ENVIRONMENTAL STUDY OF THE LANCANG-MEKONG DEVLOPMENT PLAN

Baseline Assessment

Photo: Petro Kotze (ICEM)

1. APPROACH

This brief outlines the baseline assessment of the ES of the LMPD and Pak Beng HPP. The baseline phase established the trends for the key themes of the ES. This involved trend analysis based on existing data and information, and field assessment at target river-reaches. The integrated assessment identified critical habitats for threatened and endangered (Red List species), important wetlands and potential protected areas.

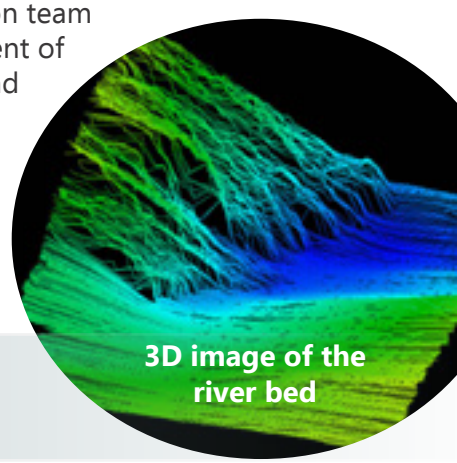
Biodiversity trend analysis:
The biodiversity team used the template shown in Table 1 (page 2) as a guide to complete the initial baseline and trends analysis. The baseline assessment was completed following further consultation with stakeholders, after the rapid integrated field survey was conducted in March 2017.

Socio-economic assessment:
The team also conducted an initial analysis assessment of the socio-economic activities along the river, including:

- Local and regional economic activities such as hydropower, agriculture, sawmills and existing trade and transport;
- Location of existing ports, landing facilities and waterway routes;
- Poverty and livelihoods analysis of local communities;
- Indigenous peoples living in the target reaches; and
- Wildlife trafficking in the study area.

'From space' assessment: Google Earth and satellite image analysis were used to show for the first time locations of rapids, shoals, deep pools, in-stream wetlands and other important natural features in addition to dangerous areas for navigation (see figure 1, page 5). GIS spatial planning was then used to build maps showing and overlaying spatial dimensions of the key environmental and socio-economic issues. Stakeholders had the opportunity to review the baseline and identify critical issues to be considered in the impact assessment.

'Swim Under' assessment: Existing hydrographic surveys were used to identify the critical habitats for fish and aquatic species. This information was used by the navigation team to determine the extent of rapid/reef blasting and dredging required to allow passage of 500DWT vessels through target reaches of the river.



3D image of the river bed

Table 1: Baseline assessment template

1.	**Description of species and status**
Describe the species and status of: • Endemic species • Endangered species (Red List) • Species of regional significance • Migratory species	
2.	**Description of aquatic habitats and status by river section**
Describe: • Unique and critical habitats • Alternative natural habitats in tributaries, and • Expand on defining the aquatic and terrestrial habits identified in Google Earth/Base Maps relevant to the key themes	
3.	**Review of existing studies, issues and information gaps for the key themes**
• Provide desktop review of existing studies, data and information identified in the Scoping Report • Gap analysis for effective management and conservation	
4.	**Trend analysis and drivers of change (see trends analysis template as a guide)**
• Baseline trend analysis (i.e. last 10 years) • Trends in species population and distribution in the study area • Trends in habitat • Describe drivers of change relevant to the key themes • If possible, project the trends forward and make assumptions on future drivers of change explicit (the baseline projection is without the navigation and Pak Beng HPP developments)	
5.	**Additional information from field work**
• Integrate findings from additional field work in target river reaches into baseline assessment	
6.	**Definition of sustainability objectives and impact assessment parameters**
• Define sustainability objectives for each theme • Define of key parameters in each theme for the impact assessment against the sustainability objectives (the parameters will be extracted from those identified for the trend analysis)	

