Baseline Assessment Report

Environmental Study of the Lancang-Mekong Development Plan

March 2019

Prepared for: **Critical Ecosystem Partnership Fund (CEPF)**

Prepared by: **ICEM - International Centre for Environmental Management**

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This report is one of four in this set on the *Environmental Study of the Lancang-Mekong Development Plan:*

1. Introduction Report
2. **Baseline Assessment Report**
3. Impact Assessment Report
4. Mitigation Recommendations Report

The report covered in this volume is bold.

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ABBREVIATIONS

AIIB	Asian Infrastructure Investment Bank
ANZECC	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ATP	Asia Turtle Program
CEPF	Critical Ecosystems Partnership Fund
DWR	Department of Water Resources
DWT	Deadweight ton
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ES	Environmental Study
GMS	Greater Mekong Subregion
HPP	Hydropower project
IUCN	International Union for Conservation of Nature and Natural resources (IUCN)
JCCCN	the Joint Committee on Coordination of Commercial Navigation on the Lancang-Mekong River
LMB	Lower Mekong Basin
LMCM	Lancang Mekong Cooperation Mechanism
LMDP	'*Development Plan of International Navigation on the Lancang-Mekong River 2015-2025*'
LNMC	Lao National Mekong Committee
MMMAP	Multi-media Monitoring and Assessment Program (MMMAP)
MONRE	Ministry of Natural Resources and Environment (MONRE)
MOPWT	Ministry Public Works and Transport (MOPWT)
MRC	Mekong River Commission
NAP	Navigation Programme
NESDB	National Economic and Social Development Board (NESDB)
NGO	Non-governmental organisation
O&G	Oil and grease
ONEP	Office of Natural Resources Environmental Policy and Planning (ONEP)
PAT	Port Authority of Thailand
PCD	Pollution Control Department
PNPCA	Procedures for Notification, Prior Consultation and Agreement
SEI	Stockholm Environment Institute
TFT	Tortoise and freshwater turtle
TMD	Thailand Marine Department
TNMC	Thailand National Mekong Committee
WQCA	Water Quality Criteria for the Protection of Aquatic Life (WQCA)
WQCH	Water Quality Criteria for Protection of Human Health (WQCH)
WWF	World Wildlife Fund

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1 INTRODUCTION

This volume contains the results of a baseline assessment of environmental and social conditions and trends along a 368 km stretch of the Lancang-Mekong River between the Golden Triangle and Luang Prabang. The volume firstly sets out the baseline assessment approach and then the presents the results within separate sections covering each of the study themes:

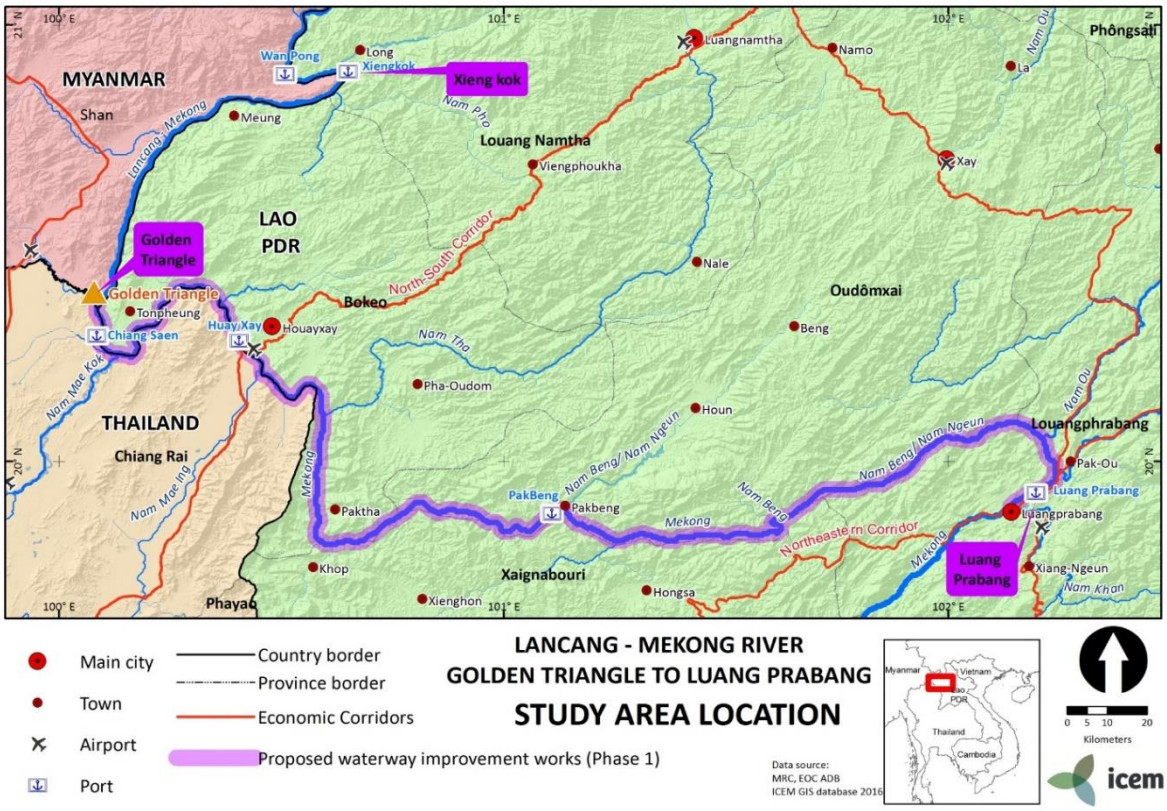
1. Hydrology and Sediment;
2. Aquatic Biodiversity and Wetlands ;
3. Fish;
4. Amphibians and Reptiles;
5. Birds;
6. Waterways; and
7. Socioeconomics and livelihoods.

The baseline assessment was the second phase of this Environmental Study of the Lancang-Mekong Development Plan (LMDP), following the scoping phase and prior to the impact assessment phase and final development of mitigation strategies phase.

1.1 ENVIRONMENTAL STUDY RATIONALE

There may be significant long-term and irreversible social and environmental impacts of the LMDP from port construction, increased waterway use and partially removing 146 rapids and shoals to improve navigation. The environmental and social impacts need to be fully assessed. As the LMDP does not currently include a comprehensive environmental management plan, the Critical Ecosystems Partnership Fund (CEPF) allocated grant funding to ICEM to conduct an Environmental Study (ES) of the LMDP from the Golden Triangle to Luang Prabang (Figure 1.1). The ES set priorities for an environmental management plan with a special focus on biodiversity to be integrated within the LMDP should the plan proceed. The LMDP would be the most significant development of the Mekong River since the proposed mainstream hydropower projects in Lao PDR and Cambodia. As the Pak Beng Hydropower Project (HPP) also falls within the study reach it has been included in the assessment. The study assumes that both the LMDP and Pak Beng HPP will proceed and only sought to formulate recommendations to improve environmental outcomes of both proposed developments.

Figure 1.1: Study area for the ES of the LMDP



The ES supports the findings of the '*CEPF Status and Distribution of Freshwater Biodiversity in Indo-Burma*' that calls for targeted ecological studies of fresh-water species in the upper mainstream Mekong River to determine the impacts of navigation development. The ES also supports CEPF recommendations to integrate aquatic biodiversity and biodiversity surveys into the SEA/environmental impact assessment (EIA) processes in the Mekong region. This ES responds to concerns raised by Mekong River Commission (MRC) member countries, donors and development partners that the cumulative and trans-boundary impacts of the LMDP and Pak Beng HPP require comprehensive environmental assessment. The MRC Navigation Programme (NAP) 'Master Plan on Regional Navigation 2015' recommended that an independent strategic environmental assessment of the LMDP be completed.

ICEM ensured that these concerns were taken into consideration in the ES including conducting a rapid integrated field survey in the development corridor between the Golden Triangle and Luang Prabang to inform strategic planning and sustainable decision-making.

2 BASELINE ASSESSMENT APPROACH

This section outlines the baseline assessment approach of the ES of the LMPD and Pak Beng HPP. The baseline phase established the trends and key drivers of change for the key themes of the ES. This step 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. Compliance with CEPF Indigenous Peoples (OP/BP 4.10) policy was considered and reported during this phase.

Biodiversity trend analysis: The biodiversity team used the following template as a guide to complete the initial baseline and trends analysis (Table 2.1). The baseline assessment was completed following further consultation with stakeholders, after the rapid integrated field survey was conducted in March 2017.

Table 2.1: Step 1 - 4 of baseline trend analysis 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 your assumptions on future drivers of change explicit (the baseline projection is without the navigation and Pak Beng HPP developments)	

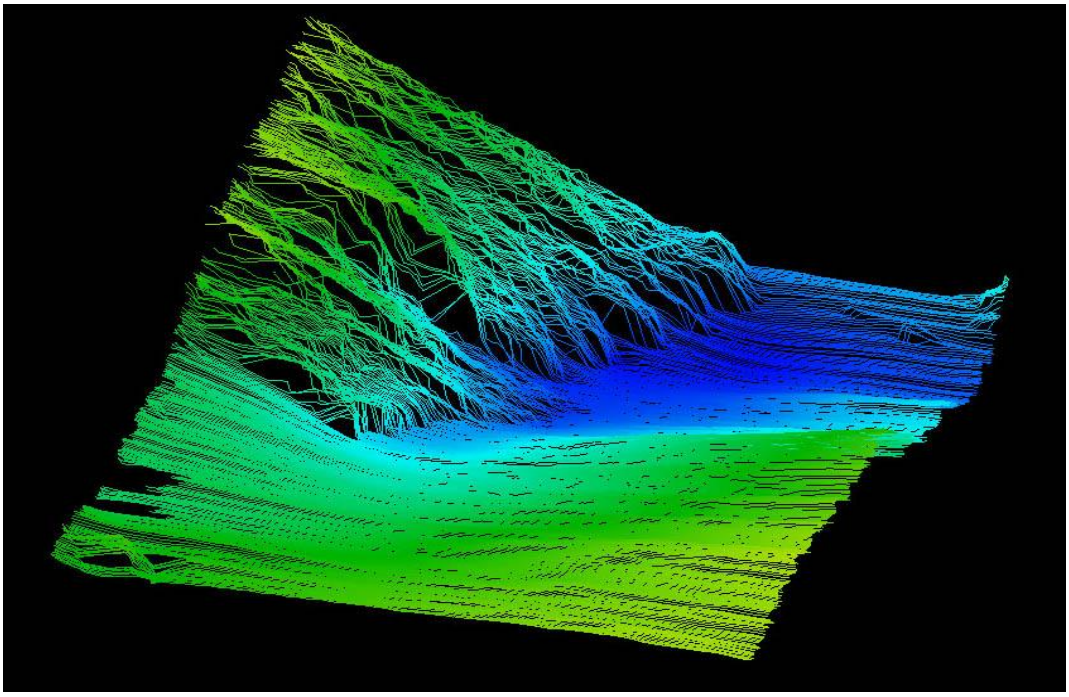
Socio-economic assessment: The team also conducted an initial assessment of the socio-economic activities along the river, including:

- 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 was 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. 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 (Figure 2.1). 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 and to conduct a number of case studies of specific "dangerous areas".

Figure 2.1: Example of hydrographic survey of the Mekong River between Houay Xay and Luang Prabang



Stakeholder consultation: Prior to the field assessment, the team held a Baseline Assessment Stakeholder Workshop for the Lancang Mekong Development Plan (LMDP) Environmental Study (ES) in Bangkok on 11 November 2016 with government and other key stakeholders. The objective of the workshop was to provide an opportunity for the team to present the initial findings and take participants on a virtual 'fly over' of critical habitats and geomorphological features and underwater (bathymetric survey) to see aquatic habitats. An interactive panel session allowed participants to discuss the key biodiversity, livelihoods and river basin developments upstream of Luang Prabang, including the Pak Beng hydropower project. Workshop participants were drawn from Thai government agencies, non-governmental organisations (NGOs) and civil society, international organisations such as MRC and universities and academics.

A number of priority issues for the ES emerged during the panel discussion:

- **Ecosystem services baseline:** ecosystem services and values for the target reach of the Mekong River and linked watersheds.

- **Impact on livelihoods**: more than 70% of riverine communities involved in agriculture and fisheries. All aspects of livelihoods and the effects of the developments on local communities including assessment of ecosystem services and products contributing to livelihoods.
- **Cultural importance of the river**: the cultural and spiritual significance of the river and its various formations is fundamental to riverine community well-being.
- **Community consultation**: ideally, a wide spectrum of local riverine communities in the target review stretch should be consulted from the earliest stages of the study;
- **Cumulative impacts of many projects**: the Mekong reach is within a Special Economic Zone (SEZ) on the Thai side of the river, therefore much infrastructure will be developed especially linked to Chiang Saen and Chiang Kong. With the Pak Beng hydropower project now likely to proceed – and the Lancang project likely, what are the cumulative effects and trade-offs.
- **Environmental audit of first LMDP phase**: 15 years ago the first phase of the navigation improvement scheme was implemented in the reach north of Chiang Saen with considerable civil society opposition and much interest in national media. It is important that an audit is conducted into the impacts of that work so the phase 2 benefits from the lessons. This important audit goes beyond the the current study TOR.
- **International border:** in the LMDP phase 1 a key issue was the potential impact on the international border – phase 2 will have similar implications – this is likely to be a issue of concern for Thailand and Lao PDR in phase 2.
- **Institutional arrangements**: Establishing a steering committee involving Thai and Lao government agencies, the MRC and NGOs would have promoted ownership of the study.
- **Communications**: The study has critical implications for development of the river and needs more publicity and communication activities.

Field assessment: A rapid 8-day integrated field assessment by boat was conducted in March 2017 during low water levels, covering the entire study stretch from the Golden Triangle to Luang Prabang. The dry season was identified as the best time of year to conduct the field work for all key themes. The team prepared the TOR for the field assessment based on the key issues identified in the Inception Report and the initial trend and spatial analysis.

A summary of the approach to field work for each of the themes is provided in the Inception Report, including the priorities for field work, timing and any other considerations or limitation for undertaking additional field work. Following the field work, the steps set out in

Table 2.2 were incorporated into the baseline assessment report from each of the themes:

Table 2.2: Step 5-6 of trend analysis for baseline assessment

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 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)

Baseline assessment report: The team used the baseline trend and spatial analysis to prepare a baseline assessment chapter on each theme, provided in the following sections.

3 HYDROLOGY AND SEDIMENT BASELINE

3.1 INTRODUCTION

Hydrology and sediment transport are river characteristics that have major implications for ecology and biodiversity. For example, flooding enables connectivity to the floodplain and rising water levels serve as a trigger for fish spawning. Sediment transport can provide new habitat for fish species, or alternatively can smother existing habitats or fill in pools.

In this report we document the current condition of hydrology and sediment transport for the study section of the Mekong mainstream - from Chiang Saen to Luang Prabang - and identify recent drivers of change. The analysis focusses on: **hydrology** based on literature reviews and analysis of MRC discharge station records for the Mekong mainstream; and **sediment transport** based on literature reviews, analysis of the Mekong mainstream longitudinal section and temporal-spatial analysis of satellite imagery. The analysis focusses on two key time frames: i) before construction of the first upper Mekong dam, the Manwan Dam (pre 1996); and ii) post construction of the first upper Mekong dam (post 1996).

The hydrological and sediment baseline analysis was undertaken as a desktop review with no detailed field study undertaken. The findings are therefore preliminary and a field study is needed to confirm and expand on the initial findings documented in this report.

3.2 HYDROLOGY CURRENT STATUS AND TRENDS

In terms of hydrology, the Mekong River is one of the world's great rivers, ranking 10th in the world on the basis of mean annual flow at the river mouth (MRC, 2005). From its 4,500-meter elevation source in the Tibetan Plateau, which it shares with the Yangtze, Salween, Irrawaddy and Red Rivers, it travels south for 4,800 km to the South China Sea. The basin drains a catchment area of 795,000 km^2 covering parts of China (21% of basin area), Myanmar (3%), Lao PDR (25%), Thailand (23%), Cambodia (20%) and Viet Nam (8%) (MRC, 2005). The Mekong Basin can be split into two distinct sections: the Upper Mekong Basin in China and Myanmar, and the Lower Mekong Basin downstream of Yunnan to the South China Sea.

The study team was able to obtain discharge time series data for two stations located on the Mekong mainstream in the study reach – the Chiang Saen station (010501) located at the upper end of the study reach, and the Luang Prabang station (011201) located at the lower end of the reach[1]. Both stations have a long set of data - Chiang Saen has 48 years from 1960 to 2007 and Luang Prabang has 57 years ranging from 1950 to 2006. In the following sections literature reviews and analysis of these times series have been used to discuss four key themes related to hydrology in the study reach: i) annual flow volumes; ii) annual flood pulse; iii) floods; and iv) influence of the upper Mekong.

3.2.1 Annual flow volumes

Annual flow volumes reflect climatic conditions, soil moisture and changes in land use (Gordon, 2004). Various studies have suggested there is little evidence of a systematic change in the annual flow

[1] There are other Mekong mainstream stations within the study reach – Pak Beng (station 10901) and Huay Xay (station 200001/200003) for example – but the study team was unable to obtain the data for these sites. Therefore, the analysis only focusses on the Luang Prabang and Chiang Saen stations.

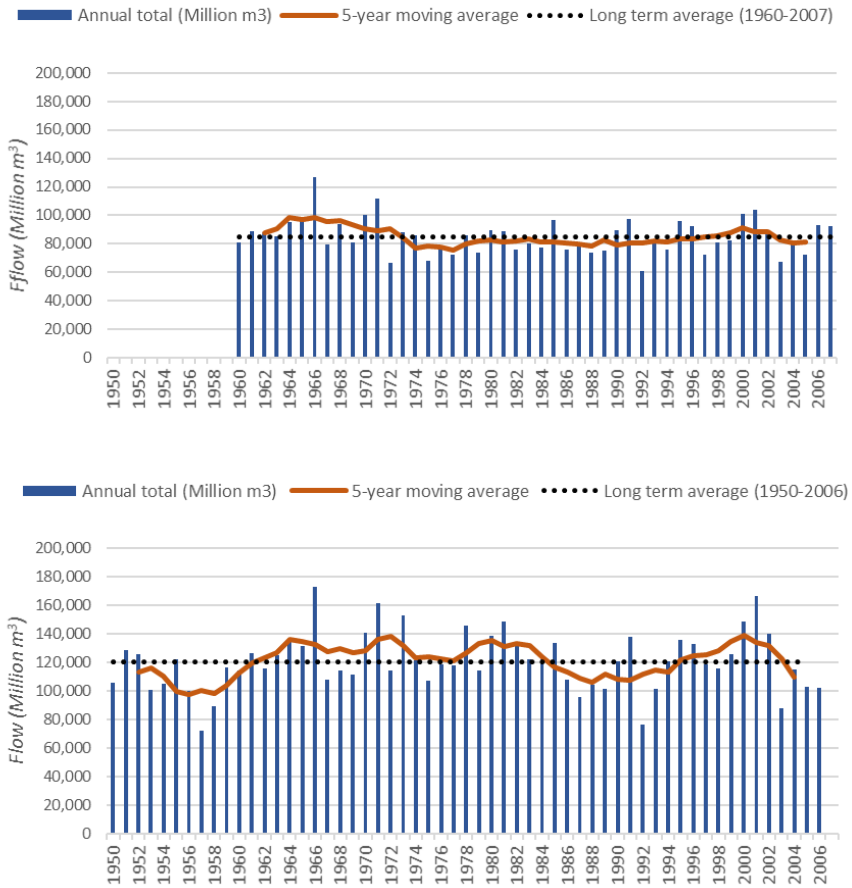
volumes in the Mekong over the past 50 years (MRC, 2005) and others have suggested that whilst the average may not have scientifically altered, there has been increasing inter-annual variability, likely due to increased El Niño Southern Oscillation (ENSO) activity (Räsänen et al, 2013).

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 (Figure 3.1). At Chiang Saen the late 1960s saw higher flow volumes, which then lowered and stayed relatively consistent just below the long term average of 85,200 Million m^3 through the 1970s to the late 1990s. In the early 2000s there is a noticeable increase in flow before dropping again to the levels of the 1970s to 1990s. At Luang Prabang the annual flow volume tends to oscillate around the long term average of 120,700 Million m^3/year with high flows in the early 1960s, 1970, 1980s and 2000s, and a noticeable dip in flows in the late 1980s and early 1990s.

Moving downstream through the study section, as the influence of tributaries on discharge increases, the variability in annual flow volume also increases. Annual flow volume at Luang Prabang is more variable than at Chiang Saen, as is visible in Figure 3.1 and confirmed by comparing the coefficient of variation (Cv) for the annual total volume – Chiang Saen is 0.15 and Luang Prabang 0.17.

Analysis of annual flow volumes at Chiang Saen and Luang Prabang shows that a large volume of water joins the Mekong along the study reach. Annual flow volumes at Luang Prabang average around 40,000 Mm^3 higher than that at Chiang Saen, and the difference has reached as high as 95,000Mm^3 (in 1971) (Figure 3.1). This volume represents the incoming water from tributaries and direct overland inflow into the Mekong along the study reach and comprises around 30% of the volume at Luang Prabang.

Figure 3.1: Histogram of annual streamflow totals for the Mekong River at Chiang Saen (top) and Luang Prabang (bottom). A 5-year moving avereage has been added to smooth year-to-year fluctuations.



3.2.2 Annual flood pulse

Analysis of monthly discharges provides useful information for understanding seasonal variations in discharge, which are controlled by climatic patterns, channel characteristics and catchment characteristics (Gordon et al, 2004). Seasonal and monthly variations are often important for ecology due to their relationships to species life-cycle stages, and in the Mekong the annual flood pulse is widely recognised as an important driver of ecological diversity (Belay et al, 2010).

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 (Lauri et al, 2012). The most dominant, the Indian Ocean monsoon, occurs during the northern hemisphere summer when temperature differences between the land and the Indian Ocean force moisture laden air to precipitate over the mountains of the Mekong basin (ICEM, 2013). The Indian Ocean monsoon divides the calendar year into wet (May – late September) and dry (October – late April) seasons. During the dry season, air flow over the Mekong is reversed as a high pressure system over the Asian land mass forces dry continental air flow over the basin, while the East Asian monsoon – originating in the Pacific Ocean – contributes minimal and erratic rainfall as most of the basin lies in the rain shadow of the Annamite Mountains (MRC 2011).

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 (Lazarus et al, 2006). Despite these major fluctuations, the study reach is located 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 (Figure 3.2). For example, the difference between the lowest and highest mean monthly discharge at Chiang Saen is 5,600m3/s, compared to 36,900m3/s at Kratie. The change in flow characteristics at low and high flows is visible in satellite imagery (Figure 3.3).

Figure 3.2: Mean monthly discharge at Chiang Saen, Luang Prabang and Kratie, showing the increasing magnitude of the flood pulse moving downstream

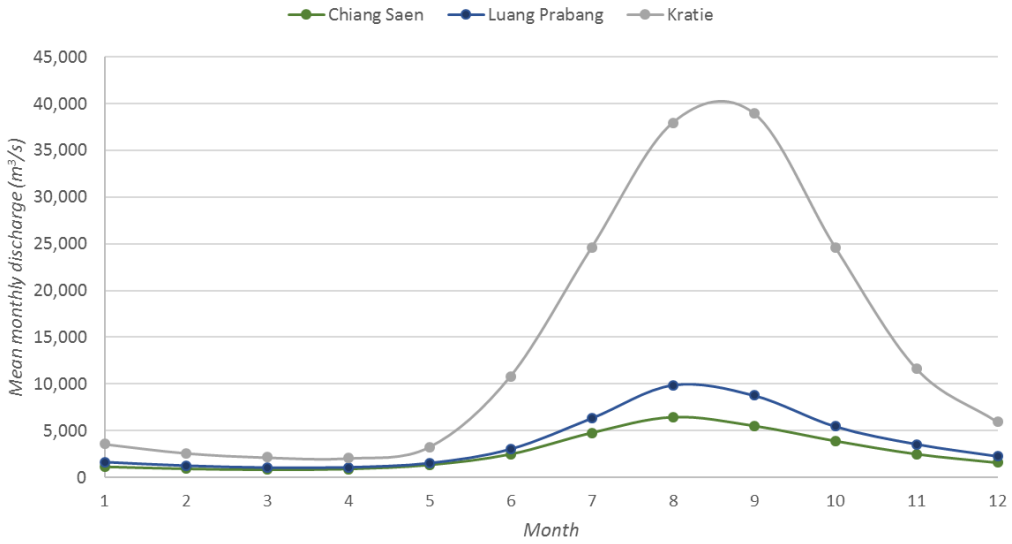


Figure 3.3: The Mekong River 2km upstream of Pak Ou confluence in dry season (left) and wet season (right)

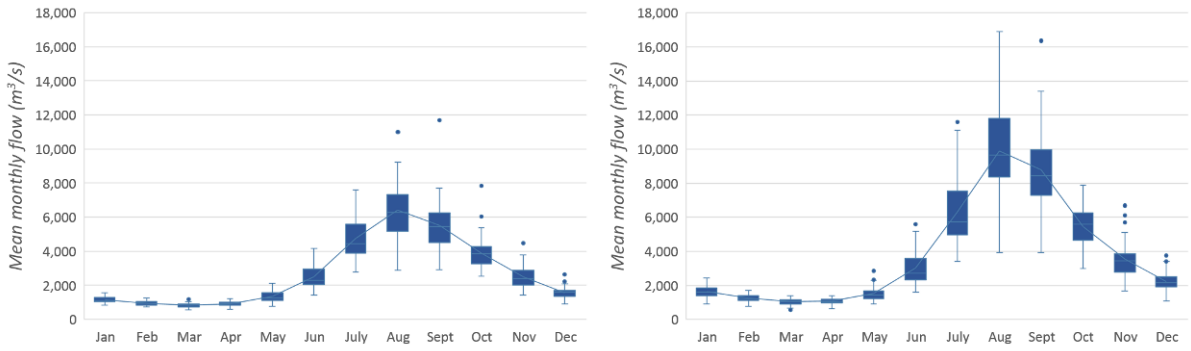
Further analysis of average monthly flows at Chiang Saen and Luang Prabang (Figure 3.4) provides a number of insights:

- Both stations have a clear flood pulse with low flows occurring from December to May, and high flows occurring from June to November with a peak in August;
- Peak mean monthly flow averages 6,430 m^3/s at Chiang Saen but can reach as high as 11,000m^3/s and as low as 2,860 m^3/s;

- At Luang Prabang the mean monthly flows in August (the peak month) averages 10,000m^3/s and has ranged between 3,930 and 16,900m^3/s;
- The lowest flows occur in March, when Chiang Saen averages 830 m^3/s and Luang Prabang averages 1,035m^3/s;
- The inter-annual variance in flows during the low flow season is much smaller than during the wet season, for example at Chiang Saen the minimum and maximum March mean monthly flow is 550 and 1,185m^3/s – a variance of 830m^3/s compared to 8,135 m^3/s for August;
- The variability between months within a year is greater at Luang Prabang, likely reflecting the influence of the tributaries joining the Mekong within the study reach; and
- The variability of each month between years is greater at Luang Prabang, likely reflecting the influence of the tributaries joining the mainstream within the study reach.

Figure 3.4: Box and whisker plot of mean monthly flow for the Mekong River at Chiang Saen from 1960 to 2007 (left) and Luang Prabang from 1950 to 2006 (right).

(Boxes indicate the range which 50% of years fall within, the whiskers indicate the range in which 100% of years fall within (excluding outliers). Dots indicate outliers.)



3.2.3 *Extreme floods*

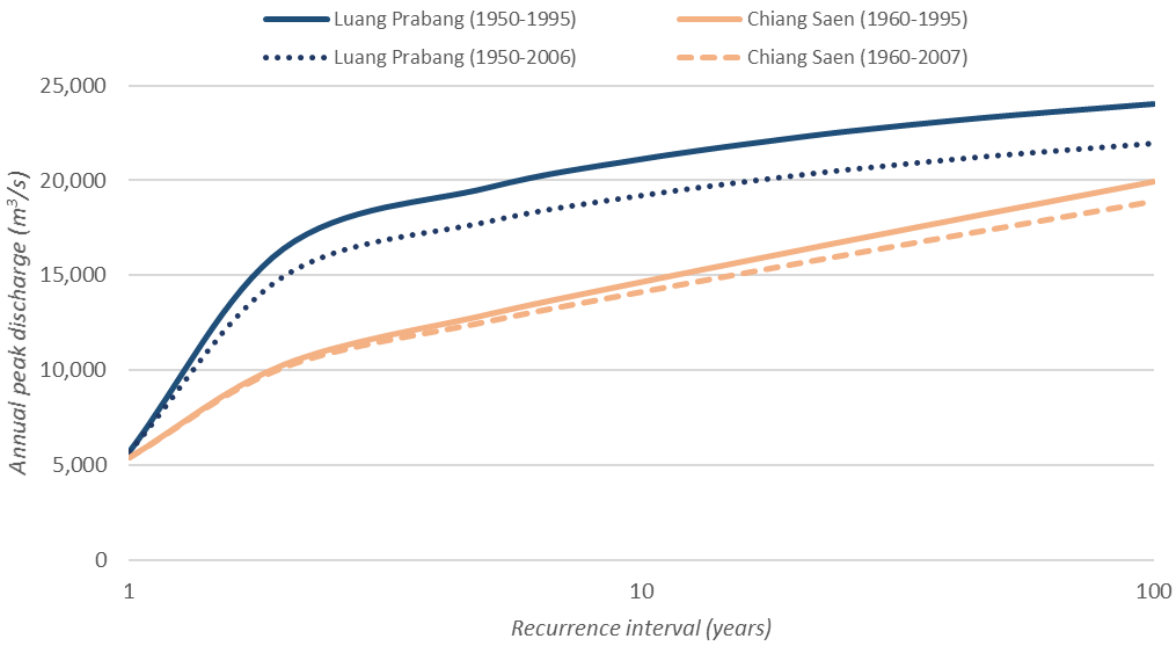
Extreme floods are a regular occurrence in the Mekong River, and can have devastating impacts on the environment and communities along the lower sections of the river (MRC 2009). For the study reach, the flood hydrology is dominated by rainfall and subsequent runoff from the upper Mekong Basin (MRC, 2005; MRC 2009).

Analysis of annual peak discharge 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 (Figure 3.5).

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. Wood et al (2008) suggest that it is a rare event at Chiang Saen where a stage of 10.5m elevation would overflow the banks or inundate part the floodplain by back flow through tributary channels. This has only occurred twice since 1960 including in in 1966 (peak flow of 23,500 m^3/s, with a greater than 100 year ARI) and 1971 (peak low of 15,400m^3/s with an ARI of around 20 years), indicating poor

connectivity of the Mekong to its floodplain in this section. Similar analysis could not be found for Luang Prabang or other areas of the study reach.

Figure 3.5: Annual peak discharge Annual Recurrence Intervals for the Mekong River at Chiang Saen (left) and Luang Prabang (right)2 – estimated using the Log Pearson Type III distribution

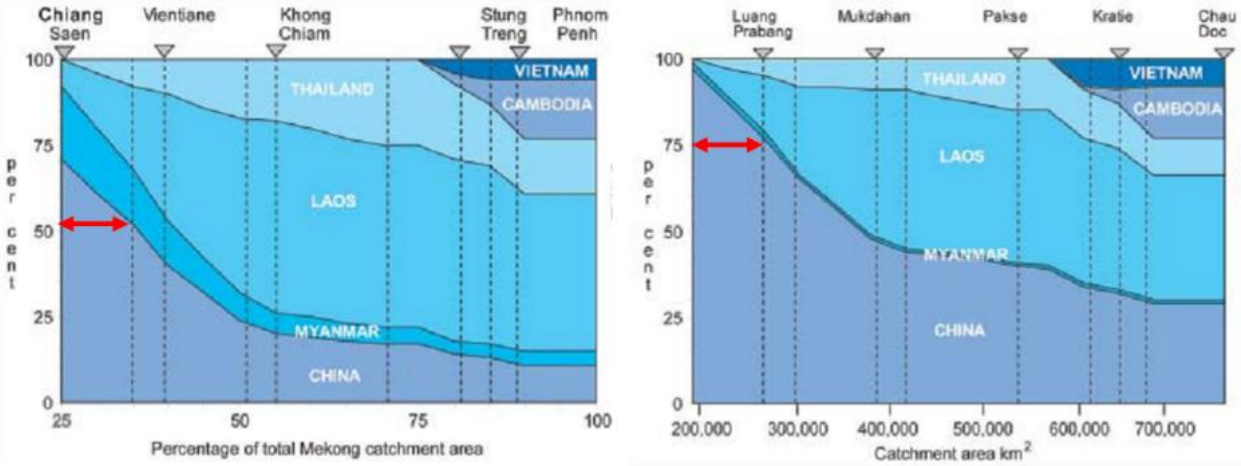


3.2.4 Influence of the Upper Mekong Basin

The study reach – Chiang Saen to Luang Prabang – is located at the top end of the Lower Mekong, approximately 250 km 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 (Figure 3.6). Moving downstream through the study section, the influence of the Upper catchments reduces significantly as the river widens and large tributaries including the Nam Ta, Nam Ou, Nam Soung and Nam Khan, enter on the Mekong River's left bank; and the Nam Mae Kok and Nam Mae Ing enter on the right bank (MRC, 2005). At Luang Prabang, the Chinese catchments contribute only 55% of wet season flow and 80% of dry season flow (Figure 3.6). Flows passing this section of the river during the dry season are important as far downstream as at Chau Doc, with the China and Myanmar sections of the river comprising 30% of dry season flows at this station (Figure 3.6).

[2] In preparing this analysis the team noted a possible error in the dataset for Chiang Saen. For 2006, the peak discharge of 23,900m^3/s (recorded as occurring on 13th October) is well outside the expected range (more than 6,000m^3/s higher than any other flow recorded since 1960). On further research, the value does not match that reported in the Mekong River Commission Annual Mekong Flood Report for 2006, and it is therefore assumed the value reported in the Flood Report is correct (12,000m^3/s).

Figure 3.6: Percentage of average flow during the wet – June to November (left) – and dry – December to May (right) season months originating in each country (MRC, 2005).



(Note that the study section is indicated by the red arrows)

3.2.5 Recent drivers of change

3.2.5.1 Upper Mekong dams

Construction of the first Upper Mekong reservoir – the Manwan– began in 1986 and the reservoir was filled in the 1992/1993 dry season (Wood et al, 2008). There are now eight dams commissioned on the Upper section of the Mekong mainstream (Table 3.1), and a further six dams being constructed (WLE Greater Mekong, 2016).

Table 3.1: Dams on the Upper Mekong River (WLE, 2016)

Name	Year commissioned	Storage (million m^3)
Manwan	1992	920
Dachaoshan	2003	890
Jinghong	2009	1,140
Xiaowan	2010	14,560
Gongguoqiao	2012	316
Nuozhadu	2014	23,703
Guoduo	2015	83
Miaowei	2016	660

Past studies on the hydrological impact of the dams have found a statistically significant trend in decreasing August flows at Chiang Saen, (Campbell, 2007; Lu et al, 2014), more variable flows in the dry season (Lu et al, 2014) and decrease in dry season flows (Lu et al, 2014; Hecht and Lacombe, 2014). Anecdotal evidence collected during the current study's field research indicates a decreasing wet season flow and increasing dry season flow over the last 10 years, possibly due to dam construction and operation.

To build on the existing literature and anecdotal reports collected during the field research, the study team have utilized the Flow Health software (see Box 1 for an introduction) to assess the hydrological impact in the study reach following the construction of dams upstream. The Flow Health software was

used to analyse the flows at Chiang Saen and Luang Prabang for a reference period before filling of the Manwan Dam (i.e. pre 1992) compared to the period since the reservoir was filling (i.e. post 1992).

The software calculates nine sub-indicators and accumulates them into an annual Flow Health Index for a reference period which represents the river in a natural flow state. The indicators for a test period are then calculated and compared to the reference indicators. The indicator score ranges between zero to one with a higher score indicating a flow regime closer to the reference period. The nine sub-indicators used by the software and summary of results for Chiang Saen and Luang Prabang are provided in Table 3.2, and detailed results provided in Figure 3.7 and Figure 3.8.

Box 1: The Flow Health Software

The Flow Health software, developed by the International Water Centre, performs a hydrological analysis to calculate indicators of flow health. The indicators used in the program have been chosen to characterise attributes of the flow regime in terms of the main ecologically relevant flow components – they are therefore necessarily general and direct links between the hydrological indicators and ecological impacts are not defined within the program. Linking of the flow indicators to particular risks for the downstream ecosystems must be interpreted by the user (Gippel et al, 2012).

The Flow Health software results largely agree with previous studies on the impacts of the Upper Mekong reservoirs. Construction of the Manwan and Dachaoshan Dams appear to have 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 an increase in dry season flows and decrease in wet season flows in the study reach. The influence of the Upper Mekong dams lessens moving downstream through the study reach. These findings are evidenced by:

- **Decrease in the High Flow sub-indicator** at both **Chiang Sen and Luang Prabang** for many years post 1992 indicates that the **volume of flow during the wet season** (calculated as April to November) has **significantly decreased** (see Appendix A for further analysis). This is particularly relevant in the years after 2010, when the large Xiaowan Dam was commissioned;
- **Decrease in the Highest Monthly Flow sub-indicator** at both **Chiang Sen and Luang Prabang after 2010,** indicates a **decrease in the highest monthly flow** in each year**;**
- **Decrease in Lowest Monthly Flow sub-indicator at Chiang Sen** for many years post 1992 indicates a **significant increase in the minimum monthly flow** for those years;
- **Decreases in the Persistently higher sub-indicator at Chiang Sen** for many years post 1992 reflect the existence of a period of time when the flow is persistently (i.e. for two or more consecutive months) **notably higher than the expected range** (higher than the 25th percentile flow for each month); and
- **Decreases in the Seasonality Flow Shift sub-indicator** at **Chiang Sen** for many years post 1992 indicates **a shift in the months of high and low flows** for those years compared to the long-term average.

The study team note that we did not have access to longer term time series (up to 2015) for other stations of the Mekong Basin, so were not able to analyse the extent that the hydrological changes noted in the study reach post 2007 are attributable to normal climate variance. Given the extent of

change, timing coinciding with the construction of large upstream dams, and agreement with literature on the broader impacts of the dams, it is reasonable to assume that the hydrological changes identified in the study reach are due to the construction of dams in the Upper Mekong.

Table 3.2: Flow Health sub-indicators and change at Chiang Saen and Luang Prabang (reference period of pre 1992 and test period of post 1992)

Flow condition sub-indicator	Description	Change at Chiang Saen	Change at Luang Prabang
High Flow (HF)	Sum of monthly flows in natural high flow period	Yes	Yes
Low Flow (LF)	Sum of monthly flows in the natural low flow period	No	No
Highest Monthly (HM)	Highest monthly flow in the year	Yes (post 2010)	Yes (post 2010)
Lowest Monthly (LM)	Lowest monthly flow in the year	Yes	No
Persistently Higher (PH)	Measure of how many sequential months in the natural low flow season were higher than expected	Yes	No
Persistently Lower (PL)	Measure of how many sequential months were lower than expected	No	No
Persistently Very Low (PVL	Measure of how many sequential months were much lower than expected	No	No
Seasonality Flow Shift (SFS)	Measure of the degree to which the seasonality of the monthly flows has been altered (detects shifting of the months of high and low flow to other times of the year)	Yes	No

Figure 3.7: Flow Health sub-indicator scores for Chiang Saen (reference period of 1960 to 1992)

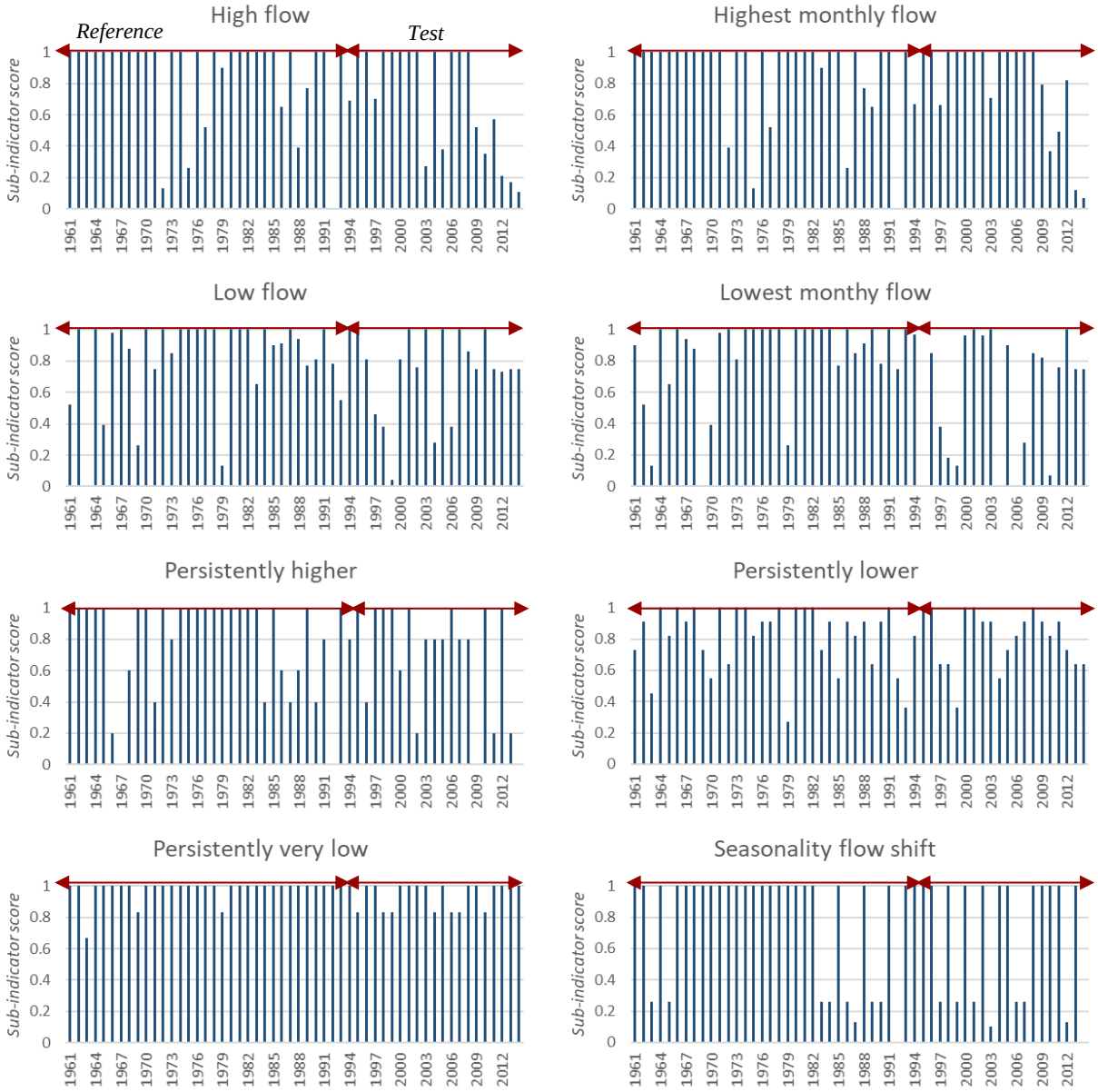
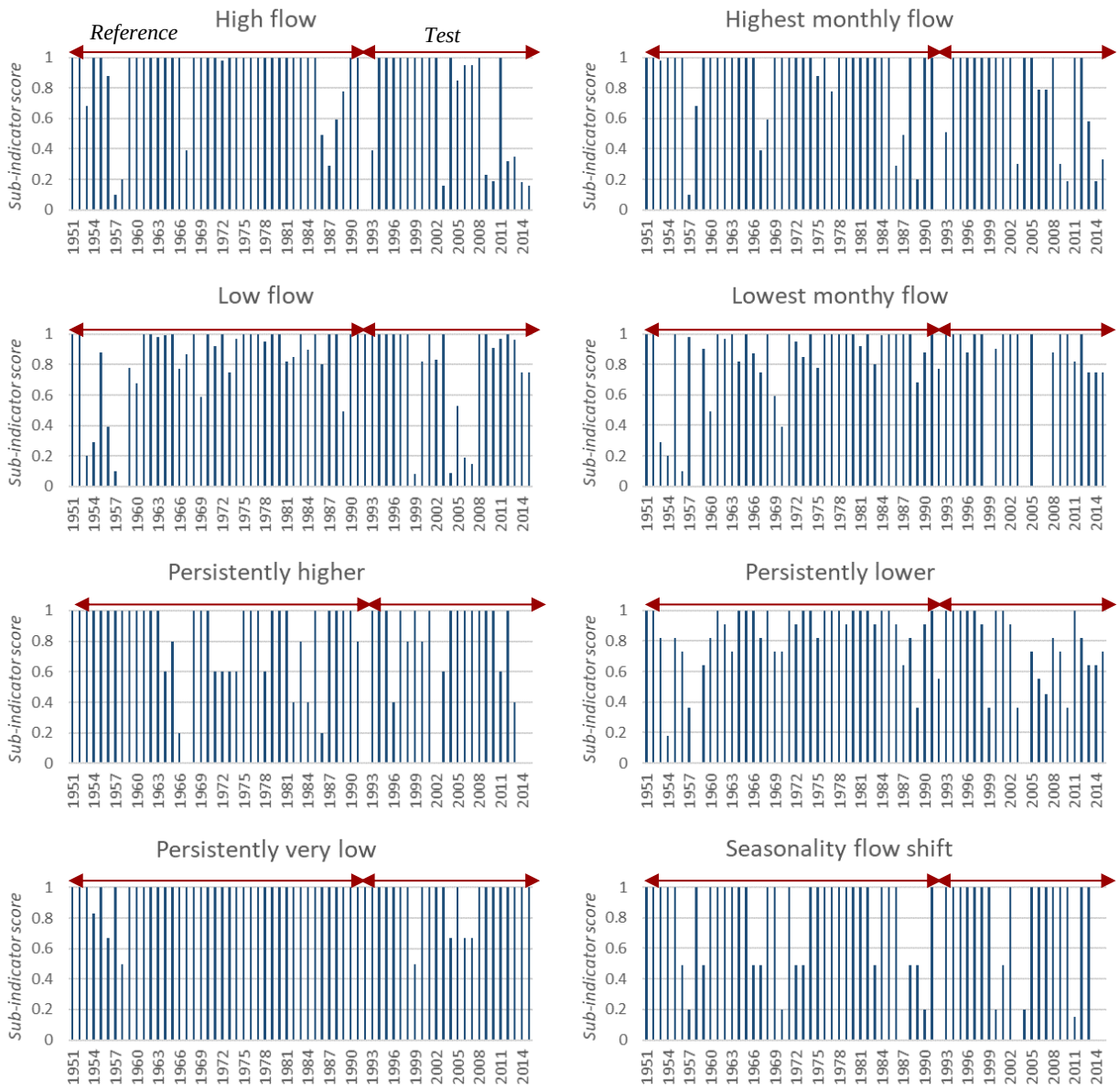


Figure 3.8: Flow Health sub-indicator scores for Luang Prabang (reference period of 1960 to 1992)



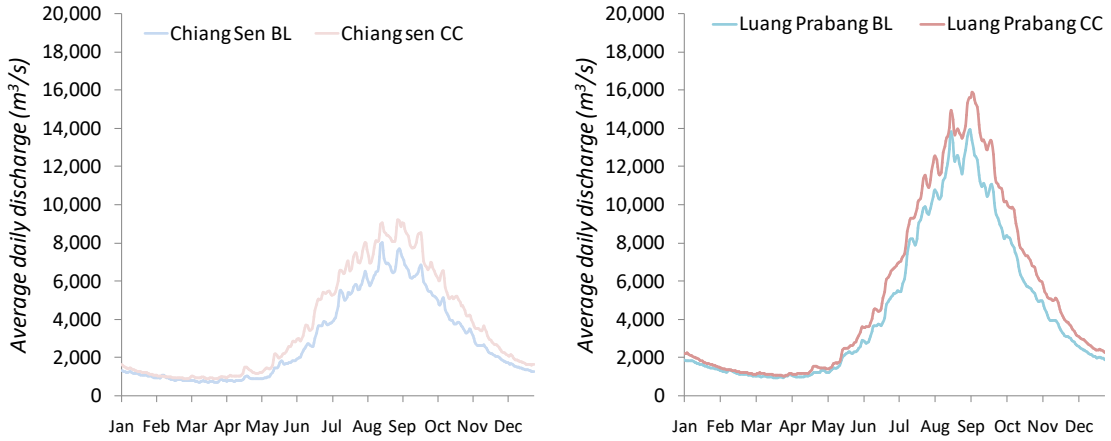
3.2.5.2 Land clearing and deforestation

Large scale land clearing and deforestation within a catchment can alter the availability of water by altering the rainfall-runoff relationship. Upstream of the study reach, in Yunnan, there has been a 22% decrease in percentage forest cover between 1960 and 2000, and a similar decrease in forest cover can be seen in the catchments of the tributaries entering the Mekong in the study reach (MRC, 2007). Over the same time period there has been no discernible increase in runoff volumes (Figure 3.1; Walling, 2008), so it appears that to date, the land use changes have not been significant enough to affect the hydrological regime of the study reach. This may change if deforestation of the upstream and tributary catchments continues.

3.2.5.3 Climate change

Climate change is projected to increase rainfall across the Mekong Basin, leading to increased annual flows in the Mekong mainstream (ICEM, 2013). At Chiang Saen and Luang Prabang the flow is projected to increase throughout the year, with the greatest increases occurring during the wet season (Figure 3.9). 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 (ICEM, 2013).

Figure 3.9: Projected changes in hydrographs at Chiang Saen and Luang (BL = 1980 to 2005 and CC = 2045 to 2069)



3.3 SEDIMENT TRANSPORT CURRENT STATUS AND TRENDS

The main drivers of sediment transport are: i) sediment supply to the river from upstream and from within the reach; and ii) the river's sediment transport capacity which is a measure of the ability of the river to transport sediment downstream.

3.3.1 Sediment supply

Sediment supply is the amount of sediment entering the channel within the study reach. There are three key sources of sediment: i) upstream catchments; ii) tributaries with confluences in the study reach; and iii) erosion of the bed and bank within the study reach. The study reach has been identified as an area of net deposition, meaning that the amount of sediment entering the river along the study section is less than that leaving. This is not to say that sediment is not transported along or out of the reach, just that on-balance sediment accumulates within the reach.

Box 2: A word of caution

Whilst numerous studies have been undertaken on sediment transport in the Mekong, there is little research available that is focussed on the current study reach, this means that any conclusions are drawn from broader research within which the study reach was included. In addition, a number of studies have raised issues with historical sediment data for the Mekong, suggesting that it has been collected with inconsistent methods, measuring different parameters and often provides widely variying estimates (Walling, 2008 and others). Finally, the current study was not able to access any sediment time series data for the study reach. Given these issues, the general trends should still be seen as reliable but the exact values provided should be viewed with some caution.

3.3.1.1 Upstream catchments

For the study reach, the upper basin is the main source of sediment supply. The catchments and the mainstream of the upper basin are steep and narrow, and soil erosion is a major issue leading to the production of a maximum Suspended Sediment Yield of 700 t/km^2/year (Walling, 2009). Due to this 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 (Walling 2009).

3.3.1.2 Tributary confluences

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.

