

NAM OU RIVER BASIN PROFILE

SUMMARY DOCUMENT

Environmental & Social Characteristics of a Key River Basin
in Lao PDR



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ACRONYMS & ABBREVIATIONS

ADB	Asian Development Bank
CIA	Cumulative Impact Assessment
COD	Chemical Oxygen Demand
DESIA	Department of Environmental and Social Impact Assessment
DO	Dissolved Oxygen
DONRE	District Natural Resources and Environment Offices
DWR	Department of Water Resources
ESIA	Environmental and Social Impact Assessment
ESL	Earth Systems Lao
FCZ	Fish Conservation Zone
FGD	Focus Group Discussions
FIPD	Forest Inventory and Planning Department
GIS	Geographic Information Systems
GOL	Government of Lao PDR
HKEC	Hydrochina Kunming Engineering Corporation
IBA	Important Bird Areas
IDOM	IDOM SA. Construction engineering company
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
IWRM	Integrated water resources management
KBA	Key Biodiversity Area
kW	Kilowatt
LECS	Lao Expenditure and Consumption Survey
Masl	Metres above sea level
MONRE	Ministry of Natural Resources and Environment
MRC	Mekong River Commission
Mt	Million tons
MW	Megawatt
NPA	National Protected Area
NTFP	Non-timber Forest Products
NUOL	National University of Laos
OAA	Other Aquatic Animals
PONRE	Provincial Natural Resources and Environment Offices
SI	Sinuosity Index
Total N	Total Nitrogen
Total P	Total Phosphorous
UNECE	United Nations Economic Commission for Europe
WWF	World Wide Fund for Nature

MESSAGE FROM THE DEPARTMENT OF WATER RESOURCES (DWR), MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MONRE)

The Nam Ou Basin Profile is a collective effort among various stakeholders at the central, provincial, district, and village levels. The Department of Water Resources (DWR) and the Provincial Offices of Natural Resources and Environment (PONRE) in Phongsaly, Oudomxay and Luang Prabang see the importance of properly managing this resource-rich river basin. We worked together with relevant stakeholders at all levels to study the physical, economic, and social characteristics of the Nam Ou Basin and its potential. We hope this Profile will be used as a reference and baseline data for the sustainable development of the Nam Ou Basin to protect its natural resources, support socio-economic development in the country, and improve the livelihoods of people living around the basin.

The DWR, a Secretariat of the Ministry of Natural Resources and Environment (MONRE) responsible for water resources management nationwide, PONRE, and the District Offices of Natural Resources and Environment (DONRE) in Phongsaly, Oudomxay, and Luang Prabang have agreed with the data, information, and approaches set out in this Profile. We expect that relevant stakeholders will use this Profile for the planning, management, and development of the Nam Ou Basin. The primary data of this Profile were collected through a field survey between January and February 2016, while the secondary data and information were collected from relevant sectors at all levels between 2013 and 2016.

We would like to sincerely thank the consultants and technical experts from different sectors at both the central and local levels for sharing their knowledge, data, information, time, and efforts in the preparation of this Profile. Special thanks to the International Finance Corporation for its technical assistance and support, and the Australian and Japanese governments for their financial assistance in its development.

Director General, Department of Water Resources
Phongsaly Head of PONRE, Oudomxay Head of PONRE, Luang Prabang Head of PONRE

ACKNOWLEDGMENTS

This Profile of the Nam Ou River Basin is the result of the collaborative effort of many people. The two principal authors of this Nam Ou River Basin Profile were the IFC consultants, Dr. Lilao Bouapao, who covered the socio-economic and water governance aspects and Mr. Peter-John Meynell, who covered the biophysical aspects. They were supported and guided by Mr. Thomas Boivin who was the first international consultant to IFC initiating the Profile development process in 2013, and who reviewed the document as it progressed, and who prepared the Synthesis document from this more detailed Profile.