2. RESULTS

1.2.1 Hydrology and sediment

The hydrological characteristics of the reach are described under five key themes:

1. **Annual flow volumes:** Analysis of the annual flow volumes at Chiang Saen and Luang Prabang reveal little long-term change in flow volumes despite annual and decadal fluctuations. A large volume of water joins the Mekong along the study reach - annual flow volumes at Luang Prabang average around 40,000[3] Mm higher than that at Chiang Saen, and the difference has reached as high as 95,000Mm[3] ;

2. **Annual flood pulse** (seasonal hydrology): The seasonal hydrology of the Mekong Basin is largely shaped by the combination of two monsoon regimes resulting in a monomodal flood pulse from July to September. Water levels recorded at Chiang Saen fluctuate by up to 10 m between mid-April and mid-August, and at Luang Prabang, the seasonal changes in water levels can exceed 15 m. Despite these major fluctuations, the study reach is in the upper section of the Lower Mekong Basin, above many of the large left bank tributaries, and its flood pulse is far less pronounced than further downstream;

3. **Extreme floods:** Extreme floods are a regular occurrence in the Mekong River. Analysis of Annual Recurrence Intervals (ARI) in the study reach indicate that floods are of greater magnitude at the lower end due to the numerous tributary confluences. For example, the 2-year ARI peak discharge at Chiang Saen is 10,130m^3/s, and 14,950m^3/s at Luang Prabang;

4. **Floodplain connectivity:** With the available datasets, particularly the lack of cross-sections, the study team were not able to estimate bankful discharge, an important indicator of the connectivity of the river to its floodplain, although other studies have suggested that it is a rare event in the study reach; and

5. **Influence of the upper Mekong Basin:** The study reach is located at the top end of the Lower Mekong, approximately 250km downstream of the Chinese Border and its hydrology is still heavily influenced by the Upper Mekong catchments. At Chiang Saen the Upper Mekong catchments contribute 70% of wet season and almost all the dry season flow.

Sediment transport status and current trends:

Sediment transport through a river reach is influenced by sediment supply (from upstream or within the study reach) and sediment transport capacity. There have been numerous sediment transport studies conducted for the Mekong River, but few focussed specifically on the study reach. Sediment transport characteristics of the study reach are described under four key themes:

1. **Sediment supply - upstream catchment:** For the study reach, the upper basin is the main source of sediment supply. Due to the high rate of erosion in the upper catchments, the average suspended sediment load at Chiang Saen (pre-construction of the Manwan Dam) has been estimated at 81.7 million tonnes a year, compared to 76.8 million tonnes a year at Luang Prabang. These volumes also show that the reach acts as a sediment sink.

2. **Sediment supply - tributaries confluence:** The supply of sediment from tributaries within the study reach could not be quantified as no literature could be found and the study team could not obtain sediment or hydrological data for the tributaries. The study team therefore took a qualitative approach using satellite imagery to identify which tributaries are likely to be supplying large amounts of sediment. Two tributaries were identified as likely to be supplying large amounts of sediment as they have large catchments with large areas of agriculture and/or mining, and sediment deposits visible in the lower tributary – Nam Ou and Nam Ngeun. Five tributaries were identified as likely to be supplying moderate amounts of sediment to the mainstream.

3. **Sediment supply - bank erosion:** Literature and analysis of satellite imagery showed that there is limited bank erosion in the study reach. Therefore, whilst bank erosion occurs within the study reach, its contribution to sediment supply is likely to be limited compared to upstream catchments and tributaries.

4. **Sediment transport capacity:** Sediment transport capacity is the capacity of the river to move sediments along the channel, and is a function of flow velocity, channel cross-sectional area, channel slope and sediment grain-size distribution. For the study reach, the suspended load is comprised of silt and clay washload as well as graded coarse sand, and bedload is dominated by sand and gravel.