Three key tributary characteristics were assessed through analysis of satellite imagery including catchment size, catchment land use and sediment deposits visible in the lower tributary. In general, a tributary with a large catchment containing large amounts of agriculture or mining is likely to have high sediment loads which would be visible as sediment deposits in the lower tributary. The three characteristics were assessed for the 14 largest tributaries with confluences within the study reach (Table 3.3).

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 sediment to the mainstream as they have medium sized catchments dominated by agriculture and sediment deposits visible in the lower tributary – Nam Tan, Nam Tha, Nam Ngao, Nam Ngam 2 and Nam Ngam 1.

Table 3.3: Tributary characteristics

Name	Catchment size	Catchment land use	Sediment deposits visible in lower tributary
Nam Khan	Large	Mostly forest	Yes
Nam Suong	Large	Agriculture/Forest	No
Nam Ou	Large	Agriculture/Forest	Yes
Nam Tan	Medium	Agriculture/Forest	Y
Nam Ngeun	Large	Forst/Mining/Agriculture	Yes
Nam Hop	Large	Forest/Agriculture	NA*
Nam Tha	Medium	Forest/Agriculture	Yes
Nam Ngao	Medium.	Agriculture/Urban/Forest	Yes
Nam Mae Ing	Large	Agriculture	No
Nam Ngam 2	Medium	Agriculture/Forest	Yes
Nam Ngam 1	Medium	Agriculture/Forest	Yes
Nam Keung L	Medium	Agriculture/Forest	No
Nam Mae Kok	Medium	Agriculture/Urban/Forest	No
Nam Mae Kham	Medium	Agriculture/Urban/Forest	No

NA* Not able to see the lower tributary due to obstructions in the satellite images

3.3.1.3 Erosion

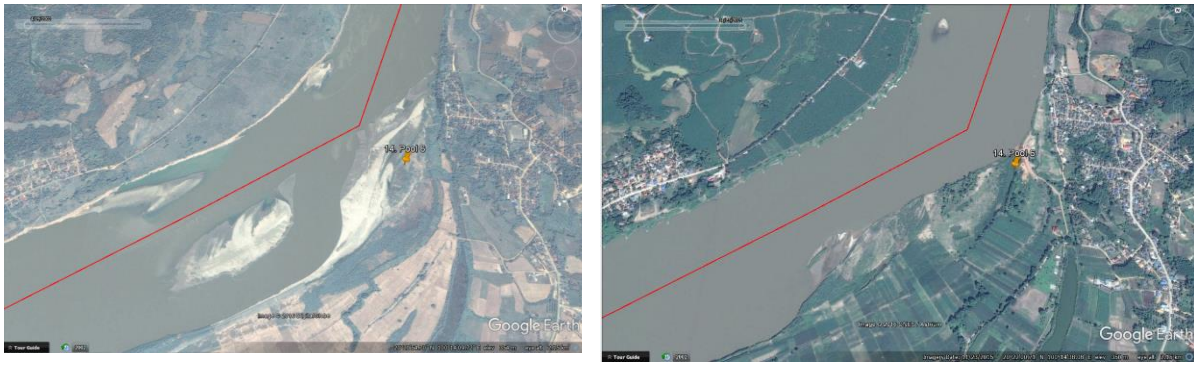
Whilst bank erosion occurs within the study reach, its contribution to sediment supply is likely to be limited compared to upstream catchments and tributaries. A 2004 report on a segment of the study reach found that only about 10% of the bank was exposed due to erosion or clearing of vegetation (Dubeau, 2004).

GoogleEarth's capacity to provide satellite imagery over various time periods enables analysis of bank erosion processes over time. In the study reach GoogleEarth tends to have imagery from 2002, 2013 and 2015, although the exact availability various throughout the reach. Using the satellite imagery available in GoogleEarth the study team confirmed that bank erosion does not appear to be a major sediment supply because:

- Meander migration in the unconfined sections has been limited between the early 2000s to 2015;
- No large areas of significant bank erosion could be identified throughout the study reach (needs to be confirmed through field visits);
- In the upper section of the study reach many of the bank terraces and in-channel bars have been colonized by vegetation between the early 2000s and 2014 (Table 4.1); and
- In the upper section there is examples of aggradation causing the channel to close and subsequent encroachment of agricultural fields into the river channel between the early 2000 to 2015 (Table 4.11).

Figure 3.10: Mekong River 4.4km below Chiang Saen showing vegetation of in-channel islands and bank terraces between February 2008 (left) and February 2014 (right)

Figure 3.11: Mekong River 40 km below Chiang Saen showing infilling of second channel and encroachment by agriculture between April 2002 (left) and November 2015 (right)

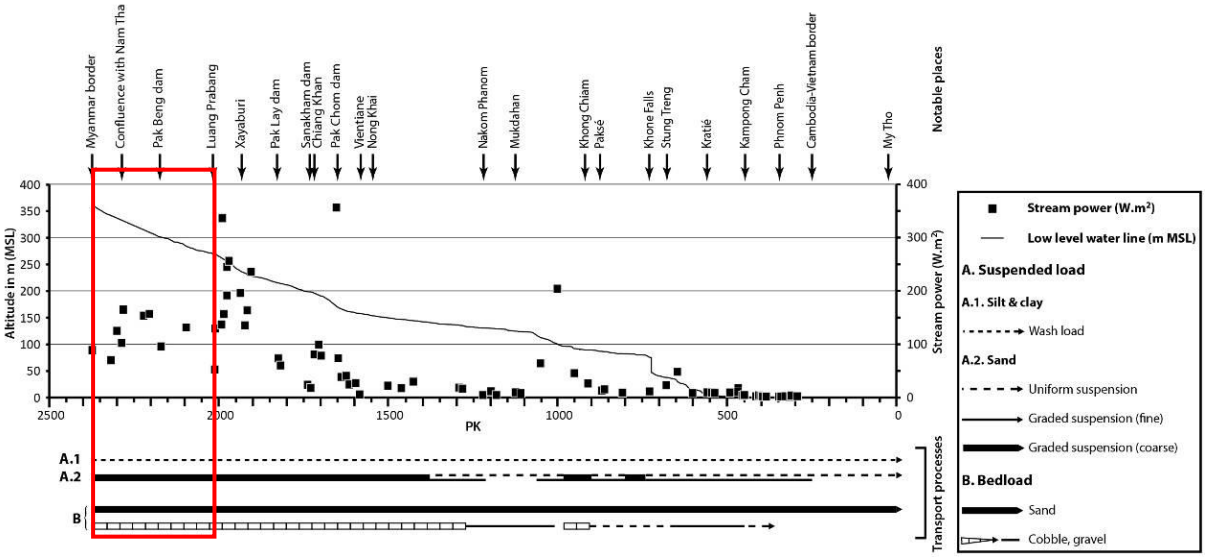


3.3.2 Sediment transport capacity

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. There are three key types of sediment transport: i) bedload consists of larger grain sizes that roll, slide or jump along the channel in frequent or continuous contact with the bed; ii) suspended load are smaller sized particles that are suspended above the bed for extended periods of time and transported downstream in the water column; and iii) washload is the portion of suspended load that is transported without deposition, essentially passing straight through the stream section (i.e. cannot be found on the bed).

A 2013 study undertaken by WWF-Greater Mekong and the University of Lyon computed unit stream powers along the Mekong. Unit stream powers are a measure of stream energy during small floods and is calculated based on slope, the 2 year ARI and channel width. Steam power provides an indication of the likley sediment sizes to be transported as suspended and bedload. For the study reach, the paper found that suspended load is comprised of silt and clay washload as well as graded coarse sand, and bedload is dominated by sand and gravel.

Figure 3.12: Long profile of the Mekong water level, downstream variation of stream power (black squares) and types of transport processes (Paul Bravard and Goichot, 2013). Study reach is indicated by the red box.



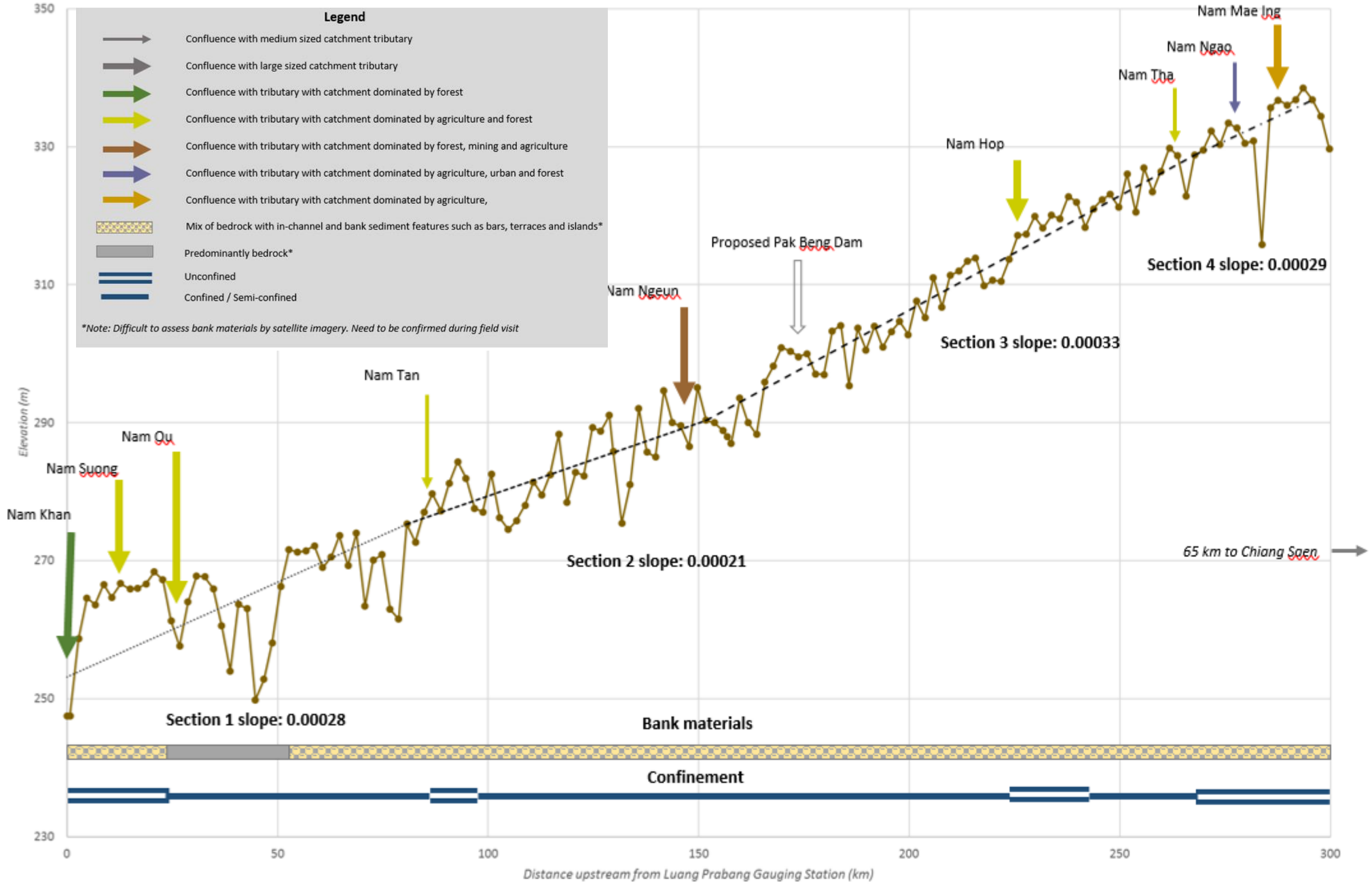
3.3.3 Longitudinal profile analysis

To assist in understanding sediment transport processes within the study reach a longitudinal section of the mainstream Mekong thalweg was obtained for the section of the study reach from Luang Prabang to 12km upstream of Nam Mae Ing. The longitudinal section was analysed to identify the mainstream slope, confluence with tributaries, bank materials visible from satellite imagery and level of river confinement based on satellite imagery (Figure 3.13). Key observations from this analysis include:

- Four slope sections are discernable
    - Section 1 with a slope of 0.00028 at the lowest end of the study section
    - Section 2 with a slope of 0.00024 beginning near the confluence with the Nam Tan and ending near the confluence with the Ngum Nguen
    - Section 3 with a slope of 0.00032 starting just upstream of the confluence with Ngum Nguen and ending just upstream of the Nam Tha, where the river leaves the section dominated by confined valleys
    - Section 4 with a slope of 0.00029 corresponding to the wider and meandering stream passing through an open valley downstream of Chiang Saen
- Most of the tributaries don't appear to have an influence on the long section, indicating they are unlikely to be supplying significant amounts of sediment compared to what the main river carries;
- The river bed appears to be degrading in the section of the Nam Nguen confluence, the reason for this is not clear and needs to be investigated during the field visit; and
- The river bed appears to be aggrading in the section of the Nam Tan confluence, the reason for this is not clear and needs to be investigated during the field visit.

Figure 3.13: Longitudinal section of the Mekong River thalweg from Luang Prabang to 300km upstream showing tributary confluences, bank materials and confinement

(note that approximately 50 km of the study reach is missing because the data could not be obtained)



3.3.4 Recent drivers of change

3.3.4.1 Change in land use

Large scale land clearing and deforestation within a catchment can increase the occurrence of catchment erosion and increase sediment loads. It is widely accepted that there has been a large increase in sediment loads in Asian rivers since civilisation began due to land use change. Upstream of the study reach, in Yunnan, there has been a 22% decrease in percentage forest cover between 1960 and 2000, and a similar decrease in forest cover can be seen in the catchments of the tributaries entering the Mekong in the study reach (MRC, 2007). This deforestation and intensification of land use has been linked to increasing sediment loads in the Upper Mekong from the 1970s, and to an increase in annual suspended sediment load at Chiang Saen and Luang Prabang between the 1960s and early 2000s (Figure 3.14) (Walling, 2008).

Figure 3.14: Comparison of annual suspended sediment load of the Mekong River at Chiang Saen, and Luang Prabang for 1961 with the load for a recent year and similar water discharge (Walling, 2008)

Station	Sediment load 1961 (10^6 t)	Water discharge 1961 (10^9 m^3)	Recent sediment load (10^6 t)	Recent water discharge (10^9 m^3)
Chiang Saen	71.3	92.0	81.1 (2002)	89.2 (2002)
Luang Prabang	112.4	126.6	118.4 (1997)	118.4 (1997)

However, sediment loads are highly variable and this increase observed in the Walling results may not be a good indication - differences of this magnitude are well within inter-annual variability.

3.3.4.2 Urban development and embankment construction

Temporal analysis of satellite imagery has identified that:

- There has been numerous embankments built within the study reach, particularly on the Thai side (Figure 3.15), this may decrease erosion on the bank where the embankment is constructed but is likely to cause erosion on the opposite bank or further downstream; and
- Rapid urban development has occurred along many sections of the river (Figure 3.16).

It is not clear how these developments are impacting on sediment transport along the study reach. Field visits are required to understand how sediment transport processes are being affected by these developments.

Figure 3.15: Construction of embankments between 2013 (left) and 2015 (right)

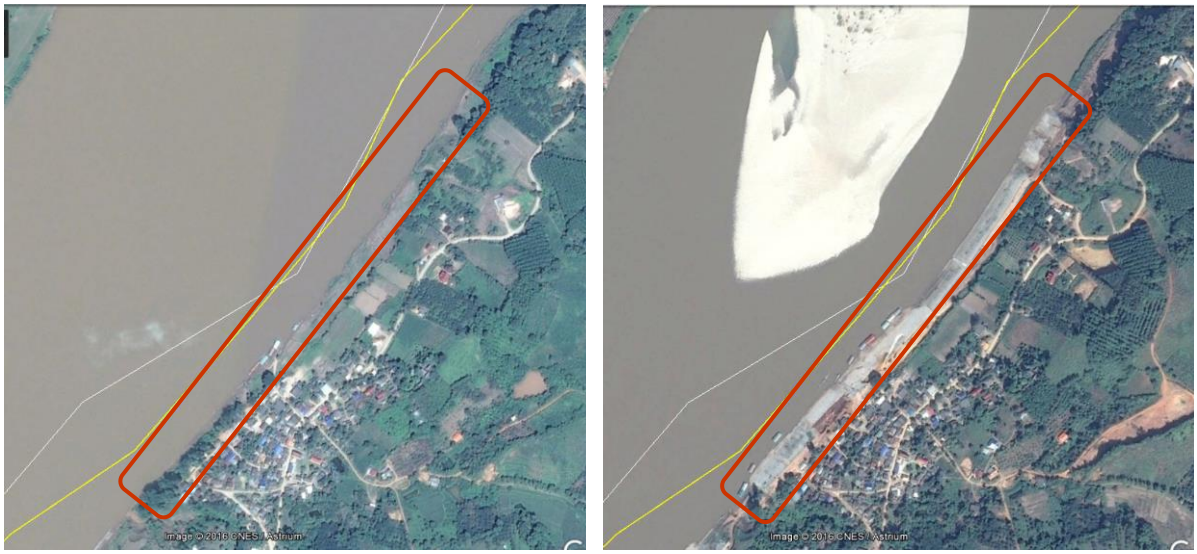
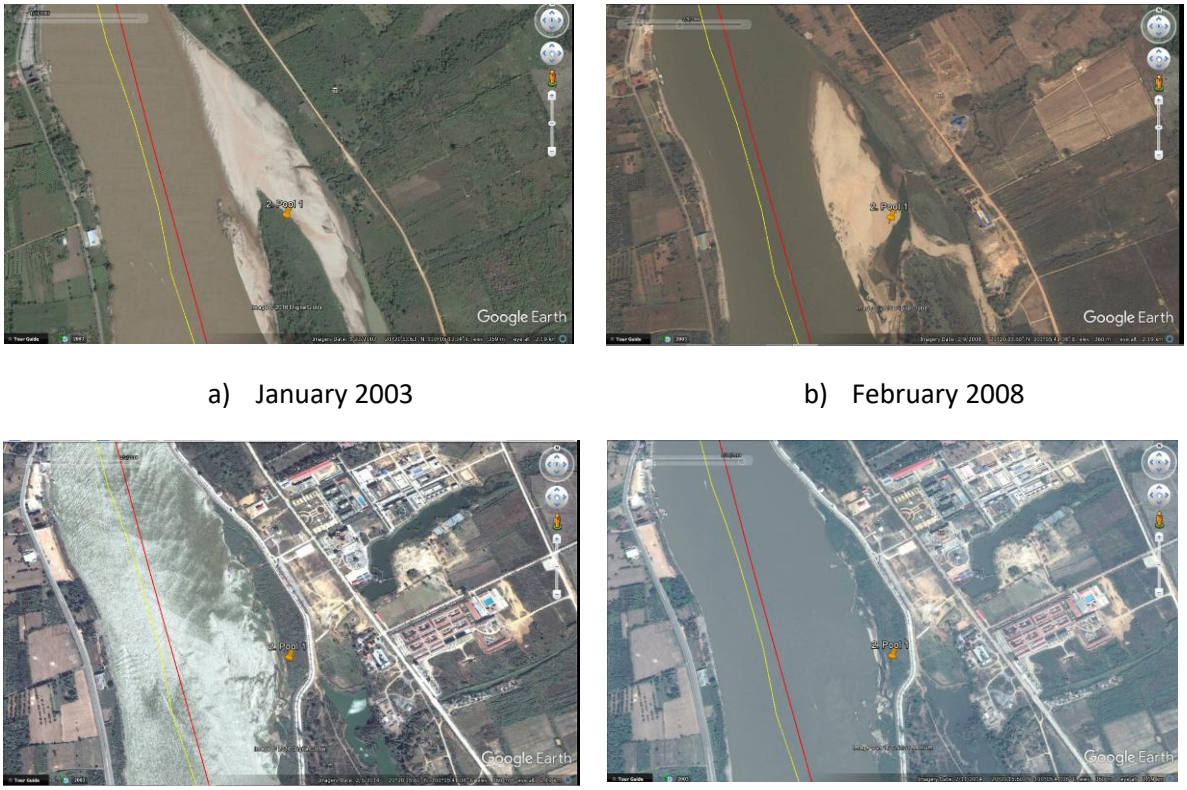


Figure 3.16: Mekong River at Chiang Saen showing major development works and vegetation of terraces



a) January 2003

b) February 2008

c) 5th February 2014 (river in flood)

d) 11th February 2014 (river in flood)

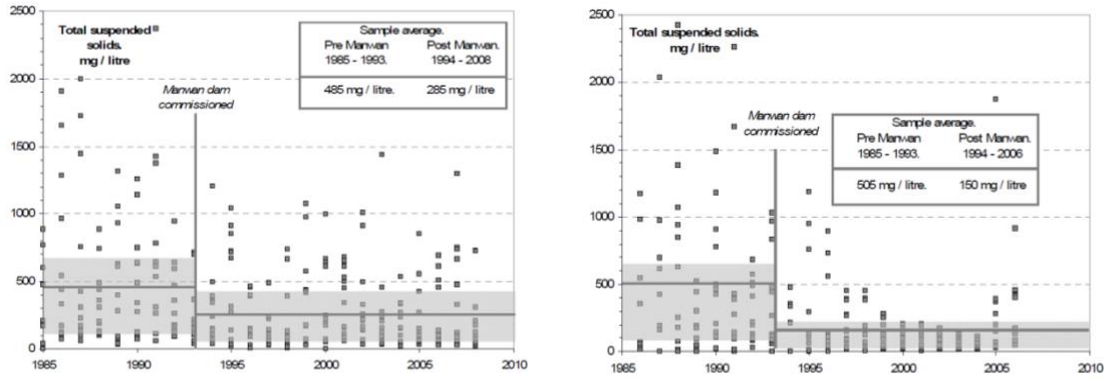
3.3.4.3 Upper Mekong dams

Reservoirs tend to trap sediment as reduced velocity leads to suspended sediment dropping out, and the physical barrier of the dam wall traps sediment. Analysis of sediment time series data by the MRC (2003) and others including peer reviewed literature (Adamson, 2009; Kummu and Varu, 2007) suggest

that there has been a significant reduction in suspended sediment concentrations at Chiang Saen after 1992 (Figure 3.17). This is likely to continue and worsen as more reservoirs are constructed upstream (Walling, 2008).

In addition, communities within the study reach have reported unusual water fluctuation patterns – likely to be related to upstream reservoir operations - that may accelerate and intensify river bank erosion (Lazarus et al, 2006).

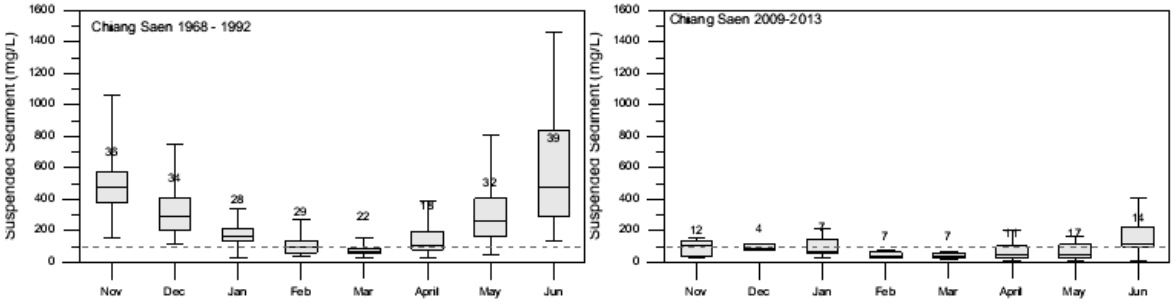
Figure 3.17: Comparison of pre and post Manwan reservoir construction TSS concentrations at Chiang Saen (left) and Luang Prabang (right) (Adamson, 2009)



However, TSS is not a good indicator of sediment transport as it is based on one sample from the surface. It is also possible that Walling didn't find a decrease in his comparison above because the impact of the dams hadn't kicked in yet. During this period there was probably a lot of construction sediment still working its way through the system as well. It is much more certain that a very large decrease in sediment has occurred since 2011 following closing of two of the largest dams. Sediment loads measured by the MRC at Chiang Saen and Luang Prabang in 2013 were ~10 Mt/yr and ~24 Mt/yr, respectively.

Decreases in suspended sediment also allows greater light penetration into the water column, and could contribute to increased algal activity during periods of low river flow (MRC, 2018).There has been a large reduction in suspended sediment concentrations (Figure 3.18) associated with development in the Upper Mekong Basin, which has reduced median suspended sediment concentrations to <100 mg/L for 6-months of the year (2009 – 2013) as compared to 2-3 months of the year prior to 1993 (MRC, 2018).

Figure 3.18: Comparison of suspended sediment concentrations at Chiang Saen during the dry season in 1968 to 1992, and 2009 to 2013 (Source: MRC, 2018)



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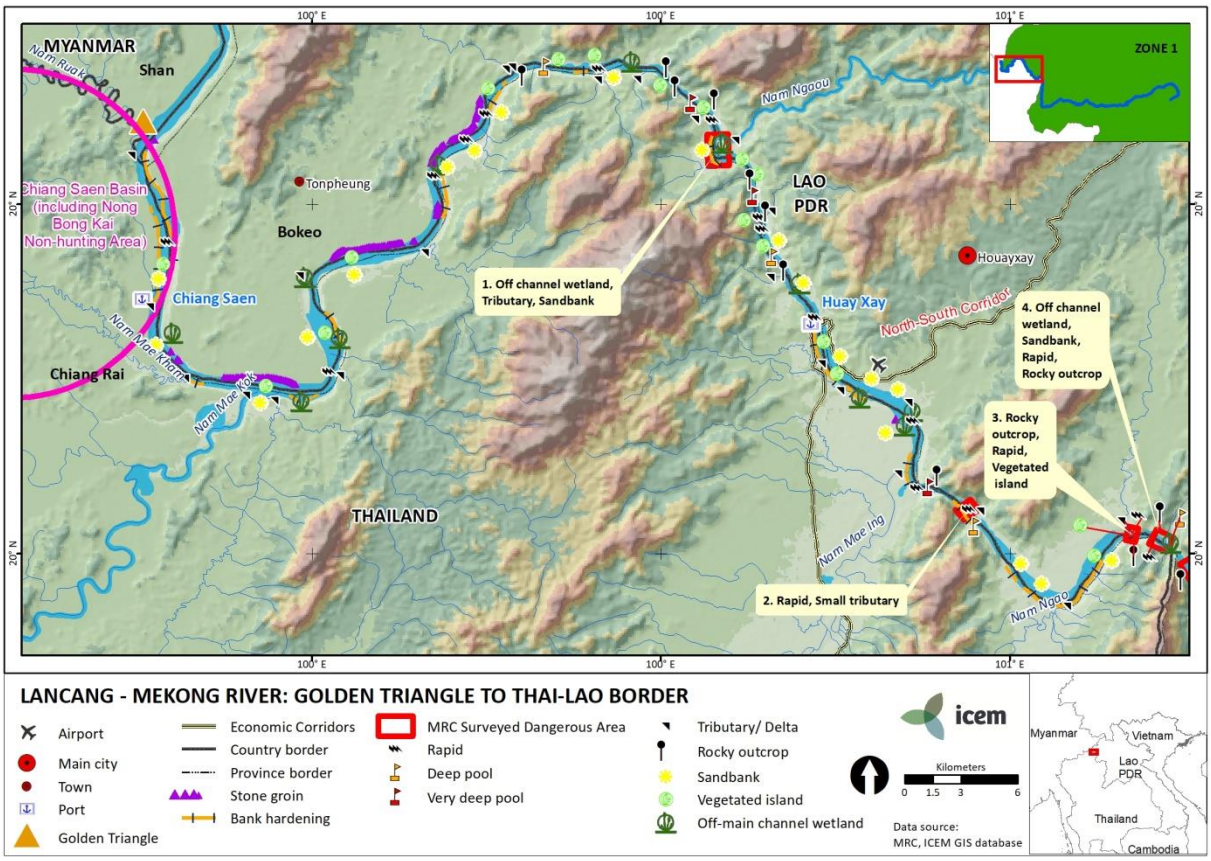
4 AQUATIC BIODIVERSITY AND WETLANDS BASELINE

4.1 OVERVIEW OF THE RIVER REACHES FROM CHIANG SAEN TO LUANG PRABANG

4.1.1. Chiang Saen to Pak Tha/ Lao PDR Thai border (Zone 1 - Figure 4.1)

The Mekong River from Chiang Saen to the Lao PDR and Thai border/ Pak Tha (98km) is relatively more developed than the lower two sections, particularly on the Thai side. Typically it has a wider channel and is sandier with more numerous and larger sand islands. The terrain either side of the river is mostly flat, particularly on bends where there are typically large alluvial floodplains with cropping or settlements. There are fewer rocky outcrops and dangerous areas.

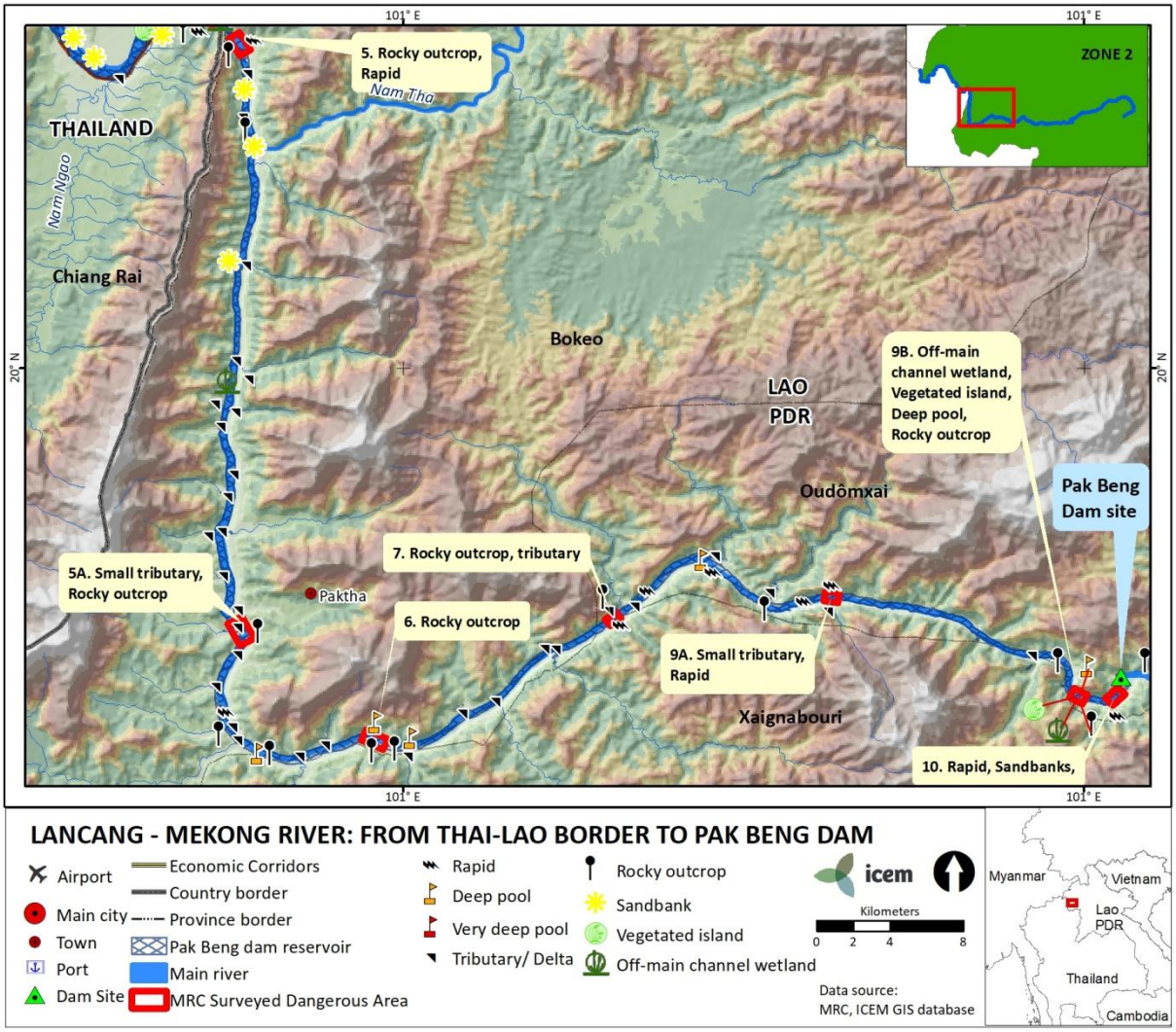
Figure 4.1: Zone 1 from the Goldern Triangle/ Chaing Saen to the Lao PDR and Thai border/ Pak Tha



4.1.2. Pak Tha to Pak Beng HPP dam site (Zone 2 - Figure 4.2)

The river in this section (94 km) is narrower, more incised, straighter and rockier than the first section. The terrain is steep with short steep valleys running perpendicular to the river down the sides of mountains, creating many small tributaries. The section is less developed with no large towns and has significant forest cover. There are more dangerous areas for navigation.

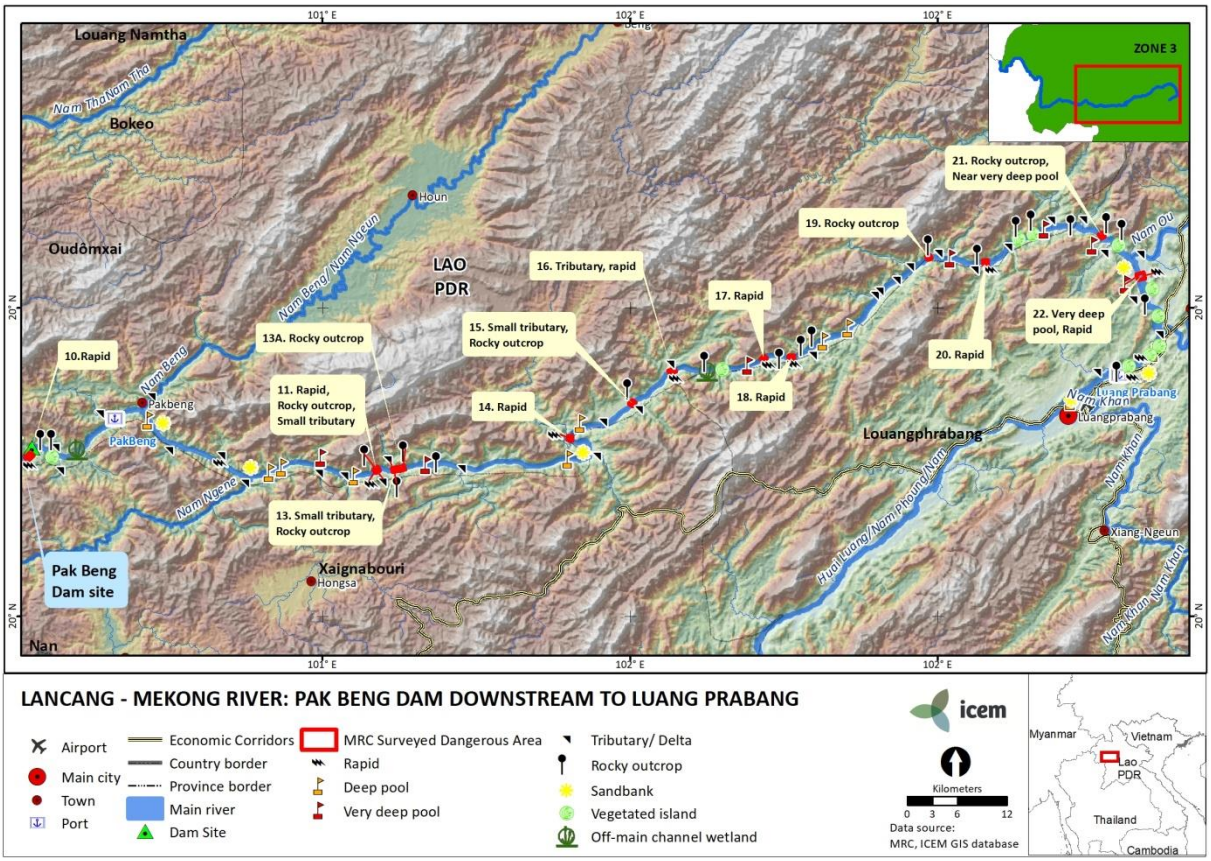
Figure 4.2: Zone 2 Lao PDR and Thai border/ Pak Tha to the Pak Beng HPP dam site



4.1.3. Pak Beng Dam to Luang Prabang (Zone 3 - Figure 4.3)

The river remains relatively narrow and rocky throughout this long section (176 km) with steep forested terrain and many dangerous areas. However, the valleys run more parallel to the river in this section compared to the previous section but there are still many small tributaries entering. The river widens and development increases closer to and including Luang Prabang.

Figure 4.3: Zone 3 Pak Beng HPP dam site downstream to Luang Prabang



In summary, the three zones have distinctive features and varying compositions of various habitat types (Table 4.1) supporting aquatic biodiversity. A summary description of the 10 km reaches between Chiang Saen and Luang Prabang is provided in Appendix 4.

Table 4.1: Habitat types and number in each of the three ES study zones

Environmentally sensitive habitats			
Habitat	**Zone 1**	**Zone 2**	**Zone 3**
Vegetated Islands	18	1	10
Deep pool	4	5	10
Very deep pool	3	0	7
Rapid	15	8	10
Rocky outcrop	10	11	18
Sandbank	19	3	6
Tributary/ Delta	23	33	33
Off-main channel wetland	12	2	2

4.2 WATER QUALITY

There are three water quality monitoring locations for this stretch of the Mekong that have been monitored by the MRC since 2004. These are listed in Table 4.2 and shown in Figure 4.4. These sampling sites are monitored on a monthly basis for different parameters as shown in Table 4.3.

Table 4.2: MRC water quality monitoring stations in the study reach

Station No.	Name of station	Station ID	River	Countries	Latitude	Longitude
1	Houa Khong	H010500	Mekong River	Lao PDR	21.5471	101.1598
2	Chiang Saen	H010501	Mekong River	Thailand	20.2674	100.0908
3	Luang Prabang	H011200	Mekong River	Lao PDR	19.9000	102.0000

Figure 4.4: Locations of MRC water quality sampling stations

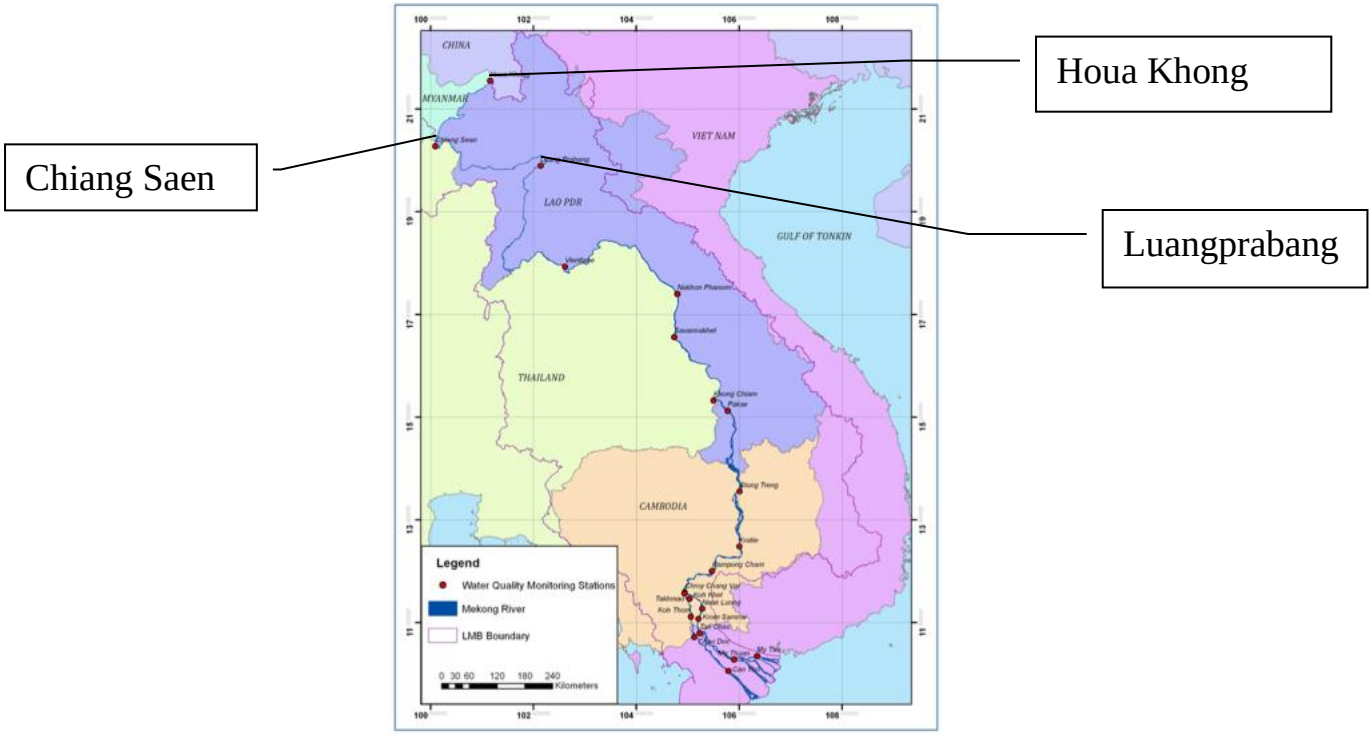


Table 4.3: Water quality parameters measured on a monthly basis

Analytical parameter	Recommended analytical methods
Temperature	2550-Temp/SM
pH	4500-H^+/SM
Conductivity (Salinity)	2510-Ec/SM
Alkalinity/ Acidity	2320-A/SM
Dissolved Oxygen (DO)	4500-O/SM
Chemical Oxygen Demand (COD)	Permanganate Oxidation
Total phosphorous (T-P)	4500-P/SM

Total Nitrogen (T-N)	4500-N/SM
Ammonium (NH_4-N)	4500-NH_4/SM
Total Nitrite and Nitrate (NO_{2-3}-N)	4500-NO_{2-3}/SM
Faecal Coliform	9221-Faecal Coliform group/SM
Total Suspended Solid	2540-D-TSS-SM
Calcium (Ca)	3500-Ca-B/SM
Magnesium (Mg)	3500-Mg-B/SM
Sodium (Na)	3500-Na-B/SM
Potassium (K)	3500-K-B/SM
Sulphate (SO_4)	4500- SO_4–E/SM
Chloride (Cl)	4500-Cl/SM

Statistical trend analysis has been prepared for these parameters between 2000 and 2015, and three indices of water quality have been developed for each site –

- Water Quality Index for the Protection of Aquatic Life (WQIal)

Parameters	Target Values
pH	6 – 9
EC (mS/m)	< 150
NH3 (mg/L)	0.1
DO (mg/L)	> 5
NO2-3 – N (mg/L)	0.5
T-P (mg/L)	0.13

Rating Score	Class
9.5 ≤ WQI ≤10	A: High Quality
8 ≤ WQI < 9.5	B: Good Quality
6.5 ≤ WQI < 8	C: Moderate Quality
4.5 ≤ WQI < 6.5	D: Poor Quality
WQI < 4.5	E: Very Poor Quality

- Water Quality Index for the Protection of Human Health with a focus on Human Acceptability (WQIha)

Parameters	Target Values
pH	6 – 9
EC (mS/m)	< 150
NH3 (mg/L)	0.5
DO (mg/L)	4
NO2-3 – N (mg/L)	5
COD (mg/L)	5
BOD (mg/L)*2	4

Rating Score	Class	Description
95 ≤ WQI ≤100	A: Excellent Quality	All measurements are within objectives virtually all of the time
80 ≤ WQI < 95	B: Good Quality	Conditions rarely depart from desirable levels
65 ≤ WQI < 80	C: Moderate Quality	Conditions sometimes depart from desirable levels
45 ≤ WQI < 65	D: Poor Quality	Conditions often depart from desirable levels
WQI < 45	E: Very Poor Quality	Conditions usually depart from desirable levels

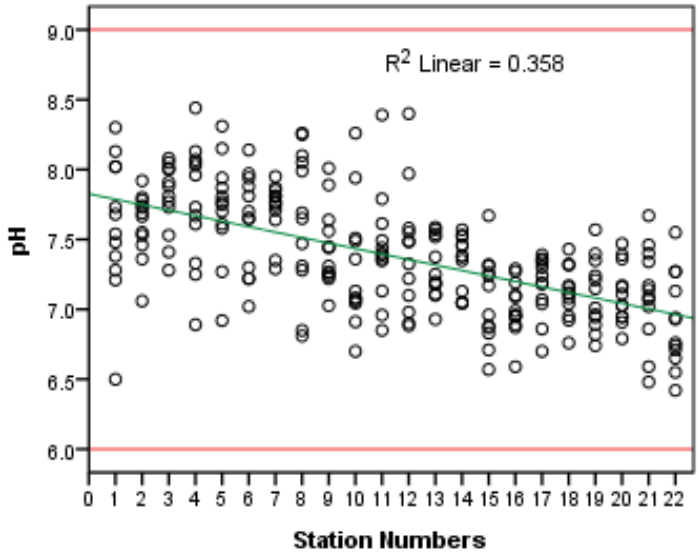
- Water Quality Index for Agricultural Use, which is divided into two categories i) general irrigation and ii) paddy rice has also been prepared, but since this is more applicable to reaches where saline intrusion could be a problem, this has not been considered here.

The results of the different parameters are shown in the following Figures, which show the median for the dataset, the upper and lower quartiles and the maximum and minimum values of the dataset.

4.2.1 pH

The pH in the first three sampling locations generally appears to be between 7.0 and 8.0 with a mean value around 7.7. There is one outlier in the Houa Khong site where the pH fell to 6.5. The lower threshold for pH is at 6.0, which was not approached in any of the three sites. In the Mekong sampling sites as a whole, there is a trend towards decreasing pH downstream, i.e. moving towards more neutral levels (Figure 4.5).

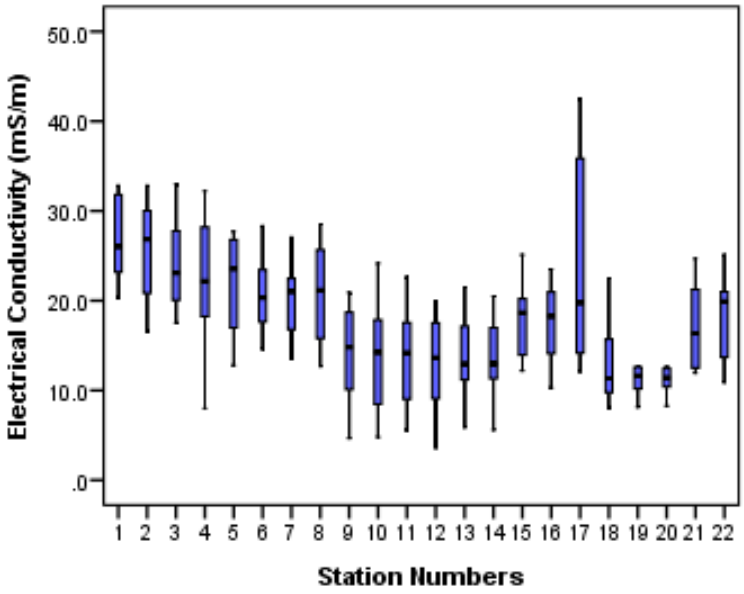
Figure 4.5: pH linear regression for Mekong sampling sites



4.2.2 Electrical conductivity

The first three sampling sites show consistent ranges between 20 and 30 mS/m, with a general trend towards decreasing Ec downstream, increasing again in the Delta (Figure 4.6).

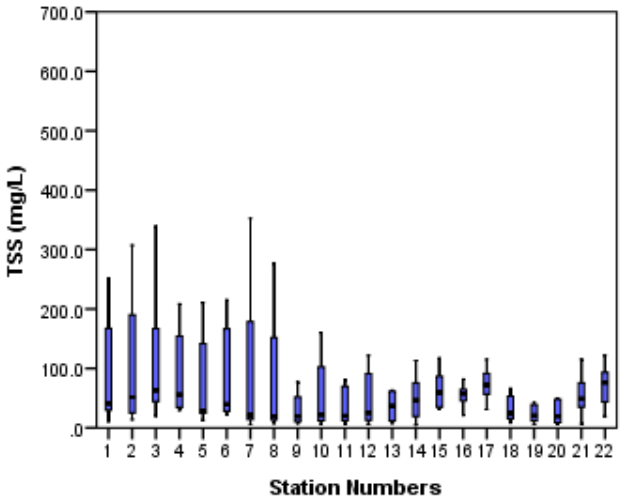
Figure 4.6: Electrical conductivity ranges for Mekong sampling sites



4.2.3 Total Suspended solids

The TSS values for the first three sampling sites, show ranges up to 300 mg/l with median values between 30 and 50 mg/l (Figure 4.7). The Luangprabang site appears to have higher TSS content, perhaps because of the influence of the Nam Ou, which has been a significant contributor to sediment in this stretch of the Mekong.

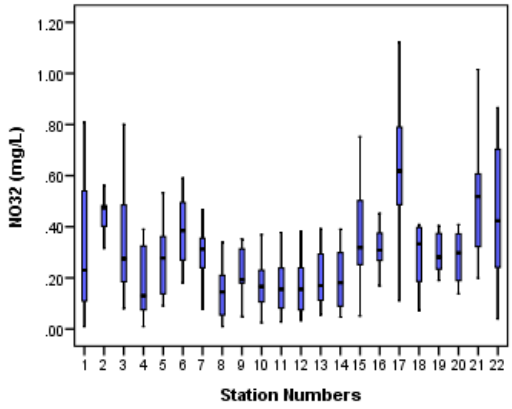
Figure 4.7: Total suspended solids in Mekong sampling sites



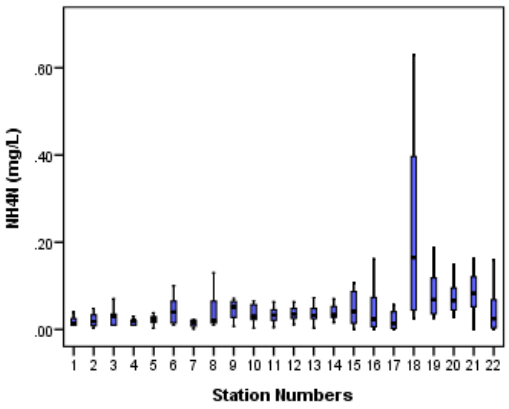
4.2.4 Nutrients – Oxides of Nitrogen, Ammonium, Phosphorus

Considering the first three stations, the oxides of nitrogen show quite a bit of variation especially at Houa Khong and Luangprabang, which have up to 0.8 mg/l of $NO_{3/2}$, while the results at Chiang Saen are much more consistent between 0.4 to 0.5 mg/l (Figure 4.8). This appears to be higher than in sampling stations further down the Mekong, and may reflect nutrient contributions from China. By contrast, Ammonium figures for the first three stations are consistently low – less than 0.02 mg/l which reflects the high oxygenation levels in the Mekong in this stretch (Figure 4.8). The total Phosphorus figures for stations 1 – 3 are similar to the oxides of nitrogen, with very high figures at the Houa Khong site, also emphasizing nutrient input to the Mekong from China (Figure 4.8).

