a</sup> to maintain river geomorphology and aquatic habitats in tributary sections	Creation of reservoirs will change the ecosystem structure from lotic to lentic. Flushing and sluicing will be only partially effective, so floodplain geomorphology and aquatic habitat structure will still change in tributaries with new HPP development.
Habitat fragmentation and fish connectivity	Minor changes from present situation; tributary systems already partially developed	Slight	Consider incorporation and design of fish passages along migration routes in tributary dams not higher than 40 meters (Lower Xe Pian, Xe Katam, Xe Namnoy 1 and 6, Xe Namnoy 2–Xe Katam 1 and dams upstream of Xe Kaman 1 in the Xe Kaman cluster); truck and transport for larger tributary dams; research on effectiveness of above	There will be minor residual impacts on fragmentation and fish connectivity only in tributary systems with more local migration because the Sekong mainstream will remain free flowing.
<b>Terrestrial habitats and biodiversity</b>				
Key conservation areas	Inundation by reservoir and habitat fragmentation by ancillary infrastructure (e.g., transmission lines and roads) confined to new developments in tributaries	Slight to moderate	Creation of biodiversity offsets for inundated areas (651 hectares) and land taken for ancillary infrastructure in tributaries	Biodiversity offsets will not necessarily reflect original conditions of lost conservation areas, but purpose is to achieve no net loss in biodiversity if feasible (and net gain if possible).
Terrestrial species	Habitat inundation and obstruction of migration routes confined to new developments in tributaries	Slight to moderate	Creation of biodiversity offsets and ensuring biological corridors for wildlife migrations in tributaries with new development	Biodiversity offsets will not necessarily reflect original conditions of lost conservation areas, but purpose is to achieve no net loss in biodiversity if feasible (and net gain if possible).
<b>Natural resource–dependent livelihoods</b>				
Fisheries	Moderate decrease in fish production and thus catches—mostly tributary fisheries—because the Sekong mainstream remains free flowing	Moderate	Enable reservoir fisheries programs and fish cage cultures (native species) in relevant tributary reservoirs	Tributary reservoir fisheries are unlikely to match the productivity of unregulated conditions, so availability of fish for consumption will decrease moderately.

<sup>a</sup> In Bolaven, flushing and sluicing should be considered in the planned Xe Katam hydropower plant (HPP) if it is possible to redesign the already commissioned Xe Namnoy 1 and 6 and Xe Namnoy 2–Xe Katam 1. Flushing and sluicing are also relevant for the Lower Xe Pian HPP. Flushing and sluicing of Nam Kong 2 and 3 are not relevant because of the large Nam Kong 1 downstream already under construction. In the Xe Kaman cluster, the larger Xe Kaman 1 (and the smaller Xe Kaman–Sanxay) has been commissioned where flushing and sluicing are not feasible, but flushing and sluicing are feasible for the Xe Kaman 2A, 2B, and 4 cascade, albeit only with local and tributary sediment transport effects.

Agriculture	Loss of riverbank gardens and agricultural lands (about 322 hectares) for new development in tributaries, especially Nam Kong 1 (174 hectares), Nam Emoun (84 hectares), and Xe Kaman 2A (43 hectares)	Slight	Development of new agricultural land	Forests will decline because of conversion of agricultural land, although there will be less pressure along the Sekong mainstream.
VEC category	Main impacts	Size of impact	Mitigation measures	Residual impacts
Forest and NTFP	Inundation of forest land (3,290 hectares), including that with valuable NTFPs solely in new development in tributaries	Slight	Reforestation of already degraded forestlands; catchment management protection measures; biggest losses on Nam Kong 1, Nam Emoun, and Xe Kaman 2A	Reforestation will not be fully effective, especially for lost conservation and protection forests.
Physical displacement and resettlement	Loss of households and people resettled in inundated areas (total about 2,200), with Nam Kong 1 and Nam Emoun constituting most (1,612 and 492 people resettled, respectively)	Slight	Basin-wide guidelines for implementation of coordinated clearance of land for agriculture and building houses for resettled people in tributaries to reduce residual cumulative impacts	There will be physical stress and impacts on resettled people in relation to loss of their original land.
Culture and heritage				
Ethnic customs, language, and religious beliefs	Resettlement affects different ethnic groups	Slight	Resettle ethnic groups to the same areas or villages; funding to support cultural events and activities as part of resettlement planning	There will be physical stress and impacts on resettled people in relation to loss of their original land.
Gender	Harms and benefits according to gender because of exposure of ethnic minorities to mainstream society following resettlement	Slight	Community development planning that specifically addresses gender, including gender awareness training to mitigate harms and enhance benefits	There will be loss of traditional gender customs (positive and negative).

Note: HPP = hydropower plant; NTFP = non-timber forest product.