Key drivers of change in hydrology and sediment transport

There are several drivers of change to the hydrology and sediment transport of the study reach. The drivers are categorized under four key themes:

1. Upper Mekong dams: Construction of the Manwan and Dachaoshan Dams (1992 and 2003) had minimal impact in the study reach due to their relatively small size. Since 2009 when the storage size of the constructed dams has increased significantly, there has been a decrease in dry season flows and increase in wet season flows in the study reach. The influence of the Upper Mekong dams lessens moving downstream through the study reach.

2. Land clearing and deforestation: At present, the large-scale land clearing and deforestation in the upper Mekong catchment appears to have had minimal impact on the river's hydrology. However, the 22% decrease in forest cover between 1960s and 2000s has significantly increased suspended sediment loads.

3. Embankment developments: Analysis of satellite imagery shows that numerous embankments have been built within the study reach, particularly on the Thai banks. These embankments may decrease erosion on the bank where the embankment is constructed but field observations suggest they cause erosion on the opposite bank and further downstream.

4. Climate change: Climate change is projected to increase rainfall across the Mekong Basin, leading to increased annual flows in the Mekong mainstream. At Chiang Saen and Luang Prabang the flow is projected to increase throughout the year, with the greatest increases occurring during the wet season. The timing of the flood peak is also expected to change, with a delay of a few days at Luang Prabang and a delay of up to 14 days at Chiang Saen.

1.2.2 Aquatic ecology and wetlands

Water quality

In general, the water quality in the reaches of the Mekong between Chiang Saen and Luang Prabang as measured by the Index for Protection of Aquatic Health, shows a Good Quality Rating (B) for 2015, though there has been a decline in water quality since 2011 when all three sampling sites achieved a High Quality rating (A). There would appear to be a trend in declining water quality since 2011.

The water quality index for Protection of Human Health is a higher standard, reflecting the acceptability of river water for human use. The patterns of this index are very similar to the Index for Protection of Aquatic Life, with general changes from High Quality to Good Quality occurring after 2011, and all three upper sampling stations now registering as Good Quality.

The Aquatic Ecological Health Index scores show that the upper Mekong near the Chinese border was in Poor health but has improved to Moderate in 2013. The sampling sites in the Mekong between Chiang Saen and Luang Prabang show Good Aquatic Ecological Health and this was confirmed through littoral macroinvertebrate survey in 2017.

Geomorphology

The geomorphology of this section of the Mekong from the Chinese border through to Luang Prabang is predominantly described as a single, bed-rock confined channel. As with many upland rivers it has a high average slope and high velocities of water flow.

However, although the river is bedrock-confined, the upper reaches of the Lancang are one of the most important areas of where sediment transport in the Mekong originates, and large volumes of sediment pass through the upper Mekong and create large alluvial deposits that are seasonally transported down the river during the wet season.

Within the structure of the rocky channel, sand and gravel banks form at specific locations, such as confluences with tributaries, mid-stream islands and point bars where there are slower sections of the channel and backwaters. This part of the Upper Mekong has a higher percentage of gravel in the bedload compared to reaches further south. The alluvial deposits provide an important substrate for vegetation and aquatic fauna that find the faster moving water through exposed bedrock more difficult to colonise.

The indicators for the changes in geomorphology include:

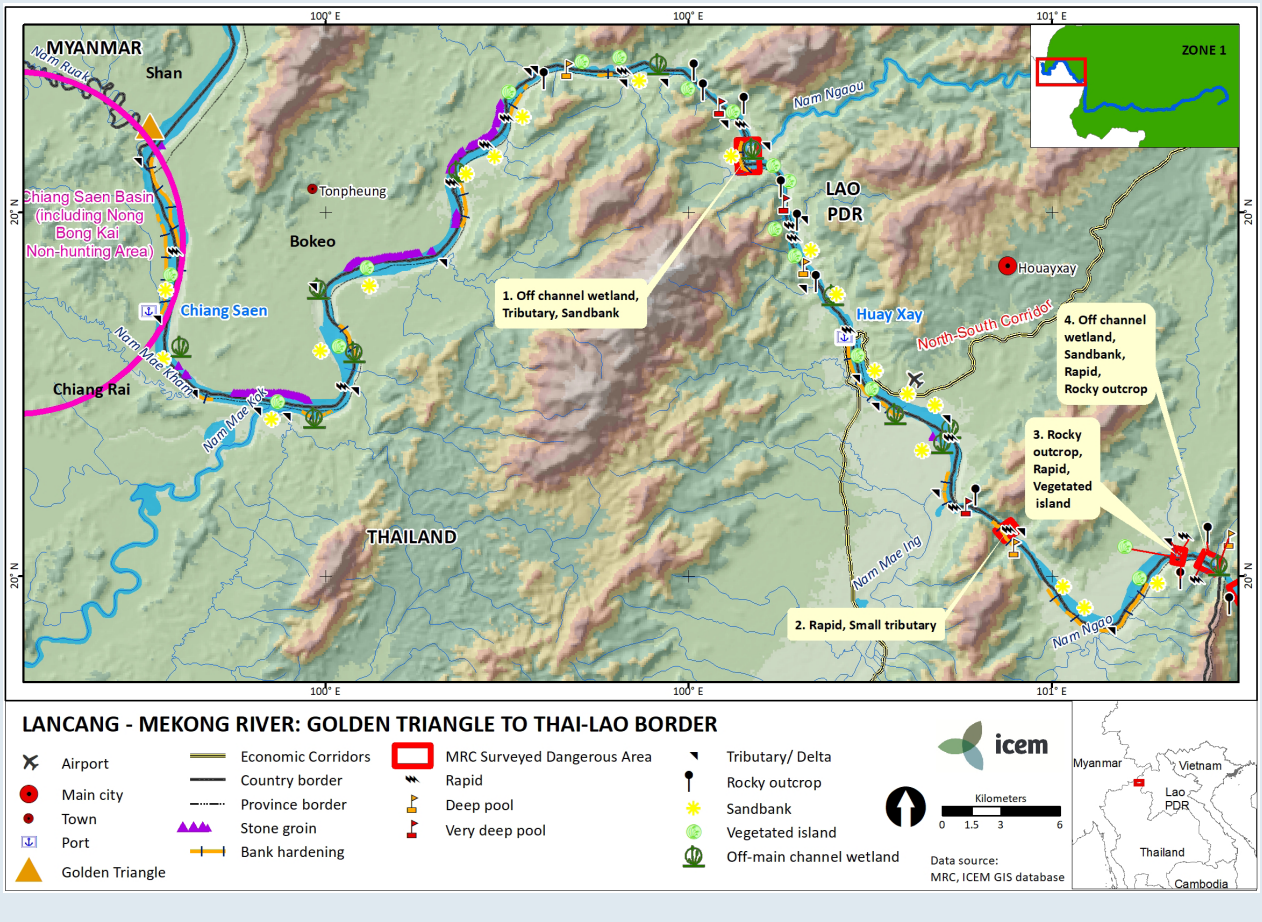
- Erosion
- Average bed sediment size in dry season
- Availability of exposed sandy habitat in dry season
- Availability of inundated sandy habitat in dry season
- Availability of exposed rocky habitats in dry season
- Availability of inundated rocky habitats in dry season
- Depths of pools in bedrock in dry season
- Water clarity and quality

Trends in these indicators since 1985 assessed by the MRC Council Study, show that apart from Erosion, which has declined from an A rating in 1985 to a D rating in 2015, there has been little change in the other indicators in the stretch down to Pak Beng. Below Pak Beng the geomorphological indicators already showed a decline in 1985 but, this has not changed by 2015.