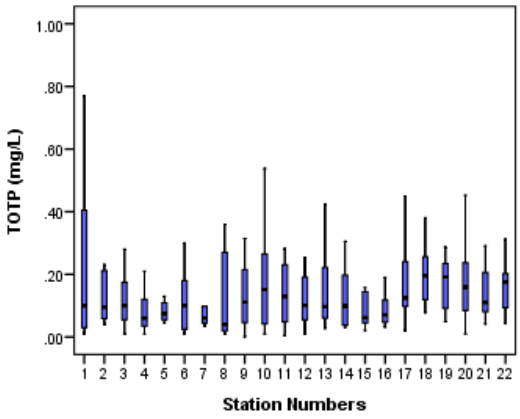
Figure 4.8: a) Oxides of Nitrogen, b) Ammonium and c) total Phosphorus in Mekong sampling sites



a)



b)



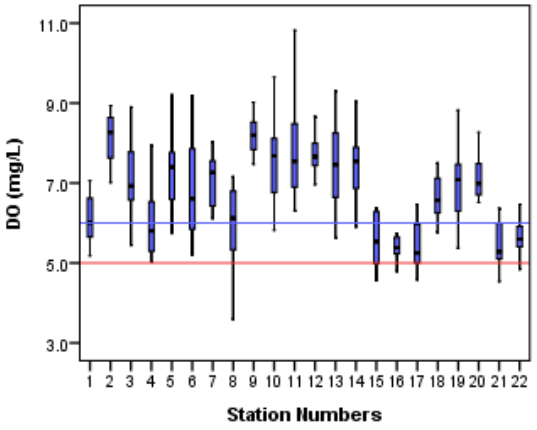
c)

4.2.5 Dissolved Oxygen and Chemical Oxygen Demand

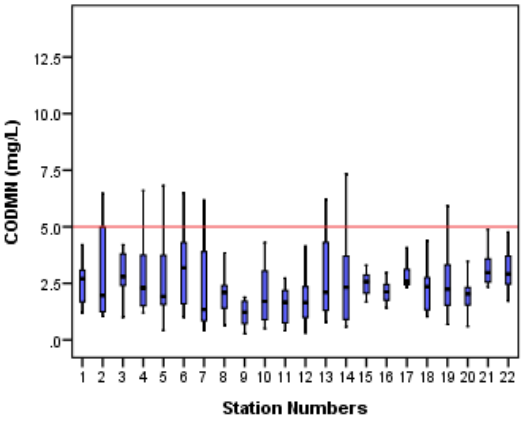
The Dissolved Ogygen figures for the Mekong in the first three sampling sites show consistently high levels of DO, well above the 5.0 mg/l standard, and generally above the mean value for all sites on the Mekong (Figure 4.9). The Chiang Saen and Luangprabang DO content generally lies above 7 mg/l.

The COD figures for the first three stations are also generally below the 5.0 mg/l standard lying between 2.5 and 4 mg/l, though the Chiang Saen results show that occasionally they can be higher than this (Figure 4.9).

Figure 4.9: a) Dissolved Oxygen and b) COD in Mekong sampling sites



a)



b)

4.2.6 Water quality Index for Protection of Aquatic Health

When these results are combined into the Index for Protection of Aquatic Health as shown in Table 4.4, all three upper stations have a Good Quality Rating (B) for 2015, though there has been a decline in water quality since 2011 when all three 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 Chiang Saen has generally been less good than the Houa Khong and Luangprabang sites.

Table 4.4: Water Quality Index for Protection of Aquatic Health

No.	Station Names	Rivers	Countries	2009	2010	2011	2012	2013	2014	2015
1	Houa Khong	Mekong	Laos	A	A	A	B	B	B	B
2	Chiang Saen	Mekong	Thailand	B	B	A	B	B	A	B
3	Luang Prabang	Mekong	Laos	A	B	A	A	B	B	B
4	Vientiane	Mekong	Laos	A	A	A	A	B	B	A
5	Nakhon Phanom	Mekong	Thailand	A	B	A	B	B	A	A
6	Savannakhet	Mekong	Laos	A	A	A	A	B	B	B
7	Khong Chiam	Mekong	Thailand	A	A	A	A	B	A	A
8	Pakse	Mekong	Laos	A	A	A	A	B	B	B
9	Stung Trieng	Mekong	Cambodia	B	B	B	B	B	B	B
10	Kratie	Mekong	Cambodia	B	B	B	B	B	B	B
11	Kampong Cham	Mekong	Cambodia	B	B	B	B	B	A	B
12	Chrouy Changvar	Mekong	Cambodia	B	B	B	B	B	B	B
13	Neak Loung	Mekong	Cambodia	B	B	B	B	B	B	B
14	Kaorm Samnor	Mekong	Cambodia	B	B	B	B	B	B	B
15	Tan Chau	Mekong	Viet Nam	B	B	B	B	B	B	B
16	My Thuan	Mekong	Viet Nam	B	B	B	B	B	B	B
17	My Tho	Mekong	Viet Nam	C	C	C	B	C	C	C
18	Takhmao	Bassac	Cambodia	B	B	B	B	B	B	B
19	Koh Khel	Bassac	Cambodia	B	B	B	B	B	B	B
20	Koh Thom	Bassac	Cambodia	B	B	B	B	B	A	B
21	Chau Doc	Bassac	Viet Nam	B	B	B	B	B	B	B
22	Can Tho	Bassac	Viet Nam	C	C	C	C	C	B	B

A: High; B: Good; C: Moderate; D: Poor; E: Very Poor

4.2.7 Water Quality Index for Protection of Human Health

The water quality index for Protection of Human Health is a higher standard, reflecting the acceptability of river water for human use as shown in Table 4.5. 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.

Table 4.5: Water Quality Index for Protection of Human Health

No.	Station Names	Rivers	Countries	2009	2010	2011	2012	2013	2014	2015
1	Houa Khong	Mekong	Laos	A	A	A	B	B	B	B
2	Chiang Sean	Mekong	Thailand	B	B	A	B	B	A	B
3	Luang Prabang	Mekong	Laos	A	B	A	A	B	B	B
4	Vientiane	Mekong	Laos	A	A	A	A	B	B	A
5	Nakhon Phanom	Mekong	Thailand	A	B	A	B	B	A	A
6	Savannakhet	Mekong	Laos	A	A	A	A	B	B	B
7	Khong Chiam	Mekong	Thailand	A	A	A	A	B	A	A
8	Pakse	Mekong	Laos	A	A	A	A	B	B	B
9	Stung Trieng	Mekong	Cambodia	B	B	B	B	B	B	B
10	Kratie	Mekong	Cambodia	B	B	B	B	B	B	B
11	Kampong Cham	Mekong	Cambodia	B	B	B	B	B	A	B
12	Chrouy Changvar	Mekong	Cambodia	B	B	B	B	B	B	B
13	Neak Loung	Mekong	Cambodia	B	B	B	B	B	B	B
14	Kaorm Samnor	Mekong	Cambodia	B	B	B	B	B	B	B
15	Tan Chau	Mekong	Viet Nam	B	B	B	B	B	B	B
16	My Thuan	Mekong	Viet Nam	B	B	B	B	B	B	B
17	My Tho	Mekong	Viet Nam	C	C	C	B	C	C	C
18	Takhmao	Bassac	Cambodia	B	B	B	B	B	B	B
19	Koh Khel	Bassac	Cambodia	B	B	B	B	B	B	B
20	Koh Thom	Bassac	Cambodia	B	B	B	B	B	A	B
21	Chau Doc	Bassac	Viet Nam	B	B	B	B	B	B	B
22	Can Tho	Bassac	Viet Nam	C	C	C	C	C	B	B

A: Excellent; B: Good; C: Moderate; D: Poor; E: Very Poor

4.3 RIVER HEALTH

The MRC carries out regular assessments of Aquatic Ecological Health of the river in similar locations as the water quality sampling. In this section of the Mekong, it has three locations where it has sampled at Ban Xiengkok (LMX) close to Houa Khong, at Chiang Saen (TCS) and at Luangprabang (LPB). The Aquatic Ecological Health index is built up from an analysis of four different types of aquatic organism resident at the locations.[3] Their diversity and populations reflect the longer-term conditions in the

[3] MRC (2010) Biomonitoring methods for the Lower Mekong basin. Mekong River Commission, Vientiane

MRC (2014) Report on the 2011 biomonitoring survey of the Lower Mekong River and selected tributaries. MRC Technical Paper. Mekong River Commission, Vientiane

MRC (2014) Report on the 2013 biomonitoring survey of the Lower Mekong River and selected tributaries. MRC Technical Paper. Mekong River Commission, Vientiane

water and capture an indication of health of the river better than spot water quality sampling. The four types of organism are:

- Benthic diatoms
- Zooplankton
- Littoral macroinvertebrates
- Benthic macroinvertebrates

Three biological metrics are used - species abundance, average species richness and Avergae Tolerance Score per Taxon (APST). A healthy aquatic ecosystem is indicated by high abundance, high average species richness and a low APST. A low score APST score reflects the relative abundance of disturbance-sensitive species.

Class A (Excellent): 10 – 12 of the 12 indicators meet the guidelines. The biodiversity and ecological capacity to support fish and other freshwater functions are similar to those at the reference sites defined by the surveys done in 2004 – 2007. These reference sites provide a baseline against which other sites can be measured. Minimal disturbance from human activities. Reference sites in 2004/5 included 2 sites on the Nam Ou, the Luangprabang site and on the Mekong about 7 km downstream of Chiang Khong/Houai Xai bridge.

Class B (Good): 7 – 9 of the 12 indicators meet the guidelines. The biodiversity and ecological capacity are slightly less than at the reference sites. Human activities may have caused some disturbance.

Class C (Moderate): 4 – 6 of the 12 indicators meet the guidelines. The biological and ecological capacity are markedly less than at the reference sites. Disturbance resulting from human activities is present

Class D (Poor): 0 -3 of the 12 indicators meet the guidelines. The biodiversity and ecological capacity are significantly less than that at the reference sites. Various disturbances from human activities a likely to be present

The results of the Aquatic Health Index for the three sites on the Mekong and one tributary (Nam Mae Kok) and downstream in Vientiane are shown in Table 4.6. This clearly shows that the aquatic health of the river just downstream of the border with China at Ban Xiengkok, has been consistently disturbed by human activities, though it may have improved somewhat in the 2013 survey.

The Chiang Saen site shows consistently good ecological health score and the Luangprabang site, has shown excellent to good scores over the years but was not sampled in 2013.

Table 4.6 : Aquatic Ecological Health Index scores, 2005 – 2013

Site Code	Location	Year			
		2005	2008	2011	2013
LMX	**Mekong River, Ban Xiengkok, Luangnamtha**	B	D	D	C
TCS	**Mekong River, Chiang Saen, Chiang Rai**		B	B	B
TKO	Kok river, Chiang Rai city	A	A	B	B
LPB	**Mekong River, Done Chor, Luangprabang**	A	B	A	x
LVT	Mekong River, Ban Huayhone, Vientiane		B	C	C

During a field survey in March 2017 of the stretch between Chiang Saen to Luangprabang, sampling of littoral macroinvertebrates was undertaken and the rapid macroinvertebrate assessment of river health was carried out using the assessment method developed by The Asia Foundation[4] for use in on the Xe Bang Fai in Lao PDR. Based upon the presence of different groups of macroinvertebrates with different sensitivities to disturbance (human activities and pollution), the river health score may be calculated as detailed in Annex 1 and summarized in Table 4.7. Each of the locations sampled were found to fall into the **Fair** river health score, though some locations had a higher diversity river health score than others. The differences may be explained by the differences in substrate and vegetation found in the sampling sites, rather than real differences in river health.

Table 4.7: Rapid macroinvertebrate assessment of river health between Chiang Saen and Luangprabang

Name	GPS no	Point description	River health score
Don Tu	20° 23.877'N 100° 18.096'E	Large island – mainly sand with gravel channels. Grasses growing on higher areas and overhanging water. Homonia shrubs in water. Midstream	**6.0**
Khon Phi Luang	20° 22.786'N 100° 21.179'E	Midstream. Rocky island with sand, grasses, Homonia shrubs	***6.6***
Chong Xai	20° 19.422'N 100° 22.811'E	Sandbank. Sampled inlet behind bank with overhanging grasses. Right bank	**4.6**
Don Ngao 1 - shallow pool left in sand	20° 9.904'N 100° 32.444'E	Right bank. Large sandy island with grasses on higher parts and channel running through it. Vegetation sweeps.	**4.75**
Don Ngao 2 – leading edge grasses in water	20° 9.845'N 100° 32.357'E		
Khon Kham island	20° 10.557'N 100° 33.446'E	Mid-stream. Rocky island at beginning of rapid with small sandy beach. Consists of many large boulders, covered with tall grasses, surrounded by Homonia in water.	**6.5**
Ban Houay Thong 1 - river	20° 9.025'N 100° 35.337'E	Left bank. Pebble and sand flats in front of ponds and gold panning workings, with Homonia shrubs. Sampled in vegetation and pebbles on river and in small pond behind the bank. + Big water beetle	**4.75**
Ban Houay Thong 2 – pond 10 m from river			
Kheang Phak	19° 52.649'N 100° 34.968'E	Clayey/muddy bank, with Homonia shrubs Left bank	**4.7**
Houay Khouak downstream of Khon Din	19° 52.854'N 100° 46.515'E	Small stream on right bank just upstream of village. Steep banks, gravelly muddy bottom, not much vegetation in water. Trees on banks above stream. Small fish.	**6.7**
Houay En	19° 49.332'N 101° 23.181'E	Small stream on right bank. Flowing down sandy bank. Varied substrate, boulders, small rocks, gravel and sand with small pools and runs.	**6.7**

[4] The Asia Foundation, Macroinvertebrate Sampling Manual
https://asiafoundation.org/publication/community-water-quality-monitoring/
http://lovelaos.org/love-our-water/

Name	GPS no	Point description	River health score
Ban Khokkham	20° 5.185'N 102° 9.788'E	Left bank opposite limestone cliff. Bank consists of sloping limestone slab with small sandy/earth beech (with earthworm diggings) at one end, and overhanging grass and Homonia bushes at the other end	**6.0**
Island downstream of Kheang Leuk	20° 1.670'N 102° 13.236'E and 20° 1.742'N 102° 13.181'E	Large sandy island, with some clay and gravel layers, and occasional bedrock outcrops. Mixed Sample 1) amongst Homonia shrubs along channel (small mayflies and crustacea 2) back pond with dragonfly larvae and chironomids. On the island a group of 14 villagers were panning for gold.	**5.2**

4.4 Aquatic and riparian habitats and Biodiversity[5]

4.4.1 Geomorphology

The geomorphology of this section of the Mekong from the Chinese border through to Luangprabang 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. The MRC Discharge and Sediment Monitoring Project shows that 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.

In 2003 and 2004 IUCN undertook two surveys to assess the biodiversity of the stretches of the Upper Mekong between Xieng Kok and Houay Xai (2003)[6] and between Houay Xai and Louangprabang (2004)[7]. The geomorphology of the river was described in the diagrams below.

Figure 4.10 shows the river features in the upper part of the river down to Houay Xai. The clear differences of the plain river stand out, with very few features from the Golden Triangle around Chiang

[5] Significant contributions to this section was drawn from Mekong River Commission (MRC). 2017. The Council Study: Study on the sustainable management and development of the Mekong River, including impacts of mainstream hydropower projects. Biological Resource Assessment Final Technical Report Series. Volume 1: Specialists' Report. Vientiane, Laos PDR. 697 pp.

[6] Author: ed. Meynell, P.J. (August 2003) Scoping Study for Biodiversity Assessment of the Mekong River in Northern Laos and Thailand, IUCN Mekong Water and Nature Initiative and Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, Bangkok.

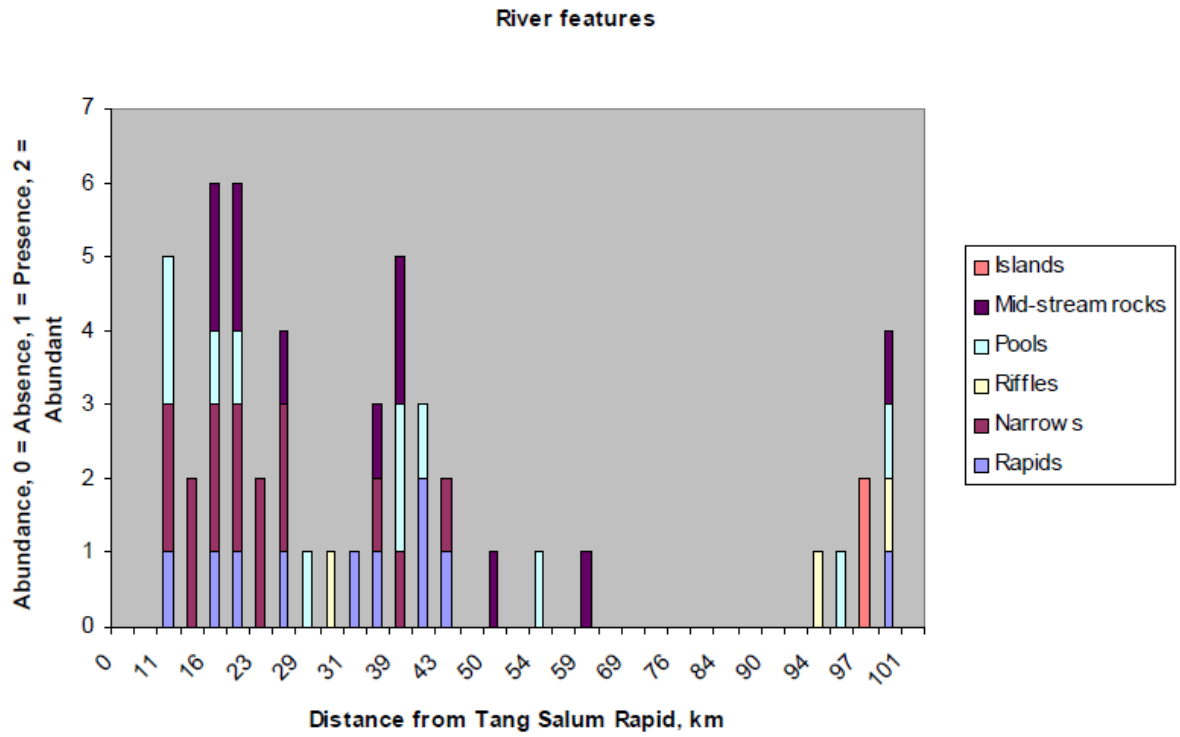
[7] ed. Dubeau, P. (October 2004) Follow-up Survey for Biodiversity Assessment of the Mekong River in Northern Lao PDR, IUCN Water and Nature Initiative and Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, Bangkok.

Saen down around the big bend to the Don Tu island compared to the upper reaches and the islands and rapids (Khon Pi Louang) before Houay Xai.

The river bank character in the same stretch is shown in

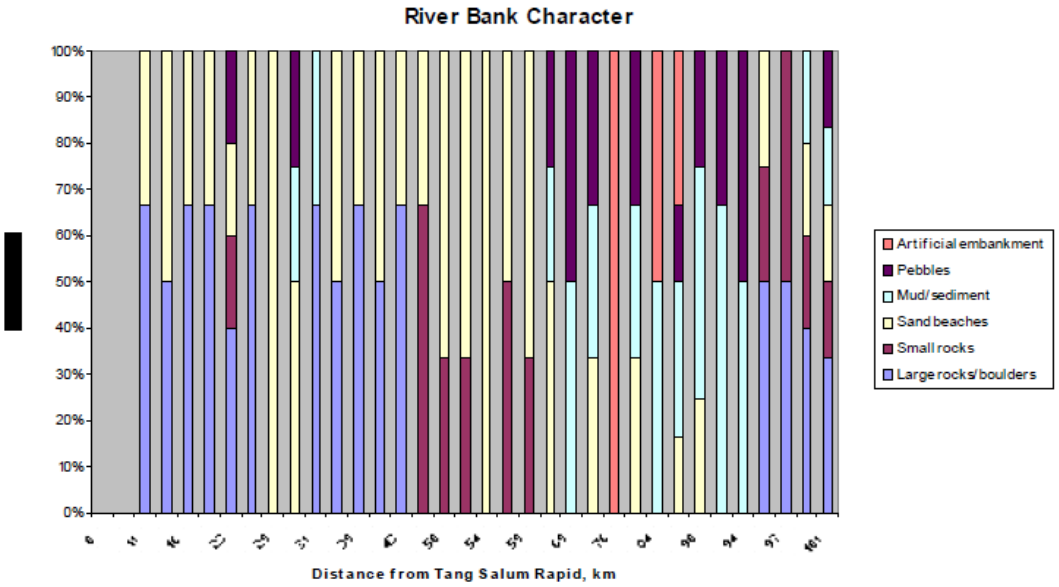
Figure 4.11. The reach between the Golden Triangle and the Thai-Lao border also stands out as being very different from the upper and lower reaches with mainly alluvial banks (sand, mud/sediment and some pebbles) compared to the large rocks and small rock banks. In 2003, the artificial embankments around Chiang Saen on both Thai and Laos sides (km 76).

Figure 4.10: River features in the Mekong in the stretch between the Tang Salum rapid (upstream Ban Xieng Kok)



Source: Meynell 2003. Note that Chiang Saen is located between km 64 - 69.

Figure 4.11: River bank character in the Mekong in the stretch between the Tang Salum rapid (upstream Ban Xieng Kok)



Source: Meynell 2003. Note that Chiang Saen is located between km 64 - 69.

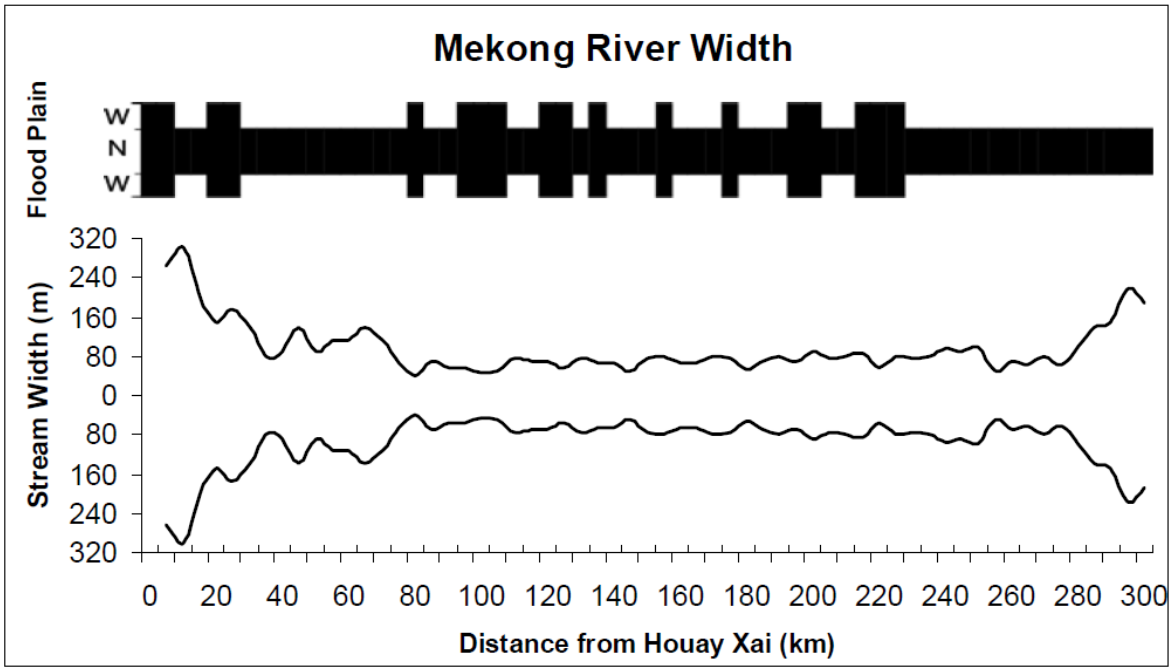
Houay Xai to Louangprabang

Figure 4.12 shows the variation in width of the dry season channel and floodplain between Houay Xai and Louangprabang. This shows the significant narrowing of the river after Houay Xai until the confluence with the Nam Ou.

Figure 4.13 shows the occurrence of islands, narrows and midstream rocks in the same stretch, and

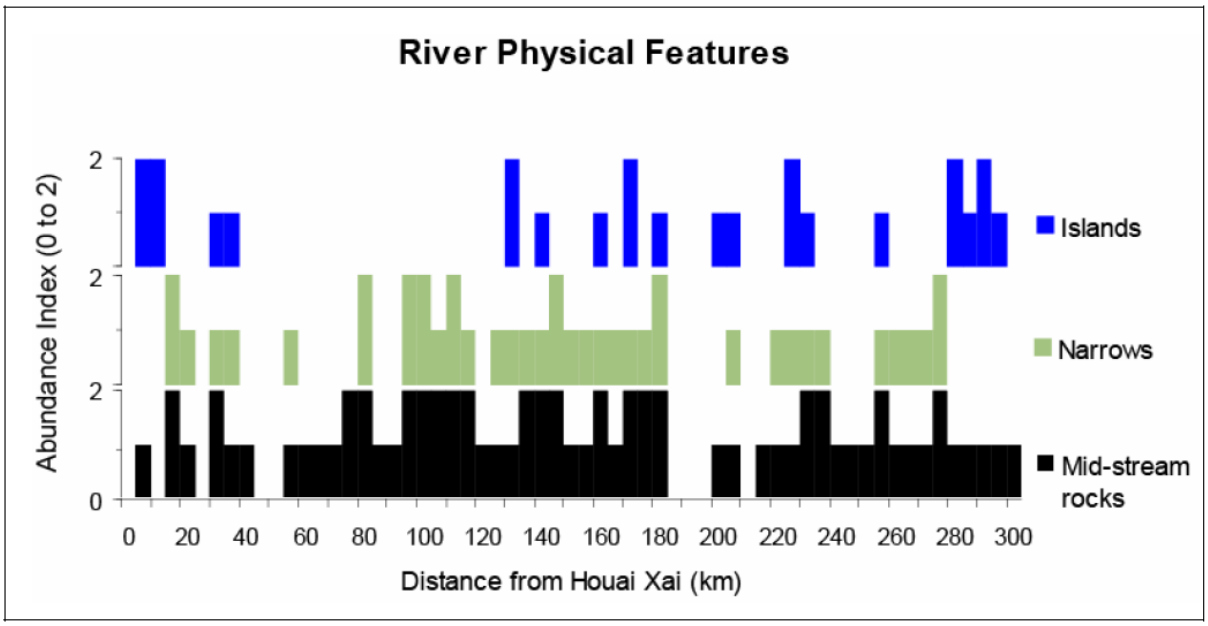
Figure 4.14 shows the correlation of stream flow characteristics with geomorphological features such as rapids, riffles, plain channels and pools.

Figure 4.12: Estimated bankfull and dry season stream width of the Mekong river between Houay Xai and Louangprabang



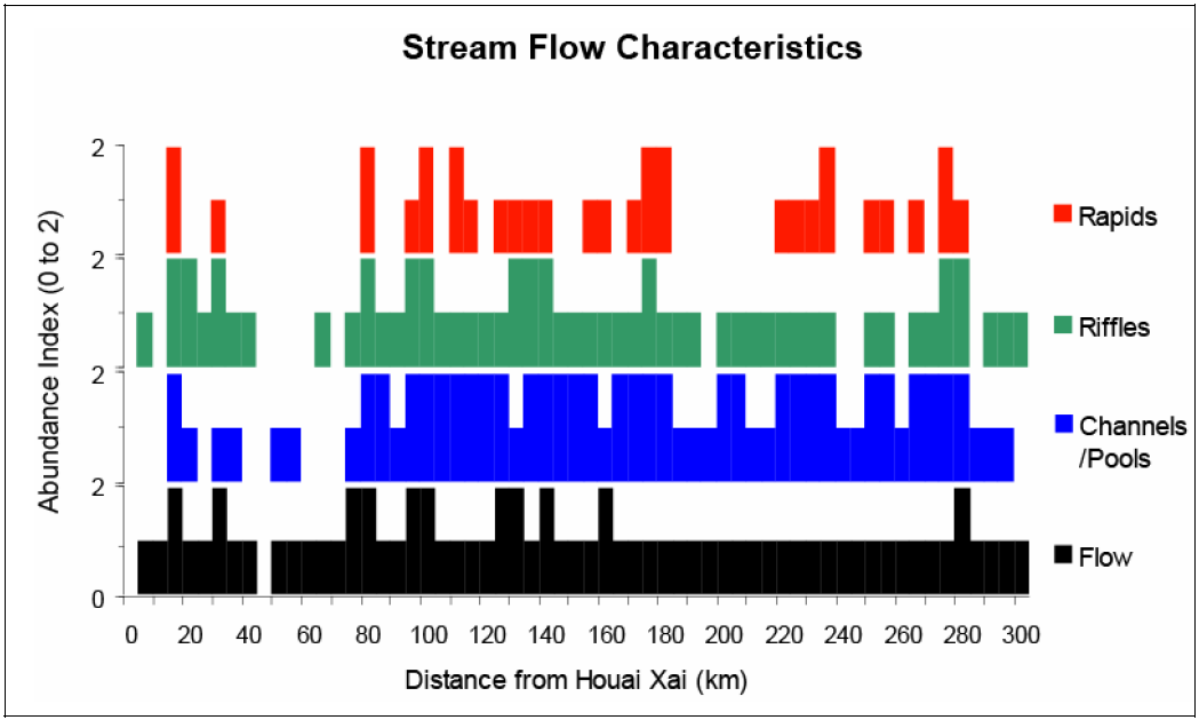
Source: Dubeau 2004. Main Channel Estimated Bankfull Width (Bottom) and Floodplain Width, Narrow/Wide (Top)

Figure 4.13: Occurrence of islands, narrows and mid-stream rocks in the Mekong river between Houay Xai and Louangprabang



Source: Dubeau 2004. Index of Abundance, Absence = 0, Presence = 1, Abundant = 2

Figure 4.14: Stream flow characteristics in the Mekong river between Houay Xai and Louangprabang



Source: Dubeau 2004. Index of Abundance : Absent = 0, Present = 1, Abundant = 2

The IUCN 2003 survey identified different wetland habitat types along the Mekong shown in **Error! Reference source not found.**. It is noted that there is a large wetland complex in the floodplain of the Nam Mae Kok just before its confluence near Chiang Saen new port. Within this floodplain area is the Ramsar site of Nong Bong Kai Non-hunting area. This area is only indirectly connected hydrologically with the Mekong.

Table 4.8: Wetland habitats along Mekong between Chiang Saen and Louangprabang

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 forest	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 rocky/sandy/muddy substratum

Source: Meynell, 2003.

4.4.2 Aquatic 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 rheophytes are confined to the lower parts of the channel, since they can not compete with higher forest trees and shrubs which are found further up the banks. They provide important refuges and food for aquatic fauna and fish during the flood season.

The middle and upper horizons of shoreline vegetation are mostly short trees, shrubs and lianas such as *Derris alborubra* Hemsl., *Premna scandens* Roxb., *Drypetes salicifolia* Ganegp., *Ficus kurzii*, with distinctive local mixtures of *Polyalthia modesta*, *Eugenia mekongensis*, *Xantonnea parviflora*, and *Phyllanthaus jullienii*, and rheophytes, such as Artabotrys, several Eugenia, Rhododendron, Salix, and Ficus. Although not considered a problem in this stretch of the river, the invasive *Mimosa pigra*, out competes many native shoreline species, and now occurs in some locations.

Further up the banks, secondary rainforest species grow such as Spondias, Hopea, Bischoffia, Mallotus, Celtis, and Elaeocarpus. However, most of these are severely disturbed and are dominated by bamboos.

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.

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. Typical species of grasses include *Saccharum spontaneum, Phragmites vallatoria, Eleusine indica*, and *Hemisorhum mekongense*. Weedy forbs include *Portulaca oleracea, Ludwigia hyssopifolia, Anaphalis margaritacea, Physalis angulata, Chenopodium fcilifolium, Amaranthus viridian, Polygonum plebeium, Rumex dentatus*, among many others, including some exotic invasives. These sandbars and banks are very dynamic and come and go from year to year, and this type of vegetation can establish itself within a season and be washed away in the next flood season. This type of vegetation is found throughout and provides fish food, breeding grounds, and cover for many types of vertebrates and invertebrates.

The vegetation section of the MRC Council Study, BioRa provides a very useful set of indicators of changing ecological conditions which are relevant to this section of the upper Mekong (

Table 4.9).

Table 4.9: Vegetation indicators used by the MRC Council Study BioRa process

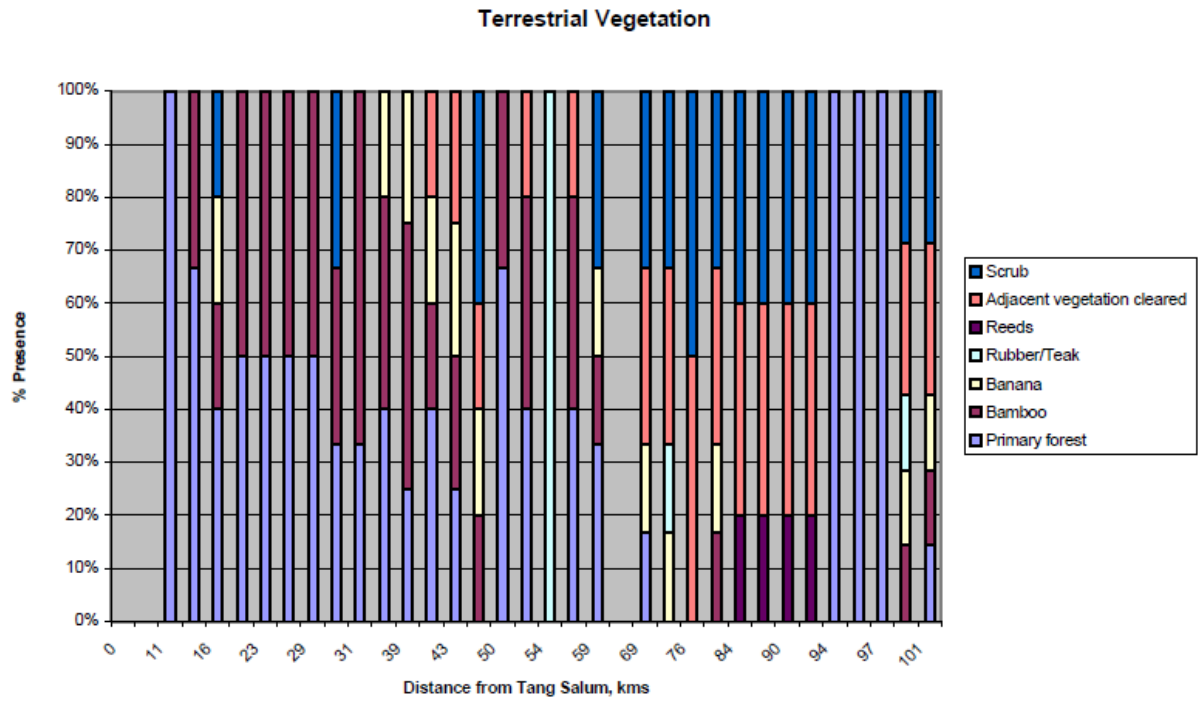
BioRa Indicator	Indicator species/groups of species	Reasons for selection
Channel_Riparian trees	*Acacia harmandiana, Zyzygium mekongensis, Phyllanthus jullienii, Salix tetrasperma, Anogeissus rivularis,*	Encountered widely, frequently or not, riparian trees can dominate banks and represent a substantial portion of the system's biomass. They often serve as keystone species as producers and providers of cover, roosting and/or nesting space for other creatures.
Channel_Extent of upper bank vegetation	*Derris alborubra, Premna scandens, Drypetes salicifolia, Ficus heterophylla, Rubus spp.*	Frequently encountered and sometimes subdominant species that occur sporadically in different Focus Areas. They are exclusive to this Indicator.
Channel_Extent of lower bank vegetation	*Homonoia riparia, Eugenia mekongensis, Phyllanthus mekongensis, Phyllanthus jullienii, Telectadium edule, Acacia harmandiana*	Frequently encountered and sometimes subdominant species that occur sporadically in different Focus Areas. They are exclusive to this Indicator.
Channel: Weeds, grasses on sandbanks and sandbars	*Digitaria spp, Rumex dentatus, Rorippa indica, Ludwigia hyssopifolia, Grangea maderaspatan, Fibristylis* spp.	Dominate disturbed areas caused either by fast-moving currents across soft substrates or human activities. Being dominant as a vegetation type, they comprise a substantial portion of the biomass and provide critical cover for many animals.
Channel_Biomass freshwater algae	*Cladophora glomerata, Aegagropila linnaei*	These specific algae are collected to sell commercially. Countless other benthic and planktonic forms serve as a crucial link in food chains.

The 2003 and 2004 surveys by IUCN noted the changing patterns of terrestrial vegetation between ban Xieng Kok and Houay Xai and down to Louangprabang.

Figure 4.15 shows that in the upper stretches the landscape was largely forested with patches of bamboo and increasing rubber and teak and some bananas. Around Chiang Saen there is no vegetation cover and around the big bend to Don Tu there were large expanses of cleared land and scrub, with some bamboo on the river banks. In the area around Khon Pi Luang, the hillsides are largely forested.

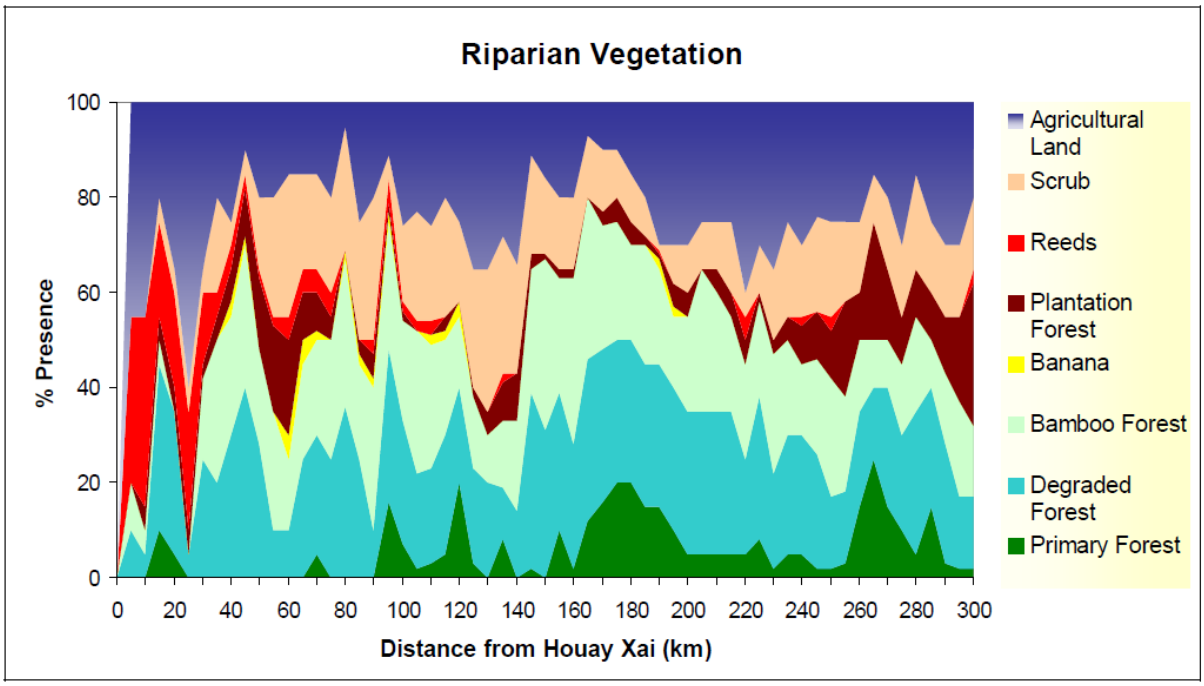
Figure 4.16 shows the patterns of terrestrial vegetation along the stretch between Houay Xai and Louangprabang. Forest (principally secondary and degraded forest with bamboo made up about 50% of the landscape, with some plantations and scrub. Agricultural land made up about 24% of the land cover.

Figure 4.15: Estimates of riparian vegetation in 2003 every 5 km between Tang Salum (Ban Xieng Kok) and Houay Xai



Source: Meynell 2003. Note that Chiang Saen is located between km 64 - 69.

Figure 4.16: Estimates of riparian vegetation in 2004 every 5 km between Houay Xai and Louangprabang



Source: Dubeau 2004

4.5 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 from the genera Baetis, Platybaetis, Gratia, and Centroptilum. Elmid beetles and snails (Lacunopsis) are taxa that live on stone or rock in fast current, feeding by scraping biofilms of the stone surfaces. The sand deposits are often very dense and do not provide a good substrate for many macroinvertebrates.

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 March 2017 survey, see Annex 1. Freshwater prawns (Macrobrachium spp) as 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 Luangprabang.

The in-channel vegetation provides, 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. These habitats are suitable for dragin flies (Odonata) and Water bugs and beetles (Hemiptera and Coleoptera).

The IUCN Redlist Assessment for freshwater species has been carried out for Bivalve and Gastropod molluscs, Dragonflies (Odonata) and Crustacea and the Integrated Biodiversity Assessment Tool (IBAT) provides the ranges of these species by HydroBasin. Consolidating the lists for this section of the Mekong to show the possible presence of 19 Bivalve species of which 5 are still Data Deficient, and 14 are of Least Concern. There are 24 Gastropod species of which 18 are Least Concern and 6 are data deficient.

There are 183 species of Odonata that may be found with the HydroBasins in this stretch of the Mekong, of which 11 are Data deficient, 169 are Least Concern, 2 are considered Near Threatened and 1 species, *Bayadera hyaline*, is Vulnerable. 6 species of Malacostraca have been redlist assessed in the region of which 3 are Data Deficient and 3 are Least Concern. There appear to be more molluscs and odonatan in the upper reaches between Pak Beng and Pak Tha and up to Houay Xai.

The macroinvertebrate section of the MRC Council Study, BioRa provides a very useful set of indicators of changing ecological conditions which are relevant to this section of the upper Mekong (Table 4.1).

Table 4.10: Macroinvertebrate indicators used by the MRC Council Study BioRa process

Indicator Groups	Reasons for selection
Insects on stones	Insects living on stones include many mayflies (e.g., Heptageniidae and Baetidae) as well as some dragonflies, caddisflies and two-winged flies. They are sensitive to changes in habitat because they require clean stony substrates for attachment and feeding, and they are often sensitive to changes in water quality such as changes in concentrations of dissolved oxygen.
Insects on sand	Insects living on sand include some mayflies (such as Caenidae and some Baetidae), some dragonflies such as Gomphidae) and others. Once again these species are quite habitat specific, and any changes which alter the amount of sandy habitat available in the river will impact these groups of invertebrates.
Burrowing mayflies	Burrowing mayflies include Potamanthidae and Ephemeridae. They have specific habitat requirements requiring clay banks or other appropriate sediments in which to excavate their burrows. They are a major contributor to dry season insect emergence, and are also sensitive to changes in water quality.
Snails	Snails are important as food for people as well as being hosts for significant parasites of both humans and stock. Changes in abundance will impact human populations by altering availability of food, and income (since some harvested snails are traded or sold) and potentially also influencing health of humans and their stock
Diversity of snails	The Mekong River is a known global diversity hotspot for freshwater snails, especially in the family Pomatiopsidae of which there are over a hundred species known from the area around Khone Falls.
Bivalves	Bivalves are an important food source for people living along the river. They are collected for food and trade throughout the river from northern Laos to the Delta
Shrimps and crabs	Shrimps and crabs are an important part of the riverine ecosystem as important shredders and collectors. They are also significant food items throughout the main channel and tributaries, being harvested for food especially during the low flow periods.
Macrobranchium prawns	Macrobrachium is a genus of freshwater prawns that are because they are widely used by people as food.
Littoral invertebrate diversity	Invertebrates constitute an important component of biodiversity, and invertebrate diversity is a useful indicator of environmental stress. Poor water or habitat quality leads to a reduction in invertebrate diversity. Invertebrates are also an important food source for fish, birds and aquatic and semi-aquatic vertebrates.
Benthic invertebrate diversity	Invertebrates are an important component of biodiversity, and invertebrate diversity is a useful indicator of environmental stress. Poor water or habitat quality leads to low invertebrate diversity. Invertebrates are also an important food of fish, birds, herpetofauna and mammals.
Zooplankton	Zooplankton are an important food source for many fish species, especially in Tonle Sap Great Lake and in the middle to lower reaches of the river.
Benthic invertebrate biomass	Invertebrates constitute an important component of biodiversity, and invertebrate diversity is a useful indicator of environmental stress. Poor water quality or poor habitat quality leads to a reduction in invertebrate diversity. Invertebrates are also an important food source for fish, birds and aquatic and semi-aquatic vertebrates. The biomass indicator was specifically included to account for invertebrates in Tonle Sap Great Lake.
Emergence	The Mekong has a very abundant dry season aquatic insect emergence at a time when water levels are low and other fish food and terrestrial insects are at their least abundance, so emergence is a potentially important fish food, and significant food source for insectivorous birds.

4.6 TRENDS IN RIVER HEALTH

Table 4.4, Table 4.5 and Table 4.6 presented earlier indicate that the water quality and river health in the Upper Mekong is still considered to be good although there has been a slight deterioration in some of the water quality parameters and a gradual decrease in the Aquatic Ecology Health Index since the early 2000s. The rapid macroinvertebrate survey carried out in March 2017 confirms the findings of the more detailed biomonitoring carried out by MRC in 2013 that the river reaches between Chiang Saen and Louangprabang are all in a Fair state of river health, but not Good or Excellent. Earlier Aquatic Ecology health samples in the reach near the Laos/China border has shown some Poor results reflecting some long-term deterioration in this stretch, but the latest results show that that has improved with a Moderate score in 2013.

The MRC Council study BioRa assessments of geomorphology, aquatic vegetation and macroinvertebrates compared the status of different indicators and species assemblages between 1985 and 2015. The changes in status of the different indicators in the two stretches of the river from the Chinese border to Pak Beng and from Pak Beng to upstream of Vientiane are shown in Table 4.11. These show considerable changes in the geomorphology of these two stretches of river from a near natural condition in 1985 to moderately modified in 2015, especially in erosion. There were smaller changes in aquatic vegetation which was considered as moderately modified, but with a decrease in the status of channel biomass of riparian vegetation. All the macroinvertebrate indicators in the upper reaches were considered as largely natural in 1985, but many of them further downstream of Pak Beng were considered to be moderately modified. By 2015 the status of most of the macroinvertebrate indicators in the reach above Pak Beng were considered to have changed to moderately modified.

Table 4.11: Changes in status of indicators for geomorphology, aquatic vegetation and macroinvertebrates between 1985 and 2015

Indicator	1985		2015	
	China border to Pak Beng	Pak Beng to Vientiane	China border to Pak Beng	Pak Beng to Vientiane
Geomorphology				
Erosion	A	A	D	D
Average bed sediment size in dry season	A	A	B	B
Availability of exposed sandy habitat in dry season	A	A	C	C
Availability of inundated sandy habitat in dry season	A	A	C	C
Availability of exposed rocky habitats in dry season	A	A	C	C
Avaialbility of inundated rocky habitats in dry season	A	A	C	C
Depth of pools in bedrock in dry season	A	A	B	B
Water clarity	A	A	C	C
Aquatic Vegetation				
Channel extent of upper bank vegetation	C	C	C	C
Channel extent of lower bank vegetation	C	C	C	C
Channel biomass of riparian vegetation	B	B	C	C
Macroinvertebrates				
Insects on stones	B	B	B	B

Indicator	1985		2015	
	China border to Pak Beng	Pak Beng to Vientiane	China border to Pak Beng	Pak Beng to Vientiane
Insects on sand	B	B	B	B
Dry season emergence	B	C	C	C
Burrowing mayflies	B	C	C	C
Snails	B	C	C	C
Aquatic snail diversity	B	C	C	C
Bivalves	B	B	B	B
Shrimps and crabs	B	C	C	C
Littoral invertebrate diversity	B	C	C	C
Benthic invertebrate diversity	B	C	C	C
Zooplankton	B	B	B	B

Table 4.12: Ecological status ratings

A	Unmodified, natural	As close as possible to natural conditions
B	Largely natural	Modified from the original natural condition but not sufficiently to have produced measurable change in the nature and functioning of the ecosystem/community.
C	Moderately modified	Changes from the original condition sufficiently to have measurably altered the nature and functioning of the ecosystem/community, although the difference many not be obvious to the casual observer
D	Largely modified	Sufficiently altered from the original natural condition for obvious impacts on the nature and functioning of the ecosystem/community to have occurred
E	Completely modified	Important aspects of the original nature and functioning of the ecosystem/community are no longer present. The area is heavily negatively imp acted by human interventions

4.7 DRIVERS OF CHANGE

Rapid surveys of the Mekong river carried out by IUCN in 2003 from Ban Xieng Kok to Houay Xai and in 2004 from Houay Xai to Luangprabang, observed the extent of disturbance of the natural habitats from the watershed, to the river banks to in-channel sand bars and vegetation, and provide a useful source of comparison with the similar rapid survey carried in 2017. Observations show that the following increases in different drivers of change that have occurred:

- **Changes of land use in the watershed** – in 2003/4 most of the landscape surrounding the river consisted of secondary forest, with a greater or lesser extent of removal of forest cover through shifting agriculture and timber extraction. The extent of bamboo is an indicator of disturbance of the forest vegetation. In 2017, it is probable that the extent of shifting cultivation in the watershed has decreased, but there has been an increase in the cover of agroforestry, especially of rubber and teak. This has occurred both on the Thai and Lao banks and is most evident on the stretch from Chiang Saen to Pak Beng.
- **Changes in agriculture down to the river banks –** one of the big changes in agriculture on the flat lands downstream from the Golden Triangle has been an intensification of cropping, in

rice paddy on the Thai side around Chiang Saen, and in banana plantations on the Lao PDR side. With intensification, there will have been increases in agricultural chemicals – both nutrients from fertilisers and pesticides. These will tend to increase the pressure upon water quality and toxicity to macroinvertebrates. In addition, much of the banana plantations extend right to the river bank, with the loss of riparian trees and shrubs which tend to protect the banks from erosion.

- **Increases in urban run-off and pollution –** The expansion of towns such as Chiang Saen, Chiang Khong, Houay Xai and Pak Beng will have increased the risks of water pollution from discharge of untreated domestic waste and urban run-off. This will tend to increase organic pollution as well as oils and grease in the water, tending to reduce the dissolved oxygen content.
- **Increases in infrastructure development.** Since 2003/4 there have been some significant infrastructure developments. These have included road construction and improvement along the river banks on both Lao and Thai sides; the bridge over the river at Houay Xai/Chiang Khong and the bridge upstream of Pak Beng in Lao PDR. Most significantly from the river ecology perspective has been the marked increase in river embankments, especially along the Thai bank downstream from Chiang Saen almost to the border with Laos. In 2004 artificial embankments made up about 1% of the river bank features (Dubeau, 2004). It is estimated that of the 32 km's of Thai river bank, some 33% of the natural river bank has been strengthened with concrete embankments or rip-rap. In Laos there is similar strengthening opposite Chiang Saen and at Houay Xai. The strengthening of river banks on one side of the river, tends to push erosion pressure either downstream or on to the opposite bank, increasing the need to continue strengthening the banks, especially when the riparian trees and shrubs have been removed.
- **Navigation improvements –** During 2003/4, there was some removal of dangerous areas of rapids upstream of Chiang Saen up to the Chinese border. There have been no major improvements for navigation downstream of Chiang Saen, although some minor removals of obstacles are reported to have been undertaken in Lao PDR. The new Chiang Saen port takes up to 10 small boats and 4 large boats (300 DWT).
- **Increase in navigation –** The river between Guan Lei in Yunnan, China and Chiang Saen has shown a marked increase in river traffic since 2003/4, as a result of the navigation channel improvements. This increases the risks of water pollution and accidental spillages of oil etc. With increase in river traffic, there is an associated pressure of bank erosion and loss of riparian vegetation from the wakes and pressure waves created by the passage of the boats, especially when the water levels are falling at the end of the wet season. At low flows, the practice of periodic release of water from the upstream dams to facilitate passage of the heavier cargo boats also leads to abnormal flow patterns during the dry season. Such changing water levels in the dry season can reduce vegetation and littoral macroinvertebrate populations.