The process of developing this Profile was guided by the Core Team with the lead of Mr. Chanthanet Bualapha, Director General, Mr. Phonesay Simmalavong, Deputy Director General, and Ms. Sengphasouk Xayavong, Project Coordinator, and the IFC staff Ms. Kate Lazarus and Ms. Amphavanh Sisouvanh.

There are many staff from the Provincial and Districts Offices of Natural Resources and Environment provided important contribution throughout the process of Profile development, including planning, primary and secondary data collection. These include Mr. Phonexay Leck (Phongsaly), Vixay Boualaxin (Oudomxay), and Doungvut Phonthajuck (Luangprabang). The full list of members of the team are provided at the end of the report.

There were five teams for the household and village surveys in each of the provinces and these included the government staff from DWR, PONRE, DONRE. Five independent enumerators contributed to the surveys and data entry, providing important inputs into the quality control and quality assurance.

Fisheries information was derived from original research carried out by Dr. Phouvin Phousavanh of the National University of Laos (NUOL), who developed the Guide to the Nam Ou Fish species and the Fish Poster used in discussions with villagers, during the field surveys. Geographic Information System (GIS) analysis and mapping was provided by Ms. Penroong Bamrungrach, Mr. Inthanongxay Haungbundit (DWR) and Mr. Philip Knight for the mapping of ecologically sensitive areas in the Nam Ou. We would also like to thank Pierre Dubeau for his assistance with preparation of this summary Profile.

Without the participation of local people of the sample villages, this Profile would not have been completed. 1,500 villagers responded in detail to the long questionnaires. Many villages chiefs, representatives of village mass organizations, fishers, farmers, traders and ordinary villagers participated in focus group discussions.

Funding for this Nam Ou River Basin Profile came from the Australian Government and the Japanese Government and the overall process was implemented and managed by IFC with the Department of Water Resources.

THE NAM OU HIGHLIGHTS

The Nam Ou Basin is located within the boundaries of 3 Provinces: Phongsaly, Oudomxay and Luang Prabang. However, not all areas of the 3 provinces fall within the hydrological boundaries of the Nam Ou Basin. There are 17 Districts within the Nam Ou basin, 7 in Phongsaly, 6 in Oudomxay and 4 in Luang Prabang. All districts in Phongsaly are in the Nam Ou Basin, as well as nearly all villages in the province. Phongsaly and Luang Prabang Provinces include the mainstream Nam Ou and territory within the 5km corridor of the river; only tributaries of the Nam Ou are in Oudomxay Province.

11

Major tributaries

Consists of

3

provinces of the Lao PDR:

Phongsaly, Oudomxay and Luang Prabang.

In 2015, the total population in these 3 provinces was 885,200.



5,554 ha

of water bodies

(total area estimated)

404,094

people (45.7%)