Table 2: Different wetland habitat types identified in this stretch in the Mekong

Wetland habitat type	Description
Rivers	Mekong and its tributaries
Streams	Several streams running through evergreen forest and joining the Mekong
Seasonal mudflats, pebble flats and sand bars	Seasonally inundated habitats
Seasonally inundated shrubland	Seasonally inundated herbaceous shrubland vegetation on either side of the Mekong river as well as in islands of the Mekong river
Seasonally inundated swamp forests	Areas with woody plants, including trees that are inundated during the rainy season, located in lowland areas beside the river
Rock outcrops	Wet rocks, boulders and cliffs emerging out of water. These would sometimes be colonised by specialised vegetation e.g. Kinsen, found at Tang Salum and Wong Wit rapids.
Riverine rapids and deep pools	Deep water pools in the river, especially in areas of riverine rapids
Pools in riverbank	Small water pools beside the river, with rock/sandy/muddy substratum

Figure 1: Identified important habitats in the Golden Triangle to Thai-Lao border section of the study area'



Aquatic and riparian vegetation

The Mekong river in this stretch has relatively steeper banks, faster moving waters and thus a smaller area of riparian vegetation. The characteristic riparian vegetation can be divided into the different horizons of the river.

The lower banks and in-channel alluvial deposits are dominated by rheophytes – plants which are adapted to growing in fast moving waters, so that they have seasonal growth patterns that follow the water level, germinating and growing during low flows and being inundated during higher flows. The characteristic rheophyte of this low horizon is Homonia riparia, which grows throughout this stretch of the Upper Mekong.

The middle and upper horizons of shoreline vegetation are mostly short trees, shrubs and lianas and further up the banks, secondary rainforest species grow.

Pioneer herbaceous annuals and perennials, often dominated by grasses occupy the loose and shifting sandy and sandy loam substrates that form islets, islands and banks with river channels.

Submerged aquatic vegetation usually consists of several species and strains of Cladophora glomerate and Aegagropila linnaei and provide riverine communities of northern Laos and Thailand with an ample, seasonal supply of green algae. This is an important commercial natural product – Mekong River weed. Clear waters are required for their culture and harvest.

The trends in indicators of BioRa for aquatic and riparian vegetation between 1985 and 2015 have been quite stable with most indicators scoring a "B" or Good, except for the biomass of riparian vegetation which was an "A" in 1985 and which declined to "B" by 2015.

Macroinvertebrates

With the river habitats in this stretch of the Mekong consisting of a bedrock channel with deep pools and bedrock benches with large boulders and deposited cobbles and pebbles, there are areas of gravel, sand and alluvial deposits. The most abundant macroinvertebrates found in this stretch are those that live on stones and bedrock such as baetid mayflies.

Macroinvertebrate species that are sensitive to disturbance and water pollution include the stoneflies (Plecoptera) and caddis flies (Trichoptera) and these are found throughout the area, indicating the fair river health conditions noted during the ES March 2017 field survey.

Freshwater prawns (Macrobrachium spp) are also sensitive to disturbance and are found in some locations, especially in calcareous regions, e.g. the stretch around the Nam Ou confluence down to Luang Prabang.

The in-channel vegetation, e.g. the stands of Homonia riparia and grasses growing on sandbanks, provide a good habitat for different types of macroinvertebrates, and often the richest macroinvertebrate diversity is found in the small side streams and tributaries entering the river. Another important habitat for macroinvertebrates are the small ponds and pools left in the alluvial deposits as the high water levels recede during the dry season.

The trends in macroinvertebrates in this reach of the Mekong shows that in 1985 all of the indicators of change in macroinvertebrates in the reaches to Pak Beng would have scored an "A" – unmodified or nearly natural, while downstream of Pak Beng was already showing a decline to "B" or even a "C" for some indicators. By 2015 the upper reach to Pak Beng was considered to have declined to "B" or even a "C" for some indicators, with the same levels as downstream from Pak Beng, reflecting a degrading trend in this foundation level of the aquatic food chain.