5 FISH BASELINE

5.1 SUMMARY

The Mekong Fisheries Database and five other published studies were used to compile species diversity information for three target areas. These areas consist of: (i) the Mekong mainstream between Xieng Kok and Xayaburi Dam site (representing the ES area), (ii) the Mekong mainstream and tributaries between Xieng Kok and Xayaburi, and (iii) the Mekong mainstream, tributaries, and sub-basins between the Lancang lower reach and Xayaburi.

There are 336 species and 41 families recorded between the Lancang lower reach and Xayaburi (including both the mainstream and tributaries). Results from this area indicate that among the 336 species, 13 (4%) are endemic, 8 (2%) are introduced, and 301 (90%) are native species. In total, 128 species are known to be migratory and 182 are non-migratory. Twelve species are listed in the IUCN Red List as critically endangered and endangered, while another 32 are listed as near threatened and vulnerable.

In the Mekong mainstream and adjacent sub-basins between Xieng Kok and Xayaburi, 272 species belonging to 40 families have been recorded. Of these species, eleven (4%) are endemic, eight (2%) are introduced, and 250 (91%) are native species.

In the Mekong mainstream only between Xieng Kok and Xayaburi Dam site (the ES area) 206 species belonging to 38 families are recorded. Of those 206 species, seven (3%) are endemic, seven (3%) are introduced, and 192 (93%) are native species.

Capture fisheries in the Mekong mainstream between Chiang Saen and Luang Prabang (i.e. the ES area) are estimated to produce 40,000-60,000 tonnes of fish per year. This section of Mekong mainstream is not widely fished because of physical and economic constraints.

Fishers and riverine villagers in this section of the river consider that fish abundance, fish size and fish species diversify have already started declining in the past 5-10 years, due to deteriorating water quality, changes in water level, and increased fishing pressure. Algae, playing an important role as feed for both fish and people, are also exposed.

Fishers surveyed during the rapid field survey believe that rock blasting in the study reach will result in several species disappearing, and 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.

5.2 INTRODUCTION

The Mekong River ranks second in the world for its biodiversity, with at least 801 species (FishBase, February 2017). Species richness increases along the course of the river, from 24 species in the headwaters in Tibet up to 486 species in the delta in Vietnam (Baran 2010). However, contrary the delta, Tonle Sap Lake or some Lao tributaries, species diversity in the Upper Mekong has not been given much attention so far (Dubeau 2004). Bin Kang et al. (2009) identified hydrological alteration, overfishing and introduction of exotic species as the biggest threats to fish in this area. In particular, migratory fish species need multiple habitats to carry out their life cycle, and development plans that alter aquatic habitats in this zone could impact the local fish resource (Dubeau 2004). They could also have negative implications on the rural communities who are dependent on fish for their livelihood.

Among recent threats to the hydrology, habitats and ecology of the Upper Mekong is the "Development Plan of International Navigation on the Lancang-Mekong River" meant to improve inland navigation efficiency and reduce navigation risks. Phase 1, to be carried out between 2016 and 2020, includes *building cargo ports at Xieng Kok, Pak Beng, and Luang Prabang*, which will require the blasting of 146 rapids and shoals. The environmental impacts of such development initiative remain to be assessed.

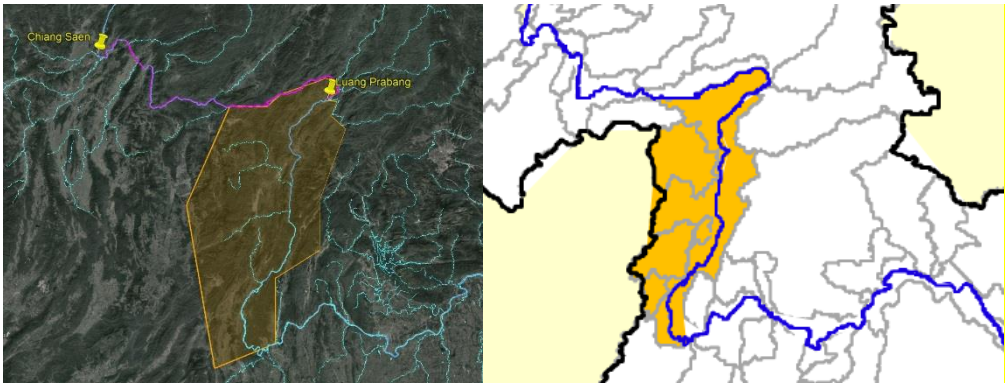
This primary objective of the present report is to summarize the information available about fish biodiversity in the Mekong stretch between the Lower Lancang in China and Xayaburi Dam site in Lao PDR. Tributaries linked to the Mekong mainstream in the Xieng Kok - Luang Prabang segment are also considered, in order to account for impacts on migratory fish in this specific part of the river. We detail below fish species richness, endemicity, conservation status and migrations in the study zone, as well as fisheries, using published literature, the Mekong Fisheries Database (2003) and the results of a field survey.

5.3 CONTEXT

The focus of the present study is on the Mekong mainstream between Chiang Sean and Luang Prabang in Lao PDR. However, in order to reflect fish migrations in corresponding sub-basins, data availability and data referencing (by administrative province in MFD 2003, the main taxonomic resource), as well as development plans in the Lower Lancang, we extended the review to the following limits:

- The upper part of the Lower Lancang. This zoogeographic zone, detailed in Bin Kang et al. (2009), stretches from the Yunnan-Guizhou Plateau (excluded) to the China-Lao border. It includes the Xiaohei, Mengga, Weiyuan, Heihe, Dazhong, Buyuan, Liusha and Mengla sub-basins.
- The Xayaburi dam site. Since watersheds at the level of Luang Prabang include extensive riverine tributaries on the left bank and several larger watershed on the right bank, we had to include all watersheds in Xayaburi province, down to a limit marked approximately by the Xayaburi dam site (Figure 5.1).

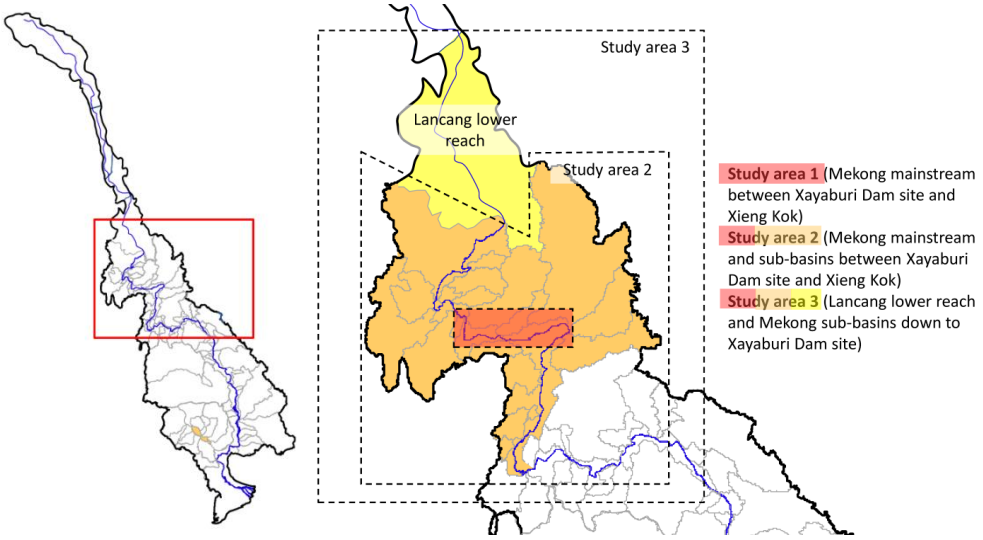
Figure 5.1: Integration of Xayaburi sub-basins in the study area



Thus, three areas are systematically distinguished in the following analyses (Figure 5.2):

- 1: the Mekong mainstream between Xieng Kok and Xayaburi Dam site – slightly bigger but essentially representing the ES area
- 2: the Mekong mainstream and the sub-basins of the Mekong tributaries between Xieng Kok and Xayaburi
- 3: the Lancang lower reach (China) and the Mekong sub-basins down to Xayaburi.

Figure 5.2: Maps of study areas in the Upper Mekong zone

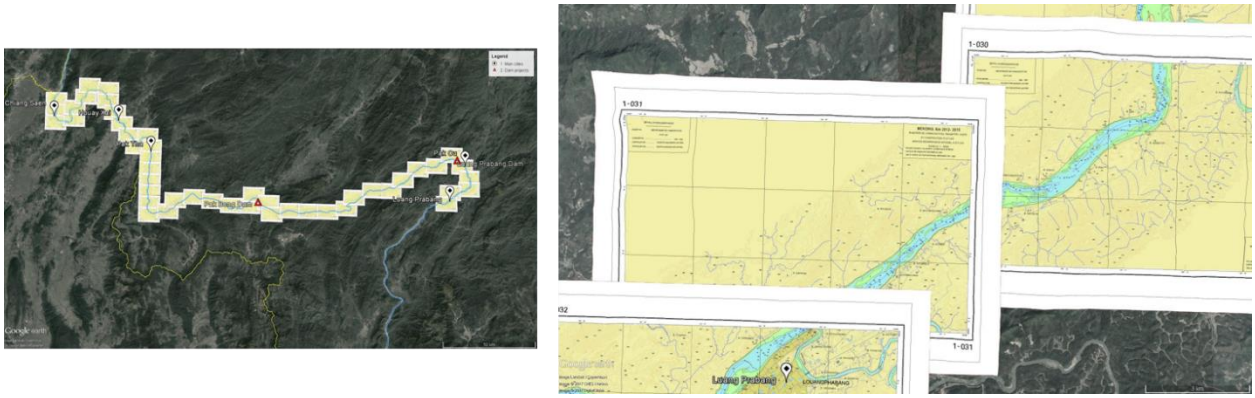


5.4 METHODOLOGY

5.4.1 Environmental characterization

River bathymetry maps from the Mekong River Commission were combined with Google Earth and overlaid with satellite views, so that deep pools and other underwater features could be delineated and characterized in Google Earth (Figure 5.3).

Figure 5.3: Integration of MRC bathymetric to Google Earth for mapping

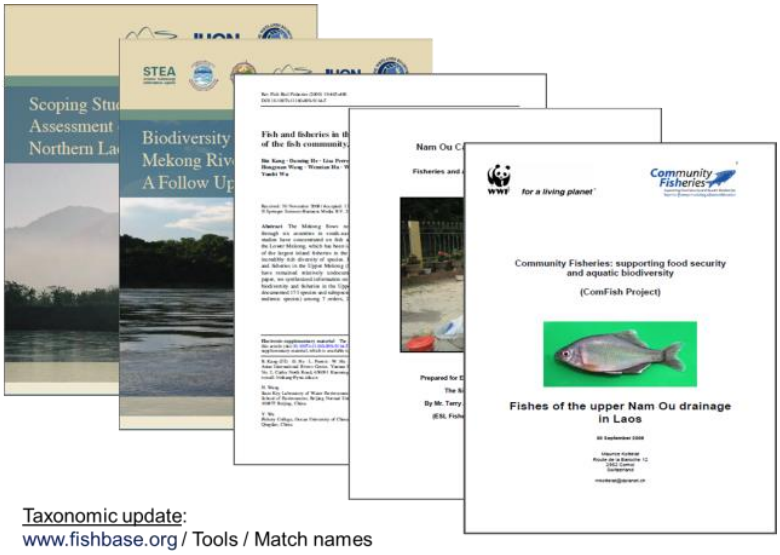


5.4.2 Species analysis

Data used to identify fish species composition between the Lancang lower reach and Xayaburi Dam site was extracted from the Mekong Fish Database (2003), and combined with five site-specific studies (Figure 5.4):

- Mekong mainstream - Meynell (2003) and Dubeau (2004),
- Mekong sub-basins - Bin Kang et al. (2009), Kottelat (2009) and Warren and Thavone Phommavong (2010).

Figure 5.4: The five main documents used for the biodiversity review



Data was organized and analysed using Microsoft Excel and Access. The Mekong Fisheries Database reflects fish surveys up to 2003 only, and since then, other studies have increased the amount of information available. For example, Dubeau (2004) looked at mainstream fish diversity between Xieng Kok to Luang Prabang. Bin Kang et al. 2009 sourced information on mainstream fish diversity in the Upper Mekong from publications and site interviews, extending from the Zaqu to the Mengla sub-basin. Kottelat (2009) surveyed fish in the upper Nam Ou drainage during February and March of 2009 using nets. Warren and Thavone Phommavong (2010) used existing information sourced by Kottelat (2009), along with surveys conducted along the Ou River mainstream of 18 villages and districts,

interviews with villagers and farmers, and District and Provincial staff, and market visits, to gain a better understanding of the Fisheries and Aquatic Resources in this area.

The native, endemic, and introduced species were identified using the tool "Information by ecosystem" in FishBase (www.fishbase.org), with a focus on the Mekong River species list.

- *Native species* are genetically unaltered indigenous fish stocks occurring within their original range; they can be found in several rivers or countries.
- *Endemic species* are native species whose geographical distribution is limited, i.e. circumscribed to a few locations only (e.g. a river, island, etc.) and in no other place worldwide. They are more at risk than species with a large distribution range and are very important from a biodiversity conservation perspective.
- *Introduced species* are species transferred by man to areas where they were not naturally found.

Duplicate and synonymous species names were removed, and the taxonomy was updated using FishBase.

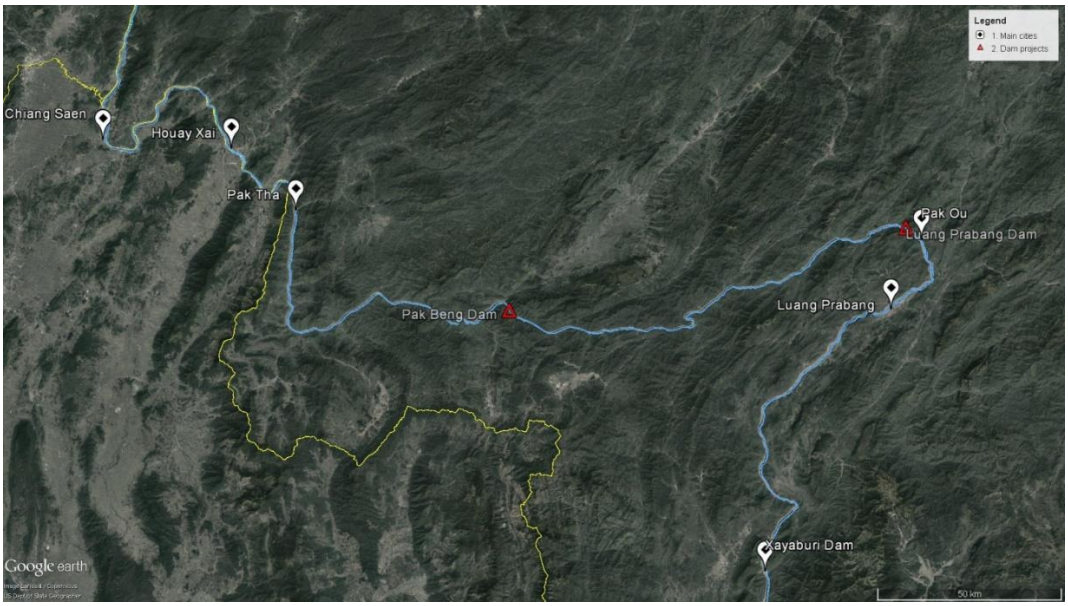
We used the list of migratory species detailed in Table S3 in Ziv et al. (2012) to identify long distance migratory fish. This list was complemented with the information on other migratory fish species contained within the MFD.

The IUCN Red list, accessed in November 2016, was used to classify the species conservation status (http://www.iucnredlist.org/).

5.4.3 Field data

Observations and data, in particular on fisheries, for the Xieng Kok - Xayaburi study zone were updated during a field trip on the river and along its banks between Chiang Saen and Luang Prabang, between 11 and 19 March 2017 (Figure 5.5).

Figure 5.5: Location map detailing cities and dam projects along the Mekong between Chiang Saen and the Xayaburi dam site



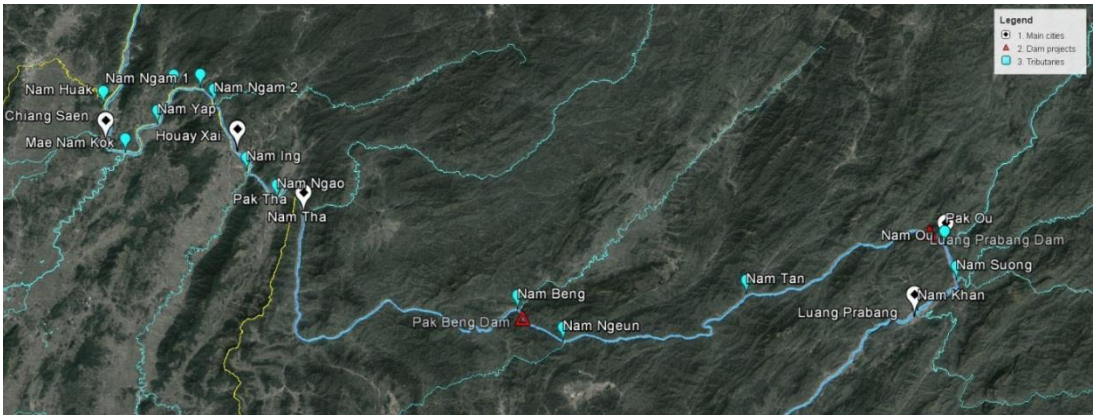
5.5 RESULTS

5.5.1 Environmental Characterization between Chiang Saen and Luang Prabang

We detail below the main environmental features and habitats (tributaries, deep pools, sandbanks, and wetlands) of the Mekong mainstream between Chiang Saen and Luang Prabang (i.e. the study area that was subject to a field survey).

In Figure 5.6, tributaries are identified between Chiang Saen and Luang Prabang. The section between Chiang Saen and Pak Ou features few tributaries, as opposed to the short section between Pak Ou and Luang Prabang where four tributaries join the Mekong.

Figure 5.6: Tributaries of the Mekong mainstream between Chiang Saen and Luang Prabang

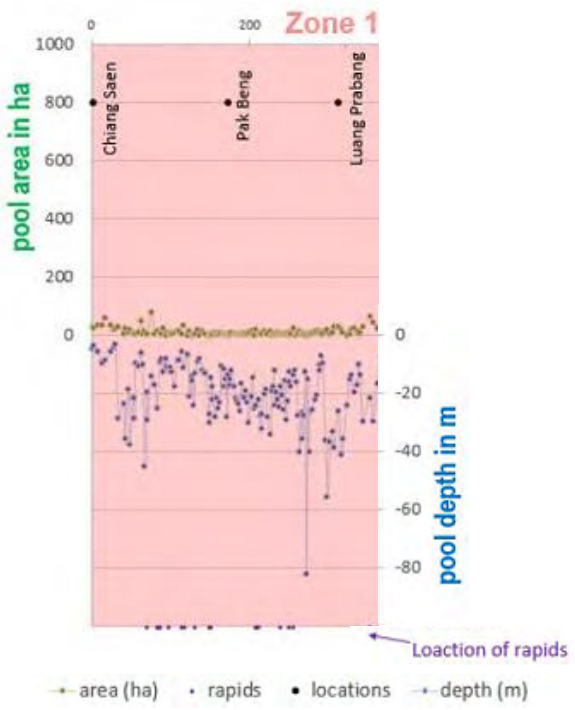


The 110 deep pools of the focus zone were identified using bathymetric indications of the MRC navigation maps, and distributed into 4 categories of depth. The two deepest categories, deep pools and very deep pools, are respectively highlighted in orange and red in Figure 5.7. Most deep pools occur in the section between Pak Tha and Pak Ou, while very deep pools are concentrated between Pak Beng dam site and Pak Ou.

Figure 5.7: Deep pools (orange sections) and very deep pools (red sections) in the Mekong mainstream between Chiang Saen and Luang Prabang

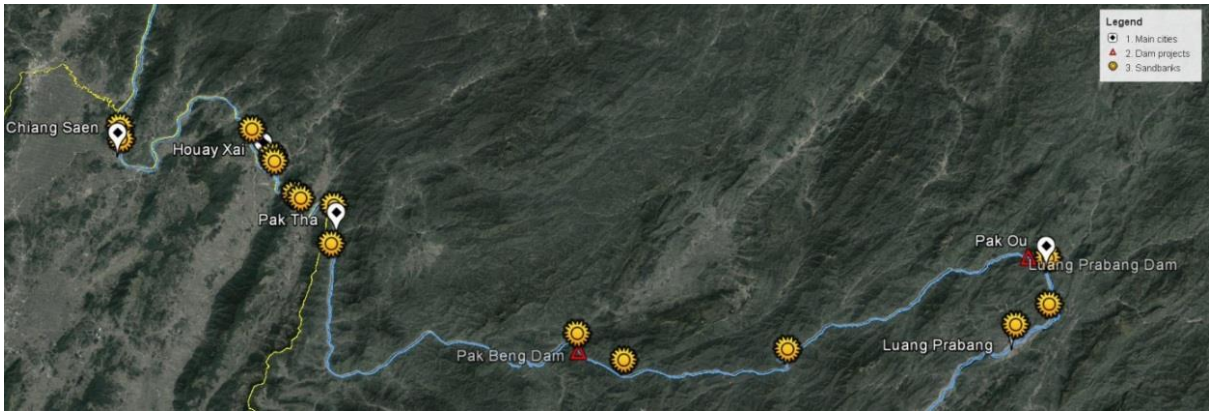
The MRC ISH study (MRC 2018) also identified and plotted deep pools along the study stretch (Figure 5.8).

Figure 5.8: Location, depth and area of deep pools and location of rapids along the the study stretch (note: the line between the pools does not reflect the riverbed elevation but is there to support the readability of the figure). MRC, 2018.



Sandbanks are marked with orange icons on the map below (Figure 5.9). These sand banks are located throughout the section studied, but more concentrated between Chiang Saen and Pak Tha.

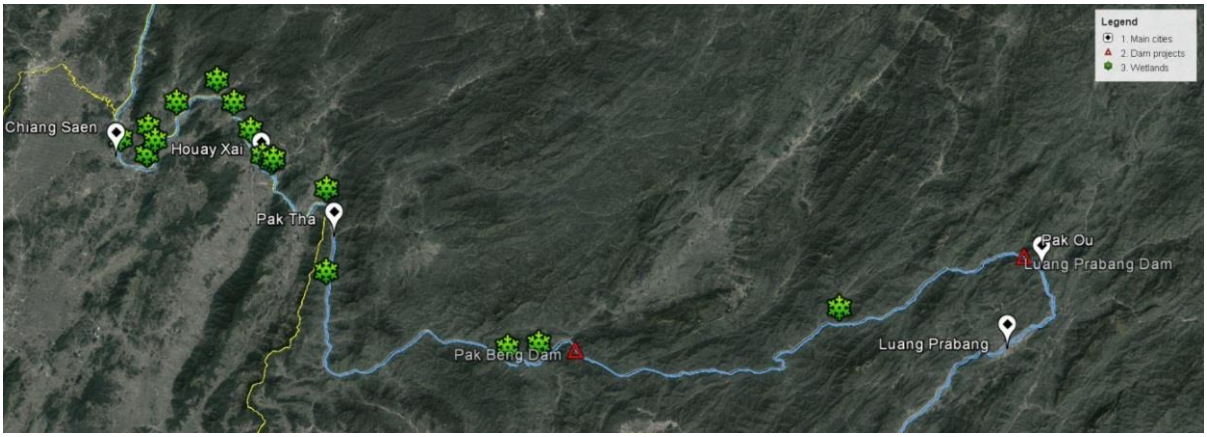
Figure 5.9: Sandbanks in the Mekong mainstream between Chiang Saen and Luang Prabang



Wetlands and shallow areas are identified with green icons in

Figure 5.10. Like sand banks, most wetlands are located between Chiang Saen and Pak Tha, and almost none between Pak Tha and Luang Prabang.

Figure 5.10: Wetlands in the Mekong mainstream between Chiang Saen and Luang Prabang



5.5.2 Species Richness

5.5.2.1 Species richness in the Lower Lancang – Xayaburi area

There are 336 fish species and 41 families known to science in the area between the Lancang lower reach and Xayaburi Dam site. Minnows and carps (Cyprinidae), stone loaches (Nemacheilidae), and loaches (Cobitidae) are the families contributing most to this biodiversity (Figure 5.11 and

Figure 5.12).

Figure 5.11: Number of families and species of fish in study area 3 (Lower Lancang)

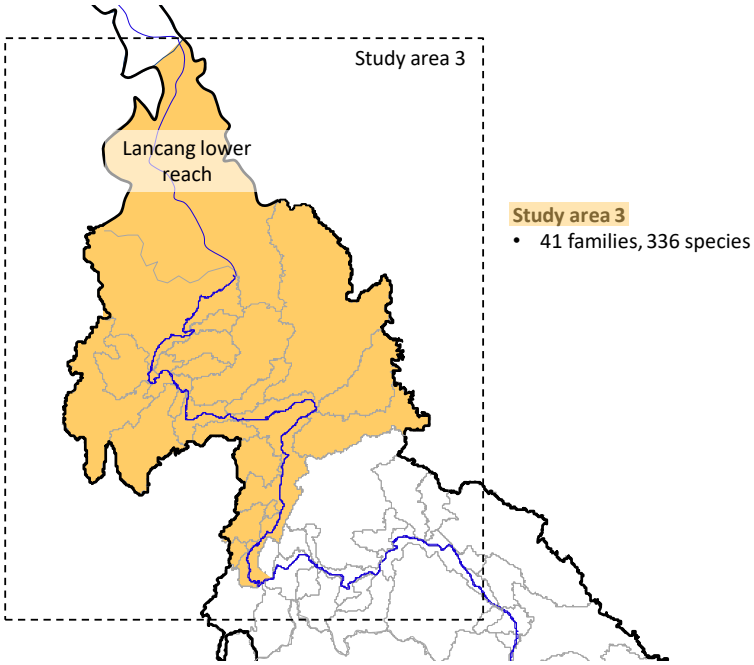
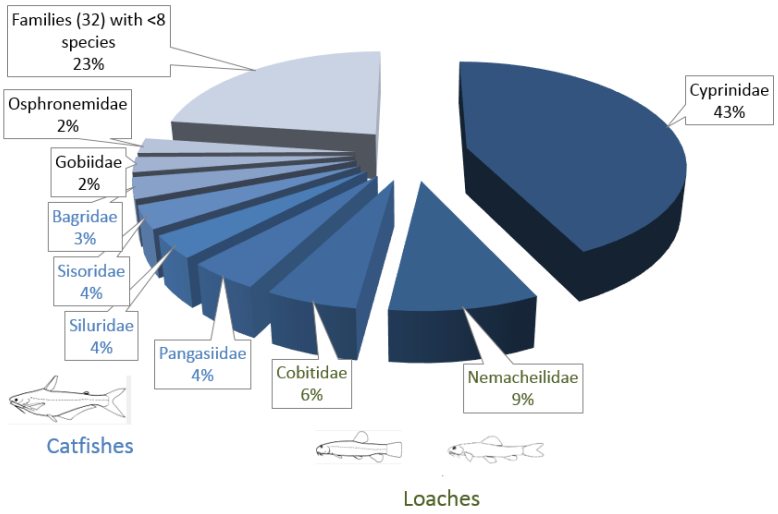


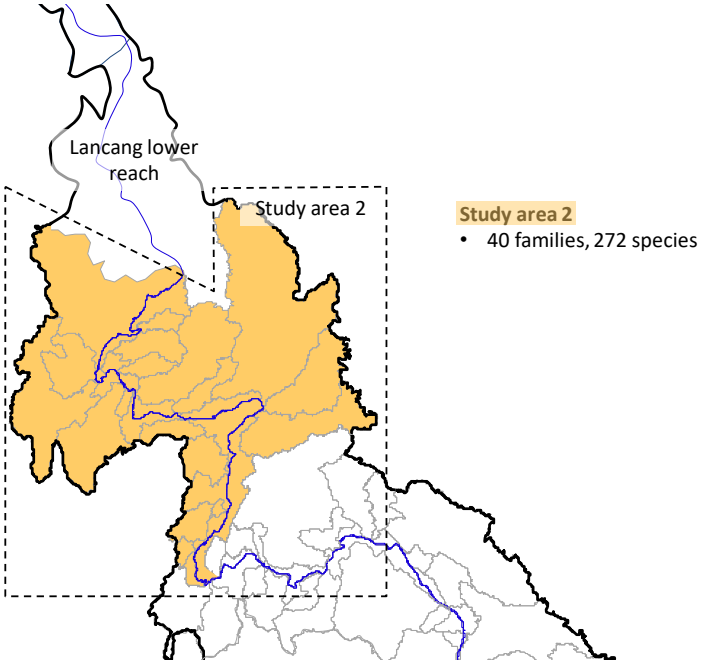
Figure 5.12: Distribution of biodiversity between families in the Lancang lower reach



5.5.2.2 Species richness in the Xieng Kok – Xayaburi area (mainstream and sub-basins)

There are 272 species belonging to 40 families recorded in the Mekong mainstream and sub-basins between Xieng Kok and Xayaburi Dam site (Figure 5.13).

Figure 5.13: Number of families and species of fish in study area 2 (Mekong mainstream and sub-basins between Xieng Kok and Xayaburi Dam site)



5.5.2.3 Species richness in Xieng Kok – Xayaburi dam site (mainstream Mekong only)

There are 206 species belonging to 38 families in the Mekong mainstream between Xieng Kok and Xayaburi Dam site (Figure 5.14). Of 38 fish families, minnows/carps, loaches and catfishes have the highest diversity (Figure 5.15).

Figure 5.14: Number of families and species of fish in study area 1 (Mekong mainstream between Xieng Kok and Xayaburi Dam site)

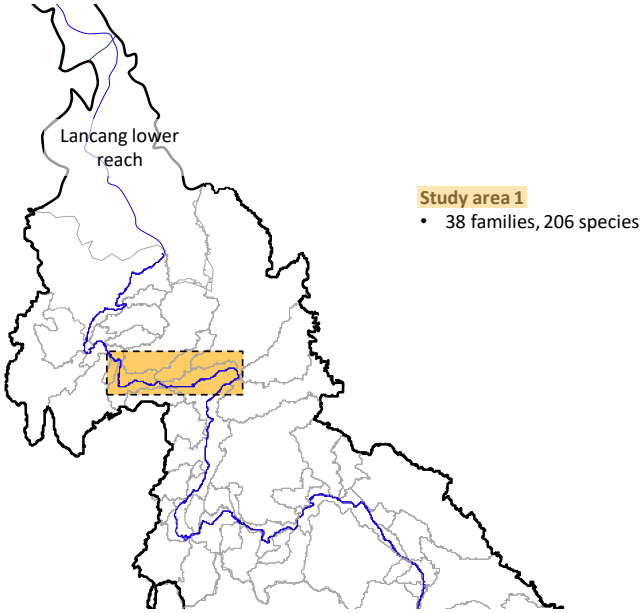
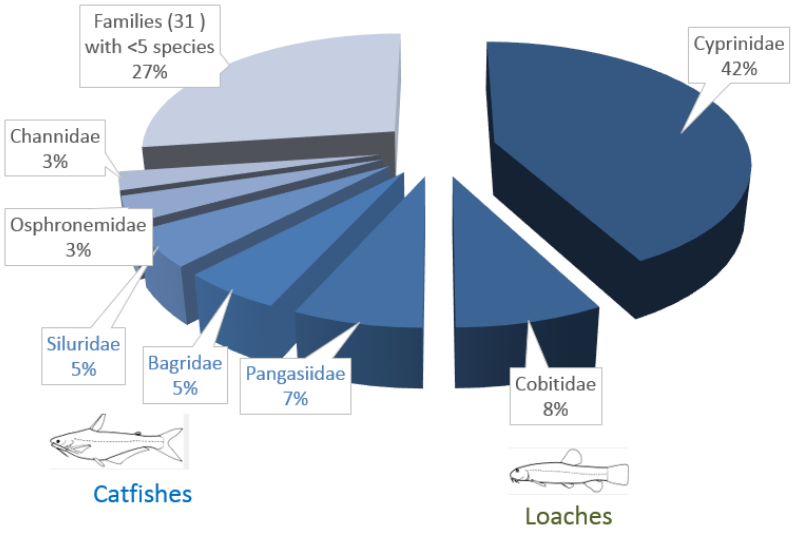


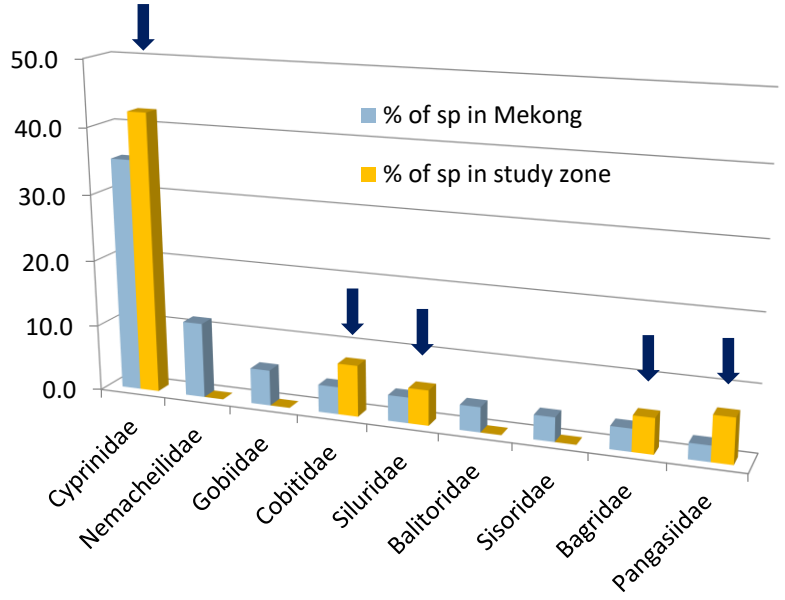
Figure 5.15: Distribution of biodiversity between families in study area 1 (Mekong mainstream between Xieng Kok and Xayaburi Dam site)



Within the Mekong, the section studied is characterized by its high diversity in Cyprinids, loaches and catfishes (

Figure 5.16) described in Box 1-5.

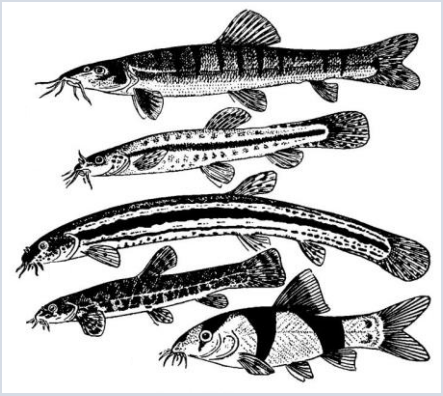
Figure 5.16: Comparison between distribution of species in the Mekong and the ES zone (study area 1)



Box 1: Cyprinidae (minnows, carps, barbs)

This is the largest family in the Mekong with 25% of fish species. Species of this family account for most of the fisheries yield in the Mekong Basin, especially during their seasonal migrations. They are also important in aquaculture. Many are popular and economically valuable. Most species are generalists; feed on a mixture of invertebrates, organic debris and plants.

Box 2: Cobitidae (loaches)

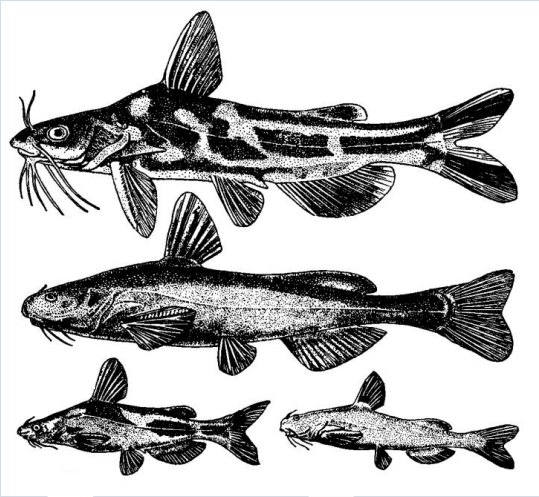


This is a family of small fishes found in rapid rivers. There are at least 27 species in the Mekong. Individuals of these species have spines under their eyes; these spines allow them to wedge themselves in rock crevices. Loaches are also capable of burying themselves very quickly in sand or gravel. Some loaches are highly migratory and seasonally important in local fisheries.

Box 3: Pangasiidae (pangas catfishes)

This is a family of medium to large fish, reaching a record length of 250 cm for the Mekong giant catfish. Many pangas undertake long migrations in the Mekong mainstream. They are a popular foodfish, and are very important in both the capture fisheries and aquaculture in the Mekong Basin. Their feeding habits are very variable depending on species, includes; fruits, invertebrates, fish, algae.

Box 4: Bagridae (bagrid catfishes)



This is a family of small to medium sized widely distributed fishes. Some of the larger species are migratory. These fishes are important food fishes throughout the Mekong Basin. Feed species from that family feed mainly on benthic invertebrates.

Box 5: Siluridae (sheat catfishes)

These are medium to large sized fishes; found throughout the Mekong. They are highly important in Mekong fisheries and at least one species (*Wallago attu*) is known to be an excellent gamefish. Some sheatfishes are pelagic, and they feed on invertebrates and fishes.

5.5.3 Fish Endemicity

5.5.3.1 Fish endemicity in the Lower Lancang – Xayaburi area

Results from the study area 3 between the Lancang lower reach and Xayaburi Dam site indicate that among the 336 species, 13 (4%) are endemic, 8 (2%) are introduced, and 301 (90%) are native species (Figure 5.17). There is no information about the endemicity of 14 species in this area.

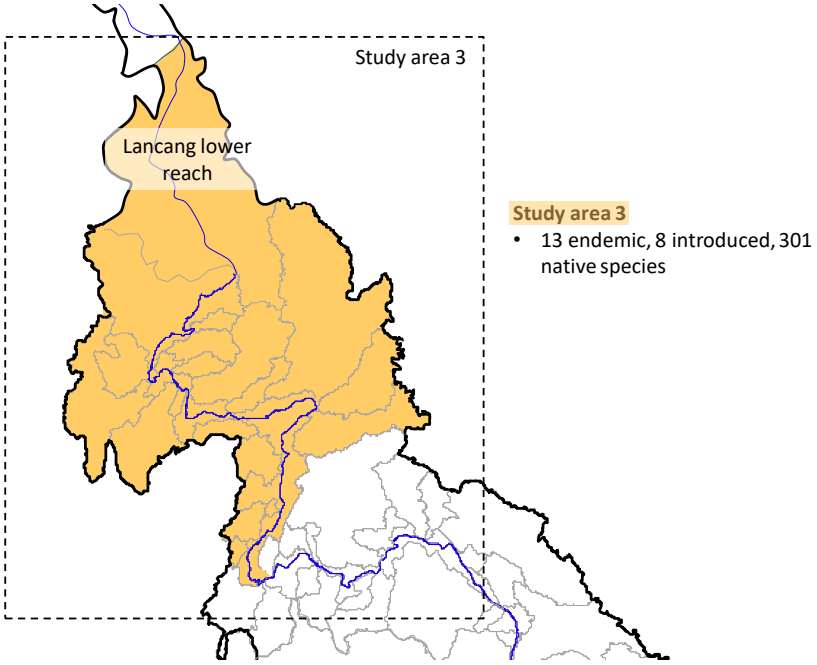
The endemic fish in study area 3 include:

Aaptosyax grypus, Balitora elongate, Hemisilurus mekongensis, Henicorhynchus lineatus, Henicorhynchus lobatus, Pangasianodon gigas, Pao baileyi, Probarbus labeamajor, Scaphognathops bandanensis, Schistura melarancia, Tenualosa thibaudeaui, Tenualosa toil and *Thryssocypris tonlesapensis*.

Species *Aaptosyax grypus, Balitora elongate, Henicorhynchus lineatus, Henicorhynchus lobatus, Pao baileyi and Schistura melarancia* have been recorded between the Lancang lower reach and Xayaburi (study area 3), but not in the mainstream between the Xieng Kok and Xayaburi (i.e. not in study area 1).

The introduced species between the Lancang lower reach and Xayaburi Dam site include *Abbottina rivularis, Cirrhinus cirrhosis, Clarias gariepinus, Cyprinus carpio, Hemibarbus labeo, Hemibarbus maculatus, Labeo rohita* and *Oreochromis niloticus* (i.e. mainly catfishes, carps and tilapia). Among those, *Hemibarbus maculatus* is present between the Lancang lower reach and Xayaburi, but not in the mainstream between Xieng Kok and Xayaburi.

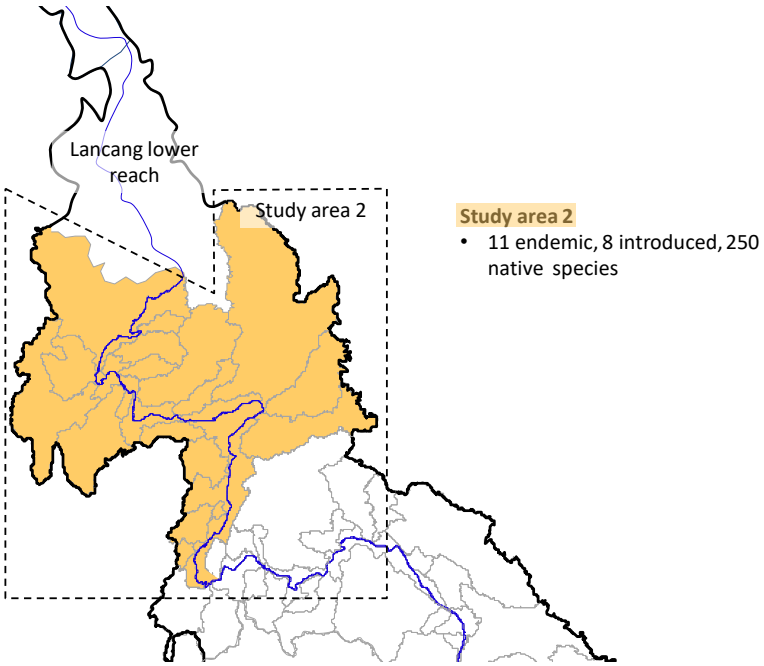
Figure 5.17: Fish endemicity in study area 3 (Mekong Mainstream and tributaries: Lower Lancang – Xayaburi)



5.5.3.2 Fish endemicity in the Xieng Kok – Xayaburi zone (mainstream and sub-basins)

Results from study area 2 (Mekong mainstream and sub-basins between Xieng Kok and Xayaburi) indicate that among the 272 species, eleven (4%) are endemic, eight (2%) are introduced, and 250 (91%) are native species (Figure 5.18). There is no information about the endemicity of three species in this area.

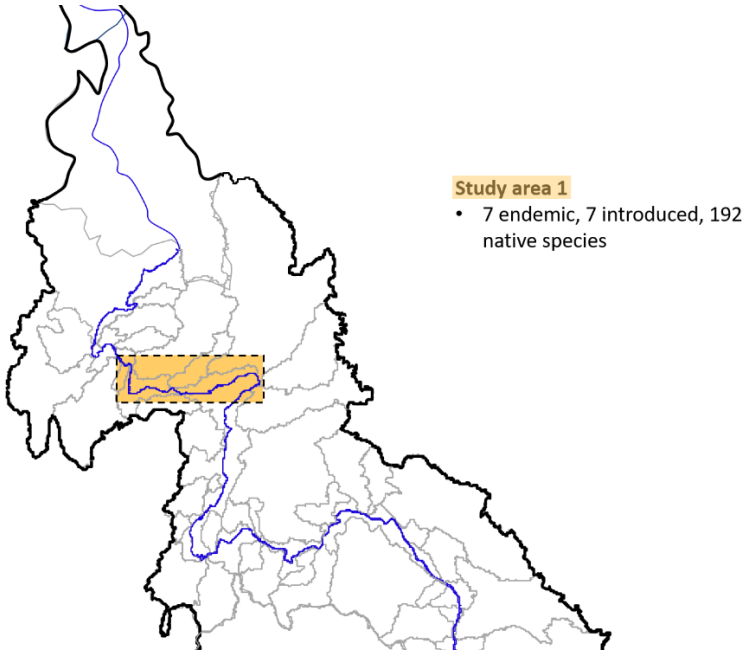
Figure 5.18: Fish endemicity in study area 2 (Mekong mainstream and sub-basins between Xieng Kok and Xayaburi Dam site)



5.5.3.3 Fish endemicity in the Xieng Kok – Xayaburi dam site (mainstream Mekong only)

Results from the study area 1 (Mekong mainstream between Xieng Kok and Xayaburi Dam site) indicate that among the 206 species, seven (3%) are endemic, seven (3%) are introduced, and 192 (93%) are native species (Figure 5.19).

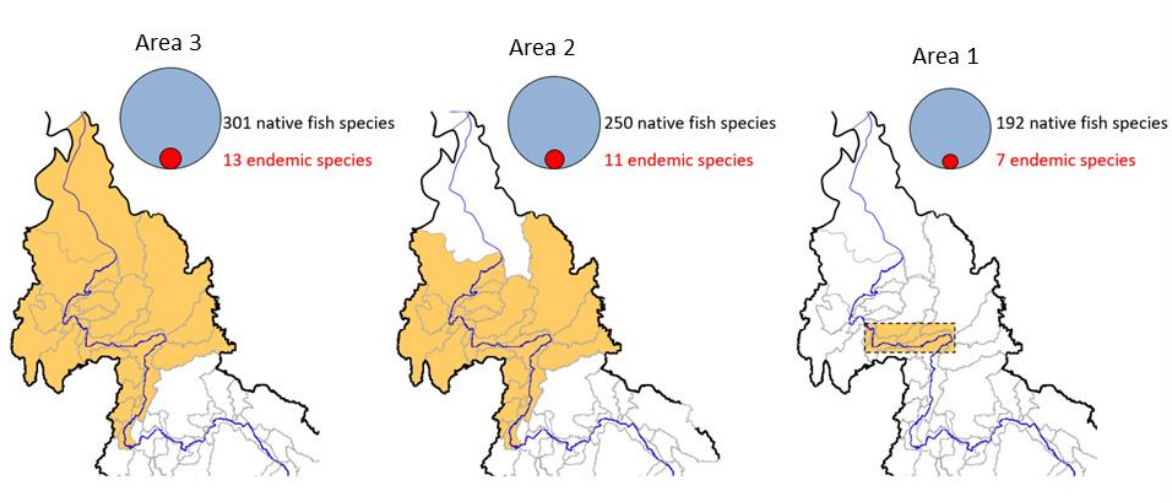
Figure 5.19: Fish endemicity in study area 1 (Mekong mainstream between Xieng Kok and Xayaburi Dam site)



A comparison of the three areas studied (Figure 5.20) shows the relative high biodiversity and endemicity in the Xieng Kok - Xayaburi Dam site section (study area 1) – closely representing ES area. Species diversity is normally proportional to the surface area of the area considered. Here the concentration of a high diversity in study area 1 can be explained by a corridor role played by this area connecting several adjacent sub-basins, and in which species counts add up –in particular during migrations. The corridor role of study area 1 (i.e. the ES area) needs to be confirmed by additional analyses.

Figure 5.20: Comparison of total species diversity and number of endemic species in the three areas considered.

The surface areas of blue and red circles is proportional to the fish diversity and endemicity in each area. Note: endemic species are those listed in FishBase as endemic to the Mekong, not endemic to the area considered.



5.5.4 Conservation Status of Fish Species

Among the 336 species in the Lower Lancang to Xayaburi dam section (study area 3), eleven species are listed as “critically endangered” or “endangered” in the IUCN Red list, while another 32 are considered “near threatened” or “vulnerable”. This includes six “critically endangered” and five “endangered” fish species (Table 5.1). These species include the Mekong giant catfish *Pangasianodon gigas*, the giant barb *Catlocarpio siamensis* and the Giant salmon carp *Aaptosyax grypus.* Sixteen additional species are listed as “near threatened”, and 16 more species are considered “vulnerable” (Figure 5.21). Data is deficient for 58 fish species, and another 56 fish species remain to be assessed, which confirms the fact that species diversity in the Mekong mainstream and associated tributaries has not been given enough attention (Dubeau 2004, Bin Kang et al. 2009). Of the species endemic to the Mekong River, two are critically endangered (*Aaptosyax grypus*, *Pangasianodon gigas*), one is endangered (*Probarbus labeamajor*), and two are listed as vulnerable (*Scaphognathops bandanensis*, *Tenualosa thibaudeaui*). All the species mentioned above are also migratory and require multiple habitats to complete their life cycles.