live within the basin boundaries

139



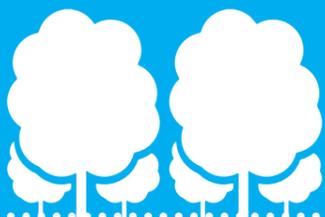
species of fish

Nam Ou basin



112,409 ha of agricultural land

over 39,000 cattle, 37,000 buffalo, and 121,000 pigs



14,596 km²

of combined natural forest lands

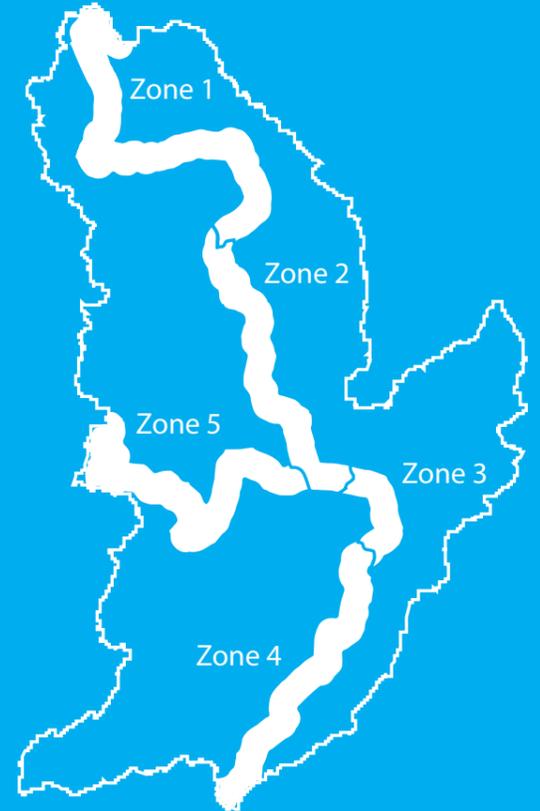




Field survey of

1,500 households in 75 villages

8 case study villages, selected along a 5-km corridor of the Nam Ou River in 5 Zones



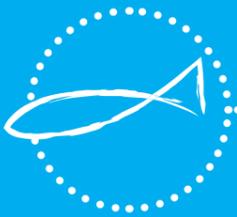
70%

of the sampled households are fishing in the Nam Ou or one of its tributaries in the previous 12 months before the survey.



90% in Zone 1

80% in Zones 2 and 3



> 5% of household heads are females



Just over half of the villages surveyed in Phongsaly (53.9%) had access to electricity. Although access is much higher in Oudomxay (74.0%) and Luang Prabang (71.0%), the electrification rate in these provinces is among the lowest in the country.



“ We need to know more about its [the Nam Ou’s] environment. We have a limited knowledge of the river’s characteristics at this point. ”

Phonexay Lek,
Head of Provincial Office for Natural Resources
and Environment in Phongsaly Province

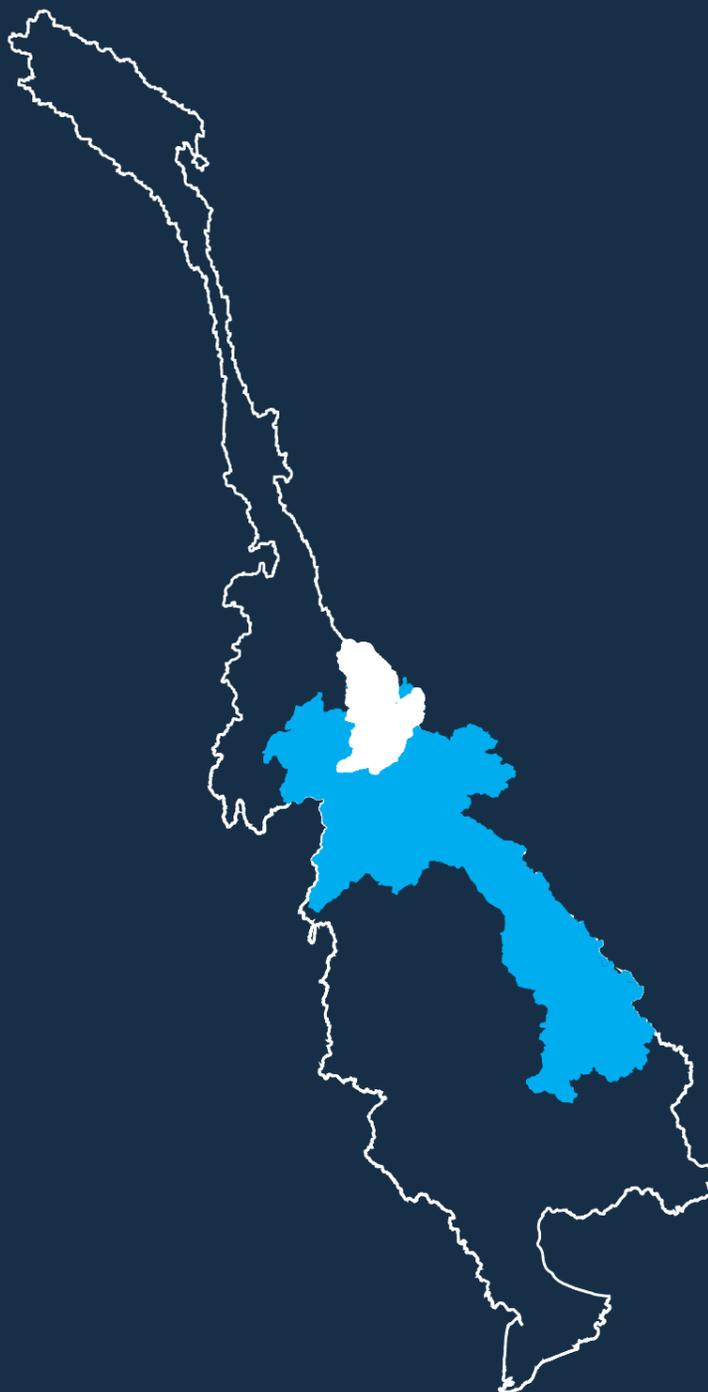
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THE NAM OU JOURNEY: AN INTRODUCTION