Key drivers of change for aquatic ecology

The main drivers of change have been identified as:

- Changes of land use in the watershed
- Changes in agriculture down to the river banks
- Increases in urban run-off and pollution
- Increases in infrastructure development.
- Navigation improvements
- Increase in navigation traffic

1.2.3 Amphibians and reptiles

A total of 25 species of amphibians and reptiles were documented during field and market surveys. An additional seven species were reported during interviews but were not directly observed by the team. Eight of the observed and reported species (six turtle species and two snake species) are globally and nationally threatened from overexploitation for food and traditional medicine. Most conservation value for amphibians and reptiles in the survey area probably lies in forested portions of the mainstream Mekong and its tributaries

Key drivers of change for amphibians and reptiles

The surveyed areas along the Mekong River were heavily impacted by human development activities, especially removal and degradation of forest for agriculture (banana plantations, rubber plantations, and rice fields), as well as infrastructure development of the Mekong (hydropower dams and embankments).

1.2.4 Fish

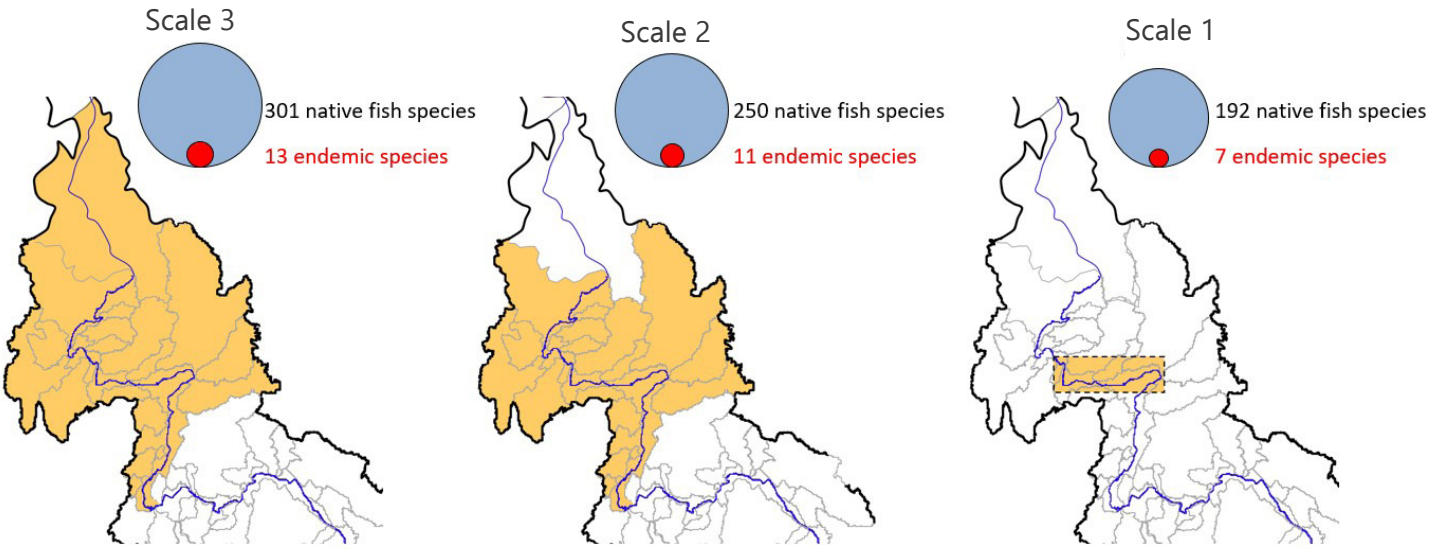
Fish diversity and endemicity were assessed at three catchment scales (Figure 2), starting at a broad scale from Xieng Kok to Xayaburi Dam (Scale 3), down to the scale of the study area (Scale 1). Within the study area there are 199 native and endemic fish species (206 species including introduced ones). Among these, about 38% are considered migratory. The study area is therefore home of an exceptionally high species diversity and concentration of Mekong endemics given its limited surface area (compared to the two larger scales). Twelve species are listed in the IUCN Red List as critically endangered and endangered, while another 32 are listed as near threatened and vulnerable.