Figure 5.21: IUCN Red list conservation status of fish species in study area 3

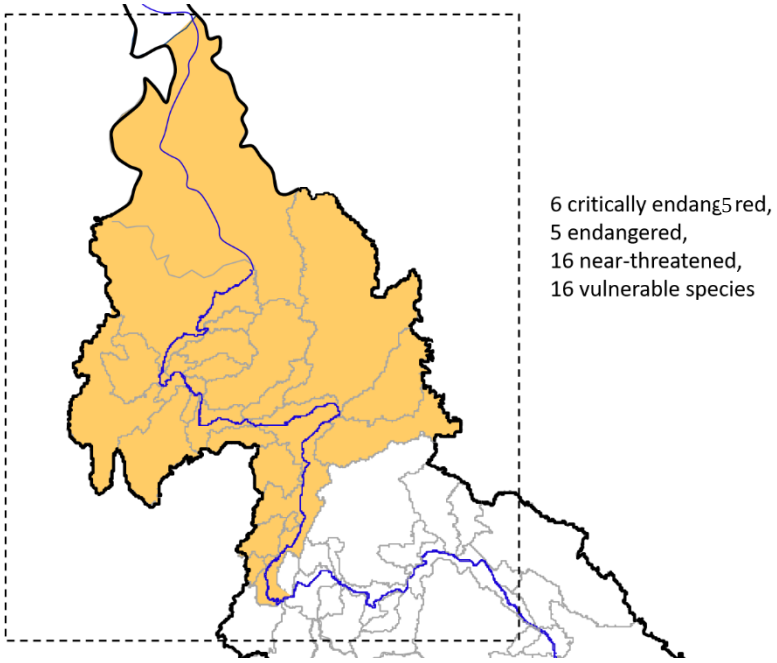
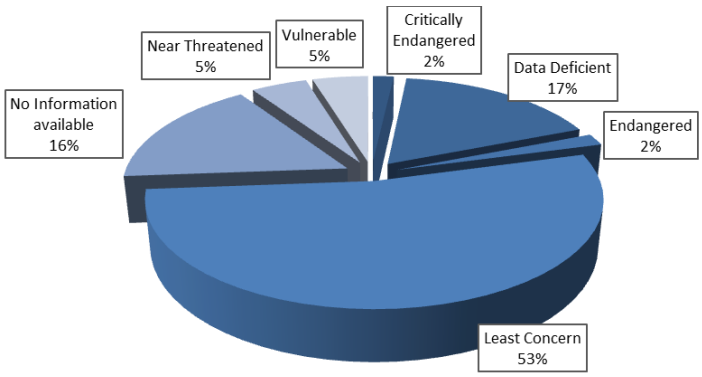


Table 5.1: List of critically endangered and endangered species found between Lancang lower reach and Xayaburi (study area 3)

Mekong species	Redl-List classification
Aaptosyax grypus	Critically endangered
Catlocarpio siamensis	Critically endangered
Ceratoglanis pachynema	Critically endangered
Pangasianodon gigas	Critically endangered
Pangasius sanitwongsei	Critically endangered
Scaphognathops theunensis	Critically endangered
Dasyatis laosensis	Endangered
Himantura polylepis	Endangered
Luciocyprinus striolatus	Endangered
Probarbus jullieni	Endangered
Probarbus labeamajor	Endangered

Figure 5.22: IUCN Red list status of 336 fish species in study area 3 (Lower Lancang - Xayaburi)



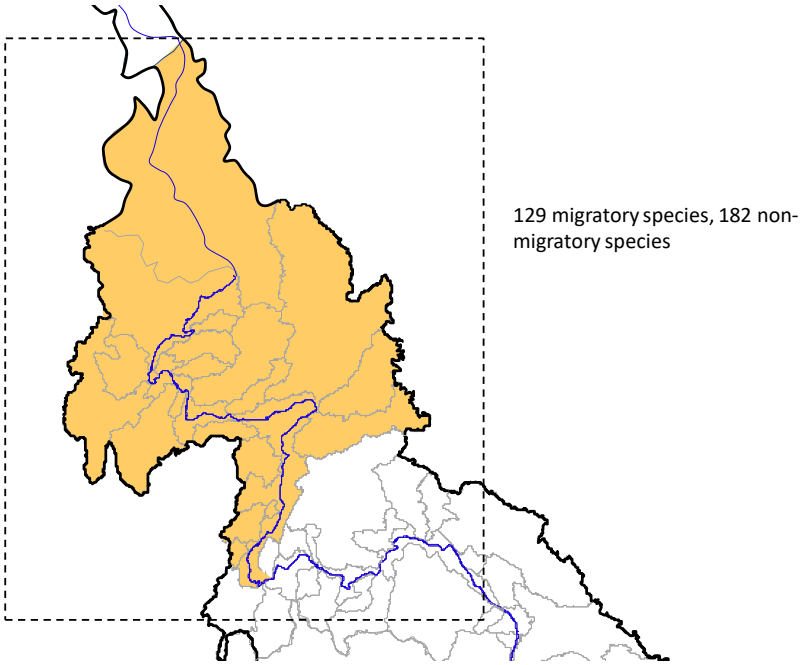
5.5.5 Migratory Fish Species

According to data combined from MFD (2003) and Ziv et al. (2012), among the 336 species in study area 3 (between the Lancang lower reach and Xayaburi), at least 128 species (38% of the species count) are migratory (Figure 5.23).

Of the 13 species endemic to the Mekong, seven are migratory; these species include *Aaptosyax grypus, Hemisilurus mekongensis, Henicorhynchus lobatus, Probarbus labeamajor, Scaphognathops bandanensis, Tenualosa thibaudeaui,* and *Tenualosa toli.*

Discrepancies were found for seven fish species whose migratory status differs between the two sources (i.e. listed in the migratory table of Ziv et al. 2012, but not considered migratory in MFD 2003). These include *Brachirus harmandi, Cirrhinus jullieni, Garra fasciacauda, Helicophagus leptorhynchus, Hypsibarbus pierrei, Labiobarbus siamensis, Luciocyprinus striolatus, Puntioplites waandersi* and *Sikukia stejnegeri*.

Figure 5.23: Number of migratory and non-migratory species in study area 3 (Lower Lancang - Xayaburi)



5.5.6 Fish and Fisheries Resources

5.5.6.1 Information from the literature

According to the Strategic Environmental Assessment of hydropower on the Mekong mainstream (SEA; ICEM 2010 and Baran 2010), fishing is not considered a significant livelihood option for local people by district leaders in the main study zone, because it is not done on a large scale in Luang Namtha, Bokeo, Oudomxay, Luang Prabang and Xayaburi provinces; local fisheries statistics reflect a very low fish production. However, the Assessment also notes that the importance of fish resources tends to be underestimated in district or province statistics.

Table 5.2: Capture fish production in some districts along study area 3

District Name	Mekong (tonnes/year)	Tributary (tonnes/yea)	Total (tonnes/yea)	Tributary Name
Paktha (Bokeo)	3.6	1.2	4.8	Nam Tha River
Pakbeng (Oudomxay)	1.8	1.5	3.3	Nam Beng River
Nan (Luang Prabang)	9	1.2	10.2	Nan River
Xayaburi	1.8	1.8	3.6	Houng River,
Paklay (Xayaburi)	3.6	1.2	4.8	Lay River, Phoun, Nham, and Nhang

Sources: Bokeo provincial economic and social development plans of 2008-2009; Oudomxay provincial economic and social development plans of 2009-2010; Luang Prabang provincial economic and social development plans of 2008-2010; Xayaburi provincial economic and social development plans 2008-2009.

As detailed in the SEA, "*in contrast with the above estimates, the study of fish consumption and catch in Luang Prabang province done by the MRC in 1999 (Sjorslev et al. 2000) and based on actual field work, systematic sampling and seasonal records concludes that the total catch of fish and aquatic animals for Luang Prabang Province is within a range of 10,000 to 14,000 tons per year*".

The SEA proposes an alternative estimate combining the population of each province with estimated fish consumption figures compiled by Hortle 2007, which leads to an estimate of 29,000 tonnes consumed, and a total estimate of 41,000 tonnes of fish harvested in this zone. This estimate is roughly in line with the alternative estimate (60,000 tonnes) resulting from a different calculation detailed in Barlow *et al.* (2008). The SEA concludes that the capture fish production in the focus zone ranges between 40,000 and 60,000 tonnes per year.

5.5.6.2 Information from the field survey between Chiang Saen and Luang Prabang

5.5.6.2.1 Fish and aquatic resources

The rapid survey indicates that fishers in the Chiang Saen - Luang Prabang section of the river catch about 95 fish species. Several among these species prefer fast flowing and rapids areas (in particular "Pa khae" *Bagarius yarelli* and "Pa khob" *Belondicthys truncatus*). Larvae of some fishes (expected to be cyprinids) were found in the small islands between Chiang Saen and Chiang Khong.

In addition to fish, the freshwater algae "kai" is the main harvest from the Mekong in the Chiang Khong area. Fishers are worried that rapid blasting would impact the development and growth of this algae that needs specific water level, flow conditions and turbidity conditions to grow and feed both people and fish during the dry season.

The Khon Phi Long Rapid area is seen by fishers as an area of specific ecological importance, with time and zone restriction for fishing. Fishers and fish traders say that large size fishes commonly caught in the area rely on the connection between the Mekong mainstream and the Nam Ing and Nam Kok Rivers.

5.5.6.2.2 Fishing in the environmental study area

In general, fishery activities from Xieng Kok to Huay Xai are less prevalent than from Huay Xai to Luang Prabang, due to the small number of villages in this section. Strong water currents occurring in the upper part of Mekong also deter from fishing. Between Xieng Kok and Luang Prabang, only a few people fish in the Mekong River, while the majority fish in smaller tributaries, back swamps and ponds where fish are easier to catch. The main reason why the Mekong is not widely fished is also that villagers do not have enough resources to invest and acquire the gear needed for fishing in the main river.

Fishers and riverine villagers consider that fish abundance, fish size and fish species diversify have already started declining, due to modern fishing equipment, deteriorating water quality, changes in water level, and increased fishing pressure. Among the species already impacted are giants such as *Himantura chaophraya* and *Pangasianodon gigas*, but also *Pangasius pangasius* and *Catla catla*.

Overall, fishing in villages along the Mekong in the study zone has significantly declined over the past 5 to 10 years, with fishers turning to mining gold by artisanal filtration along the river banks, becoming construction workers, or developing small trade.

5.5.6.2.3 Environmental and resource changes

Fishers say that in recent years, water quality and level have significantly changed. Water level in the dry season has decreased, making beaches, islands and rocks more apparent. The duration of low water levels is also shorter. Day-to-day fluctuation of the water level is also commonly observed nowadays (as opposed to 5-10 years ago when it would vary over a week minimum). The problem of fluctuating levels is that they make fishing more difficult, and therefore impact daily food supply.

Under pristine conditions, the Mekong water was turbid in March and April, but currently the water is not turbid at all.

5.5.6.2.4 Feedback from villagers about rock blasting

Fishers and farmers disapprove of rock blasting in the mainstream because they consider that the fish they depend on in this area will be affected, several species being expected to disappear. People highlight that losing more river fish would be critical to their food security, as the current supply of fish and river resources is already minimal. Unlike fishers, boat owners see rock blasting in some critical places as a good option.

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5.7 APPENDIX 1: SPECIES DATABASE CREATION

Three datasets were generated to identify fish species at different levels, as detailed below.

5.7.1 Lower Lancang – Xayaburi area

This dataset was created using the species list from the mainstream and tributaries between Lancang lower reach and Xayaburi Dam site (Bin Kang et al. 2009), and the MFD database (2003) for fishes found in Luang Namtha Province.

[Bin Kang et al. 2009] Species composition in 8 sub-basins of the Lancang lower reach (Xiaohei, Mengga, Weiyuan, Heihe, Dazhong, Buyuan, Liusha, and Mengla sub-basins)

[Luang Namtha] Access query run based on Luang Namtha province [Basin = Mekong, Sub-basins= Nam Tha, Nam Youan]

[Taxonomy] Taxonomic update following FishBase

[Endemicity] Classification from FishBase

5.7.2 Xieng Kok – Xayaburi area (mainstream and sub-basins)

This dataset was created using the species list from the mainstream Mekong fish between Xieng Kok and Xayaburi, as well as published literature from Kottelat 2009, Valbo MFD, Warren and Thavone

Phommavong 2010, and the MFD database to identify fishes found in the Xayaburi, Luang Prabang, Oudom Sai, Bokeo, Phongsali, and Chiang Rai provinces.

[Kottelat 2009] Species composition list from Kottelat 2009 study

[Valbo MFD] Species composition list form Valbo MFD study

[Warren 2009] Species composition list from Warren 2009

[Sub-basins] Access query run based on Bokeo, Chiang Rai, Oudom Sai, Xayaburi, Luang Prabang, and Phongsali provinces (including non-mainstream fish) for provinces

[Taxonomy] Taxonomic update following FishBase

[Endemicity] Classification from FishBase

5.7.3 Xieng Kok – Xayaburi mainstream Mekong

This dataset was created using the Mekong mainstream fish species identified in Dubeau 2004 (Xieng Kok to Luang Prabang) and the MFD database (Bokeo, Chiang Rai, Oudom Sai, Xayaburi, Luang Prabang).

There is no species list from Meynell (2003) since the species recorded by Meynell were integrated in Dubeau's follow up study one year later in the same zone.

[Query- MK mainstream] Access query run based on provinces Bokeo, Chiang Rai, Oudom Sai, Xayaburi, Luang Prabang, inclusive of only mainstream data

[Dubeau 2004 list] species composition list from the Dubeau 2004 study

[Taxonomy] Taxonomic update following FishBase

[Endemicity] Classification from FishBase

5.7.4 Additional data

[Migratory info] Data compiled from Ziv et al. 2012 and MFD 2003

[IUCN Red list] Information on the conservation status

6 AMPHIBIANS AND REPTILES BASELINE

6.1 INTRODUCTION

6.1.1 Existing knowledge of the area's fauna

No studies on amphibian and reptile (herpetofaunal) biodiversity have been conducted on the stretch of the Mekong River between Luang Prabang, Laos and Chiang Saen, Thailand. However, four sources of literature data exist on records of amphibians and reptiles from Luang Phabang, Xaignabouli, Oudomxay and Bokeo Provinces, Laos, and from Chiang Rai Province, Thailand. The earliest records are primarily based on Henri Mouhot's voyage from Xiagnabouli Province, Laos, to Luang Phabang, Laos, during April-November 1861 (e.g., Gray, 1862; Günther, 1864; Mouhot, 1864). A second period of records are primarily based on Malcolm A. Smith's expedition to the "Upper Mekong of French Laos" around January 1920. Smith's collecting localities were all on the Mekong River, within about 80 km of Pak Lay, there in encompassing riverine portions of Xaignabouli and Luang Phabang Provinces, Laos (e.g., Smith, 1922, 1923a, 1923b, 1931). Beginning mid 20th century, new sampling in northern Thailand, including Chiang Rai Province, primarily by Edward H. Taylor (e.g., Taylor, 1960, 1962, 1963, 1965; Taylor & Elbel, 1958), improved knowledge of amphibians and reptiles in the Thailand portion of the study area. More recent records are based on surveys conducted through IUCN by B. L. Stuart, Sengvilay Seateun, Mark Bezuijen and colleagues on the mainstream Mekong River in Luang Phabang and Xaignabouli Provinces during 2011-2012 (Stuart et al. 2013), regional reviews of amphibians and reptiles that include records from the vicinity of the study site (e.g., Chan-ard 2003; Cox et al. 2012), and primary literature that includes records and species descriptions from the vicinity of the study site (e.g., Vogel et al. 2004; David et al. 2007; Pomchote et al. 2008; Pipatsawasdikul et al. 2010; Teynié et al. 2013, 2015; Schneider et al. 2014; Phimmachak et al. 2015).

Despite these records in the literature, sampling of amphibians and reptiles along the Mekong River between Luang Phabang, Laos and Chiang Saen, Thailand remains limited and patchy. There have been no focused surveys for these taxa in the study area. As such, information on amphibians and reptiles at the study area can only be inferred by summarizing literature records from geographically proximate localities in similar habitats and elevations. This information gap can be best resolved by directed field sampling of amphibians and reptiles in the study area. Herein, the results of a very preliminary field survey of amphibians and reptiles in the study area are presented.

6.2 METHODS

6.2.1 Interviews and trade surveys

Interviews and surveys of animals in trade were conducted at six markets (two markets at Chiang Saen; one market at Chiang Khong, one market at Pak Tha, one at Pak Beng, and one at Luang Phabang), two temples (Wat Pha Ngao, Wat Pra Pukhao) near the Mekong River, and numerous villages along the Mekong River between Chiang Saen and Luang Phabang. Twenty-five local residents, including fishermen, a wildlife trader, fish sellers, and villagers, were interviewed. Interviewees were shown color photographs of amphibians and reptiles and asked by SP in the Lao or Thai language about the socio-economic importance of amphibians and reptiles to the interviewees, namely how and why they harvested and/or traded amphibians and reptiles.

6.2.2 Field surveys

Visual surveys for amphibians and reptiles were conducted at night (usually between19h00 and 22h00). Surveys were primarily focused on riparian areas near the Mekong River, including the river bank, streams, ponds, rice fields and under cover such as rocks and fallen logs. Coordinates were obtained using a handheld Garmin GPSMAP 60CSx (datum WGS84). The date, time, coordinates, and general descriptions of macro-and microhabitat were recorded for every individual of amphibian and reptile encountered. No voucher specimens were collected during the survey.

6.3 FINDINGS

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 (Table 6.1). Examples of species observed and sample and interview locations are shown in Figure 6.1 and Figure 6.2, respectively.

Table 6.1: Species of amphibians and reptiles observed or reported by interviewees during the study between Chiang Saen, Thailand, and Luang Phabang, Laos, during 11–19 March 2017.

Species that were reported during interviews but not directly observed by the survey team are indicated in [brackets]. Source of the record refers to survey (S) or interview (I). IUCN Red List status taken from IUCN (2017) and Lao national status taken from Stuart (1999).

Taxon	Source	Location	IUCN Red List	Lao Status
REPTILES				
Agamidae				
Calotes emma	S	Near temple.	None	None
Emydidae				
Trachemys scripta elegans	S	Captive in temple.	Least Concern (LC)	None
Geoemydidae				
Cuora mouhotii	S	Two carapaces of consumed individuals in village.	Endangered (EN)	At Risk in Lao PDR
Cyclemys oldhamii	S, I	Captive in temple	Least Concern (LC; evaluated as *C. dentata*)	Potentially At Risk in Lao PDR (evaluated as *C. dentata*).
Heosemys annandalii	S	Captive in temple	Endangered (EN)	At Risk in Lao PDR
Platysternidae				
Platysternon megacephalum	S	Captive in temple	Endangered (EN)	At Risk in Lao PDR
Testudinidae				
[Manouria impressa]	I	Reported from hill forest	Endangered (EN)	At Risk in Lao PDR
Trionychidae				
[Amyda cartilaginea]	I	Reported from Mekong and its tributaries	Vulnerable (VU)	At Risk in Lao PDR
Gekkonidae				
Hemidactylus frenatus	S	Villages	Least Concern (LC)	None

Taxon	Source	Location	IUCN Red List	Lao Status
Hemidactylus platyurus	S	Villages	None	None
Gekko gecko	S	Villages	None	None
Scincidae				
Eutropis macularia	S	Near villages	None	None
Eutropis multifasciata	S	Near villages	None	None
Pythonidae				
[Python reticulatus]	I	Caught in net by fishermen	None	Potentially At Risk in Lao PDR
Homalopsidae				
Enhydris plumbea	S	Stream near village	Least Concern (LC)	None
Colubridae				
Bungarus fasciatus	S	Mekong riverbank	Least Concern (LC)	None
Elapidae				
[Naja sp.*]*	I	Interview	Species uncertain	Species uncertain
[Ophiophagus hannah]	I	Interview	VU	Potentially At Risk in Lao PDR
AMPHIBIANS				
Ichthyophiidae				
[Ichthyophis kohtaoensis]	I	In agricultural lands near Mekong	Least Concern (LC)	None
Bufonidae				
Duttaphrynus melanostictus	S	Rice fields and villages	Least Concern (LC)	None
Microhylidae				
Kaloula pulchra	S	Rice fields and on road	Least Concern (LC)	None
Microhyla butleri	S	Near stream near village	Least Concern (LC)	None
Microhyla fissipes	S	Rice fields and ponds	Least Concern (LC)	None
Microhyla pulchra	S	Rice fields and ponds	Least Concern (LC)	None
Micryletta inornata	S	Rice fields and ponds	Least Concern (LC)	None

Taxon	Source	Location	IUCN Red List	Lao Status
Dicroglossidae				
Fejervarya limnocharis	S	Rice fields, ponds, near streams	Least Concern (LC)	None
Hoplobatrachus rugulosus	S	Rice fields and ponds	Least Concern (LC)	None
Limnonectes cf. kuhlli	S	For sale in Luang Phabang market	Species uncertain	Species uncertain
Occidozyga martensii	S	Near ponds	Least Concern (LC)	None
Ranidae				
Hylarana erythraea	S	Near ponds	Least Concern (LC)	None
Hylarana nigrovittata	S	For sale in Luang Phabang market	Least Concern (LC)	None
Rhacophoridae				
Polypedates leucomystax complex	S	Near ponds in agriculture lands, for sale in Luang Phabang market	Least Concern (LC)	None

Figure 6.1: Example species of amphibians and reptiles observed during the survey between Chiang Saen, Thailand to Luang Phabang, Laos during 11-19 March 2017

A. Plastron of *Cuora mouhotii* ; B. carapace of *C. mouhotii*; C. Trap used to capture *Amyda cartilaginea*; D. *Fejervarya limnocharis*; E. *Kaloula pulchra*; F. *Micryletta inornata*; G. *Enhydris plumbea*; H. *Hylarana erythraea.*

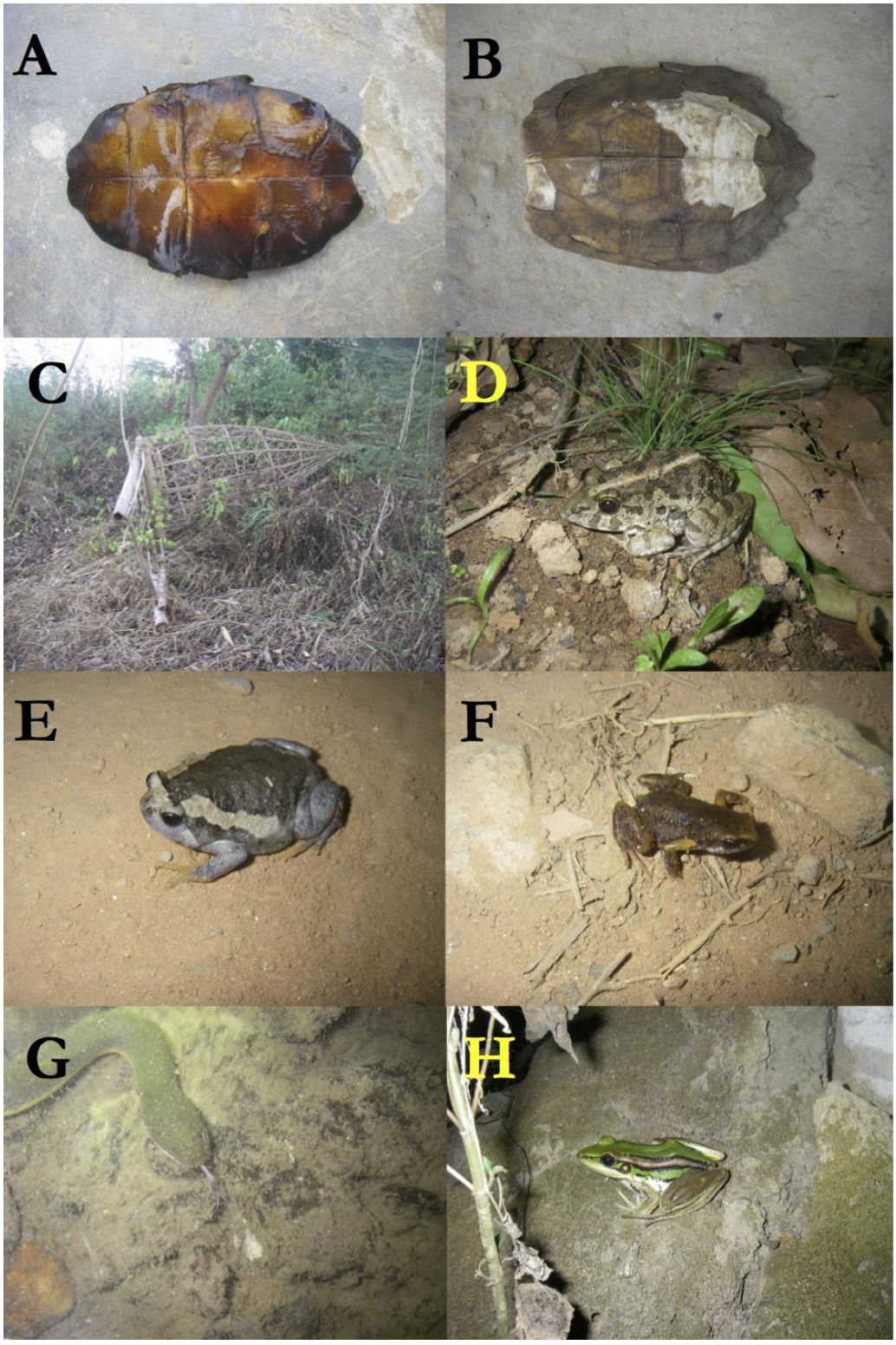
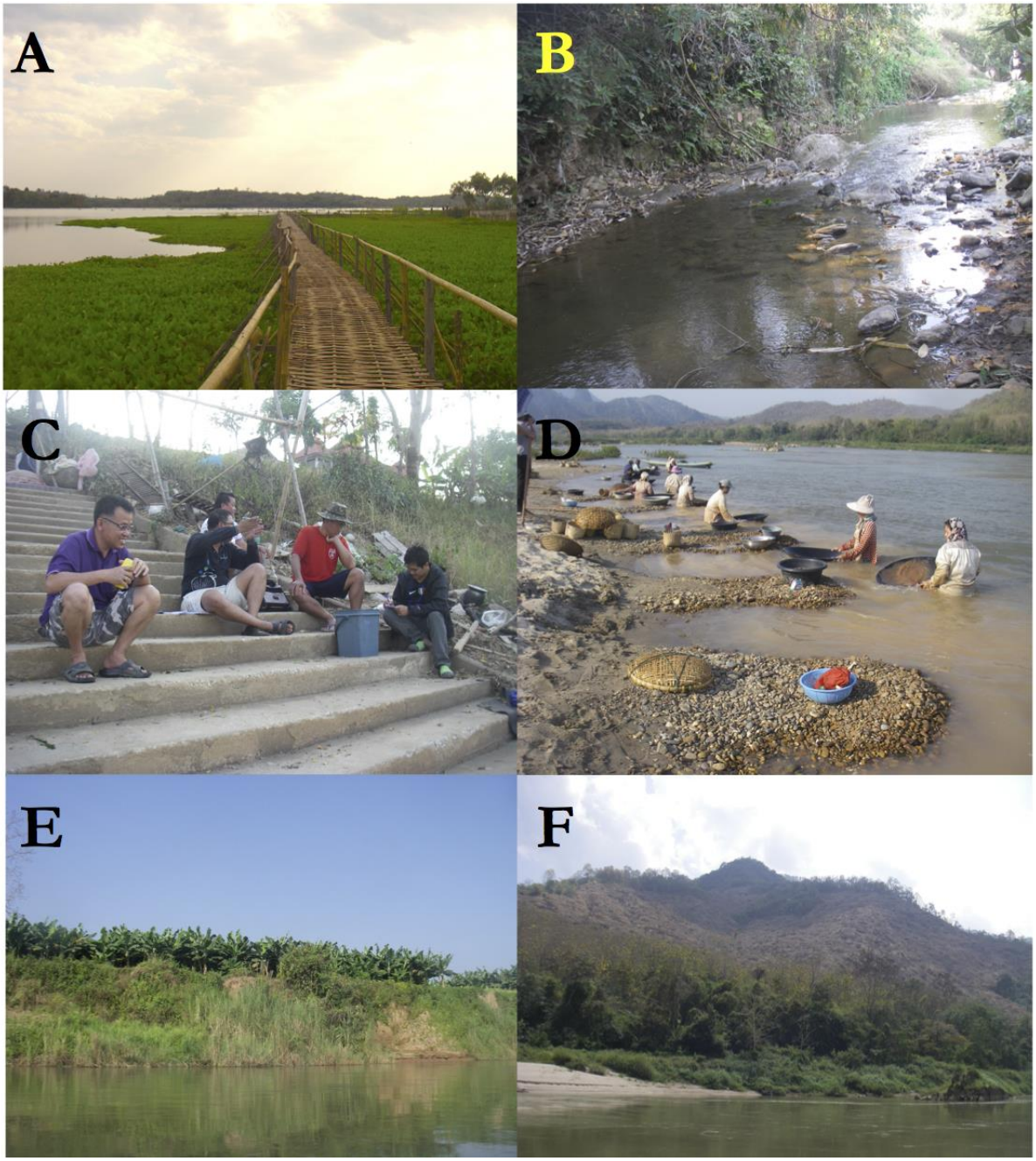


Figure 6.2: Example survey and interview localities between Chiang Saen, Thailand to Luang Phabang, Laos during 11-19 March 2017

A. Nong Bong Khai; B. Houay Kheuw in Paktha; C. fishermen interviewees in Chiang Khong, and D. Gold panning along Mekong Bank in Luang Phabang. E. Banana plantation in Boekeo Province, F. Slash and burn for agriculture in Oudomxay Province.



6.3.1 Selected species accounts

Species that were reported during interviews but not directly observed by the survey team are indicated in [brackets].

Fanged Frog *Limnonectes* cf. *kuhlii* (species uncertain)

Not listed globally or nationally.

Many species in the *Limnonectes kuhlii* complex are very similar in morphology and are difficult to identify without the aid of molecular data (McLeod et al. 2012). Several individuals of *Limnonectes* cf. *kuhlii* were observed in the Luang Phabang Market, mixed in plastic bags with other frogs (*Fejervarya limnocharis*, *Polypedates leucomystax*, and *Hylarana nigrovittata*). These were being sold for 30,000 kip per bag (approximately 1kg/bag). Species in the *L. kuhlii* complex occur only in clear, rocky, forested hill streams.

Keeled Box Turtle *Cuora mouhotii*

Globally Threatened – Endangered; At Risk in Lao PDR

The Keeled Box Turtle was documented on this survey by remains of two consumed individuals (one plastron and one carapace) held in Ban Kokkham (20.08540°N, 102.16388°E; 283 m a.s.l.), Pak Ou District, Luang Phabang Province (Fig. 1 A&B). The species was also reported in interviews of a villager at Had Kiane (20.02588°N, 102.22044°E; 269 m a.s.l.), Chomphet District, Luang Phabang Province, a villager at Had Kiane, and a local wildlife trader in Ban Lat Han (20.08702°N, 102.12369°E; 282 m a.s.l.), Nga District, Oudomxay Province. The trader reported that a 400g of turtle of this species was recently sold in Ban Lath Khamoun, Nga District, Oudomxay. Interviewees reported harvesting the species for selling to Vietnamese traders for food, traditional medicine and pets. The Ban Kokkham individuals were eaten for food, and the carapaces were retained for selling to Vietnamese traders for 2,000 kip/each.

This species is usually associated with limestone karst forest and is known from Xaysomboun Province (Phimmachak 2015) and Hin Nam No National Protected Area (Stuart and Platt 2004). Elsewhere it occurs in northeastern India, Myanmar, northern Thailand, southern China and Vietnam (Zhao and Adler 1993).

Yellow-headed Temple Turtle *Heosemys annandalii*

Globally Threatened – Endangered; CITES Appendix II; At Risk in Lao PDR.

A single live individual was observed in a pond at Dhat Pha Ngao temple, Chiang Saen, Chiang Rai Province, Thailand. This large-sized species is heavily harvested for food and trade in Laos (Stuart and Platt 2004). Elsewhere it occurs in wet areas at low elevations in Cambodia, Malaysia, Thailand, and Vietnam (Van Dijk, 2000).

[Big-headed Turtle *Platysternon megacephalum]*

Globally Threatened – Endangered; CITES Appendix II; At Risk in Lao PDR.

The Big-headed Turtle was reported in interviews of a fisherman Ban Khonedin (19.88093°N, 100.77307°E; 324 m a.s.l.), Pakbeng District, Oudomxay Province, a trader from Ban Lat Han, Nga District, Oudomxay Province, and villagers in Ban Kokkham, Pak Ou District, Pak Ou District, Luang Phabang Province. Interviewees reported that this species is rare in their area but can be found in

small streams in evergreen forest in the mountains near their villages. The trader from Lat Han village had recently bought about ten kilograms of this species from villagers. They caught the turtles from Houay Han and sold to the local trader for 800,000/kg. The turtles were re-sold to a Vietnamese trader in Luang Phabang at the higher price of 1,300,000kip/kg.

This species occurs throughout Laos at higher elevations in rocky streams in evergreen forest (Stuart 1998b, Pritchard 1995, Showler *et al*. 1998). It was reported to be eaten for food (Stuart 1998a) and sold to Lao traders (Pritchard 1995) and Vietnamese traders at relatively high prices (Stuart 1998b, 1998c), presumably for the Vietnamese and Chinese consumption trade.

[Impressed Tortoise *Manouria impressa]*

Globally Threatened – Endangered; CITES Appendix II; At Risk in Lao PDR.

Residents from two villages (Ban Paktha, Paktha District, Bokeo Province, and Ban Kokkham Pak Ou District, Luang Phabang Province) reported finding this species in the mountains on the west side of the Mekong River. The Ban Paktha interviewee stated that these were not usually consumed, but the Ban Kokkham interviewee stated that these were harvested for food.

[Asiatic Softshell Turtle *Amyda cartilaginea]*

Globally Threatened – Vulnerable; CITES Appendix II; Potentially At Risk in Lao PDR.

The Asiatic Softshell Turtle was reported in interviews of two fish traders at Nong Sam Kha fish market (20.23643°N, 100.12555°E; 361 m a.s.l.). The market was located near the confluence of the Kok River and the Mekong River. The trader reported buying an 8kg turtle of this species from a fisherman about three months prior for 300 baht/kg, which was re-sold for 400 baht/kg. The interviewees reported that eight to ten small-sized turtles (1-2kg/individual) were offered in the market each month. These were usually obtained from the Kok and Mekong Rivers. Five fishermen from Ban Done Thee (20.35387°N, 100. 37148°E; 358 m a.s.l.), Chiang Khong District, Chiang Rai Province, Thailand; Ban Paktha, Paktha District, Bokeo Province; Ban Khonedin Pakbang District, Oudomxay Province and Ban Kokkham, Pakou District, Luang Phabang Province, Laos, reported that this species could be caught in the Mekong river tributaries, as well as the mainstream Mekong during the dry season (at low water level). The turtles were reportedly caught using fishing nets, traps (Fig1.C), and hook and line fishing gear.

Amyda cartilaginea is known from throughout Laos (Stuart and Platt 2004). The species occurs widely in Southeast Asia, from Myanmar to Indonesia (Asian Turtle Trade Working Group 2000). It is likely found in many protected areas throughout Laos.

[Reticulated Python *Python reticulatus* (= *Broghammerus reticulatus*)]

CITES Appendix II; Potentially At Risk in Lao PDR

This species was reported to be caught accidentally in fishing nets by fishermen in the study area. A Thai fisherman reported that small individuals would be discarded, but large individuals would be retained for eating or selling (200 to 300Baht/kg in the local market). A wildlife trader from Ban Lat Han bought 20kg of this species last month from other villagers, and re-sold them at the Luang Phabang market for the higher cost of 500,000kip.

The species is known to be harvested for food by local people, or harvested for sale to Vietnamese traders, throughout Laos (Phimmachak, 2015). It occurs widely from Myanmar to Indonesia and the Philippines (Das 2010).

[King Cobra *Ophiophagus hannah*]

Globally Threatened – Vulnerable; CITES Appendix II; Potentially At Risk in Lao PDR

A villager at Had Kiane (20.02588°N, 102. 22044°E; 269 m a.s.l.) reported that this species is rare, but that he saw a King Cobra once near his village last year.

In Laos, this species is often harvested for sale for medicinal purposes, and is also often killed because of perceived risk to people and their livestock from this dangerously venomous snake (Phimmachak, 2015). The species is known throughout Laos (Deuve 1970). It occurs widely from India across southern China, southward to Indonesia and the Philippines (Zhao and Adler 1993).

6.3.2 Completeness of the survey

Species continued to be added to the list at the end of the survey, indicating the incompleteness of the survey. Owing to lack of permission from relevant Thai and Lao governmental authorities, limited opportunity was available for conducting night surveys in desired appropriate habitat (e.g. forested tributaries of the Mekong River). Consequently, very few species were documented, and most of those that were documented are species that are tolerant of human-modified environments, including villages and agricultural lands. Many more species, including those of higher conservation importance, are expected to occur in the study area.

Three things are needed in future work to improve the completeness of the survey: (i) the ability to survey at night in appropriate habitat (e.g. forested tributaries of the Mekong River) by obtaining necessary permission letters from Thai and Lao governmental authorities; (ii) the ability to collect representative samples as voucher specimens (with associated tissue samples for molecular analyses) to verify identifications and permanently document species occurrence at the sites prior to disturbance from development; and (iii) opportunity to conduct longer-term field sampling, including a minimum of at least three days/nights per site, and sampling during different seasons to capture variation in activity patterns of species.

6.3.3 Conservation importance

6.3.3.1 Current reptile and amphibian conservation value of the project area

Two observed species (*Cuora mouhotii* and *Heosemys annandalii*) and five reported species (*Platysternon megacephalum*, *Manouria impressa*, *Amyda cartilaginea*, *Python reticulatus*, and *Ophiophagus hannah*) have been assessed as having global or national level threat status. All seven of these species are primarily threatened from harvesting for food or trade. One additional reported taxon, *Naja* sp., might also be determined to be a species having global or national level threat status after determining the actual species (three species of *Naja* potentially occur in the vicinity of the survey area).

No taxa were found that are believed to represent new species to science. One taxon, *Limnonectes* cf. *kuhlii*, is known to be a member of a complex of cryptic species (McLeod et al. 2012), and there are probably undescribed species in this complex in Laos. Accurate identification of members of this

species complex usually requires studying voucher specimens and molecular (DNA sequence) data. This taxon was observed on this survey in the Luang Phabang market, and like other large-sized frogs in Laos, is consumed for food.

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7 BIRDS BASELINE

7.1 INTRODUCTION

This chapter presents information about the birds that inhabit the Mekong channel and banks, with some reference to those of directly adjacent habitats, between the 'Golden Triangle' (the Myanmar – Thai border on the Mekong's right bank) and the city of Louang Prabang in Lao PDR. This is referred to as the 'study stretch'. The report is written from a thin information base. Many uncertainties remain detailing the study stretch bird community. Yet, 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. Since 2000, a number of upstream dams, in China, have become operational. These have led, in the upper Lao Mekong, to sometimes unnatural patterns in water level for the time of year. Whether these changes are sufficiently disruptive to the nesting community to have accelerated local population declines in channel-nesting birds is not known, but it is certainly possible. One consequence of the gap between observations and this document is that the 'current' study-stretch river-channel bird community described here could already have changed significantly. If it has, it will surely have become even more impoverished, although a few resilient species may have increased.

The chapter is compiled from ICEM Bird Specialist Will Duckworth's personal experience of surveying river-channel birds along most of the Lao Mekong and in many of its major tributaries from 1992 to date, supplemented by personal observations of others, and set in the context of a number of variably detailed expedition write-ups from the 1890s to the 1940s. It was not possible to conduct a detailed field survey in the current study, restricting conclusions in terms of spatial precision, current applicability, and even broad appreciation of status of a number of cryptic and/or seasonally visiting species. Nowadays inspection of aerial imagery is often pushed as a substitute for field survey. No use was made of it here because while it could show (in imagery of suitable resolution, taken in the mid to late dry season) habitat with potential to support bird species of particular conservation importance, it could not reveal what is actually there. That depends as much on human use patterns in the stretch and on upstream water flow management decisions as it does on the visible habitat. Furthermore, a brief look at what is currently available on Google Earth indicated that some images are not from the low-flow season and on some the image quality is too poor to be sure what habitats are exposed in the channel bed.

While the general picture of an enormous loss in the study-stretch bird community over the last century is reflective of the overall Mekong system and is not open to question, the factors driving this change remain poorly understood. Clearly, operating over such a long time scale, this systemic trend is not primarily, if anything, to do with 'modern' activities such as large dams, channel reconfiguration for navigation improvement, or industrial sediment collection. It must depend from the longstanding ordinary activities of people living in and boating through the area over the decades. This may include killing and/or collection of adult birds, young birds and eggs by people; predation by the dogs that accompany so many people and by rat populations larger than 'natural' from their scavenging of refuse; trampling by domestic stock; nest failure through the repeated close proximity of people at egg- and/or chick stage; and quite possibly other factors. Throughout this chapter, the shorthand term

'the local people package' is used to distinguish this basket of inter-related and difficult-to-disentangle factors from other actual and potential anthropogenic threats to the channel avifauna.

The study stretch includes only the river channel (permanent water; areas exposed some of the year but underwater for the rest; features projecting permanently above water which are not properly replicated on land such as rocky cliffs, bank-tops and riverine woody vegetation). It does not include the adjacent plains, even their wetlands, or the plains 'isolates' comprised by permanent islands in the river channel with habitats indistinguishable from those of adjacent plains. Where the birds of these latter habitats are mentioned, their non-channel status is always made explicit.

7.2 DESCRIPTION OF SPECIES AND STATUS

Photographs of all species considered can be found at the Oriental Bird Club's Oriental Bird Images collection on the internet (http://orientalbirdimages.org/). There are some differences in taxonomy and nomenclature between OBI and the IUCN Red List of Threatened Species; the latter is used here as the taxonomic and nomenclatural baseline. Care should be taken consulting images elsewhere on the internet, given the frequent misidentifications there.

7.2.1 Endemic bird species

No bird species endemic to the study stretch are known. Indeed, no bird endemic to the Lao Mekong is known. It is possible that so-far undescribed endemic species occur(s) or occurred: two bird species each endemic to a small part of the Mekong mainstream, major tributaries and/or associated flood-plain wetlands were described only recently, Mekong Wagtail Motacilla samveasnae Duckworth et al., 2001 and Cambodian Tailorbird Orthotomus chaktomuk Mahood et al., 2013. With the exception of the Chiang Saen area, the study stretch has been much less well surveyed for birds than parts of the ranges of these two species at the time of their discovery.

7.2.2 Globally threatened bird species

Table 7.1 lists the globally threatened bird species (as of January 2018) recorded in, or likely to occur at least occasionally and/or previously in, the study stretch of the Mekong. Most (25) of these species warrant no consideration in management decisions because they are (i) at best only vagrants; (ii) while potentially formerly common, long extirpated and with minimal short- to mid-term prospect of natural recolonisation under any plausible scenario; or (iii) species of the adjacent plains land and/or wetland habitats making only little, if any, use of the river channel. These species are not considered further, except for those in group (ii), for discussion of long-term trends.

Seven globally threatened species occur, potentially occur, or until recently did occur regularly in the study stretch. Yellow-breasted Bunting is presently in free-fall global population decline, driven, it is believed, by unsustainable mass-trapping in much of its wintering and passage range. Into the 2000s, roosts of thousands occurred in winter in tall graminoid beds in plains wetlands of Thailand and Lao PDR. As recently as February 2016 up to 350 were found at a regularly used winter roost at Mai Ai in the Mekong drainage of Chiang Mai (P. D. Round *in litt*. 2018). Its winter use of seasonally exposed dry parts of river channels remains poorly documented, and may have been unusual: the typical bunting in that habitat in northern Indochina is Black-faced Bunting *E. spodocephala*. Based on observations further downstream, short-stay passage flocks of Yellow-breasted Bunting can safely be assumed to have occurred, containing up to several hundred birds, in the seasonally exposed well-vegetated

channel (as well as in plains wetlands and stubbles), although it is unclear if any were ever documented there. The river channel habitats were probably not of any particular importance to the species given the wide spread of habitats within which passage birds in Lao PDR were recorded in 1992–2016.

Two species of long-distance migrant eagle, Eastern Imperial and Steppe, perhaps overfly the area in spring and autumn and could potentially overwinter. Observation effort in and around the study stretch coupled with the pattern of their records more widely in Thailand, Lao PDR and Cambodia make it a fairly safe assumption that there is neither regular wintering of either of these species nor any regularly used passage feeding area in or adjacent to the study stretch. By contrast, the annual fly-over total of a third species, Greater Spotted Eagle, could potentially run into hundreds of birds, with occasional roosting and feeding potentially anywhere in and adjacent to the study stetch; and the adjacent plains may hold regular overwintering birds, at last in Thailand. It is unlikely that the channel itself is of any conservation importance to any of these species.

For the other three globally threatened species in Table 7.1, speculations on their status in the area, and thus its potential significance to their conservation, are less confident. Until the late 1990s, the winter range of White-browed Reed Warbler, which breeds in North-east Asia, was poorly clarified. It is now known to be mainland South-east Asia in and south of Cambodia. The study stretch is unlikely to support the species in winter. One of only a few records of passage birds, from anywhere in the world, was a concentration at the Pakxan wetlands, Bolikhamxai province, Lao PDR, in in mid-May 2005. That site has never been revisited in suitable weeks of other years to determine if it is a regular stop-over site for the species. Possibly, somewhere in or adjacent to the study stretch, but probably a well-vegetated plains wetland rather than a part of the main channel, could support a comparable concentration. The extent to which individual stopover sites are vital for the species (versus, if lost, readily replaceable with others) is unknown.

The morphologically highly distinctive White-eyed River Martin is one of the world's least-known bird species. It is known only from a series of records at a central Thai wetland around 1970, to which it was presumed to have been a non-breeding visitor. Potentially, it could have occurred, even bred, in the study stretch.

Wood Snipe is poorly known in South-east Asia; in South Asia, it breeds in mountain forest. Records from the Nakai plateau in the 1990s–2000s and the Xiangkhouang plateau in the 1930s–1940s indicate at least occasional dispersal to lower altitudes. There are no records from Mekong altitudes in Lao PDR or Thailand (recent Thai records come from the forested uplands [P. D. Round *in litt*. 2018], recent Lao records from only the Nakai plateau), but it is so cryptic that it could have been overlooked there. It is possible that it is a regular non-breeding visitor to the area, but equally it might not occur there at all.

In sum, there is neither evidence, nor strong predictive reasoning, that the study 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 conclude that it does not have such importance. It seems unlikely to be the case for any threatened species except potentially White-browed Reed Warbler.

Table 7.1: Globally threatened bird species (as of January 2018) recorded in, or likely to occur at least occasionally and/or previously in, the study stretch of the Mekong.

Species potentially relevant to consideration			
English name; Red List category	**Scientific name**	**Occurrence**	**Season and abundance**
Wood Snipe; VU	*Gallinago nemoricola*	Predicted	Unknown; may never have occurred at all
Greater Spotted Eagle; VU	*Clanga clanga*	Recorded; mostly fly-overs	Non-breeding visitor, now at best rare, potentially previously much more common
Steppe Eagle; EN	*Aquila nipalensis*	Predicted; mostly fly-overs?	Non-breeding visitor, now at best rare, potentially previously more common
Eastern Imperial Eagle; VU	*Aquila heliaca*	Predicted; mostly fly-overs?	Non-breeding visitor, now at best rare, potentially previously much more common
White-browed Reed Warbler; VU	*Acrocephalus tangorum*	Predicted; wetland graminoid beds, which are rare in channel	Passage migrant, abundance cannot be predicted
White-eyed River Martin; CR	*Eurochelidon sirintarae*	Predicted	Unknown; may never have occurred at all
Yellow-breasted Bunting; CR	*Emberiza aureola*	Recorded, primarily solely adjacent to channel	Passage migrant an winter visitor, formerly abundant still locally common
Species irrelevant to consideration			
English name	**Scientific name**	**Status**	**Channel dependence**
Green Peafowl	*Pavo muticus*	Long extirpated*	Mid
Swan Goose	*Anser cygnoid*	LDMW(straggler)	n/a
White-winged Duck	*Asarcornis scutulata*	Long extirpated	Low
Baer's Pochard	*Aythya baeri*	Almost extirpated	Low
Common Pochard	*Aythya ferina*	LDMW(straggler)	n/a
Scaly-sided Merganser	*Mergus squamatus*	LDMW(straggler)	n/a
Great Slaty Woodpecker	*Mulleripicus pulverulentus*	Long extirpated	No use, save in riverine forest
Sarus Crane	*Antigone antigone*	Long extirpated	Low
Masked Finfoot	*Heliopais personatus*	Long extirpated	Low
Far-eastern Curlew	*Numenius madagascariensis*	LDMW(straggler)	n/a
Spotted Greenshank	*Tringa guttifer*	LDMW(straggler)	n/a
Great Knot	*Calidris tenuirostris*	LDMW(straggler)	n/a
Spoon-billed Sandpiper	*Calidris pygmaea*	LDMW(straggler)	n/a
Indian Skimmer	*Rynchops albicollis*	Long extirpated	High
Black-bellied Tern	*Sterna acuticauda*	Long extirpated	High
White-rumped Vulture	*Gyps bengalensis*	Long extirpated	Low
Slender-billed Vulture	*Gyps tenuirostris*	Long extirpated	Low

Red-headed Vulture	*Sarcogyps calvus*	Long extirpated	Low
Chinese Egret	*Egretta eulophotes*	LDMW (straggler)	n/a
White-shouldered Ibis	*Pseudibis davisoni*	Long extirpated	Mid
Asian Woollyneck	*Ciconia episcopus*	Long extirpated	Mid
Lesser Adjutant	*Leptoptilos javanicus*	Long extirpated	Mid
Greater Adjutant	*Leptoptilos dubius*	Long extirpated	Mid
Fairy Pitta	*Pitta nympha*	LDML (straggler)	n/a
Grey-sided Thrush	*Turdus feae*	LDML (straggler)	n/a

*but a large population thrives in nearby Phayao province (P. D. Round *in litt*. 2018).

LDMW (straggler), long-distance migrant waterbird (always rare): no or very few records known from study stretch, but all waterbird species migrating from the Palaearctic to tropical eastern Asia probably occur at least very occasionally in the study stretch as stopovers or vagrants. Individual sites of occurrence within the stretch, and probably even total use of the stretch, have no relevance to population stability or conservation of the species.

LDML (straggler), long-distance migrant landbird (always rare): no records known from study stretch, but regional pattern of records suggests that occasional stopovers or vagrant individuals of these species might occur. Numbers are safely predictable to be too low to have any relevance to population stability or for their sites of occurrence to bear on the conservation of the species.

Long extirpated: known to, or safely presumed to have (or, for Masked Finfoot, potentially to have), occurred regularly in the study stretch, but extirpated for decades and with no realistic possibility of natural recolonisation under any plausible scenario (occasional vagrants may still occur).

7.2.3 Nationally 'threatened' bird species

The study stretch lies within Lao PDR and Thailand, with its upstream boundary set by the Thai–Myanmar border. There is apparently no national Red List or equivalent for Myanmar's birds. The national Red List of the birds of Thailand was revised in 2017 (OEPP 2017). There is no national Red List, using IUCN categories and criteria, for Lao birds, but a 1999 review of the national status of tetrapod vertebrates (Duckworth *et al*. 1999) proposed a list of species At Risk in Lao PDR together with those Potentially At Risk in Lao PDR and those Conditionally At Risk in Lao PDR (i.e. not confirmed to occur in the country, but if they did, would presumably be at risk).

Table 7.2 lists species recorded in, or likely to occur at least occasionally and/or previously in, the study stretch of the Mekong, that are categorised as At Risk in Lao PDR (as of 1999) and/or nationally threatened in Thailand as of 2017, supplemented with those species subsequently and informally considered likely now to warrant At Risk in Lao PDR categorisation; the justification for most of these is given in Duckworth & Timmins (2013) and/or Duckworth (in press). It excludes those species presently (January 2018) considered globally threatened (these are given in Table 7.1).

As with the globally threatened species, many (49) of these species are not relevant to consideration of the effects upon birds of the LMDP or of the Pakbeng dam (Table 7.2b). In total, up to 23 species are known or reasonably inferred to have been of regular occurrence in, and locally dependent upon, the Mekong channel in the study stretch but to have been extirpated. The true number may be much higher given the patchiness of early information. 'Extirpation' as used here does not exclude the occasional occurrence of straggler individuals of these species even today, but the study stretch is no

longer of any significance to these species' conservation. Many of these species have been absent for decades; Little Cormorant has not been recorded for over a century.

Some (6–8) species are only, and as far as can be inferred, during historical times only ever have been, stragglers to the stretch, while some others (up to 10) included in the table have never been recorded anywhere near the study stretch but, because they are typically difficult to find without specific searching, might occur there but have been overlooked. Three classes of species are known, or reasonably inferred, to occur regularly 'along' the stretch but either do not occur in the channel and/or banks themselves, or even though occurring in it are reliant primarily on other habitats (plains, including plains wetlands; side-streams; and forest). For all these species (up to 27) the channel is of little significance to their conservation except at the most parochial of levels.

Individuals of all these 'nationally threatened' species that were recorded at all were counted in December 1999 – January 2000 and in April 2000 along the entire study stretch (Duckworth *et al*. 2002). These 1999–2000 counts from the study stretch are repeated here as Table 7.3, along with the assessment of 2000–2012 change given in Duckworth & Timmins (2013) for the Paklay – Vientiane stretch.

In 1999–2000, the study stretch demonstrably supported good numbers of spot-billed duck(s) (presumed to be Indian Spot-billed Duck), River Lapwing and Asian Plain Martin. Blue-tailed Bee-eater was found only once, and only just upstream of the study stretch (and the sighting was not confirmed to be of this species), but could well have been somewhat overlooked; it could potentially be quite common in the stretch. Pied Kingfisher was very rare, possibly no longer resident in the stretch, with only one sighting. Large-billed Crow was found only twice, both times singly, and was clearly very rare in the stretch. Similarly, Great Cormorant was also very rare: in fact the two records were the first ones for Lao PDR for decades, and that in the Thai–Lao stretch was only the third recent record for Thailand. Previously it had been abundant in this part of the Mekong. Stork-billed Kingfisher might then have persisted in the study stretch at a low level, but the lack of any record means that it was certainly not numerous; based on national trends it may well have been entirely extirpated already by then.

Methodology and/or seasonality of the 1999–2000 survey were not apt to determine the local status of Common Buttonquail, Eastern Grass Owl, Brown Fish Owl, Indian Nightjar, Savanna Nightjar, Oriental Darter and Red Avadavat. The much more intensive survey of the Louangphabang – Vientiane stretch in 2011–2012 found none of these to be common there, although the survey was not seasonally apt for determining Buttonquail or Darter status, while Grass Owl could easily have been overlooked. Apart from these latter three species, it would be extraordinary if any of these species were to be found to be common in the study stretch.

The local status of Asian Openbill is in an entirely different class. It is undergoing an explosive population and range increase in Thailand and, through movement of Thai birds, in Lao PDR. It is not possible to predict from the 2000 survey of the study stretch, or even the 2011–2012 survey of the adjacent stretch, its current status in the study stretch. It may well now be common. On the adjacent plain in Chiang Saen it is now regular occurrence though P. D. Round (*in litt*. 2018) is not aware of any breeding records there yet.

Table 7.2: Bird species At Risk in Lao PDR* or nationally threatened in Thailand (as of 2017) recorded in, or likely to occur at least occasionally and/or previously in, the study stretch of the Mekong. Species considered also to be globally threatened are omitted (see **Table 7.1**).

*This list has not been reassessed figuresince 1999 but those species likely to warrant consideration as At Risk in Lao PDR at present are included here, coded by '[ARL]'. Discussion of these species's Lao status was given in Duckworth & Timmins (2013) and/or Duckworth (in press).

a. **Species potentially relevant to management consideration**

English name; category	Scientific name	Channel dependence	Season and abundance	Category
Indian Spot-billed Duck	*Anas poecilorhyncha*	Mid	Resident, localised	[ARL]
Common Buttonquail	*Turnix sylvaticus*	Mid	Presumed resident, abundance unclear	ARL
Stork-billed Kingfisher	*Pelargopsis capensis*	Mid	Resident, possibly extirpated already	[ARL]
Pied Kingfisher	*Ceryle rudis*	High	Resident, approaching extirpation	ARL
Blue-tailed Bee-eater	*Merops philippinus*	High	Wet-season breeding visitor, presumably much reduced	[ARL]
Eastern Grass Owl	*Tyto longimembris*	Mid	Unknown	Th-VU
Brown Fish Owl	*Ketupa zeylonensis*	Mid	Resident, much reduced	[ARL]
Indian Nightjar	*Caprimulgus asiaticus*	Unclear	Unclear	[ARL]
Savanna Nightjar	*Caprimulgus affinis*	Mid	Presumed resident, much reduced	[ARL]
River Lapwing	*Vanellus duvaucelii*	High	Resident, locally common	ARL; Th-VU
Oriental Darter	*Anhinga melanogaster*	Mid	Presumed wet-season non-breeding visitor, extirpated, recolonising or likely soon to do so	ARL; Th-VU
Great Cormorant	*Phalacrocorax carbo*	Mid	Winter visitor? Scarce	ARL
Asian Openbill	*Anastomus oscitans*	Low	Rapidly increasing non-breeding visitor; no publicised breeding records as of early 2018	ARL
Large-billed Crow	*Corvus macrorhynchos*	Mid	Resident, much declined, extremely rare on Lao plains, more frequent on the Thai plains, in channel itself overall unusual	[ARL]
Asian Plain Martin	*Riparia chinensis*	High	Locally common resident	ARL; Th-VU

b. Species irrelevant to management consideration

English name	Scientific name		Reason					Category
		Extirpated	Straggler	Far from known range	Side-streams	Plains non-forest	Forest	
Greylag Goose	*Anser anser*		X					ARL
Bar-headed Goose	*Anser indicus*		X					ARL
Ruddy Shelduck	*Tadorna ferruginea*		X					ARL
Common Shelduck	*Tadorna tadorna*		X					ARL
African Comb Duck	*Sarkidiornis melanotos*	X?	X	X?		X		ARL; Th-CR
Cotton Pygmy-goose	*Nettapus coromandelianus*					X		ARL
Ferruginous Pochard	*Aythya nyroca*					X		[ARL]; Th-VU
Great Hornbill	*Buceros bicornis*	X					X	ARL
Austen's Brown Hornbill	*Anorrhinus austeni*	X					X	Th-VU
Wreathed Hornbill	*Rhyticeros undulatus*	X					X	ARL
Blyth's Kingfisher	*Alcedo hercules*		X		X			Th-CR
Crested Kingfisher	*Megaceryle lugubris*	X						Th-EN
Blue-throated Bee-eater (breeding)	*Merops viridis*	X?		X		X?		[ARL]
Tawny Fish Owl	*Ketupa flavipes*			X				[ARL]
Buffy Fish Owl	*Ketupa ketupu*			X				[ARL]
Ashy-headed Green Pigeon	*Treron* **phayrei**	X?					X	ARL
Green Imperial Pigeon	*Ducula aenea*	X					X	ARL
Watercock	*Gallicrex cinerea*					X		ARL
Purple Swamphen	*Porphyrio porphyrio*					X		ARL
Indian Thick-knee	*Burhinus indicus*		X?					[ARL]
Great Thick-knee	*Esacus recurvirostris*	X?						Th-CR

River Tern	*Sterna aurantia*	X						ARL; Th-CR
Little Tern (breeding)	*Sternula albifrons*	X?		X				ARL
Black Kite (other than passage)	*Milvus migrans*	X				X		ARL; Th-EN [[[is this *M. m.* sensu lato?]]]
Brahminy Kite	*Haliastur indus*	X?						ARL
White-bellied Sea Eagle	*Haliaeetus leucogaster*			X				ARL
Lesser Fish Eagle	*Icthyophaga humilis*	X			X?			ARL; Th-EN
Grey-headed Fish Eagle	*Icthyophaga ichthyaetus*	X?		X?				ARL; Th-CR
Cinereous Vulture	*Aegypius monachus*		X?			X		ARL
Little Cormorant	*Microcarbo niger*	X				X?		ARL
Purple Heron	*Ardea purpurea*					X		[ARL]
Egrets (breeding)	four species of four genera	X?		X?		X?		[ARL]
Black-crowned Night Heron (breeding)	*Nycticorax nycticorax*	X?		X?		X?		ARL
Eurasian Bittern	*Botaurus stellaris*					X		ARL
Black-headed Ibis	*Threskiornis melanocephalus*	X?		X?				ARL; Th-VU
Spot-billed Pelican	*Pelecanus philippensis*	X						ARL; Th-VU
Painted Stork	*Mycteria leucocephala*	X						ARL
Black Stork	*Ciconia nigra*	X						ARL
Black-necked Stork	*Ephippiorhynchus asiaticus*	X						ARL; Th-EW;
Brown Dipper	*Cinclus pallasii*				X			Th-EN
Asian Pied Starling	*Gracupica contra*					X		[ARL]
Streaked Weaver	*Ploceus manyar*					X		[ARL]
Baya Weaver	*Ploceus philippinus*					X		[ARL]
Asian Golden Weaver	*Ploceus hypoxanthus*					X		ARL
Red Avadavat	*Amandava amandava*					X		[ARL]
Black-headed Munia	*Lonchura atricapilla*					X		[ARL]

Reasons for assessment as not relevant for further consideration:

Extirpated: the species is known or inferred to have been formerly of regular occurrence in the study stretch, but this is no longer so (stragglers may still occur and be recorded). A 'X?' can mean either it is unclear whether it ever was of regular occurrence, or it is unclear whether it is yet extirpated, or both.

Straggler: the species does not occur regularly in the study stretch and so the stretch, and changes within it, are considered irrelevant to the species's conservation. Many species other than those marked X are likely to be present-day stragglers to the study stretch; short superficial surveys are unlikely to record species of highly sporadic occurrence. Straggler status is not indicated for those species categorised as extirpated, although for a number of such species there are recent occasional records; the effort to trace and evaluate for reliability all such records would be out of all proportion to the minimal additional useful insight.

Far from known range: there are no records of the species in or even close to the stretch; only such species are included in the table which are easy to overlook, and thus might potentially be occurring regularly in the study stretch.

Extirpated / **Far from known range**: for some species not currently of regular occurrence, it is difficult to determine whether they have been extirpated from the study stretch, or were never of regular occurrence there. These receive 'X?' in cells for both 'Extirpated' and 'Far from known range'.

Side-streams: the species's occurrence 'in' the study stretch relates primarily to occurrence up side-streams. Some such species do occur regularly in the channel but this is not their core habitat.

Plains: the species's occurrence 'in' the study stretch relates primarily to occurrence on the adjacent plains, often, in particular, in plains wetlands. Some such species do occur regularly in the channel but this is not their core habitat.

Forest: the species's occurrence 'in' the study stretch relates primarily to occurrence in the adjacent forest, but the species shows no preferential association with riverine or streamside forest.

7.2.4 Bird species of regional significance

Included in this section are species of birds for which the study area mainstream river channel populations are plausibly significant to their conservation at the Indo-Burma hotspot level, but which are not considered either globally or nationally threatened. Species predominantly of the plains and/or tributaries are not considered at all. The uneven and poor information on bird populations across the region means that no fixed, evidentiary threshold can be used to define regional significance. What is intended is that, were populations known (of the study stretch and of the entire Indo-Burma region), the study stretch would hold typically at least 1% of the regional population. This designation may relate only to one part of the year, for example breeding or wintering. Some river channel species remain much more common in Myanmar than in the countries to the east and species are also included as having regionally significant study stretch populations, even if these are likely to be below 1% of the Indo-Burma population, if they are guessed to exceed 10% of the Mekong basin population.

In 1999–2000 the study stretch supported good numbers of Little Ringed Plover (presumed to be predominantly of the breeding race), Grey-headed Lapwing, Little Pratincole and Jerdon's Bushchat; the counts surely underestimate hugely the study stretch populations of all of them, and of the plover and bushchat in particular. Wire-tailed Swallow was at much lower density than downstream of Paklay, even though superficially optimal habitat was widespread: Pakbeng was the upstream limit of potential breeding observations, and the species was frequent only somewhat downstream of there. Methodology and/or seasonality of survey were not apt to determine the local status of Long-billed Plover and resident-race White Wagtail. The former is very difficult to find from moving boats and records of the latter species were not, mostly, identified to race. Based on their status in the Louangphabang – Vientiane stretch, both are probably widespread and locally numerous in the study stretch.

7.2.5 Threatened migratory bird species

Because national threat lists exist for both countries in the study stretch, all migratory bird species threatened at the national or global levels have been covered above.

7.3 DESCRIPTION OF AQUATIC HABITATS AND STATUS BY RIVER SECTION

7.3.1 Unique and critical bird habitats

Duckworth *et al*. (2002) proposed a bird-habitat classification for the Upper Lao Mekong. Subsequent survey work along the Lao Mekong has corroborated the proposed classification as generally and usefully applicable to understanding the bird communities of the Lao Mekong and the lower reaches of its major tributaries. Reference to 'project species' in this discussion means those species in Tables 24–27.

Stretches of the Upper Lao Mekong channel comprise three basic habitat types. First, featureless stretches: those with few or no seasonally exposed rocks, vegetation, islands or marginal sedimentary features, that are therefore flanked by mostly steep banks for most or all their length. Second, stretches seasonally exposing many and/or large unconsolidated sedimentary features (mostly sand-, but with sometimes some mud- or gravel-bars), but few rocks, and only sparse or patchy woody vegetation growing in the seasonally exposed channel bed. In the siltier, lower-lying, areas ephemerals may form large dense patches, but during low water most of the exposed bed comprises bare unconsolidated sediment. Third, mosaic stretches, where the stream channel at low-flow season comprises a rich and varied mix of extensive sand and gravel features, reaching out from banks as bars, and as islands, and extensive rock outcrops. These mosaic stretches often have wide colonisation by bushland and/or grassland. Among the bushland, *Homonoia riparia* (Euphorbiaceae) is typically a predominant species. The permanently above-water parts of islands are in essence disjunct examples of plains vegetation and avifauna; excepting their seasonally exposed banks, they are of no special river bird interest. All reference hereon in to 'islands' refers to islands that are entirely underwater during the highest water levels. Some are, during the lowest levels, linked by land to the banks. Thus, they may be 'islands' in the vernacular sense only outside extreme low and/or full high water levels.

Featureless stretches can easily be travelled and hunted by people. The banks are often heavily settled. Birds persisting in them are mostly adaptable species of agricultural areas. In less settled stretches, as of 2000 a few River Lapwings persisted along the water margins, and substantial numbers of Asian

Plain Martins fed and probably bred. Other project species were largely unrecorded, and many were surely largely or entirely absent. Long such stretches presumably coloured the view of Delacour and Greenway (1940a) of the fauna of the upper Lao Mekong as being poor and monotonous, with nothing more exciting than innumerable River Lapwings, kingfishers, wagtails and rock thrushes, and far from the exuberant avian life of the lower Mekong.

In stretches with open sandy islands and bars, human access is also easy and in most such areas species sensitive to the 'local people package' (as defined above) are scarce. Amongst project species, Little Pratincole was often common in such stretches. Muddier areas support various migrant waders and, in areas with lower disturbance, River Lapwings. Historical sources indicated that formerly the large sand-bars supported many terns, large waterbirds (such as storks and cormorants) and other species sensitive to the local people package; these are almost entirely gone. The best areas for large birds in 1999–2000 seemed to be near big towns, notably the Ban Muangmom – Chiang Saen area. Here, there were an impressive number of large, potentially shootable, migrants such as egrets, ducks, cormorants and gulls, although resident species of such birds are extinct. Presumably, these birds are less likely to be shot here than in less populated areas, because shooting in border areas is strongly discouraged, and there is more chance of being caught and punished when closer to a town. These large birds are all long-distance migrants except for a proportion (probably a high one) of the spot-billed ducks, and so the Mekong wintering population can be replenished each year by fresh arrivals. By contrast, for resident species sensitive to the local people package, there was no indication of any significant protective effect of riverside towns.

Mosaic stretches support by far the most interesting bird communities and those of highest conservation value. This comes partly from habitat heterogeneity (sheer rocks for Wire-tailed Swallow; rocky bushland for Jerdon's Bushchat; sandbars for River Lapwing; etc.) but doubtless also reflects the difficulties of human access. A well-braided stream through rugged rocks and tangled bushland cannot easily be crossed either by boat or on foot, and species sensitive to the local people package can presumably survive here better than in the other sorts of channel. These stretches support almost all the project species that remain anywhere in the study stretch, and, for most of them, at the highest encounter rates and thus, presumably, densities. Nonetheless, populations of species sensitive to the local people package are seriously depressed even in these habitats. Observations in the 2000s from Cambodia suggest that these habitats would have supported formerly some species now gone, or nearly gone, from the Upper Lao Mekong such as River Tern, Great Thick-knee and sedentary large waterbirds. Whether such stretches would support other now-vanished species, notably Indian Skimmer, is unclear. The limited information from elsewhere in Indochina suggests that mosaic stretches probably would not be suitable for Black-bellied Tern and Little Tern, at least during the breeding season: all recent breeding-season records of these in the Mekong system were from sand-bar stretches.

The breeding season bird community of channel bushland at Paksang (Vientiane Municipality) was described by Duckworth (1996). In the non-breeding season, the similar-looking bushland in Bokeo also supported large numbers of a few species of passerines: Red-throated Flycatcher *Ficedula albicilla*, Oriental Magpie Robin *Copsychus saularis*, Common Stonechat *Saxicola torquatus*, Jerdon's Bushchat, Dusky Warbler *Phylloscopus fuscatus*, Yellow-browed Warbler *P. inornatus*, Olive-backed Pipit *Anthus hodgsoni* and Black-faced Bunting. Apart from the bunting and bushchat, these species

are all common in adjacent plains land habitats. While hunters were not openly encountered in channel mosaic, many wader snares were found in it around Ban Namgnon-Kao, one of which contained a live Pintail Snipe *Gallinago stenura*. These were set by the edge of small pools within the mosaic. In the shallow water of larger pools and at the main stream margin, were set many hooks baited with small fish. Although these were probably set for large fish, they would also be capable of catching fish-eating birds. Decades ago, Delacour and Greenway (1940a) noted such habitat around Ban Houayxai as much more bird-filled, in particular with larger numbers of terns, waders, herons and egrets, and storks.

Most of the study stretch comprises simple channel with few or no in-channel habitat features exposed in the dry season. Channel features significant to the avifauna occur in various parts of the study stretch and are not uniformly distributed. The upstream part of the study stretch, from the Thai–Myanmar border past Ban Muangmom, Ban Thonpheung and Ban Houayxai to Ban Paktha contains most of the study stretch's high-quality broad channel mosaic and broad sandbanks, although even in these stretches the good areas for project species alternate with 'featureless' stretches currently of low value. This coincides with the sector of the study stretch between the Thai–Myanmar border and the Lao–Thai border on the right bank. The stretch from Ban Paktha to Ban Pakbeng (the current project's middle stretch) contains some exposed channel mosaic but the patches are mostly narrower, shorter and more widely separated than are those upstream. The current project's downstream stretch, from Ban Pakbeng to the town of Louang Prabang is heterogeneous. From Ban Pakbeng via Ban Thaxoang and Ban Bo downstream to Ban Lay the channel is mostly 'featureless', with little high-value bird habitat. From Ban Lay downstream past Pak Ou to Louangphabang there are again some patches of channel mosaic that are large, especially broad, enough to be of moderate value, but overall even this stretch is inferior to that from Ban Muangmom to Ban Paktha, in the study stretch between the Thai–Myanmar border and the Lao–Thai border. This variation in avifaunal community value is reflected by the counts in Table 7.3. In reality, the variation in importance is probably underestimated by the counts because a much higher proportion of the individuals of project species will have been detected in 'featureless' compared with in wide channel mosaic. Set against that, some species were not amenable to useful survey with the methods employed, so could conceivably show habitat distribution at variance with that of the overall community; but it is unlikely that any project species would turn out to be preferentially associated with 'featureless' stretches over other types.

Based almost solely on the information in Duckworth *et al*. (2002), BirdLife International defined Important Bird Area LA027 'Upper Lao Mekong' from upstream of the study stretch (up to Ban Xiangkok) down to Ban Bo, a stretch of some 377 km (Ounekham & Inthapatha 2003). On the Thai side, IBA TH007 around Chiang Saen includes the Mekong channel from a little downstream of the Thai–Myanmar border (opposite Ban Thonpheung in Lao PDR) downstream for a further few kilometres; the IBA is based around plains wetland habitats (Pimathi et al. 2004) and its Mekong stretch is entirely within IBA LA027.

A more precise presentation of spatial heterogeneity would require a serious survey of the study stretch's birds; inspection of aerial imagery could not substitute (see 'Introduction').

Table 7.3: Counts of selected bird species* from the study stretch (Ban Muangmom to Louangphabang) in 1999-2000, and change in status of these species in the stretch immediately downstream (Louangphabang – Vientiane) between 2000 and 2012.

Stretch number	2	3	4	5	6	7	8	9	10	Rec	Change 2000 – 2012
Length (km)	17.5	61	38	103.5	28	41	30.5	41	26		
Number of trips	2	2	1	1	1	1	1	3	3		
	2	2	1	1	1	1	1	1	1		
Best boat type	Slow	slow	tour	tour	tour	tour	tour	slow	slow		
	Slow	slow	tour	tour	tour	tour	tour	tour	tour		
Species											
Spot-billed duck sp(p). (*1)	24	-	-	-	-	-	-	-	-	fair	Unclear
	22	12	-	-	-	-	-	-	-		
Pied Kingfisher, s	-	1	-	-	-	-	-	-	-	fair	Extirpated by 2000?
Little Ringed Plover (*3)	-	4	1	7 (6)	-	-	-	3 (2)	3 (2)	poor	Plausibly stable?
	4 (2)	8 (5)	2 (2)	1	-	-	-	1	2 (2)		
Small plover sp(p).	1	4	3	-	-	-	-	2	-	poor	n/a
	-	4	2 (2)	-	-	-	-	-	-		
River Lapwing	-	17 (5)	6 (4)	13 (6)	6 (2)	9 (5)	-	8 (2)	3 (2)	fair	Possibly fairly stable?
	2 (2)	6 (4)	3 (3)	15 (12)	2 (2)	10 (6)	2 (2)	3 (2)	5 (4)		
Grey-headed Lapwing	-	33	4	1	-	-	-	-	-	fair	Unclear
	-	11	4	-	-	-	-	-	1		
Lapwing sp(p)., w	-	4	-	1	-	-	-	-	-	poor	n/a
Little Pratincole	840	200	230	-	-	-	-	-	34	poor	Possibly fairly stable?
	380	202	315	-	-	-	-	-	2		
Great Cormorant, w	2	-	-	-	-	-	-	-	1	fair	No records
Large-billed Crow	-	-	-	-	-	-	-	-	-	poor	Unclear
	-	-	-	-	2 (2)	-	-	-	-		
Jerdon's Bushchat *4	-	-	-	-	-	-	-	1	-	poor	Plausibly stable?
	-	3	1	2	-	-	1	2	8		
Asian Plain Martin	3	2	20	23	1	13	7	10	-	fair	Decline
	1	4	2	-	-	1	3	4	-		
Wire-tailed Swallow	-	-	-	-	2	-	1	6	6	fair	Unclear
	-	-	-	-	-	-	2	1	1		
White Wagtail *5	-	-	6	c	3	1	1	12	c	fair	Unclear
	-	2	2	15	2	-	-	3	-		

Stretch numbers: 2, Ban Muangmom–Ban Tonpheung^{T}; 3, Ban Tonpheung–Ban Khonkeo^{T}; 4, Ban Houayxai–Ban Paktha^{T}; 5, Ban Paktha–Muang Pakbeng^{L}; 6, Muang Pakbeng–Ban Thaxoang^{L}; 7, Ban Thaxoang–Ban Bo^{L}; 8, Ban Bo–Ban Lay^{L}; 9, Ban Lay–Pak Ou^{L}; 10, Pak Ou–Louangphabang^{L} (^{L} indicates that much or all of the stretch has Laos on both banks; ^{T} indicates that much or all of the stretch has Thailand on one bank). Stretch 1 included the upstream-most part of the study stretch but extended to Ban Xiangkok, well upstream of the study stretch and counts of birds within the study stretch cannot now fully be disaggregated from those upstream of it.

Boat-type: tour, tourist barge, speed adequately slow but not able to scan above or to all forward angles; slow, slow boat with observer sat in bows and able to scan to all forward angles and above.

Rec: this refers to the comprehensiveness of recording for each species, i.e. it estimates the proportion of birds present that were actually recorded. In some stretches heavy braiding of the channel meant that some birds were not even potentially visible. In most stretches limited attention was paid to the sky and so high-flying aerial species were under-recorded. Small, cryptic, skulking and/or bold species unlikely to flush were in general recorded less efficiently than were larger, easily visible, prominently perching, flying and/or flushing species.

Counts for species give the maximum on any trip through the stretch, the upper row for winter (27 December 1999 – 8 January 2000), the lower row for spring (7–11 April 2000); species recorded in only one of the two seasons are indicated 'w' (winter) or 's' (spring). In stretch 3 there were significant land-based observations and where, for waders (lapwings, Little Pratincole) these exceeded the count from the boat, the land-based observations are included. 'c' indicates that the species was present but not counted in the stretch; most such species were common. Where two figures are given, the first is the number of individuals and the second (in parentheses) the number of groups. A dash (-) means that no birds were seen. Particularly for smaller and/or less conspicuous species, the lack of records should not be taken to imply absence. Rows for 'sp(p).' exclude counts of birds identified to species.

*Species notes: *1: not identified to taxon; most or all were probably Indian Spot-billed Duck. *3: not identified to taxon; most or all were probably C. d. jerdoni. *4: land-based observations showed the counts from boats to be huge underestimates: in all channel bushland checked, present in winter, and present, in many sites abundant, in spring. *5: not identified to taxon; M. a. alboides was present but proportion unknown.*

**Species considered globally threatened as of 2017 (Table 7.1), At Risk in Lao PDR or nationally threatened in Thailand as of 2017 (Table 7.2), or for which study area populations are considered likely to be regionally significant for Indo-Burma (Table 7.4).*

Table 7.4: Bird species for which the populations in the study stretch are judged likely to be of regional (Indo-Burmese) significance.

English name	Scientific name	Channel dependence	Season and abundance
Long-billed Plover	*Charadrius placidus*	High	Winter visitor, presumed scarce
Little Ringed Plover (breeding race)	*Charadrius dubius jerdoni*	High	Resident, widespread and common
Grey-headed Lapwing	*Vanellus cinereus*	Mid	Winter visitor, locally common
Little Pratincole	*Glareola lactea*	High	Dry-season breeding visitor, locally abundant
Jerdon's Bushchat	*Saxicola jerdoni*	High	Locally abundant breeder, probably only short-distance dispersal
Wire-tailed Swallow	*Hirundo smithii*	High	Locally common resident breeder
White Wagtail (breeding race)	*Motacilla alba alboides*	Mid	Locally common resident breeder

Excludes species listed as globally threatened (none strongly likely to be present in regionally significant numbers; Table 7.1) or threatened in Thailand / At Risk in Lao (Indian Spot-billed Duck, River Lapwing and Asian Plain Martin; Table 7.2).

7.3.2 Alternative natural bird habitats in tributaries

The value of the study stretch to the bird species that are globally threatened, nationally threatened, or present in regionally significant numbers come largely from its comprising a large, in some stretches very wide, river with diverse and structurally varied habitats exposed in the bed during the low-flow season. Tributaries have little similar habitat: only the widest one flowing into the study stretch of the Mekong, the Nam Ou, is probably wide enough, and only in its lowest reaches, to have supported all or almost all the project species that occur or occurred in the study stretch of the Mekong. A number of the project species are almost independent of river width, with some occurring even on streams too narrow to break the forest canopy (e.g. Stork-billed Kingfisher). For these, the tributaries do provide substantial potential habitat.

The Nam Ou was surveyed briefly in March 1996 and November 2004 (Fuchs *et al*. 2007). Table 7.5 predicts the comparative value of tributaries for the project species and presents records from the Louangphabang Nam Ou. Only a few project species were found on these 1996 and 2004 surveys. River Lapwing was found only in the part of the Nam Ou in Phongsali province and only in 1996; by 2004 it had seemingly been extirpated. Two project species, Large-billed Crow and Asian Plain Martin, were recorded along the Louangphabang Nam Ou in 1996 but not in 2004. Surveys were too brief to be sure they had genuinely disappeared in the interim, but such a change would be consistent with the great rarity of the crow along the Mekong upstream of Vientiane of the decline of the martin in the Louangphabang – Vientiane stretch between 2000 and 2012. Many more project species may have been present in the Louangphabang Nam Ou but, given the brevity of both 1996 and 2004 surveys, have been overlooked. However, given their general status in Lao PDR, it is implausible any project species are common in the Louangphabang Nam Ou other than Long-billed Plover, Little Ringed Plover (breeding race), Grey-headed Lapwing, Jerdon's Bushchat, Wire-tailed Swallow and White Wagtail (breeding race). All these species are included as project species because of regional significance, rather than through being globally or nationally threatened. It is implausible that the Louang Prabang Nam Ou now supports regularly, and in numbers significant to conservation, many globally or nationally threatened project species; Yellow-breasted Bunting, on passage, is the most likely. The Nam Ou would however, have supported a much richer river-bird community a century ago (see below). No other tributary entering into the study stretch comes anywhere near the width of the Nam Ou and it is unlikely that any supports meaningful numbers of even mid-width, let alone wide, river species.

The possibility of tributaries providing meaningful alternative, rather than additional, habitat for any project species is very low. For species that remain at broadly natural densities, suitable habitat in the tributaries is effectively full of those species already. By contrast, for the many project species that have been reduced by direct or indirect human factors other than habitat alteration, the tributaries hold vacant habitat which for some species (such as Stork-billed Kingfisher) is extensive. However, for these tributaries to provide a genuine alternative for any occupied habitat lost on the Mekong mainstream, rapid major societal change would be needed in terms of hunting, river channel use, potentially dog and livestock husbandry, possibly even littering and very probably some other factors

(i.e. in the 'local people package'). It is implausible that this could occur simultaneously with loss of main channel habitat.

Table 7.5: The extent to which tributaries are predicted to support the project species of bird.

English name	Tributary use	Lower Nam Ou
Globally threatened		
Wood Snipe	Unclear; possibly superior	
Greater Spotted Eagle	Broadly as mainstream	
Steppe Eagle	Broadly as mainstream	
Eastern Imperial Eagle	Broadly as mainstream	
White-browed Reed Warbler	Negligible	
White-eyed River Martin	Unclear	
Yellow-breasted Bunting	Broadly as mainstream	
Nationally threatened		
Indian Spot-billed Duck	Only in the wide parts	
Common Buttonquail	Only in the wide parts	
Stork-billed Kingfisher	Broadly as mainstream	
Pied Kingfisher	Only in the wide parts	
Blue-tailed Bee-eater	Only in the wide parts	
Eastern Grass Owl	Unclear	
Brown Fish Owl	Broadly as mainstream	
Indian Nightjar	Unclear	
Savanna Nightjar	Unclear	
River Lapwing	Only in the wide parts	
Oriental Darter	Broadly as mainstream	
Great Cormorant	Broadly as mainstream	
Asian Openbill	Broadly as mainstream	
Large-billed Crow	Broadly as mainstream	1996 (present)
Asian Plain Martin	Only in the wide parts	1996 (present)
Red Avadavat	Broadly as mainstream	
Regionally significant		
Long-billed Plover	Only in the mid-width and above parts	
Little Ringed Plover (breeding race)	Only in the widest parts	1996, 2004 (species present)
Grey-headed Lapwing	Only those of least mid-width	
Little Pratincole	Only in the widest parts	
Jerdon's Bushchat	Only in the widest parts	
Wire-tailed Swallow	Only those of least mid-width	2004 (locally common)
White Wagtail (breeding race)	Broadly as mainstream	2004 (frequent); 1996 (species present)

7.4 REVIEW OF EXISTING STUDIES, ISSUES AND INFORMATION GAPS FOR THE KEY THEMES

7.4.1 Existing studies, data and information

Table 7.6 presents the main written sources providing bird information from the study stretch of the Mekong, and, for comparative purposes, from the Mekong mainstream elsewhere in Lao PDR and in Cambodia, from a variety of tributaries, from the immediately adjacent land and wetland habitats, and for international and national context.

Up to 1950, a number of collecting expeditions visited the Lao and Thai Mekong, including the study stretch. The information that these provide is based strongly around the specimens collected, meaning that it is unwise to conclude that any species not mentioned was not present. In this era, sight records were considered at too high risk of error generally to be taken very seriously, meaning that many contemporary accounts did not even mention them; Delacour & Greenway (1940a, 1940b) did contain, however, a very valuable commentary on birds observed as the team travelled around. Most collectors operated some, often evidently high, level of selectivity in what they collected meaning that a species with no specimens could be any of (i) absent; (ii) present but not considered worthy of collection; (iii) present but not detected or not recognised and thus unintentionally not collected; or (iv) present and desired for collection, but not secured. Understanding abundance at time of historical-era surveys is even more fraught with interpretive problems such that it usually has to be left unknown unless explicitly commented upon. An extreme example is that, but for Meyer de Schauensee's (1934: 175) throw-away remark that "early on the afternoon of the twelfth we arrived on the banks of the Mekong River at Chiang Saen…we stayed for two days at this interesting village…in the evening, just before sunset, a beautiful sight was afforded by the peacocks [footnote *Pavo m. muticus*] which came down to the river's edge to drink, sometimes in fairly large flocks", there would perhaps be no proof that Green Peafowl had ever occurred in the study stretch! Few observations were made and little was published from the 1950s to the 1990s.

The 1990s saw an explosion of bird survey activity in Lao PDR but because this was based largely around the national protected area system (itself proposed in the 1990s) coverage of the Mekong was fragmentary. Some of the tributary systems, notably the Nam Kading/Nam Theun and Xe Kong, received much better coverage. Apart from a few incidental observations around Louangphabang, the Mekong upstream of Muang Sangthong in Vientiane Municipality remained almost unsurveyed from the Lao side. The Chiang Saen area of Thailand throughout the 1990s was an increasingly visited recreational birding hotspot but no synthesis has been made of observations. However, Thailand's system of a 'recent [bird] reports' slot in the *Bird Conservation Society of Thailand Bulletin* allows a confident general status picture for globally and nationally threatened river channel specialists at that time.

The 2000s and 2010s saw the first serious coverage of the Mekong north of Sangthong, covering all the study stretch and the stretch between Louangphabang and Vientiane in December 1999 – January 2000 and the former also in April 2000. However, much travel was by boats which could not be stopped at will. With little opportunity to walk in the exposed channel bed, many individuals and some species, entirely, will have been overlooked (see Duckworth & Timmins 2013). There has been no comparable survey of the study stretch since then. The closest indicative information comes from an adjacent stretch. In January 2000, the stretch from Paklay to Vientiane had been covered by methodology fairly comparable to that in the study stretch in 1999–2000. This Paklay – Vientiane stretch received much more intensive survey in 2011–2012. This allowed some confident deductions as to what had happened to populations of these species in that stretch in the intervening 11 years. In the absence of any credible information from nearly all the study stretch since 2000, it is more reasonable to propose that similar trends may have occurred in the study stretch in that period and that they will have continued during 2012–2018, than to assume stasis in the study stretch since 2000. The volume of

highly dispersed information from the Chiang Saen area of Thailand from 2000 to the present does not seem to contradict any of these assessments but has proven unfeasible to collate and distil in full.

Much wildlife 'information' generated and circulated in Lao PDR in the 2000s and 2010s contains many obvious errors of identification and the study stretch of the Mekong has not been immune to this problem. The 2000s saw multiple intensive bird surveys in the Cambodian Mekong and tributaries giving valuable context for the interpretation of what remains in the Lao stretches. Cambodia is the only part of the Mekong in which any research has taken place to try to determine why river channel birds have declined so steeply. In Thailand during this period recreational birding visits continued frequently to Chiang Saen as did BCST's 'recent reports' system. The EIA conduted for the Pak Beng Hydropower Project in 2011 was reviewed and does contain survey information on birds. However the information collected in the report was unreliable and was therefore not used in this assessment.

To prevent endless repeated citation of many sources, this report omits citations where statements made here result from considering the full sum of information in all the relevant sources.

Table 7.6: Written information base for birds of the Mekong between the Thai–Myanmar border and Louangphabang. Sources are assigned to era based on information content, not time of publication.

Source	Contents
Pre-1990	
Bangs & Van Tyne 1931	Specimen-based notes on birds of the Nam Ou but for the study stretch, only Pak Ou – Louangphabang; far from complete list of what was present
Bingham & Thompson 1901	Information on the Mekong avifauna of the southern part of Shan State, Myanmar; this area was much better studied by 1900 than were the adjacent parts of Thailand and Lao PDR
David-Beaulieu 1949–1950	Information on the Mekong avifauna of Savannakhet province in the 1940s
Deignan 1945	Annotated avifauna of northern Thailand including the Lao–Thai border part of the study stretch. No special focus on the river
Delacour & Greenway 1940a, 1940b	Wide-ranging collecting expedition covered the study stretch between Louangphabang and Chiang Saen, but collected only incidentally within the channel, being more focussed on land habitats
Dickinson 1966	Account of breeding by two of the focal species in the study stretch
Duckworth & Tizard 2003	Observations, mostly from Vientiane, in the early 1960s and 1980s, including many from that part of the Mekong
Engelbach 1932	Information on the Mekong avifauna of South Lao PDR province in the 1920s; the most comprehensive and final of several works by the author on the birds of this part of Lao PDR
Meyer de Schauensee 1930	Wide-ranging collecting expedition visited the study stretch around Chiang Saen, but more focussed on land habitats
Meyer de Schauensee 1934	Wide-ranging collecting expedition visited the study stretch around Chiang Saen, but more focussed on land habitats
Oustalet 1898	Specimen-based notes on birds of the study stretch, but far from complete list of what was present
Robinson & Kloss 1931	Incomplete account of birds collected and seen downstream of the study stretch (Paklay – Central Lao PDR) in 1929
1990s	
BirdLife International 2001	Detailed knowledge review of Asian bird species then assessed as globally threatened
Duckworth 1996	Account of channel mosaic avifauna, Muang Sangthong, Vientiane, based on observations in March, June and July 1996

Source	Contents
Duckworth 1997	Account of the M. Sangthong Jerdon's Bushchat population with review of the species's global distribution, habitat use and conservation status
Duckworth *et al*. 1998a	Review of Lao status of the River Lapwing, the largest ground-nesting river-channel bird still widespread in Lao PDR
Duckworth *et al*. 1999	Annotated Lao avifauna, with more detail on species identified (through the process of compilation) as of elevated conservation concern in the country
Evans *et al*. 2000	Surveys of the Lao Mekong between Phou Xiangthong NBCA and the Lao–Cambodia border, and of parts of the Xe Kong system, 1996
Evans 2001	Observations from the Mekong around Savannakhet, 1997
Fuchs *et al*. 2007	Boat-based bird counts of Nam Ou from Pak Ou upstream into Phongsali province (entire Louangphabang stretch covered), March 1996 and November 2004
Thewlis *et al*. 1998	Detailed review of Lao records (historical and up to 1996) of bird species identified as of elevated conservation concern, including many of the project species. Very little contemporary information from the study stretch, but better coverage of the South Lao Mekong and of some tributary systems
2000s–2010s	
Bezuijen *et al*. 2007	Covers the Cambodian Mekong between Kratie and Strung Treng surveyed multiple times in 2006–2007; the most intensive bird surveys of any stretch
Claassen 2004	Documents the first serious attempt to determine why ground-nesting river channel specialists are in such precipitous declines; north-east Cambodia
Claassen 2015	Cambodia; pointers for conservation activity relevant to study stretch
Claassen 2016	Comparative status information from Cambodia
Claassen 2017	Comparative status information from Myanmar
Claassen in prep.	Cambodia; pointers for conservation activity relevant to study stretch although this species has already been extirpated
Claassen & Ou 2007	Comparative status information from Cambodia
Claassen & Rawson 2008	Comparative status information from Cambodia
Claassen *et al*. 2017	Cambodia; pointers for conservation activity relevant to study stretch
Claassen *et al*. in press	Research into determinants behind breeding success of river-bed nesters in Cambodia
Dersu 2008	Intensive surveys of the Nakai plateau river system in 2007, incorporating fully information from shorter surveys in 1994 (Evans & Timmins 1998) and 1995 (Duckworth *et al*. 1998b) with records from other years.
Dubeau 2004	As Meynell (2003)
Duckworth in press	Exhaustive review of the birds of the Nam Ngum catchment, Lao PDR, with particular focus on non-forest species and set in national context. Report, commissioned by ADB, finalised in 2009 but seemingly never produced or distributed
Duckworth & Timmins 2013	The most intensive survey of any part of the Lao Mekong; Louangphabang – Vientiane, 2011–2012, both wet and dry seasons; supplementary information from other years notably 2004
Duckworth *et al*. 2002	Boat-based bird counts of entire study stretch, December 1999 – January 2000 and April 2000, supplemented very locally by foot-based survey; also adjacent plains on the Lao side. Includes a few additional records from other short visits
Fuchs *et al*. 2007	Boat-based bird counts of Nam Ou from Pak Ou upstream into Phongsali province (entire Louangphabang stretch covered), March 1996 and November 2004
Goes 2014	Annotated Cambodia avifauna, with more detail on species identified (through the process of compilation) as of elevated conservation concern in the country
Goes *et al*. 2010	Discussion on the evident extinction of Black-bellied Tern from the entire Mekong system

Source	Contents
IUCN 2018	IUCN Red List which assesses all species of birds globally. Short accounts for each species.
Meynell 2003	Provides an annotated list of birds purportedly found in the study stretch and upstream to Ban Xiangkok. Some wholly implausible species are included and many species common and obvious there are omitted. This source should be ignored (and the large mammal information is farcical)
OEPP 2017	National Red List for Thai vertebrates, including comprehensive assessment of birds
Ounekham & Inthapatha 2003	Directory of Important Bird Areas in Lao PDR including one IBA overlapping with the study stretch; contains no additional otherwise unpublished information on the study stretch
Phat *et al*. in prep.	Cambodia; pointers for conservation activity relevant to study stretch
Pimathi *et al*. 2004	Important Bird Area directory for Thailand, including one IBA overlapping with the study stretch
Schwilk, A. & Claassen 2013	Comparative status information from Cambodia
Seak *et al*. in prep.	Cambodia; pointers for conservation activity relevant to study stretch
Timmins 2003	Initial evaluation of the Mekong avifauna between Stung Trend and Kratie, Cambodia
Timmins 2006	Detailed evaluation of the avifauna of the Mekong Ramsar site, Stung Treng, Cambodia
Timmins & Men 1998	Initial evaluation of the avifauna of the Mekong mainstream and tributaries of north-east Cambodia
Timmins *et al*. 2003	Evaluation of the avifauna of some tributaries of north-east Cambodia

7.4.2 Gap analysis for effective management and conservation

The existing information base for the study stretch's avifauna is thin, for multiple reasons. First, away from Chiang Saen there is almost no information on the stretch's bird community since 2000; given the pace of river bird decline it is a safe assumption that many channel specialists will have continued to decline and the status of some species may have changed hugely (as was found by W. W. Thomas between his two periods of residence by the Mekong in Vientiane in the early 1960s and early 1980s, a separation comparable to that between 2000 and now). Second, the 1999–2000 surveys took place mostly from moving boats, a method guaranteed to result in major under-counting (and, for some, total overlooking) of many species, as was shown on those surveys by comparing foot-based searches in the channel with the results of boat passes of the same stretches. Third, the 1999–2000 surveys were brief, lasting only a few days in each of the two time periods. Particularly with scarce and/or cryptic species, even birds present in numbers significant to conservation could be overlooked. As a comparison, Duckworth & Timmins (2013) took two weeks to cover in dry season 2012 the Paklay – Vientiane stretch that Duckworth *et al*. (2002) passed through in only two days: yet the 2012 survey still found a project species for the first time even on its last day (Red Avadavat). Finally, the 1999–2000 surveys took place only in December–January and April. Species present only outside those periods could not be detected.

Despite all these caveats,, the methodology was highly apt and the duration and intensity sufficient to give a good feel for overall status and broad distribution patterns along the river of most of the ground- and bank-nesting species of the channel (terns, skimmers, waders, martins, swallows, bee-eaters, kingfishers) and large waterbirds that feed and loaf in the open (e.g. storks, most herons and egrets, cormorants, darters). The seasonality of timing was suitable for understanding breeding distribution of most species, which seem to return rapidly to breeding areas on the dropping of water levels through October, with most individuals of most species probably having spent the wet season

somewhere in or adjacent to the Upper Lao Mekong. This is not so for Little Pratincole or Blue-tailed Bee-eater, which leave the area entirely or almost entirely; while the pratincole is fully returned in the early dry season, the bee-eater does not appear until around April and was probably only very poorly surveyed in 1999–2000. Duckworth *et al*. (2002) included an assessment of how well each species had been surveyed on these surveys relative to the actual presence at time of survey, but did not speculate on under-counting because of seasonally inappropriate timing.

Understanding of trends with time is impossible from the stretch itself, but inference can be made from the Mekong between Louangphabang and Vientiane: this was surveyed in 2000 and in 2011–2012. This insight can be supplemented by less structured observation around Vientiane and in some of the tributaries during 1992–2017.

It is certainly safe to say that, nowadays, the study stretch has lower importance regionally and globally for bird conservation than do various other stretches of the Mekong, and that this is in large part because of sustained losses from its avifauna for many decades rather than to any inherent unsuitability of habitat. But the available information is far from adequate to allow effective management and conservation of what remains and what might, if human activities were managed appropriately, recolonise. Most important is a survey along the river channel in the style of that by Duckworth & Timmins (2013) for the Louang Prabang – Vientiane stretch. This should use a boat as a survey base, spend the nights in the channel in the best sites for project species that call by night (e.g. nightjars, fish owls and thick-knees) and by day walk extensively in all areas of mosaic and large sandbanks to detect birds unlikely to be found from the boat. This should take about 3 weeks in each of the cold dry season (to understand the status of winter visitors), the hot dry season (to understand the breeding community; some cryptic breeding species do not start singing until after many winter visitors have left) and one week in the wet (with much less exposed land in the channel at this season than in the dry, effective survey is much quicker). This would allow comparison with the 1999–2000 information for conspicuous species, expansion of the number of species for which credible survey has occurred in this stretch after 1940, the first understanding of wet-season status and threats, and the determination of exactly which parts of the study stretch retain the most importance for the avifauna and therefore warrant the most consideration in management.

If it be considered important to improve the precision and perhaps accuracy of the speculations (above) concerning the study stretch's likely importance to globally threatened species, surveys are needed for Yellow-breasted Bunting (late March to late May, and October to November) in the river channel; White-browed Reed Warbler (May and autumn) in large stands of tall graminoids; Wood Snipe (October – March); and White-eyed River Martin (all seasons, all habitats but particularly the channel where habitat differs strongly from that around the parts of Chiang Saen visited heavily by leisure bird-watchers, on the grounds that if it used the habitats there, it presumably would have been found there already). It is quite plausible that all this effort would give no useful information on these species other than that the stretch is simply not very important to them.

7.5 TREND ANALYSIS AND DRIVERS OF CHANGE

7.5.1 Past trends

The overall picture for the trend in the bird conservation values of the study 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. This is derived from information from the Lao Mekong as a whole. Table 7.7 gives the inferred trends for all project species' populations in the study stretch, plus those which would have been considered project species were they not already extirpated from the stretch. The confidence in some of these inferred trends is low, because the species may have already become very rare by the start of observations from the study stretch. For example, there is only one historical record from this part of Thailand or Lao PDR of either adjutant species, yet both occurred in Shan State, Myanmar (just upstream of the study stretch) in the late nineteenth century and both were common in the lower Mekong well into the twentieth century. So it seems likely that they had occurred in the study stretch previously but had already become very rare by the early twentieth century.

In total, 32 river-channel species are assessed as extirpated or nearly so. These comprise 13 large waterbirds, five ground-nesting species of the seasonally exposed channel bed, six raptors, three kingfishers and five others. The major extirpation phase seems likely to have occurred in the middle third of the twentieth century, but it is likely that many species now lost were already in steep decline for decades before that, and some seem to have been lost by the beginning of the twentieth century. By contrast, some now extirpated survived well into the late twentieth century. Many of the small species are believed to remain mostly at densities similar to those that they would show in the absence of people. 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 study stretch at all). Some small species are almost certainly in decline, notably Asian Plain Martin.

Table 7.7: Population trends inferred for project species of bird in the study stretch of the Mekong

Species, season	Trend
Globally threatened	
Green Peafowl, R	Present, perhaps still common, into the 1930s, probably extirpated within a few decades
White-winged Duck, R	May already have been very rare by 1930s, probably extirpated soon after if still then present
Baer's Pochard, W	In plains wetlands, still regular and common into the 1990s; now exceptionally rare. Never regular in the channel
Sarus Crane, ?R	Major decline to extirpation probably in the early 20th century, potentially much earlier
Masked Finfoot, ?B	Unclear, but long extirpated if it ever was there at all
Wood Snipe? ?W, ?P	Unknown
Indian Skimmer, ?R	Probably extirpated late 19th or early 20th Century, surely by 1940s; no records but highly implausible it was never there
Black-bellied Tern, R	Massive decline during mid 20th Century, extirpated by 1980s
White-rumped Vulture, R	Massive decline during mid 20th Century, extirpated by 1980s
Slender-billed Vulture, R	Presumed massive decline during mid 20th Century, extirpated by 1980s, if it ever occurred
Red-headed Vulture, R	Massive decline during mid 20th Century, extirpated by 1980s
Greater Spotted Eagle, W, P	Unknown but presumably steeply downward during the 20th Century
Steppe Eagle, W, P	Unknown but presumably steeply downward during the 20th Century
Eastern Imperial Eagle, W, P	Unknown but presumably steeply downward during the 20th Century
White-shouldered Ibis, R	Massive decline during early–mid 20th Century, extirpated by 1980s
Asian Woollyneck, R	Massive decline during early–mid 20th Century, extirpated by 1980s

Species, season	Trend
Lesser Adjutant, R	Presumed massive decline by early 20th Century, extirpated by 1980s
Greater Adjutant, R	Presumed massive decline by early 20th Century, extirpated by 1980s
White-browed Reed Warbler, P	Unknown, potentially fairly stable
White-eyed River Martin, ?	Unknown
Yellow-breasted Bunting, P, ?W	Probably fairly stable to the 1980s but huge decline subsequently
Nationally threatened	
African Comb Duck, ?	Steep decline to extirpation, if it ever occurred
Indian Spot-billed Duck, R	Probably long-term shallow decline which still continues
Common Buttonquail, B	Unknown, probably declined, perhaps steeply
Stork-billed Kingfisher, R	Perhaps fairly stable till mid or late 20th Century but subsequent massive decline, probably to extirpation
Crested Kingfisher, R	Perhaps fairly stable till mid or late 20th Century but subsequent massive decline to extirpation
Pied Kingfisher, R	Perhaps fairly stable till mid 20th Century but subsequent massive decline, plausibly approaching extirpation
Blue-tailed Bee-eater, B	Perhaps fairly stable till mid 20th Century but probably subsequent steep decline
Eastern Grass Owl, ?R	Unknown
Brown Fish Owl, ?R	Steep decline, probably mostly since mid 20th Century
Indian Nightjar, ?R	Probably steep decline, probably mostly since mid 20th Century
Savanna Nightjar, ?R	Probably steep decline, probably mostly since mid 20th Century
Great Thick-knee, R	Steep decline during and since mid 20th Century, to extirpation
River Lapwing, R	Probably steep decline during mid 20th Century, perhaps relatively stable since 1990s
River Tern, R	Steep decline during and since mid 20th Century, to extirpation
Little Tern, R	Steep decline during and since mid 20th Century, to extirpation – if it ever occurred
Brahminy Kite, R	Steep decline by mid 20th Century, to extirpation – if it ever occurred
Lesser Fish Eagle, R	Steep decline during 20th Century, to extirpation – if it ever occurred
Grey-headed Fish Eagle, R	Steep decline during 20th Century, to extirpation – if it ever occurred
Oriental Darter, N, potentially R	Massive decline to extirpation in mid- to late 20th Century; probably has recently or will shortly recolonise
Little Cormorant, ?	Evidently common in 1890s but extirpated by 1930s
Great Cormorant, W, potentially N, R	Massive decline to extirpation in mid- to late 20th Century; probably has recently or will shortly recolonise
Black-headed Ibis, ?	Steep decline by mid 20th Century, to extirpation – if it ever occurred
Spot-billed Pelican, N	Steep decline by mid 20th Century, to extirpation
Painted Stork, N	Steep decline during 20th Century, to extirpation
Asian Openbill, N, potentially R	Probably not present regularly until the 21st Century; colonised recently as a non-breeding visitor and likely to do so shortly as a breeder
Black Stork, W	Steep decline during 20th Century, to extirpation
Black-necked Stork, ?R	Steep decline during 20th Century, to extirpation
Large-billed Crow, R	Massive decline since the early / mid 20th Century. May possibly be showing a shallow resurgence
Asian Plain Martin, R	Perhaps fairly stable till mid 20th Century but probably subsequent steep decline
Red Avadavat, R	Unknown
Regionally significant	
Long-billed Plover, W	Probably fairly stable

Species, season	Trend
Little Ringed Plover (breeding race), B	Probably fairly stable
Grey-headed Lapwing, W	Unknown. Still likely to be regular and fairly common. Probably well below the stretch's carrying capacity, but wintering habitat may not be limiting
Little Pratincole, B	Probably fairly stable to the mid 20th Century with shallow decline subsequently
Jerdon's Bushchat, R/B	Probably fairly stable
Wire-tailed Swallow, R	Probably fairly stable to the mid 20th Century with shallow decline subsequently
White Wagtail (breeding race), R	Probably fairly stable

Species in bold face are extirpated from the study stretch (this does not exclude occasional occurrence by wanderers from elsewhere); many others may also be lost already, but because they are sufficiently difficult to detect relative to survey effort to date, it cannot be excluded they persist.