Key drivers of change for fish

Fishers and riverine villagers in this section of the river consider that fish abundance, fish size and fish species diversity have declined in the past 5-10 years due to deteriorating water quality, declines in benthic fauna and flora, changes in water level, and increased fishing pressure. Algae, playing an important role as feed for both fish and people, has also declined.

Fishers surveyed fear that losing more river fish would be critical to their food security, as the current supply of fish and river resources is already minimal.

Figure 2: Comparison of total species diversity and number of endemic species at three different scales



*The surface areas of blue and red circles is proportional to the fish diversity and endemicity in each zone.

1.2.5 Birds

No bird species endemic to the project stretch is known. Seven globally threatened species occur, potentially occur, or until recently did occur regularly in the project stretch. However, there is neither evidence, nor strong predictive reasoning, that the project stretch of the Mekong is important for any bird species categorised (as of early 2018) as globally threatened. But the information base is far too thin to avert that it does not have such importance - although this importance seems unlikely to be the case for any birds except potentially for the White-browed Reed Warbler.

In total, 32 river-channel species are assessed as extirpated or nearly so. There is no strong evidence for the extirpation of any small species, although White-eyed River Martin is a candidate (but it may well never have occurred in the project stretch). Some small species are almost certainly in decline, notably Asian Plain Martin.

Key drivers of change for birds

Many uncertainties therefore remain in surmising the detail of the project stretch bird community. However the take-home message – avifaunal collapse over the past 100–150 years, largely or entirely in response to ordinary people doing their ordinary day-to-day activities year in, year out – is unquestionably sound. The overall picture for the trend in the bird conservation values of the project stretch is of a sustained and massive decline over the last century and more, with probably the major changes from the 1940s to the 1970s.

1.2.6 Socio-economics and livelihoods

People (including ethnic minorities)

There is an estimated (combining census data and satellite imagery assessment) total population of just over 100,000 people living along the river banks in the study reach. Approximately 19,000 of these people live in Thailand and the remainder in Laos, and of the 100,000 people, over 75% (76,000) live within the first 100 km below the Ruak-Mekong confluence (Zone 1 of the study area). Data on ethnicity was only able to be sourced for the Laos side of the border, and it shows that about 36% of the Lao population in the area are likely to be from the majority Lao-Tai ethnic family, around 33% from the Mon-Khmer peoples, and around 15% from each of the Hmong Lewmien and Sino-Tibetan peoples.

1.2.6.2 Poverty and livelihoods

Poverty rates in the study area are high, and while fishing is not a full-time occupation for many households, most do fish during the year. This gives them access to a critical source of protein and micronutrients in their diet. Most fish caught are for household consumption, and provide an important food security buffer, particularly for ethnic minority and other poor communities.

The Lao PDR Government is promoting agri-business to foreign companies in order to generate foreign direct investment, however there are concerns that this is undermining the ability of ethnic minority and other poor communities to ensure their own livelihoods and food security. Linked to this, the government has been working with international donors to title land, but has focused heavily on urban areas to date. Providing poor rural communities with official permanent title to their customary lands would provide them with additional security when negotiating land rights with developers. There are also some risks in the study area associated with outsiders who hold land concessions, but who log illegally outside the concession boundaries. In addition to logging, wildlife trafficking is big business in Laos and likely to occur in or through the study area, although most illegal wildlife products are sourced internationally.

Key drivers of change for socio-economics and livelihoods

There are three main trends highlighted by the baseline assessment:

- Annual population growth rates ranging from 0.38% in Chiang Rai, up to 2.1% in Bokeo;
- Promotion of agri-business is coming at the expense of the livelihoods and food security of poor and vulnerable communities;
- Illegal logging is continuing to grow.

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