Seasonality:

R, resident (presumed to disperse to adjacent plain and/or roam along river length during high water season)

W, winter non-breeding visitor from northern breeding populations

N, non-breeding, mostly wet-season, visitor from South-east Asian breeding populations

B, breeding visitor

P, passage visitor during migration seasons

?, unknown

? combined with R, W, N, B or P: assessment is uncertain

7.5.2 Potential drivers of change

None of these declining or extirpated species has been studied in the stretch well enough to know precisely what drives its decline there. It is unlikely that there is one factor responsible for all these species' declines, and that this is the sole significant cause across all times and places. The balance of factors driving declines is likely to vary, substantially, between species, and within species between eras and localities. But some general patterns are apparent. Most of these species occur across a wide area of tropical Asia. There is a general pattern of stronger populations remaining in India than in South-east Asia, and in Myanmar than in the rest of South-east Asia. Within the Mekong, there is a general pattern of lower losses in the stretches less settled and in general less used by people, such as the north Cambodian Mekong. This is apparent at a much more local scale, upstream of Vientiane, within the stretch between Louangphabang and Paklay. While the pattern within the Mekong matches well with human activity patterns, areas of India with considerably higher human densities and use (for transport, fishing, grazing, quarrying and others) than in much of the Mekong mainstream retain far healthier riverine bird communities than in the Mekong. This suggests that geographic patterns in human behaviour, not just human population densities, may play a large part in explaining geographic patterns of river bird decline. Direct killing seems likely to bear a large part of the responsibility for the Mekong's avifaunal collapse. Indeed, it is almost axiomatic in conservation that hunting-sensitive species, from Tiger *Panthera tigris* and rhinoceroses (Rhinocerotidae) downwards in size, remain in far healthier numbers in India than in South-east Asia, reflecting far lower cultural predisposition to kill wildlife in India than in South-east Asia.

As well as direct persecution, other factors may also be significant, at least for some species or at some times: predation by rats (which plausibly may have increased over time with increasing refuse carried by the river), predation by dogs (which accompany many people in their activities in the river channel, particularly those staying overnight), and trampling by domestic bovids (which are grazed heavily in the channel in the late dry season, which is when the ground-nesters breed). Also, the most problematic period in the life history may vary between species: it could be the loss of eggs, of chicks, or of full-grown individuals, and with the latter, be predominantly at any one of various life stages. Because of the Mekong channel's marked seasonal change in water levels, it has been difficult for people to use it for any activity resulting in major habitat change, in contrast to the general devastation of habitat on the adjacent plains. Conversion of unconsolidated sediment banks to hard banks has occurred in some areas (particularly on the Thai side), small areas of channel bushland have been lost, and sediment is mined widely from the stretch's bed. But none of these has occurred over the majority of the study stretch. Until recently, habitat factors will have led to acute bird population changes only at the very local scale, but even 1 km from towns and villages changes will have been, mostly, minimal. The largest uncertainty concerns the possibility that one or more of the many introduced large plants of the seasonally exposed channel bed (e.g. *Mimosa pigra*) could have changed markedly the balance between vegetated and non-vegetated areas: these plants have changed hugely in abundance in the study stretch over the last 20–200 years. While there is little information on when each had its main expansion phase, that most of the introduced species are common introductions also in India suggests it is unlikely that vegetation change is a major driver of Mekong-channel bird population declines.

Recently, the possible role of habitat in driving bird community declines has changed, with the completion of upstream dams. The dams' operation modifies the natural seasonal patterns in water flow and levels. The channel breeders are adapted to nest during the dry season when water levels are low. Within-season fluctuation in water levels reflecting release from and storage by dams can flood nests and pre-flight young. Reduced seasonal amplitude of water level (i.e., lower rainy season high levels and higher dry-season low levels) affects the distribution of habitat broadly in proportion to the magnitude of its own change, and timing changes in the rise and fall of water levels can affect the value of such habitat even if the extent does not change much (see below). While these water-level factors may (or may not) be important determinants of bird numbers at present, they clearly have not been responsible for the overall community declines which began a century or so, at least, before dams were influencing Mekong mainstream water levels.

7.5.3 Forward projection

It seems unlikely that there will be any major change in bird conservation attention to the Mekong mainstream as a whole in the next decade or two. Taking this assumption, and that no additional dams that affect water levels in the study stretch of the Mekong will be built in that period (a far less tenable assumption), various trends are possible for the study stretch's avifauna in a scenario of no LMDP and no Pakbeng HPP.

First, there is likely to be a rise or rebound in project-stretch non-breeding-migrant populations of hunting-sensitive species that are conserved elsewhere. Most notably, these include the populations of Oriental Darter, Painted Stork and Spot-billed Pelican at the Great Lake of Tonle Sap in Cambodia. These were in freefall decline until the 1990s, driven by harvest (mostly of nest contents rather than of full-grown birds). Effective conservation action has allowed population growth. The increase in

numbers in Oriental Darter visiting Lao PDR was already apparent by the mid 2000s. So far this has not been seen for other species, but it presumably will occur if their growth continues. Similarly, the rise in Great Cormorant numbers in northern Thailand since 2000 seems to reflect population growth elsewhere. Somewhat related to this is the explosive population rise in Asian Openbill in Thailand, perhaps based on a new, high-density food source for them, the Golden Apple Snail *Pomacea canaliculata*. Asian Openbill was recorded in Lao PDR only once before 2000 but is now locally and seasonally common. Some of these species predicted to increase in non-breeding numbers in the study stretch would also plausibly begin to breed in or near the study stretch if persecution levels dropped.

Second, there may be a rise in synanthropic populations of low commercial value birds that are not restricted to the channel. This has been dramatic in Vientiane since the mid 1990s. Leisure-time hunting had extirpated, or almost extirpated, by the early 1990s species such as mynas, Large-billed Crow, pigeons and doves, egrets and various others, which are now common residents or at least winter visitors. This change, which really got going in the early to mid 2000s, is presumed to reflect the great decrease for urban residents of time on their hands, following economic liberalisation and the consequent opportunity to use one's spare time to make money rather than amble round with a catapult or airgun pot-shotting at birds. This latter activity generates much less supplementary income than do the many contemporary business activities available. In theory, this phenomenon could occur also with river channel birds in rural areas, which are of low trade value. However, there is no sign of a decline in severity of the local people package, presumably in part reflecting that most of the plethora of business opportunities in urban areas is not available in rural places. It may also be relevant that people out in the channel may hunt and seek birds' nests in down-time between checking fishing nets, moving livestock, working shifts on sediment extraction teams, etc. The mass roll-out of electronic toys and communication devices certainly reduces the level of non-commercial hunting (where children in peri-urban Vientiane carried catapults in the early 1990s, now they carry mobile phones and suchlike); but if the threats to river channel birds stem more from the people's associated dogs, bovids and rats than from the people directly, as long as people are undertaking fundamentally the same activities in the dry-season channel, the threats and current trends are likely to continue.

Thus, the third circumstance is the converse of the foregoing, in that the local people package, whatever its precise make-up, continues to operate. Plausibly, the largest-bodied species left will be the next to go, such as Indian Spot-billed Duck and River Lapwing. But that there is good circumstantial evidence for the decline of even the tiny Asian Plain Martin in the adjacent downstream stretch of the Mekong suggests that even some of the small species might disappear: these are most likely to be those that nest in conspicuous places, such as the sandbank breeding colonies of Plain Martin.

Fourth, the existing upstream dams and their effects on downstream water levels (see below) may intensify or initiate declines of channel-breeding species, particularly those which nest on the ground: Great Thick-knee, Little Ringed Plover, River Lapwing, Little Pratincole, and Indian and Savanna Nightjars (some of these may be already extirpated).

For two species, however, it is difficult to conceive of any factor which would drive declines other than the loss of channel rocky bushland to dams: Jerdon's Bushchat and White Wagtail both nest above the ground, non-colonially and not particularly conspicuously. Moreover they are so small that the incentive to find their nests or shoot the full-grown birds is low.

7.6 DEFINITION OF SUSTAINABILITY OBJECTIVES AND IMPACT ASSESSMENT PARAMETERS

7.6.1 Definition of sustainability objectives for birds

Sustaining the current river channel avifauna in terms of no further loss of project species and the retention of the rough population level, today, of each would be a very modest aim given how severely depleted the bird community was even by 2000. A quantitative definition of sustainability cannot be set without first a baseline survey to define a starting point. It is possible that even maintaining today's populations could be challenging if the water level modifications resulting from the existing dams are adding to previous causes in driving current declines.

More ambitious an aim would be the part-rebuilding of the channel bird community. This could occur at little cost to the people and businesses of the study stretch for long-distance non-breeding visitors such as Great Cormorant, Oriental Darter, Painted Stork and Spot-billed Pelican, if numbers in Cambodia (or the source of the Great Cormorants) continue to rise. Asian Openbill's recent colonisation as a non-breeder seems likely to lead to breeding in the area as well. Even the recolonisation by channel breeders such as Great Thick-knee is not an impossibility: some of these species, at least, roam considerable distances during the high-water season. However, these species are in decline throughout the Mekong system and it seems unlikely that the societal changes necessary for their populations to change from decline to increase will occur in time.

Definition of key parameters for birds to assess impact against using the sustainability objectives. For all the project species, the assessment of impact of any given factor would be highly uncertain because the factors causing the current long-term declines have been neither characterised nor assessed in relative importance. However, tracking changes in status would be much simpler. The two key parameters are distribution and population. It would be practicable, with some species, to count the number of pairs and map each one's location in the study stretch overlooking sufficiently few as not to invalidate this approach (e.g. River Lapwing). For many of the others, counts per survey unit (which might be the number visible/audible from suitable viewpoints; counts per km of channel; feeding flock size) would have to be used as an index assumed to be proportionate to the population, with distribution within the study stretch assessable relatively simply. For the more cryptic species, such as nightjars and fish owls, species-specific approaches would be needed, which would have to be highly selective in terms of spatial coverage and, ideally, allow extrapolation to understand the stretch as a whole (one could not feasibly check every potential area for these species at dawn or dusk). The need for a variety of methods reflects the variation among the project species in terms of various natural history attributes such as levels of territoriality, visual detectability and song season (if any). There is little point attempting to define in detail what should be done in advance of a baseline survey.

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8 WATERWAYS AND NAVIGATION BASELINE

The following surveys were carried out in the study area by the MRC Navigation Programme NAP:

- **2008-2009** - MRC Navigation to Aids Project, a survey of 22 dangerous sections between Houay Xay and Luang Prabang above and below the river surface
- **2010** - MRC Lowest known river level project, a new river chart datum was created
- **2012/2013** - First GPS map project ever undertaken on the Mekong river between Houay Xay and Luang Prabang (310 kms)
- **2013** - As part of the quality control work on the GPS Project, an echo sounding exercise took place following the deepest channel from Houay Xay to Luang Prabang and all the deep pools could be extracted from this survey data, but this will take time and funding
- **2014** - Brief site survey assessment between Houay Xay and the Golden Triangle (70 kms)

Those studies were done to improve the safety of navigation, reduce shipping accidents and facilitate trade and transport along the Mekong River. The condition surveys of dangerous areas include rapids, reefs and rocky outcrops which also provide important habitats for aquatic species. The bathymetric surveys will be used to demonstrate some of the key aquatic habits. The NAP promoted an *'adapt the ship, not the waterway*' approach and initiatives such as the GPS routes and surveys of navigation channels can reduce the need for reef/rock blasting and dredging.

There are still limitations in relation to underwater surveys in this stretch of the river, including:

- No bathymetric survey has been carried out by Vientiane Geographic Services (VGS) between Golden Triangle and Houay Xay, however it is understood that the Royal Thai Navy has surveyed this area as a basis for the Lao/Thai border project
- An area known as Keng Kon Din has serious low level river issues and has not been surveyed.

There are still several issues with vessel safety in the Lancang-Mekong. A difficult task in the past has been the educating of various captains and pilots of how to read the available Navigation Charts including the GPS system devised several years ago. Mainly due to budget restraints, limited numbers of captains attended the MRC training session. It would help if all captains who sail vessels over a certain tonnage, including those who wish to sail tourist boats, are forced via a form of licensing to attend various lectures on how to use the various charts, GPS maps and river gauges established along the waterway, as shipping accidents do happen (Figure 8.1).

Figure 8.1: Shipping accident on the Mekong River

Depending on the vessel specifications for future use on the river, most sections of river between Houay Xay to Luang Prabang have been successfully surveyed and/or has sufficient data to make minimal adjustments within 'dangerous areas'. The main areas of concern, are:

- **Keng Kon Din** - Extremely shallow during the dry season, with serious rapids at certain areas
- **Houay Xay to the Golden Triangle** - rocky outcrops abound and some sections are very shallow in the dry season.

8.1.1 Existing inland navigation in the Upper Mekong

Inland navigation in the Lancang Mekong River is characterised by increasing cargo transport between PR China and Chiang Saen Commercial Port in Thailand, and passenger transport from Houie Xay to Luang Prabang in Lao PDR. The volume of petroleum products transported from Hachiang Commercial Port in Thailand and China is also increasing (Figure 8.2). However, the environmental impacts of inland navigation are not being effectively managed or mitigated. Water quality monitoring has detected increased levels of heavy metals at the Lao PDR/China border and Luang Prabang, and elevated levels of phenol at Chiang Saen Pier and Chiang Khong. Though oil spill response plans and waste management facilities are in place along the waterway, these are limited and largely inadequate.

Figure 8.2: Chinese tanker refueling at Hachiang commercial port: Chiang Sean, Thailand

8.1.1.1 Water quality issues

The Mekong River Commission (MRC) conducted a multi-media monitoring and assessment program (MMMAP) in 2011 to assess the levels of persistent micro-pollutants in water, sediment and biota in the Lower Mekong Basin (LMB). A total of 28 stations were included in the field survey; 25 of these stations are regularly monitored under the MRC water quality monitoring programme; three additional stations were monitored downstream of potential contaminant sources. The findings relevant to navigation in the Lancang Mekong include the detection of phenol, oil and grease and elevated levels of heavy metals (lead and mercury):

- **Phenol:** Most phenol values in water were low, but levels at the Chiang Sean Pier and Chiang exceeded the MRC Water Quality Criteria for the Protection of Aquatic Life (WQCA) and Human Health (WQCH) thresholds of 0.005mg/L. Elevated values of phenol at these stations indicate possible leakage of petroleum products close to navigation routes (MRC 2014a)
- **Oil and grease (O&G):** Elevated levels of O&G were detected at Luang Prabang, it was likely that high levels of navigation activity in the river and heavy rain before and during sampling could be the sources or O&G
- **Lead (Pb):** All 27 stations exceeded the ANZECC[8] thresholds for both lowland and upland rivers and exceeded mercury levels found at Chiang Khong in Thailand (MRC2014a).

8.1.1.2 Previous waterway improvement works

Previous Lancang-Mekong waterway improvements have drawn heavy criticism for failing to address the environmental impacts of rock/reef blasting and dredging. As a case in point, the EIA for Navigation Improvement Project (2001) was heavily criticised by development partners and civil society, and

[8] ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality

downstream countries voiced concern about the possible impacts of the project on them (Lazarus et al 2006). Independent reviews of the EIA reported:

- Limited investigation of quantitative data for fisheries and the value of ecosystem services (McDowall 2001);
- Lack of consideration of cumulative impacts or current and future volumes of river traffic; and
- No consideration of the potential impacts of increased shipping accidents, pollution and the costs of maintaining navigation channel depth (Finlayson 2002).

The International Union for Conservation of Nature and Natural resources (IUCN) also commissioned several independent studies in response to these river improvements for navigation between China and Chiang Saen and the impacts of waterway improvement projects.

Key baseline findings for navigation and waterways are:

- The MRC surveyed 23 dangerous areas for navigation between Chiang Sean and Luang Prabang in 2008
- There have been no major improvements for navigation downstream of Chiang Saen
- There have been minor removal of obstacles in Lao PDR
- There is a new Chiang Saen Port: capacity for 10 small, 4 large (300 DWT) boats
- There is 32km (33%) hardened river banks on Thai section of the study area – with consequent geomorphological changes and bank erosion on the Lao PDR side
- Cargo flows increased significantly from 2004-14

9 SOCIO ECONOMIC BASELINE

9.1 SUMMARY

This socio-economic baseline assesses the livelihoods of the people, including all major industries in the ES stretch between the Golden Triangle and Luang Prabang.

The agriculture sector still forms a major part of the economy of Lao PDR, despite growth in the industry and services sectors in recent years. Agri-business investment from foreign companies generates foreign direct investment, however there are concerns that the granting of land concessions for plantations, hydropower projects, mining and for logging are 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.

The granting of land concessions for plantations, as well as for hydropower and mining have been linked to illegal logging practices, which are a major problem across the country. Some reports suggest that 9 out of 10 logs are exported illegally. Another illegal activity of note is wildlife trafficking. Most wildlife trafficked in Laos is sourced internationally, although some pangolins and serow are probably captured in the country. Lao people are not big consumers of wildlife products, with most being sold to Chinese and Vietnamese tourists.

While there are few people in the study area who fish as a full-time occupation, most households do fish during the year. This provides poor and vulnerable people with a critical source of protein as well as micronutrients in their diet. Most fish caught is for household consumption, and fishing provides an important food security buffer, particularly for ethnic minority and other poor communities.

9.2 INTRODUCTION

This chapter details a socio-economic baseline assessment of the ES stretch of the Lancang-Mekong River between the confluence of the Ruak and Mekong rivers (where the borders of Laos, Myanmar and Thailand meet), and Luang Prabang. For this assessment, the 360 km stretch of river has been divided into three sections related to the environmental conditions. Zone 1 is approximately 100 km long, from the confluence of the Mekong and Ruak rivers, to the village of Pak Tha (located 7 km downstream from where the Mekong River leaves the Thai-Lao border and heads into inland Laos. Zone 2 is approximately 85 km long, from Pak Tha to the proposed site for the Pak Beng Dam. Zone 3 is approximately 170 km long and runs from the Pak Beng dam site to the outskirts of the city of Luang Prabang.

Zone 1 is the most densely populated of the three zones, with around 76,000 people (57,000 in Laos, and 19,000 in Thailand) spread along the 100 km section. Nearly half of the Lao population in Zone 1 live in the area around Houay Xai, and the border crossing into Thailand. Zone 2 of the river is home to around 7,500 people, mostly in the first half of Zone 2. Zone 3 has a similar population density to Zone 2, but being twice as long accommodates around 13,000 people. For the purposes of this study, the city of Luang Prabang was not included in the estimate of population.

This socio-economc assessment has has three sections. First, background information on the physical aspects of the river is provided including an overview of communities that live near the surveyed dangerous areas, as well as changes in discharge rates of the Mekong River over the last 50 years. Second is a section that provides detail about the people and communities that live along and nearby the river. Within this section, provincial level population data for the region is provided, including gender and ethnicity breakdowns. Following this, the population living along the river is calculated, including an estimation of the gender breakdown of the population. The final sub-section about people focuses on the ethnic breakdown of the population that live along the river. Third, a poverty and livelihoods analysis is presented. As most people living in the study zone are farmers, this section begins with a consideration of agricultural contributions to the economy of the region. This is followed by a sub-section on trade including tourism in the region, and then a sub-section on the role of fish and fishing in people's livelihoods. Wildlife trafficking is then considered because wildlife trade is a large threat to biodiversity conservation, and this is followed by a section on deforestation and forest degradation. Finally, during the research and analysis for this report, it became apparent that land tenure is a major issue in Laos, especially for poorer and ethnic minority communities. Because of this, the baseline socio-economic report finishes with a sub-section that discusses land tenure and land titling in Laos.

9.3 METHODS

The information and data for this report was gathered via a desk-based study. By triangulating academic and grey literature with Lao government policy documents, a picture was derived of the socio-economic situation in the study area. As a desk-based study, there are some limitations to this report. Particularly, there was a scarcity of data about the specific study area, as most reports and articles focus on the national or the provincial scales, with some focusing on particular districts or villages. An example of this is that census data for Lao PDR mostly focuses on the national level, with some provincial level data. The data from the census was used in calculations to estimate population in the study area including gender and ethnic breakdowns, but field surveys would significantly enhance the accuracy and robustness of this data. For this reason, this report should be treated as an overview of the situation.

9.4 THE RIVER

The Mekong River is a source for livelihoods and a means of transport for riparian communities. This section of the report provides the physical background on the river that forms the basis for the subsequent sections of the report.

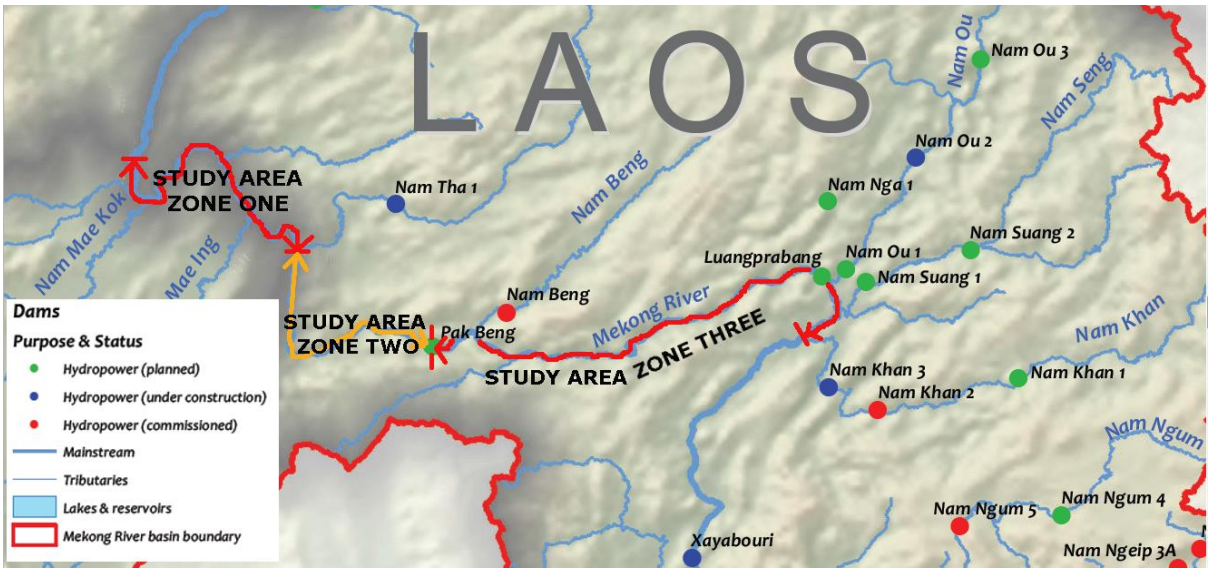
Zone 1 of the river (from the confluence of the Mekong and Ruak rivers down to the town of Pak Tha) is the most developed of the three zones. The channel of the river here is also wider than further downstream, tending to have a sandy bottom and numerous sand islands. The surrounding lands are predominantly flat, with floodplains on the bends that are under cultivation.

Zone 2 is narrower than the preceding zone, and is less meandering and rockier. The surrounding countryside is steep with valleys running perpendicular to the river up into the hills. There are far fewer people living along the river here than in Zone 1.

Zone 3 continues to be narrow and rocky, surrounded by steep forested countryside. The valleys in this section tend to run parallel to the Mekong River, rather than perpendicular as is the case in Zone 2. Towards the end of Zone 3 the river widens and the level of development increases as the river approaches Luang Prabang.

As per Figure 9.1 below, there are two operational hydropower dams on tributaries that flow into the study area of the Mekong. These are: 1) The Nam Beng dam, up the Nam Beng River from the Pak Beng township; and 2) The Nam Khan 2 dam on the Nam Khan river that flows into the Mekong in Luang Prabang. In addition to these, there are three dams under construction (the Nam Tha 1, the Nam Ou 2 and the Nam Khan 3), and seven dams planned, including the Pak Beng dam and the Luang Prabang dam.

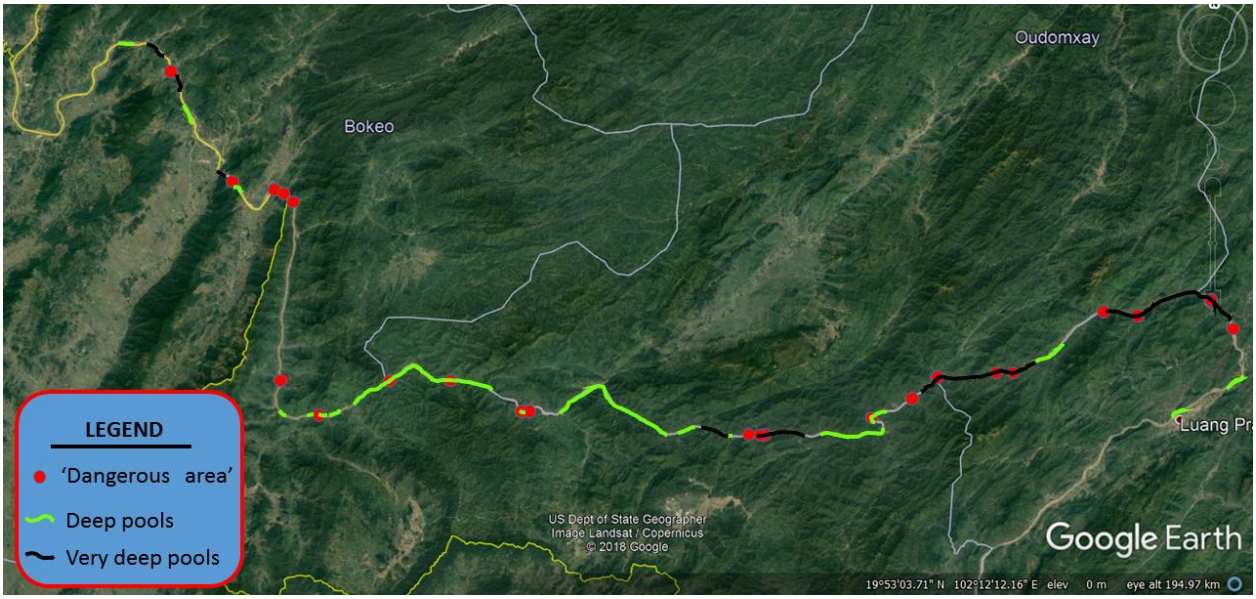
Figure 9.1: Planned, underway and commissioned hydropower in northern Laos, overlaid with study areas



Source: CGIAR (2016)

People living along the river rely on the resources it provides for their livelihoods, whether this be water for household use, for irrigation and for livestock, fish and other aquatic resources for consumption and sale or for getting from one place to another. The communities that live closest to the dangerous areas that have been surveyed for dredging and rock blasting will be those that are most exposed to the impacts of navigation upgrade works, and so it is important to know where people are living in relation to the dangerous areas. Table 9.1, below provides some information on the proximity of communities to the 23 surveyed dangerous areas in the study area. In addition, the table includes information on proximity of the dangerous areas to deep and very deep pools along the river. The deep and very deep pools range in depth from around 7 or 8 metres to around 80 metres. Information on the location of some of these pools is included because they provide breeding sites and habitats for a variety of fish that people may rely on for their food security, and if sand or rock from the dredging/blasting is deposited in these holes it may negatively impact fish stocks and hence diminish people's food security. Figure 9.2, below shows the location of the deep and very deep pools in relation to the 23 surveyed 'dangerous areas'.

Figure 9.2: Deep pools, very deep pools, and surveyed 'dangerous areas'



Locations of 'dangerous areas', deep and very deep pools provided by the International Centre for Environmental Management (ICEM)

Table 9.1: Proximity of communities and pools to the 23 surveyed 'dangerous areas'

Dangerous Area	Nearby Deep Pools*	Nearby Very Deep Pools*	Nearby Communities	Notes
#1	-	Yes, immediately downstream	• **Large communities/towns** Both river banks, adjacent, and spreading upstream. • **Small residential areas** Both river banks, downstream area	
#2	Yes, immediately downstream	Yes, immediately upstream	• **Small communities** Both banks, adjacent • **Large communities/towns** Both banks, from 2.5 km downstream	
#3	-	-	• **Medium-large community** Left bank, adjacent • **Some dwellings** Right bank, adjacent and upstream	
#4	-	-	• **Medium sized community** Left bank, adjacent • **Some dwellings** Right bank, adjacent	
#5	-	-	• **Medium sized community** Left bank, immediately downstream • **Some dwellings** Right bank, adjacent	
#6	Deep pool ~6 km downstream	-	• **Medium-sized community** Right bank, adjacent • **Small-medium community** Left bank, 0.5 km downstream	

Dangerous Area	Nearby Deep Pools*	Nearby Very Deep Pools*	Nearby Communities	Notes
#7	Deep pools immediately up and downstream	-	Nil	
#8	Deep pools extending both up and downstream	-	• Medium sized community Right bank, immediately downstream	
#9	Deep pools extending both up and downstream	-	• **Small community** Left bank, immediately upstream • **Very small community** Left bank, 2.5 km downstream	
#10	Deep pool immediately downstream	-	Nil	
#11 (several km upstream of Pak Beng dam site)	Deep pool immediately upstream	-	• **Small-medium communities:** Right Bank, 3.5 km downstream Left bank, 4.5 km downstream	
#12	Deep pools extending downstream		Nil	poor satellite imagery
#13	Deep pools extending downstream		Nil	poor satellite imagery
#14	Deep pools extending downstream		Nil	poor satellite imagery
#15	Deep pools extending 3 km downstream		• **Small Community** Left bank, 4.5 km downstream	
#16		3 km downstream are very deep pools	• **Very small community possible** Right bank, adjacent	poor satellite imagery
#17	In the middle of extensive section of deep pools		• **Medium sized community** Left bank, immediately upstream • **Small community** Left bank, up valley (inland)	
#18	In the middle of extensive section of deep pools		• **Medium sized community** Right bank, adjacent	
#19	In the middle of extensive section of deep pools		• **Small-medium sized community** Left bank, ~1.8 km downstream	

Dangerous Area	Nearby Deep Pools*	Nearby Very Deep Pools*	Nearby Communities	Notes
#20		Very deep pools extending many km downstream	• **Medium sized community** Left bank, adjacent • **Small-medium sized community** Left bank, 3 km downstream	
#21		In the middle of extensive very deep pools	• **Medium sized communities** Right bank, adjacent, 2.8 km and 4.1 km downstream	
#22		Towards the end of an extensive section of very deep pools	• **Small-medium sized communities** Left bank, 1.6 km upstream, and 1 km downstream	
#23		Just below end of an extensive section of very deep pools	• **Small community** Right bank, adjacent • **Medium-large community** Left bank, 1.6 km upstream • **Medium community** Right bank, 2.2 km downstream (From 3.6 km downstream river banks become more developed on the fringes of Luang Prabang)	

** The location information on deep and very deep pools comes from the fish baseline section (Figure 5.7).*

The three zones of the river, as described in this sub-section, have distinct characteristics that have an impact on the way people interact with the river. More people live in Zone 1, with its broad sediment laden plains. Zones two and three are much less developed, apart from commissioned hydropower dams, for example the Nam Beng dam (up the Nam Beng river from Pak Tha), those under construction such as Nam Ou 2, and many planned hydropower dams such as the Pak Beng dam. As rapids are known fish breeding areas, it is not surprising that most of the dangerous areas that have been surveyed have communities living near them, even along the sparsely populated lengths of the river.

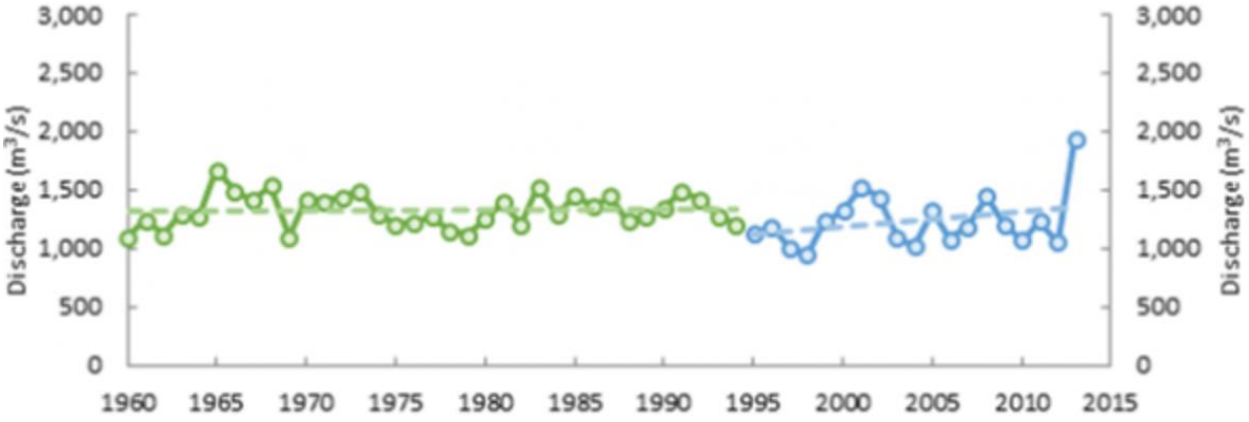
9.4.1 Flow rates of the Mekong – Current impacts of upstream dams

Riparian communities in northern Laos have adapted their socio-cultural lives to the rhythm of the river. The Mekong has a distinct wet season flood pulse, that brings with it sediments that provide the fertility for growing rice and vegetables along the flood plains near the river, as well as on the river banks themselves. Because of the significance of the river and the flood pulse to the lives of people in the study area, minimising negative socio-economic impacts of the LMDP and Pak Beng HPP must take into account the broader trends including around flow patterns for the river, or risk possible mal-adaptations. For this reason, background information on Mekong River flow rates and how they are changing are included here.

The amount of monsoonal rainfall in the Mekong Basin is what drives the degree of inundation in the region, with around 85 or 90% of the river's discharge occurring in the wet season. Despite this, wet season discharge over the twentieth century dropped around 10%, independent of rainfall

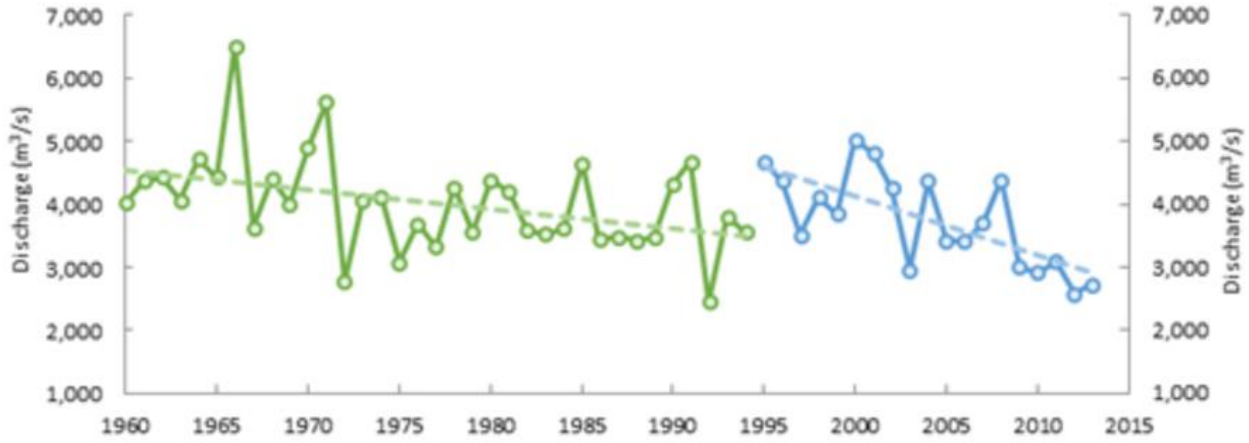
fluctuations. This is suggestive that dam building activities in the basin, which began in the 1950s, have been responsible for the changes in Mekong flows. In addition, dams have been identified as the projects with the largest systematic regional risks – particularly relating to the displacement of vulnerable peoples, the impacts on river flows and follow-on environmental, economic and livelihood impacts (Baran *et al.* 2007). Verifying the arguments about changes in water flows, Räsänen *et al.* (2017) used river discharge data and a hydrological modelling system for the period 1960 – 2014 to assess discharge changes. They found that there have been considerable discharge changes since 2011 as a result of hydropower dams, with particularly notable changes around the Chiang Sean area. Monitoring by the Mekong River Commission highlights increased dry season flows and decreased wet season flows, as per Figure 9.3 and Figure 9.4 below (note, the separation between the blue and green colours, with their separate trend lines, relates to the completion of the Manwan dam in 1995 – the first dam on the Lancang River mainstream).

Figure 9.3: Dry season flows at Chiang Sean 1960 - 2014



Source: MRC (2017, Online)

Figure 9.4: Wet season flows at Chiang Sean 1960 - 2014



Source: MRC (2017, Online)

Changes in flows in the Mekong will have flow-on ramifications such as trapping of sediments, with half the sediment that reaches the Mekong Delta originating from the Lancang River, in China (Baran *et al.* 2007).

9.5 PEOPLE

This section of the report presents an overview of the population living within 5 km of the Mekong mainstream between Luang Prabang and the confluence of the Ruak and Mekong rivers. It is largely based on a linear down-scaling of data from the provincial level, and is broken into three sections. First is some broad population data, which is then broken down in more detail for the people living in the study area. The final part of this section focuses on ethnic minority communities.

9.5.1 Provincial level population

Over the 360 km stretch of the study area, the Mekong River runs through or alongside four Lao provinces and one Thai province. These are the provinces of Bokeo, Oudomxay, Xayaburi and Luang Prabang in Laos, and Chiang Rai Province in Thailand. The average number of people per house in each of the provinces, disaggregated by urban/rural, are presented in Table 9.2, below. The term "urban" is not defined in either the Lao 2015 census or the Chiang Rai 2010 census. For this report it has been assumed that the US Census Bureau definition of any locality where more than 2,500 people dwell has been used (https://www.census.gov/population/censusdata/urdef.txt).

Table 9.2: Average household sizes in the five provinces

Country	Province	Average household size (rural)	Average household size (urban)
Lao PDR	Bokeo*	5.5	4.6
	Xayaburi*	5.0	4.6
	Oudomxay*	5.5	4.9
	Luang Prabang*	5.2	5.0
Thailand	Chiang Rai#	3.0	2.8

**Data: Lao Statistics Bureau (2015)*

 # Data: Thai National Statistical Office (2012)

In Chiang Rai province of Thailand, 72% of the population had worked in the year preceding the 2010 census, and 62% of the population worked in the agricultural sector (Thai National Statistical Office 2012). Almost all households (99.1% of the population) had improved sanitation facilities, and 82.6% of households had safe drinking water (tap water, treated water, rain water or bottled water, but private wells were not classed as a safe water supply). In Chiang Rai, 71% of the population either worked for themselves (42%) or were classed as unpaid family workers (29%).

The situation in Laos is quite different. According to the Agricultural Census Office (2012), only 19% of rural villages in northern Lao have access to safe water, compared with 59% in central Lao and 75% in the south. Across the country, nearly 50% of rural villages source their household water from a dam, a river or a stream. Nationally, just over 70% of the employed population of the Lao PDR work in the agricultural sector, however the Lao PDR census data does not break this information down by province (Lao Statistics Bureau 2015).

The gender breakdown of the population favours men in Laos, and women in Thailand, as per Table 9.3 below.

Table 9.3: Gender breakdown in each of the five provinces

Country	Province	Women		Men	
		Number	Percentage	Number	Percentage
Lao PDR	Oudomxay*	152937	49.72%	154687	50.28%
	Bokeo*	89270	49.80%	89973	50.20%
	Luang Prabang*	213191	49.36%	218698	50.64%
	Xayabury*	186439	48.89%	194937	51.11%
Thailand	Chiang Rai[#]	594836	50.71%	578092	49.29%

**Data: Lao Statistics Bureau (2015)*

[#] Data: Thai National Statistical Office (2012)

Data on ethnicity was not available for Chiang Rai Province in Thailand. In Laos, data is available on the four main ethnic family groupings at the provincial level. Table 9.4, below, provides the breakdown of the population by ethnicity for the four Lao provinces that the study area lies within:

Table 9.4: Breakdown of provincial populations by Lao ethnic groupings

Province	Ethnic Groupings			
	Lao-Tai	Mon-Khmer	Hmong Lewmien	Sino-Tibetan
Oudomxay	20.6%	60.5%	12.3%	5.7%
Bokeo	37.1%	28.4%	15.1%	18.2%
Xayabury	73.6%	15.8%	9.9%	0.1%
Luang Prabang	30.0%	51.4%	17.6%	0.2%

Source: ADB (2015)

Nationally in Laos the population growth rate fell between the two most recent censuses. From 1995 – 2005 the annual population growth rate was 2.08%, and this fell to 1.43% for the period 2005 – 2015. The population growth rate in Chiang Rai is also falling, and in 2010 was 0.38%. Table 9.5, below, gives the individual provincial growth rates with estimated current populations and projected populations in 2025.

Table 9.5: Current and projected populations (for 2025) in the study area

Province	Growth Rate[#, ##]	Current estimated study area population	Approximate projected study area population in 2025
Oudomxay	1.5% p.a.	9,000	10,000
Bokeo	2.1% p.a.	62,100	71,900
Luang Prabang	0.60%	5,700	5,900
Xayabury	1.20%	4,200	4,600
Chiang Rai	0.38%	19,300	19,800
Total	**1.69% p.a.**	**100,300**	**112,200**

[#] Growth rate data for Lao provinces sourced from (Lao Statistics Bureau 2015)

[##] Growth rate data for Chiang Rai sourced from (Thai National Statistical Office 2012)

Having provided a brief overview of the study area, and those living within it, more detail is provided in the sections below. First is a down-scaled analysis of the population living along the river. This is followed by definitions and data in relation to ethnic minority communities to finalise the people focused section of the report.

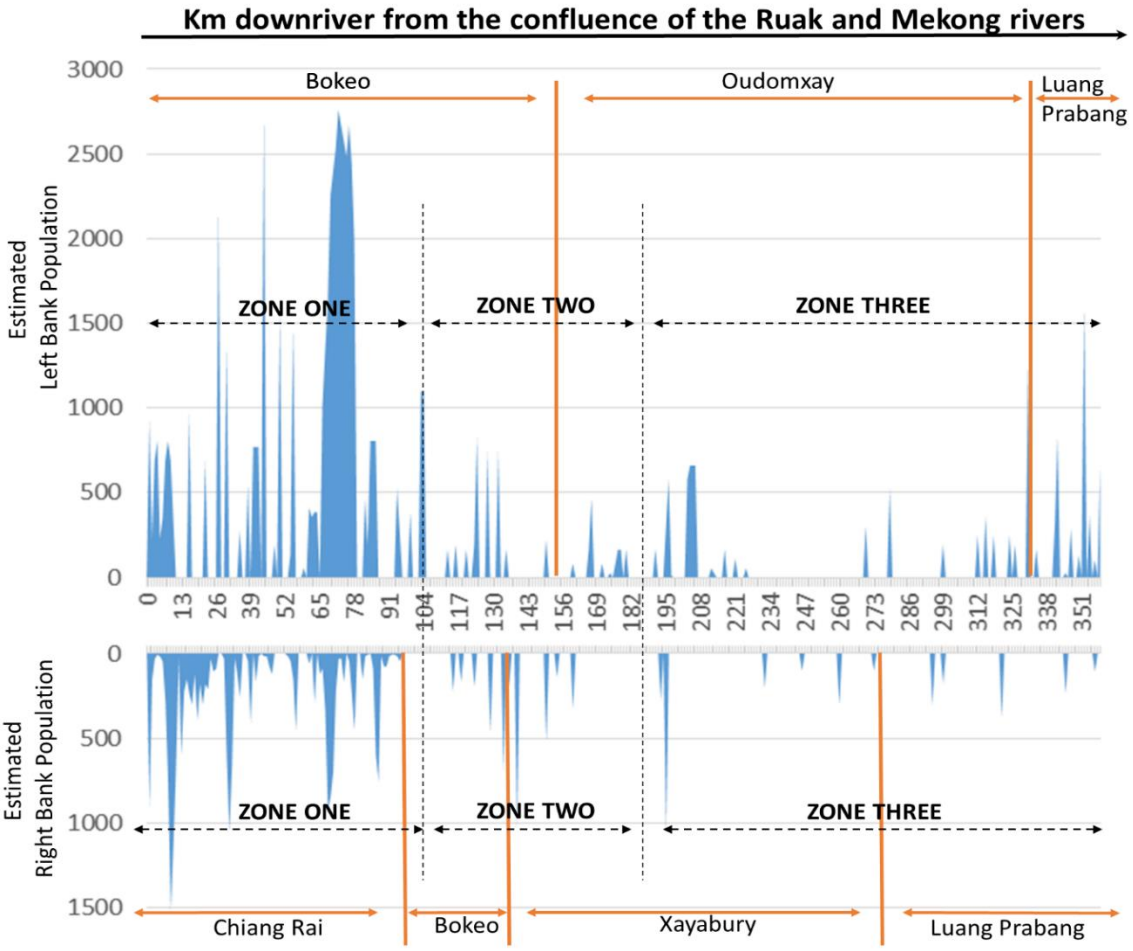
9.5.2 People living along the target stretch of the Mekong River

In order to understand the socio-economic situation for the study area, an estimate of the population living along the river was necessary. To conduct this estimate, census data was merged with primary data collected via Google Earth and Google Maps. Primarily using Google Earth, a visual estimate was made of the number of houses located within the study area. Houses were counted by kilometre below the confluence of the Ruak and Mekong rivers. Following this, provincial level population data from the Lao PDR and the Chiang Rai censuses was used to calculate the approximate population within the study area, including gender and ethnic breakdowns.

There were some limitations with the estimates. Firstly, time limitations did not allow individual houses to be counted, rather the estimate relied on the researcher's experience in estimating the number of houses by clusters of 10 – 50 houses. Secondly, not all the Google Maps and Google Earth imagery along the target stretch of the river is of the same resolution. In the majority of sections individual houses were reasonably clearly identifiable, in some the houses were rather blurred making the estimations more challenging, and in some short sections of the river the imagery was blurred to the point that villages were generally identifiable, but accurately counting the number of houses was impossible. Thus, the data on the population along the river should be treated as a professional estimate, and field surveys would significantly increase the accuracy of the data. The estimate of the total population along the 360 km stretch of river (not including Luang Prabang itself) is:

- Left Bank (as heading downstream): 74,000 people (all in Lao PDR)
- Right Bank (as heading downstream): 19,000 people in Thailand, and 7,000 people in Lao PDR
- Total estimated population between the Ruak and Mekong confluence and the outskirts of Luang Prabang, living within 5 km of the river is 100,000 people.The spread of population is depicted in the graph in Figure 9.5, below.

Figure 9.5: Populations = (Average provincial household size) x (Estimated number of houses per km)



The results of breaking the data from the figure above into zones and banks are presented below in Table 9.6.

Table 9.6: Estimated population in study area by zone and province

	Chiang Rai	Bokeo	Oudomxay	Xayabury	Luang Prabang	TOTAL
ZONE ONE						
Left bank population	n/a	57,000	n/a	n/a	n/a	**57,000**
Right bank population	19,300	-	n/a	n/a	n/a	**19,300**
ZONE TWO						
Left bank population	n/a	3,400	1,400	n/a	n/a	**4,800**
Right bank population	n/a	1,700	n/a	2,200	n/a	**3,900**
ZONE THREE						
Left bank population	n/a	n/a	7,600	n/a	4,500	**12,100**
Right bank population	n/a	n/a	n/a	2,000	1,200	**3,200**
TOTALS	**19,300**	**62,100**	**9,000**	**4,200**	**5,700**	**100,300**

The information provided above, about people living along the Mekong River in the study area, should give the reader a good sense of the density of population within the study area. The most densely populated region is the left bank (in the Lao PDR) in Zone 1 of the study area. This is followed by the right bank in the same zone (which is almost all in Thailand), which has a little over a third of the population on the left bank. From the beginning of Zone 2 of the study area (104 km downstream from the confluence of the Ruak and Mekong rivers), the river banks and surrounding areas are much more sparsely populated, until the outskirts of Luang Prabang are reached, with the right bank being home to fewer people than the left bank.

Gender is an important socio-economic consideration, as women's and men's roles in community and economic life tend to be quite different. The gender ratio in the five provinces in which the study area is situated are shown in Table 9.3. To down-scale the percentages of women and men in the five provinces down to the study area itself, the percentages of men and women from Table 9.3 were multiplied by the estimated population in the study area. The results of this calculation are presented in Table 9.7, below.

Table 9.7: Gender breakdown of the population living in the study area

Country	Province	Total estimated population within 5 km of the Mekong, by province	Women	Men
Lao PDR	Oudomxay	9,000	4,500	4,500
	Bokeo	62,100	30,900	31,200
	Luang Prabang	5,700	2,800	2,900
	Xayabury	4,200	2,100	2,100
Thailand	Chiang Rai	19,300	9,800	9,500
TOTAL		**100,300**	**50,100**	**50,200**

In Table 9.8, below, the population by gender data has been broken down into study area zones and which bank of the river people live on.

Table 9.8: Breakdown of population by gender, zone and bank

	Women	Men	Total
ZONE ONE			
Left bank population	28,400	28,600	57,000
Right bank population	9,800	9,500	19,300
ZONE TWO			
Left bank population	2,400	2,400	4,800
Right bank population	1,900	2,000	3,900
ZONE THREE			
Left bank population	6,000	6,100	12,100
Right bank population	1,600	1,600	3,200
TOTALS	**50,100**	**50,200**	**100,300**

9.5.3 Culture

Northern Laos is predominantly rural, with the population venerating esteemed ancestors through spirit sites, where they make offerings at the beginning of each year's agricultural season. In exchange for these offerings, the spirits are believed to be able to offer protection, and even intercede on behalf of their communities in cases of natural disaster or other calamity (Kunming Engineering Corporation Limited 2015).

While much of the population lives in riparian communities, offerings are generally buffalo, chickens, or pigs, rather than fish. In fact, fish are not highly prized way by the riparian cultures along the Mekong. Despite this, there are some ceremonies in the region that involve fish. For example, snakehead fish are sometimes sacrificed in Thailand in a call for rain, and in Laos several species of the large catfish are eaten immediately following religious rituals (Baran *et al.* 2007).

Apart from venerating their ancestors, another important cultural element for the people of northern Laos is their music. Music is used to tell stories about things such as wealth, safety and security as well as communal unity, and is particularly important around the time of rice harvesting. One style of music is the khub, which is important in northern areas of Laos including in Luang Prabang. Khub is used to relate stories from ancient literature, usually with a focus on morality, ethics and manners (Swangarom *et al.* 2015).

9.5.4 Ethnic Minorities / Indigenous Peoples

Also important to consider are the ethnic minority populations who may be affected by the navigation plan for the Mekong River. The census for Chiang Rai Province in Thailand did not include any data on ethnic minority groupings, despite there being a variety of ethnic minority groups living in northern Thailand. For this report, ethnic minority groups in Thailand have not been considered. In the Lao PDR there are 49 different ethnic groups, which are commonly divided into four families of ethnicities. Census data for the Lao PDR only provides population breakdown among the 49 different ethnic groups at the national level. At the provincial level data is broken down into the four family groupings of ethnicities, and that is what has been used here.

This report uses the definition of indigenous peoples from the World Bank's Operational Policy 4.10 (for safeguarding the rights and well-being of indigenous peoples). Indigenous Peoples refers to a distinct, and vulnerable group of people who to a greater or lesser extent possess the following characteristics:

> "(i) self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;
>
> (ii) collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
>
> (iii) customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and
>
> (iv) a distinct language, often different from the official language of the country or region" (World Bank 2005, pp. 1-2)

Ethnic minority groups in Laos fit the definition of indigenous people. Nationally, minority ethnic groups make up around 34% of the population of the Lao PDR. While there are many ethno-linguistic groups officially recognised by the government, they are classified into four families including the majority Lao-Tai family that makes up 67% of the population. The Mon-Khmer (Khmu, Khuan, Samtao etc…) ethno-linguistic family constitutes around 23% of the population. The Hmong Lewmien (Hmong-Tien and Yao groups) account for another 7% of the population, and the Sino-Tibetan groups make up the remaining 3% of the population (ADB 2015).

Table 9.9: Provincial population breakdown by ethnic family (percentage)

		Population along the Mekong (in Laos) by Ethnic Groupings			
	Tot. Pop within 5km of the Mekong by province	Lao-Tai	Mon-Khmer	Hmong Lewmien	Sino-Tibetan
Oudomxay	9,000	20.60%	60.50%	12.30%	5.70%
Bokeo	62,100	37.10%	28.40%	15.10%	18.20%
Xayabury	4,000	73.60%	15.80%	9.90%	0.10%
Luang Prabang	5,700	30.00%	51.40%	17.60%	0.20%

Table 9.9, above, provides data on the breakdown of ethnic groups within the four target provinces in the Lao PDR. The percentage breakdown data has been used to calculate the number of people from each ethnic family among the the population living along the Mekong River. It is acknowledged that the ethnic breakdown within provinces are not uniformly distributed. For example, in the social impact assessment (SIA) for the Pak Beng dam, the Kunming Engineering Corporation Limited (2015) noted that in the 100 kilometres downriver from the dam site 70% of people are ethnic Khmou, 25% are Lao ethnicity, and 5% are Hmong people. However the exact wording in the SIA is vague about the area surveyed, and there is no other geographically referenced census data of the area below the provincial level. For this reason, for the ethnic breakdown calculations in this study, a simple linear downscaling (ie. it has been assumed that the ethnic breakdown at the provincial level is mirrored at the smaller scale among the riparian communities) from provincial data, has been applied.

Multiplying the percentages of people by ethnicity by province (as per the table in the previous section) by the estimated population within 5 km of the Mekong River between Luang Prabang and the confluence of the Ruak and Mekong provides the following statistical estimation of population breakdown by ethnicity along the 360 km stretch Mekong River above Luang Prabang. See Table 9.10, below.

Table 9.10: Calculated population by ethnicity and province within the study area

	Population in the Study Area, by Ethnic Groupings			
	Lao-Tai	Mon-Khmer	Hmong Lewmien	Sino-Tibetan
Oudomxay	1,900	5,500	1,100	500
Bokeo	23,100	17,600	9,400	11,300
Xayabury	3,000	600	400	0
Luang Prabang	1,700	2,900	1,000	0
TOTAL	**29,700**	**26,600**	**11,900**	**11,800**

Breaking the information from the table above into ethnicity of the population by bank and zone of the study area is presented in Table 9.11, below.

Table 9.11: Calculated population breakdown by ethnicity, zone and bank

	Lao-Tai	Mon-Khmer	Hmong Lewmien	Sino-Tibetan
ZONE ONE				
Left bank population	21,100	16,200	8,600	10,400
Right bank population*	unknown	unknown	unknown	unknown
ZONE TWO				
Left bank population	1,600	1,800	700	700
Right bank population	2,300	800	500	300
ZONE THREE				
Left bank population	2,900	6,900	1,700	400
Right bank population	1,800	900	400	0

** The right bank, zone one, population are all in Chiang Rai Province, for which data on ethnicity is unavailable.*

Considering ethnic minority groups is important because these groups account for two thirds of the population in the study area. They also tend to be more vulnerable than the majority Lao-Tai population (as per the World Bank definition of ethnic minorities provided above). For example, people from ethnic minorities in northern Lao PDR tend to have significantly poorer health than the majority population. The reasons for this include: 1) Remote living locations and associated inaccessibility of health facilities; 2) Lower educational levels (particularly for women); and 3) Lower sanitation and hygiene standards because they often speak different languages therefore making public health communication more challenging.

Aside from health issues, ethnic minority groups have suffered from a significant loss of the variety of natural resources (e.g. non-timber forest products) from which they have traditionally sourced food products (Kunming Engineering Corporation Limited 2015, see also King and van de Walle 2012). These groups also tend to face larger difficulties integrating into a market economy than the dominant Lao-Thai people (ADB 2010). Many of the public health-related challenges described above (e.g. different languages, remote living locations, lower education levels) also inhibit ethnic minority integration into the market economy. Lack of integration into the market economy also links to the slower decline in ethnic minority poverty rates, when compared with the dominant Lao-Thai people (ADB 2010).

There are some concerns expressed in the literature about commodification of ethnic minority groups and of some ethnic groups fading out of sight. For example, Holt (2009) discusses concerns held himself and other authors about the secularisation of New Year's festivals in Luang Prabang under the communist governments of the 1980s. What are described as 'colourful' minorities were relegated to being players for the tourist industry, while others, who had lost their traditional roles, faded out of societal view altogether.

To summarize this section on people in the study area: there is a total population of just over 100,000 people who will be affected by the LMDP. 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.

9.6 POVERTY AND LIVELIHOODS ANALYSIS

Having provided some baseline information and data on the population in the study area, including gender and ethnicity breakdowns, this next section of the report provides details on poverty and livelihoods in the area. This section of the report begins with an overview, which is followed by sub-sections on agriculture, trade, fishing, wildlife trafficking, logging and land tenure.

Poverty rates do not remain static over time, and they do not always reduce, even with targeted poverty alleviation interventions. For example, Table 9.12, below, shows the poverty rates in 2013 for the four Lao provinces that are co-located with the study area, as well as the changes in poverty rates between 2008 and 2013:

Table 9.12: Poverty rates & changes in poverty rates in the 4 target provinces

Province	Poverty rate 2013	Change in poverty rate since 2008
Oudomxay	30.1%	-3.6%
Luang Prabang	25.5%	-1.7%
Xayabury	15.4%	-0.2%
Bokeo	44.4%	+11.8%

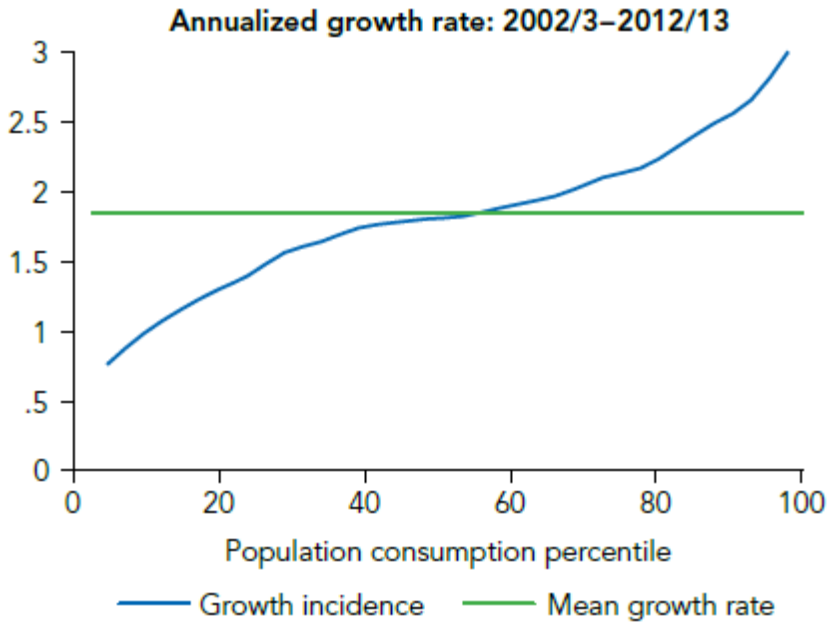
Source: World Bank (2014)

Urban poverty rates in the Lao PDR are declining faster than rural poverty rates, which remain at 28.6% nationally (World Bank 2014). Almost 90% of poor people in Lao PDR live in rural areas, and the decline in poverty rates is not universal. For example, as per Table 9.12, above, the poverty rate in Bokeo province rose during the period 2008 – 2013. In 2013 almost 45% of people in Bokeo were living in poverty. The rise in poverty rates in Bokeo up to 2013 highlight "that even in areas which have [in the past] achieved impressive poverty reduction, gains can easily be overturned in later periods if the households or the region experience shocks or setbacks" (World Bank 2014, p. xi). The government of Lao PDR supports this assessment, noting that "[h]ouseholds in agriculture are twice more likely than non-farm households to fall back into poverty, as they are highly vulnerable to shocks" (GoL 2018, p. 17). World Bank data highlights that 80% of the Lao population live on less than US$2.50 per day (or approximately three times the national poverty line) and, particularly in the face of shocks, people in this situation have a one in ten chance of falling back into poverty. The major drivers of people falling into poverty are agricultural and health related shocks, with additional factors including dependency on agriculture for livelihoods, being part of an ethnic minority, and having lower than average educational attainments (World Bank 2015).

Even where poverty in monetary terms in Lao PDR has declined significantly, the decline is not necessarily linked to positive changes to other indicators that are considered drivers of long term poverty reduction. For example, in some districts in Lao PDR where targeted poverty reduction interventions took place between 2003 and 2008, the proportion of people living below the poverty line fell almost 10%. However, despite this success in reducing monetary poverty, growth in secondary school enrolments in the same districts has been slow (World Bank 2014). Another concerning factor

is that growth in Lao PDR over the period 2003 – 2013 favoured the wealthier segments of the population, as per the figure below. Figure 9.6 below shows that those people who consumed more than average (ie. had more money to spend) experienced a higher than average growth in income between 2002/3 and 2012/13, while those who consumed less than average experienced a lower than average growth in income over the same period. This means that the gap between the rich and poor in Laos is growing wider.

Figure 9.6: consumption changes by wealth in Lao PDR 2003 - 2013



Source: World Bank (2014, p. 5)

The Chiang Rai census data doesn't include information on income levels or the percentage of the population living under the poverty line. As an alternative, data on upper secondary education by gender is presented here for Chiang Rai province, and compared with national Lao PDR data for upper secondary education by gender for the whole population. This data is presented in Table 9.13, below.

Table 9.13: Upper secondary education achievement in Lao PDR and in Chiang Rai province by gender

	Chiang Rai province*	The Lao PDR#
Total percentage of males completed upper secondary education	3.4%	2.6%
Total percentage of females completed upper secondary education	3.55%	4.4%

* *Calculated by the author from data in Thai National Statistical Office (2012).*

\# *Sourced from Lao Statistics Bureau (2015).*

Data is not available for educational achievements by province in the Lao PDR census data, however educational achievements (particularly at upper secondary level) in the remote northern provinces of Lao PDR are likely to be significantly lower than the national average. Table 9.13, above, indicates that Chiang Rai educational achievements are comparable with the national average in Laos, and thus significantly higher than the likely educational achievements in the four target Lao PDR provinces.

There is a strong correlation between increasing educational outcomes and reductions in poverty levels (see e.g. Ezebuilo and Emmanuel 2014), and so the author would expect that poverty rates in Chiang Rai are significantly lower than in Bokeo, Oudomxay, Xayabury and Luang Prabang. This expectation is further reinforced by the national level economic data for the two countries: that Thailand is a middle income country and the Lao PDR is a least developed country (UN Committee for Development Policy 2018, World Bank 2018).

Low education levels in the Lao PDR, combined with high to very high poverty rates in the four target provinces in the country (ranging from 15.4% to 44.4% of provincial populations classified as living in poverty in 2013), make the communities in the study area very vulnerable to shocks and changes in the environment that impact on their lives. This is because people who are poor and people who are less well educated have a lower ability to cope with shocks that they are exposed to than wealthier and better educated people (see e.g. Yusuf and Francisco 2009). As one way of combatting this, the Lao government is committed to improving educational outcomes, as can be seen from the 17% of government expenditures (as reported in the 8th National Socio-Economic Development Plan) being allocated to education and sport (MPI 2016). Despite this investment, the planning and investment ministry sees a variety of challenges in improving education, such as stemming the dropout rates from primary school, and trying to achieve gender parity in education (MPI 2016).

9.6.1 Agriculture

Agriculture forms an important part of this socio-economic study for several key reasons. Firstly, Laos is a predominantly rural country, with around 70% of the population living in rural areas. This is particularly the case for areas such as the north of the country, outside the sphere of Vientiane. Secondly, agriculture in the study area may benefit from improved river transport because farming inputs become cheaper and because it may improve access to markets for produce, however accelerating commercial agriculture may also have negative impacts, such as undermining food security of those living near or below the poverty line.

The economy of the Lao PDR relies heavily on the agricultural sector, although both industry and services are growing in importance in the country. The Lao government is promoting large scale agri-business as part of a push to transform traditional practices with modern and industrialised forms of production (Bartlett 2012, McAllister 2015). The agriculture and forestry ministry also raises this as an issue, noting that land concessions are promoted because they bring in much needed foreign direct investment, but that there are a number of negative elements associated with this. For example, the ministry highlights that Lao farmers are not receiving benefits from these land concessions, but face stressors such as reduced grazing land for their livestock and reduced land for their own food security, while still having restricted market access for their own produce (MAF 2010). While this is a clear government acknowledgement of these issues, Bartlett (2012, p. 29) observed that in general, "promotion of large-scale agribusiness at the expense of small-scale production is not reflected in government policy documents". It is not surprising therefore, that the 2018 voluntary review of progress towards the 2030 sustainable development goals emphasises working with small holder farmers in order to shift away from subsistence farming towards market-oriented agriculture (GoL 2018). One area where market-oriented agriculture can be seen is in Lao's rubber boom. In 1999 there were just a few hundred hectares of rubber under cultivation in the Lao PDR. By 2011, 49,000 farm households were growing rubber and around 66,500 hectares of land was being used for rubber

cultivation, with most of this in the north of the country (Agricultural Census Office 2012, Epprecht *et al.* 2018). By 2015 the area of land under rubber cultivation had grown to 250,000 hectares, but of this, only 36,000 hectares had trees of harvestable age (GoL 2015). This supports Bartlett's (2012) assertion that large scale agri-business is being supported and promoted, as the rate of planting (214,000 hectares of rubber trees not yet of harvestable age) appears too large to have been solely take-up by small-scale farmers.

As part of its drive towards a modern agri-business model of agriculture, the government of the Lao PDR has made repeated efforts to reduce shifting agriculture (e.g. swidden farming, slash and burn agriculture), towards intensive agriculture focusing on producing just a few crops in order to generate income (Freund 2010, Bartlett 2012). Transitioning to intensive mono-crop style agriculture links to increasing amounts of foreign investment in agricultural land in Laos in the way of land concessions and grants (Hanssen 2007). This foreign investment began to occur in the 1990s, and by the 2000s had become a significant part of Lao's economy (Bartlett 2012). The spread of commercial farming, and the land concessions that have come with it are increasing the traditionally low usage of chemical fertilizers (FAO 2018). Reducing shifting agriculture impacts most heavily on poorer and ethnic populations, as it is these people who have traditionally practiced shifting and swidden agriculture, and who have relied heavily on forests products (as well as fish) for their food security (Freund 2010). In many cases, these populations are losing access to their traditional lands. For example, according to McAllister (2015), rubber plantations are primarily established on lands that are designated as state forests, but which are inhabited and farmed under a variety of different forms of customary tenure. McAllister's observation, and the rate at which rubber plantations are growing in Lao, highlight issues of good governance, as brought up by the World Bank (2010). The bank noted that when too many projects are beginning at the same time, particularly in countries where there is limited capacity to manage and monitor projects, there is a high potential for governance to deteriorate. Thus, projects may not achieve high financial returns, and may not include appropriate environmental and social infrastructure components. This concern of the World Bank's has been echoed by the Lao PDR's vice-chair of the National Assembly's Economic, Planning and Finance Committee, who observed that "Laos has approved many projects particularly those related to mining, hydropower, industrial tree plantations and agriculture sectors, with some of these investments not operating in accordance to the laws and regulations of the country" (Vientiane Times 2014, Online). Lack of environmental and social infrastructure when implementing development projects such as plantations and hydropower dams could undermine the potential for natural resource development to enhance growth and reduce poverty in the long-term (World Bank 2010).

Linked to acknowledged weak governance in Laos (e.g. Koch 2017), it is difficult to know the exact nature of agricultural change in northern Laos without extensive field studies because transparency is poor, and accessing data on issues like land concessions is challenging (Bartlett 2012). Others, such as Kenney-Lazar (2016), Koch (2017) and FAO (2018), have asserted that close to five percent of national territory, around 1.1 million hectares, has been granted to investors for hydropower, mining and plantations.

The government of the Lao PDR does recognise that food insecurity remains a problem, assessing that 11% of rural households having poor or borderline food consumption. They further note that two of the factors threatening food security are: 1) Large scale investment projects; and 2) Increasing

pressure on available land due to a growing population GoL (2018). The promotion of modern agri-business, combined with the large scale investment projects threatening food security, is of concern for ethnic minority communities because, particularly in northern and southern Lao PDR, ethnic minorities "have been disproportionately affected by rubber concessions and contract farming arrangements because many live in remote villages in 'state forests' and practice various forms of shifting cultivation, and therefore their lands are often targeted" (McAllister 2015, p. 818). For example, McAllister (2015) described a 40 year land concession granted in 2007 for 7,000 Ha in Pak Ou district of Luang Prabang province which encompassed five (rural, no access by road) Khmou villages. The ethnic minority communities affected resisted the encroachment on their customary land, but significant pressure was applied by local government officials. While waged labour on a plantation may, from an external perpective, offer improved livelihoods, forcing this type of change on ethnic minorities can take away their autonomy, does not allow them the choice of continuing to practice "subsistence affluence" (see Chamberlain 2008, p. 19), and can negatively impact on traditional cultural practices.

The moves in Laos towards a market economy can be seen in the agricultural sector with a third of farmers across the country primarily selling what they produce. Despite this, the majority of the rural population maintain subsistence livelihoods, relying on rice, livestock and collecting food from the 'wild' for nutrient-rich foods (FAO 2018). Adding weight to this observation, the Agricultural Census Office (2012) observed that 41% of farm households grow vegetables in areas such as small kitchen gardens or on river banks. While subsistence is pervasive in rural Lao, according to the Agricultural Census Office (2012), most rural villages sell some of their produce, including 94% of rural villages in northern Lao. As part of the selling of farm produce, over 10% of villages in the Lao PDR have some contract farming present (Agricultural Census Office 2012). Contract farming means there is a forward agreement (contract) between a farmer and a processing or marketing firm for the farmer to supply products, normally at a pre-determined price (Eaton and Shepherd 2001). Eaton and Shepherd (2001) argued that well organised contract farming is a way to create linkages between farmers and their inputs (e.g. seeds, extension advice and/or financial credit) as well as with markets that are guaranteed and profitable. This means that the farmer does not have to shoulder the burden of risk related to market fluctuations in the product being produced, but could leave the farmer vulnerable to unethical practices on the part of the processing or marketing firm (see e.g. PEI and NERI 2015). As argued by Eaton and Shepherd (2001), contract farming may offer a viable pathway for poverty reduction, however it must be considered in light of World Bank concerns regarding good governance because of the need for it to be well regulated.

Agri-business is being promoted in the form of cash crops such as rubber or palm oil. One alternative that is often ignored is job's tears, a grain that is a relative of maize. In the Lao PDR, it is traditional crop of ethnic minority groups such as the Khmou and Hmong peoples. It is primarily used for household consumption and animal feed. It is mostly grown in upland rain-fed fields with other crops such as upland rice and sesame. At first glance, job's tears should be a desirable product to grow: it grows well in poor soils, requires less weeding than rice, has a higher yield than upland rice as well as a shorter harvest period. Another advantage of job's tears is that, like rice, it can be eaten as well as sold. However, cultivation of job's tears is not currently being actively supported through, for example, subsidies. In addition factors including frequent market value fluctuations for the grain and limited

access to market mean that growing areas remain limited to certain regions (Epprecht *et al.* 2018). For the four provinces that cover the study area, the number of hectares in which job's tears were cultivated in 2010/11 are shown in Table 9.14 below.

Table 9.14: Job's tears under cultivation in 2010/11 in four provinces

Province	Area of job's tears cropping in 2010/11 across both wet and dry seasons (Ha.)
Bokeo	1,084
Oudomxay	1,590
Xayabury	12,799
Luang Prabang	7,304

Source: (Epprecht et al. 2018)

While Epprecht *et al.* (2018) did not detail the changes in coverage of job's tears, as a traditional crop in Laos it is reasonable to assume that the changes have not been significant. In comparison, rubber cultivation grew enormously over the period 1999-2011, as detailed in Table 9.15 below.

Table 9.15: Changes in rubber cultivation in four Lao provinces (Source: (Epprecht et al. 2018))

	Change in area under rubber cultivation 1999 – 2011 (Ha.)	
Province	1999	2011
Bokeo	0	7,738
Oudomxay	0	10,599
Xayabury	0	3,192
Luang Prabang	0	3,116

Similar to the growth in rubber cultivation, maize is another crop primarily grown in northern Laos whose land area has grown significantly. The Agricultural Census Office (2012) reported a fivefold increase in hectares planted between 1998/99 and 2010/11.

While small-holder farmers are mentioned as the focus are for transitioning to modern industrialised agriculture in Laos, many foreign companies are taking advantage of the opportunities available to take possession of large land concessions. While the resulting foreign investment in Laos is positive from a macro-economic point of view, at the smaller scale the land concessions are undermining the ability for poor farming communities, including ethnic minority communities, to meet their own livelihood and food security needs. While it could be argued that the LMDP is focused on the river, and improving people's livelihoods through upgrading navigability, there are links between enhanced river transport and changes to what happens in agricultural areas accessible from the river.

9.6.2 Trade and economics

The Mekong River remains the main transport route through northern Laos, and upgrading shipping capabilities along the river is likely to have large repercussions on trade and tourism. For example, foreign direct investment is not the sole domain of agricultural plantations. Laos is known for a variety of mineral ores that attract foreign investors. Lao government statistics show that by March 2015 there were 15 Lao companies that had received concession approvals for mining ore, and 53 foreign owned companies with approved mineral exploitation concessions (GoL 2015).

Two of the four Lao provinces that are co-located with the study area have tourism management plans. These are Oudomxay and Luang Prabang (TIIGP 2016a, 2016b). The Oudomxay plan recognises several challenges to achieving their vision of pro-poor sustainable tourism for the province. These include conflicts between economic development activities such as plantations and large dam development,

and expansion of tourism in the province, as well as a lack of understanding about tourism and business among existing service providers. The plan also notes that in 2011 tourism in Pak Beng accounted for 65% of all tourism in the province, and argues that a strategy is required to develop the province as a destination because otherwise improved infrastructure (e.g. roads) will mean that tourists don't stop in the province (TIIGP 2016a). According to the Oudomxay tourism management plan, currently there are approximately 10 hotels, 68 guest houses and 4 resorts in the province. The Luang Prabang tourism management plan focuses very heavily on the city of Luang Prabang (TIIGP 2016b), which is beyond the scope of this study (the study area ends on the northern outskirts of Luang Prabang). As a comparison however, Luang Prabang province has approximately 312 hotels and guesthouses in total (TIIGP 2016b). The tourism forward planning of these provinces has been undertaken with support from organisations including the Asian Development Bank and SwissContact. Depending on the degree to which the local tourism authorities had ownership of developing the vision and report, the forward planning may put these provinces in a position to support their local communities to take advantage of tourism-related opportunities and changes that are likely to arise as the river becomes navigable by larger vessels.

Shipping along the Mekong River is mostly in the delta and above Chiang Rai. The amount of shipping above Chiang Rai has grown rapidly. In 1991 just 500 tonnes was shipped from China into Chiang Sean, and by 1995 the amount shipped was 40,000 tonnes (Berman 1998), and by 2011 300,000 tonnes was being shipped annually between Kunming and Chiang Sean (Kunming Engineering Corporation Limited 2015). The growth in shipping in this area ties to work that has been done to upgrade the navigability of the Lancang River in China (see e.g. LRSA 2008). While LMDP implementation is unlikely to result in a re-routing of goods bound from Kunming to Bangkok, the growth in shipping, linked to the upgrades in navigability of the stretch of river upstream of the study area suggests that downstream of Chiang Sean would see similar growth patterns in trade, and likely tourism as well.

9.6.3 Fishing

When we consider upgrading an ecosystem such as a river for human uses, we also have to consider other facets of the ecosystem and the services it provides for people, particularly those in the immediate area. One of the services provided by the Mekong ecosystem are the fish that supplement people's diets in northern Lao, particularly when there is a shortage of other food. Thus, many households rely on part-time fishers to ensure their food security.

Fish play a very important food security role for the peoples living in the Mekong Basin. For example Baran *et al.* (2007, p. 236) noted that small fish and fish products provide much of the essential calcium for people in the region, particularly as milk is not a traditional part of the Southeast Asian diet. More recent studies have highlighted the importance of fish protein as well as lysine in the diet of rural peoples in the Mekong (see e.g. Hall and Bouapao 2010, Pittock *et al.* 2017). A number of authors have investigated the quantities of fish and other aquatic products at the provincial level in Lao. A summary of available information relating to the study area is presented in Table 9.16, below.

Table 9.16: Aquatic animals (including fish) consumption in selected provinces

Province	Aquatic products consumed per capita per year (kg)
Oudomxay	17.1
Xayabury	15.1
Luang Prabang	29.0

Source: (Baran et al. 2007, p. 253)

Despite the high levels of fish consumption in Lao, official statistics for capture fisheries in northern Mekong provinces of Laos indicate very low levels of capture fishery, as opposed to aquaculture. For example, the fish section of the baseline report in this environmental study highlights that in Pak Beng district 1.8 tonnes of capture fish are reported as the annual production. However, multiplying the consumption figures from Table 9.16, above, by the population of just the town of Pak Beng, in Oudomxay Province, (calculated at 577 people in the study area) gives the following:

(1) (17.1kg/person/year) x 577people = 9.87 tonnes of aquatic animals consumed per year, most of which is presumably fish.

The main reasons for the under-reporting in official statistics is that the statistics tend to only capture aquatic products that are traded, and because other aquatic resources, such as algae, prawns, wild water plants and vegetables, are ignored in national statistics (Baran *et al.* 2007). The lack of collected data on the role that fisheries play in supporting food security and livelihoods significantly disadvantages poor people. This is because official records, which are used for forward planning purposes, development decisions and impact assessments, only detail what is sold, produced and consumed by wealthier segments of society (Baran *et al.* 2007). Baran *et al.* (2007) also observed that poorer segments of the population are becoming more reliant on wild fish capture because of increasing levels of indebtedness as well as displacement from their customary lands. Thus, most fish are caught by subsistence and part-time fishers, and that these catches play an important role in rural livelihoods through expenditure saving as well as providing a survival strategy in terms of food security. The importance of including data on this type of catch and use is vital in providing a full impact assessment on livelihoods.

Table 9.17: Households engaged in aquaculture and capture fisheries (Source: (Agricultural Census Office 2012, p. 10)

FARM HOUSEHOLDS ENGAGED IN FISHERIES ACTIVITIES (2010/11)	# OF FARM HOUSEHOLDS
Total number of farm households	782,800
Number of households engaged in aquaculture	68,200
Households with aquaculture as main income source	1,000
Aquaculture households with different main income source	67,200
Households that sold some aquaculture produce	21,300
Households that did not sell any aquaculture produce	45,800
Number of households engaged in capture fisheries	526,300
Households where capture fisheries are the main income source	5,900
Capture fishery households with different main income source	520,300
Households that sold some capture fisheries produce	111,200

Table 9.17, above, highlights that fishing in Laos is, like farming, primarily a subsistence occupation. For example, just over 1% of households that engage in capture fisheries have it as their primary income source, and only about 21% sell some of their catch. This data from the agricultural census is reinforced and validated by Hall and Bouapao (2010), who argued that fish forms a central component of subsistence livelihoods in the Lao PDR and will continue to do so for the foreseeable future (see also Kunming Engineering Corporation Limited 2015).

There are concerns reported by residents in the study area that fish catches are declining (see section 5.4.6.2.2 of the baseline report). This is a concern that reported widely in the region, however in Cambodia, for example, it has been shown that while catches per fisher reduced between the 1940s and 1990s, the overall catch doubled in the same period. The reduction in catch per fisher is the result of population growth, with the Cambodian population tripling over the 50 years in question (Baran *et al.* 2007).

Whether this is the case in the study area is currently difficult to confirm because estimates of fish caught in the Lao PDR vary widely depending on the methodology used for the analysis, but there is a general trend upwards in estimates. At the lower end of the scale was a 1997 estimate of around 38,000 tonnes, and at the upper end a 2001 estimate, based on consumption figures, of around 205,000 tonnes.

Within the study area, most fishing is done in smaller tributaries and ponds, rather than in the Mekong mainstream. This is because fish are easier to catch in the smaller water bodies where the currents are smaller. In addition, there are upfront costs for equipment purposes for those wishing to fish in the mainstream, and this deters villagers living near the poverty line. Despite this, the smaller tributaries and ponds do not constitute entire ecosystems in themselves, and it is their connection to the Mekong mainstream that means they have fish for the population to catch.

Larger fish in the Mekong tend to spend the dry season in deep water pools. For example, the critically endangered giant *Pangasius* catfish spends much of its time in deep water pools in the Mekong River (Hogan 2011). Linked to this, there is a long history in Laos of establishing fishing conservation zones around deep water pools because local fishermen and women realize that these deep pools form an important part of the life cycle of fish in the river (Bartley *et al.* 2016). Most fish in the Mekong spawn during the flood season, and many species are reported by local fishermen to use deep water pools as their dry season habitat. For example, based on 120 focus group discussions, followed by individual interviews with 355 expert local fishers, Valbo-Jorgensen and Poulsen (2000) generated a list of 53 species that spend the dry season in deep water pools, as per Figure 9.7, below.

Figure 9.7: Species reported as living in deep water pools over the dry season

Species	Reports	Species	Reports
Chitala ornata	12	*Botia modesta*	3
Helicophagus waandersi	10	*Cirrhinus microlepis*	3
Paralaubuca typus	10	*Cosmochilus harmandi*	3
Wallago attu	10	*Hemibagrus nemurus*	3
Mastacembelus armatus	9	*Pangasius sanitwongsei*	3
Micronema sp	9	*Pangasius siamensis*	3
Puntioplites falcifer	9	*Wallago leeri*	3
Morulius chrysophekadion	8	*Hypsibarbus malcolmi*	3
Bagarius yarelli	7	*Pangasius djambal*	2
Pangasius macronema	7	*Tenualosa thibeaudeaui*	2
Pangasius polyuranodon	7	*Trichogaster trichopterus*	2
Probarbus jullieni	7	*Bagarius bagarius*	2
Probarbus labeamajor	7	*Bangana behri*	1
Cyclocheilichthys enoplos	6	*Botia helodes*	1
Hampala dispar	6	*Channa striata*	1
Hampala macrolepidota	6	*Chitala lopis*	1
Henicorhynchus siamensis	6	*Cirrhinus molitorella*	1
Pangasianodon hypophthalmus	6	*Hemibagrus wycki*	1
Pangasius conchophilus	6	*Laides hexanema*	1
Pangasius krempfi	6	*Lycothrissa crocodylus*	1
Pangasius pleurotaenia	6	*Mekongina erythrospila*	1
Catlocarpio siamensis	5	*Osphronemus exodon*	1
Chitala blanchi	5	*Osteocheilus hasselti*	1
Pangasius larnaudiei	5	*Pristolepis fasciata*	1
Barbodes gonionotus	4	*Puntioplites proctozysron*	1
Notopterus notopterus	4	*Boesemania microlepis*	1
Pangasius bocourti	4		

Source: Valbo-Jorgensen and Poulsen (2000)

The cyprinid *Hypsibarbus malcolmi* has been observed to spawn in some deep pools over the course of the dry season period. It also appears likely, but not certain, that a variety of other species also spawn in deep water pools (see e.g. Poulsen *et al.* 2002).

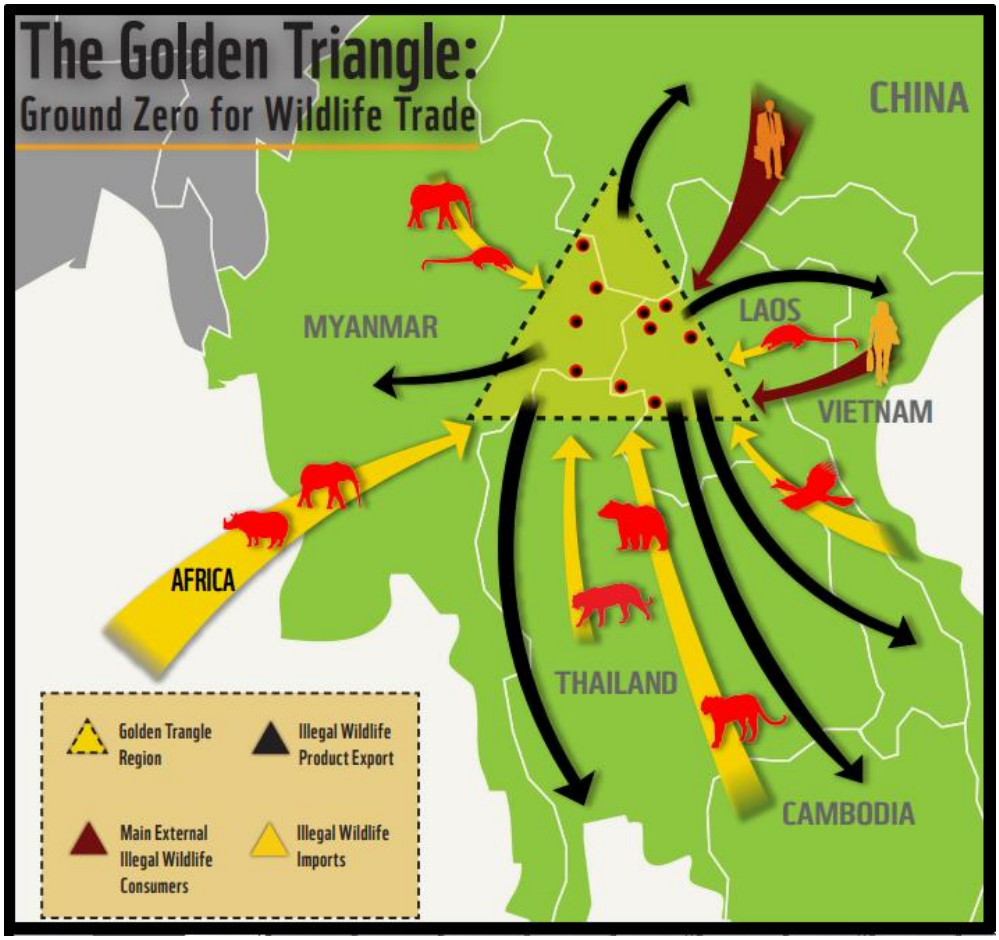
9.6.4 Wildlife trafficking

People along the river fish mostly for household consumption and food security, however there are others who hunt animals to sell, including those who traffic in illegal wildlife. Wildlife trafficking has been included in this report for two reasons. First, northern Laos is a world hub of the illegal wildlife trade, suggesting it is an important economic activity in the region around the study area. Increased shipping on the Mekong, as well as developments including ports and associated road upgrades may: 1) Make it easier to ship illegal wildlife and wildlife products (because they can be more easily concealed in larger vessels); and 2) Increase the access to local wildlife for trapping and trafficking. Second, linked to greater access to local wildlife, there are strong correlations between the wildlife trade and biodiversity in the Lao PDR. Maintaining biodiversity is an important aspect of ensuring that ecosystem services remain available to people today as well as to following generations.

Laos is a major hub of the world illegal wildlife trade, with wildlife imported via various routes into the country from as far away as Africa, and sold there, mostly to Chinese and Vietnamese tourists.

The Golden Triangle, at the confluence of the Ruak and Mekong rivers, is known for its illegal wildlife trade, particularly as a place that tourists from nearby areas come to purchase traditional medicines concocted from protected species including pangolins from Lao PDR. Another endangered animal from Laos whose presence in wildlife trading hubs is increasing is the serow, a goat-like animal that lives in remote mountainous areas, including those in northern Lao. Serow meat is sold, and the animal is also used in the production of traditional medicine products (WWF 2017). Figure 9.8 below depicts the primary source countries, and destinations, for illegal wildlife products that can be found in the Golden Triangle.

Figure 9.8: The hub of the illegal wildlife trade in Southeast Asia



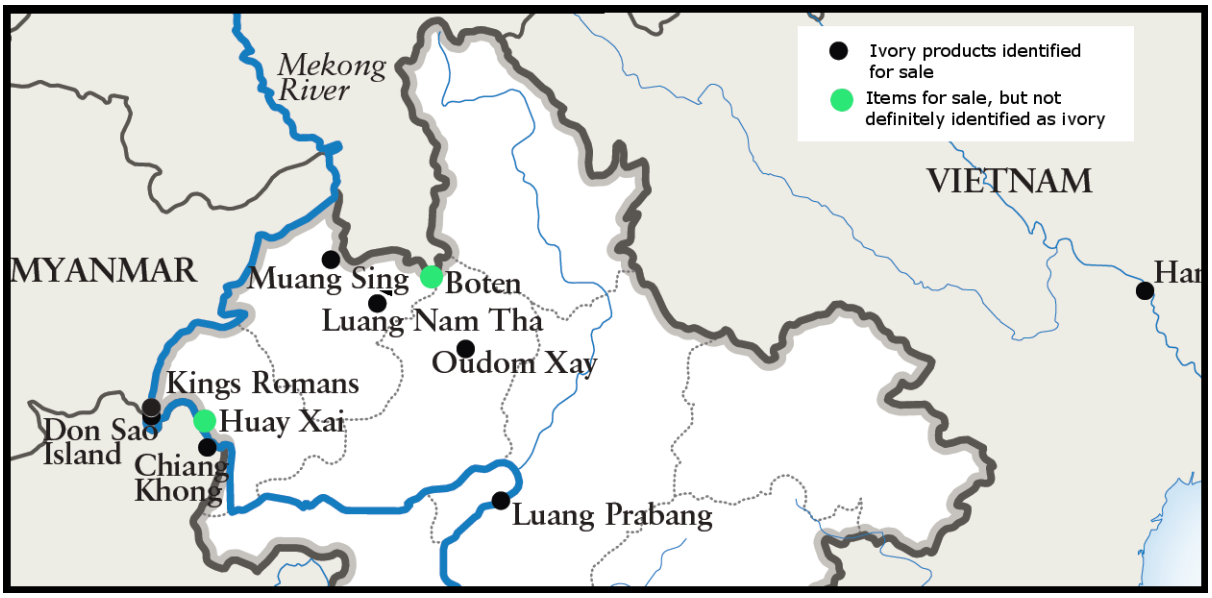
Source: WWF (2017)

While the elephant population in Lao PDR has been decimated (e.g. Elephant Conservation Centre 2017), the country is still a hub for the sale of ivory products sourced primarily in Africa. For example, Vigne and Martin (2017) spent a month in Lao PDR in November and December 2016 tracking retail outlets for ivory, the origins of elephant tusks, the trade routes into and through Lao PDR, as well as wholesale prices and where processing was being done. Lowering of demand for ivory products in China is driving the growth of the illegal trade in Lao PDR. Most ivory coming into Lao PDR comes in raw form, either shipped through Vietnam or Bangkok, but in order to protect the network of smugglers involved there is generally no paperwork to associate it with Lao PDR. Some of the illegal ivory reportedly comes via Myanmar and down the Mekong River, crossing into Lao PDR at places such

as the friendship bridges where Lao PDR, Thailand and Myanmar converge and in the Golden Triangle, at the confluence of the Ruak and Mekong rivers.

Carving of ivory products in the past was done by hand, often by Vietnamese artisans, however there is a growing trend for traders to use machines to rapidly carve multiple uniform items (Vigne and Martin 2017). The retail trade in ivory products is not restricted to northern Lao. Figure 9.9 below shows the locations where ivory products are sold in retail shops.

Figure 9.9: Ivory retail trade locations in northern Lao PDR



Source: Vigne and Martin (2017)

In Luang Prabang, all the ivory traders selling recently made ivory products are Chinese, and most customers are Chinese tourists. Fewer than 5% of the almost 5,000 ivory products that Vigne and Martin (2017) surveyed were antiques, with the rest made recently. Boten, on the Chinese border, in Luang Namtha province had been a large illegal wildlife trade centre, with a casino catering to Chinese tourists and a special economic zone. In 2011 the casino was closed, but recently the special economic zone began to be re-vamped, with large scale forest clearing and development of, for example, the largest jade outlet in Lao PDR. Vigne and Martin (2017, p. 57) find it hard to imagine how the area will be kept free of crime, including trade in illegal and endangered wildlife. They warn that the illegal wildlife trade "could become even more widespread than before, if the activities of traders are not carefully monitored and laws are not enforced". This warning matches with the WWF report on the wildlife trade that is centred on the confluence of the Ruak and Mekong rivers (WWF 2017).

Similar to the trade in ivory, the trade of pangolin products in the Lao PDR largely focuses on Chinese customers, and sold through shops owned and operated by people of Chinese ethnicity (Gomez *et al.* 2016). Seizures of pangolins have involved shipments both into the Lao PDR from Thailand and out to Vietnam and China. Similar to the illegal trade in timber, the illegal wildlife trade in the Lao PDR flourishes because of factors including weak legislation, poor enforcement and endemic corruption. As with ivory, the Lao PDR is a recognised hub for the trade in pangolins. For example, because the four Asian species of pangolin (including the two species native to the Lao PDR) are declining in

number, the trade of pangolin products in the Lao PDR is being supplemented with African pangolins (Gomez *et al.* 2016). Poor enforcement and the Lao PDR as a trade hub are also observed in CITES (2016). For example, they noted that specimens of tigers and bears are "allegedly imported, exported and re-exported in violation of the Convention" to which the Lao PDR has been a signatory since 2004 (CITES 2016, p. 4). CITES (2016) further noted that Lao nationals are not big consumers of wildlife products, either because they haven't traditionally been consumers, or perhaps because of high prices. Overall, actors in wildlife conservation argue that there is a strong need for improved capacity in law enforcement to stem the illegal wildlife trade (CITES 2016, Gomez *et al.* 2016, Vigne and Martin 2017, WWF 2017, Krishnasamy *et al.* 2018).

9.6.5 Deforestation and forest degradation

Wildlife is hunted in forests, and a discussion that focuses on damage to forests is included here because increased shipping and associated development may: 1) Make it easier to conceal illegal timber products in large vessels and amidst legal commerce; and 2) Increase access to exploit local forests.

Illegal logging in Thailand is largely under control, and almost a quarter of Thailand's forest cover are planted forests, with half of this being rubber plantations managed by small holder farmers (EU FLEGT 2018). Thailand is, however, a manufacturing hub for timber products, and approximately one fifth of the timber that Thailand imports for manufacture of timber-based products is thought to be illegally sourced, with Laos being one of Thailand's major sources of timber (Chatham House 2018).

Despite the Lao government recognising the importance of environmental protection, logging, both legal and illegal, pose a threat to forest land in Laos as well as to the livelihoods of those who rely on forests to supplement their food supplies. For example, even though forest cover in Lao PDR grew as a percentage of land area between 2010 and 2015, including in northern Lao PDR, measurements of primary forest in the Lao PDR show a steady decline over the period 1990 – 2015 (Koch 2017). Some of the underlying factors that drive forest degradation and deforestation in Lao PDR are poverty, international demand for products such as timber, rubber, food and electricity, combined with factors including unclear legislation, lack of enforcement as well as corruption (Koch 2017). Timber extraction is linked closely to infrastructure development, particularly hydropower dam development, and to establishment of plantations including banana and rubber plantations (Koch 2017, see also Thomas 2015).

Examining timber import data from China and Vietnam (96% of Lao PDR wood exports in dollar terms go to Vietnam and China) shows that Lao exports of timber increased eight fold between 2009 and 2014. The Lao PDR does not have reliable information related to timber exports (both in terms of quotas and in terms of registered volumes of timber and timber products shipped): Official Lao PDR data is an order of magnitude less than what is registered as being imported into neighbouring countries, indicating that the majority of timber leaving Laos is logged illegally (Smirnov 2015). Linked to this, the share of unprocessed timber (i.e. logs) has been steadily increasing: in 2002 the dollar value of logs accounted for 14% of all timber exports and by 2014 it had risen to 56% (Smirnov 2015).

Increases in timber exports in Lao PDR typically follow on the heels of "Chinese and Vietnamese investments in mining, agriculture, forestry and hydropower" (Smirnov 2015, p. 1-2). It is also worth

noting that in many cases from 75-100% of the logging that has taken place in association with land concessions has been illegal in nature (e.g. outside the concession boundaries) (Smirnov 2015).

The rate of logging in the country is concerning because forested lands are very important to farm households, with the Agricultural Census Office (2012) reporting that 81% of farm households in Luang Prabang, for example, exploit public forest land for wood to burn as fuel, as well as collecting fruit, vegetables and mushrooms from public forest land. Koch (2017) reported that in addition to shifting cultivation, illegal logging is a major driver of forest degradation. Traditionally, shifting cultivation was conducted on a rotational basis with lands being left fallow for periods of 7 to 12 years. This allowed soil time to recover its productivity, and thus shifting cultivation was sustainable in the long-term. While a seven year fallow period is sustainable ecologically it does place limits on the amount of food that can be grown. The Lao government has been focussing on improving agricultural outputs, and is encouraging people to move away from shifting agriculture, including through legislating for shorter fallow periods (Cairns 2017). In addition to policy levers such as this, a combination of population growth and moves to market-focused commercial agriculture, have further incentivised a reduction in fallow periods, and agricultural lands are being expanded and are encroaching on forested areas (Koch 2017). Thomas (2015) noted that small scale shifting agriculture (i.e. less than 1 hectare) that encroaches on forests has a lesser impact on forests than larger scale agriculture. Despite the lesser impact of small scale farming, the loss of socio-cultural, ecological and economic functions associated with natural forests is already negatively impacting on the livelihoods of rural peoples of Lao PDR. This is because of declining productivity, declines in biodiversity and associated loss of environmental functions and services (Thomas 2015).

In line with reports on illegal logging, Thomas (2015) observed that in the period 2000 – 2012 there was not a single province that even for one year had a net forest cover gain. The average national deforestation rate in Lao PDR over this period was 0.71% per year. The four provinces of the study area for this report have all experienced a lower than average annual deforestation rate, as shown in Table 9.18.

Table 9.18: Annual forest change cover 2000 - 2012 for four Lao provinces

Province	Net annual average percentage change in forest area 2000 – 2012 (forest defined as minimum crown cover of 20%)
Bokeo	-0.67% p.a.
Oudomxay	-0.67% p.a.
Xayabury	-0.43% p.a.
Luang Prabang	-0.57% p.a.

Both logging and expansion of plantations are resulting in degradation to forests in Laos. There is a need to improve levels of enforcement to ensure that plantation owners do not log illegally outside their concession boundaries, as well as a need to improve enforcement of national legislation around logging and shipping of timber. For example, currently there is a significant mismatch between registered exports of timber and registered imports across international borders, particularly into China and Vietnam.

9.6.6 Land tenure

Many aspects of this livelihoods analysis have brought up concerns around ethnic minorities and others losing their customary access to their traditional lands. Thus, a brief section on land tenure and land titling in the Lao PDR is included here.

As a country with a predominantly rural population, the peoples of Laos have adapted their lives and cultures to their particular ecological contexts, resulting in what has been described by Chamberlain (2008, p. 19) as "subsistence affluence". With this term, Chamberlain argued that subsistence often has connotations of backwardness, but that for the villagers in places such as Laos and the Pacific islands their subsistence farming traditions have been carefully constructed to preserve quality of life. However, these traditions are threatened, as described in preceding sub-sections of this report. According to Ironside (2017), legal provisions for recognising customary title are weak as well as being poorly implemented, with these problems being exacerbated because communities are often unaware of their legal rights and lack of experience dealing with the government bureaucracy. He further argued that customary tenure management can play an important role in improving livelihoods and poverty reduction (Ironside 2017, p. iv).

In light of this, it is unsurprising that there has been an emphasis on securing land tenure through titling in Lao PDR. However despite this, land titling in Laos to date has focused on commercial and residential land in urban areas. The Lao government estimates that there are a total of around 2.6 million plots of land that need to be registered across the country. Of these 1.1 million have been successfully registered and titled, including just 100,000 in rural areas (Derbidge and Sisoulath 2018). Following a trial that began in 2015, GIZ is supporting a scale up of rural land titling, and expects that over the next three years (at a cost of US$7.5 million) to be able to complete land titling across three provinces: Luang Namtha, Houaphan and Xayabury (Derbidge and Sisoulath 2018).

9.7 CONCLUDING COMMENTS

Laos remains reliant on its agricultural sector, despite growth in the industry and services sectors in recent years. The Lao 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. The granting of land concessions for plantations, as well as for hydropower and mining, have been linked to illegal logging practices, which are a major problem across the country. Some reports suggest that 9 out of 10 logs are exported illegally. Another illegal activity of note is wildlife trafficking. Most wildlife trafficked in Laos is sourced internationally, although some pangolins and serow are probably captured in the country. Lao people are not big consumers of wildlife products, with most being sold to Chinese and Vietnamese tourists.

Fishing is not a full-time occupation for many people in the study area, but most households do fish during the year to access this critical source of protein and micronutrients in their diet. Most fish caught is for household consumption, and provides an important food security buffer, particularly for ethnic minority and other poor communities.

There are three main trends highlighted by this 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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