The main objective of the Nam Ou River Basin Profile is to compile and present available background information on the Nam Ou Basin, one of the most important river systems in Lao PDR. It aims to provide baseline data for monitoring changes and comparing past and future trends for the planning and management of: (i) water resources allocation, (ii) hydropower development, (iii) community livelihoods, and (iv) emergency responses. The Profile was developed in collaboration with Government of Lao PDR water resource managers at the national, provincial and district levels.

This compilation of data and information will further our understanding of the Nam Ou in relation to the Mekong River and the knowledge gained may be applied to other river basins and sectors in Lao PDR. Water basin managers around the country can use this Profile as a tool for developing a management plan for the Nam Ou Basin in the future.

In addition to providing a comprehensive Profile of the Nam Ou River Basin, this document also includes conclusions and recommendations for further action. The full version of the Profile, including all data and information collected and analyzed, case studies, and the Nam Ou fish poster, may be obtained from IFC's website: ifc.org/hydroadvisory.



The Nam Ou is one of the most important and significant tributaries of the Lower Mekong Basin. Lying in the far north of Lao PDR with its source near the Lao-Chinese border (Figure 1), the Nam Ou is 485 km¹ long and flows from north to south through three provinces – Phongsaly, Oudomxay, and Luang Prabang. It meets the Mekong River about 25 km upstream from Luang Prabang city.

The Nam Ou has the largest catchment area in Lao PDR, which includes nearly 26,000 km² of mountainous terrains and uplands, flowing through a mostly rocky channel in a relatively narrow river valley. There are 11 major tributaries that enter the Nam Ou along its length, the largest of which are the Nam Phak, the Nam Bak, and the Nam Nga; one of the tributaries, the Nam Noua, arises in Vietnam near the town of Dien Bien Phu. Thus, the Nam Ou is a transboundary river of both national and international importance. Its flow contribution to the Mekong has been estimated at 610 m³/sec, making it the third most important tributary of the Mekong in Lao PDR.

Over 500,000 people live in the Nam Ou Basin, the third-largest in Lao PDR after the Xebang Hieng and Nam Ngum basins. The river has been home to a number of cultures for several centuries, including the Khmu, Akha, Songsiri, Hmong, Lue, and Lao ethnic groups. Local people rely on the Nam Ou for their livelihoods, including water supply, agriculture, fisheries, and navigation.



¹ The Nam Ou River's length based on GIS measurements from the source, carried out by this Profile.

Box 1

What is a River Basin Profile?

A River Basin Profile provides baseline information on the physical, biological, social, and cultural aspects of a river basin; such information can be used for the future management and conservation of natural resources within the basin. For the Nam Ou, its Profile includes a compilation of available information on the river supplemented with primary data collected through field and household surveys as well as case studies conducted between January and February 2016. The Profile provides analysis of environmental and social trends in the Nam Ou over time and recommendations on how to address management challenges from ongoing and planned hydropower, irrigation, and other water-resource developments.

The purpose of developing the Nam Ou River Basin Profile is to:

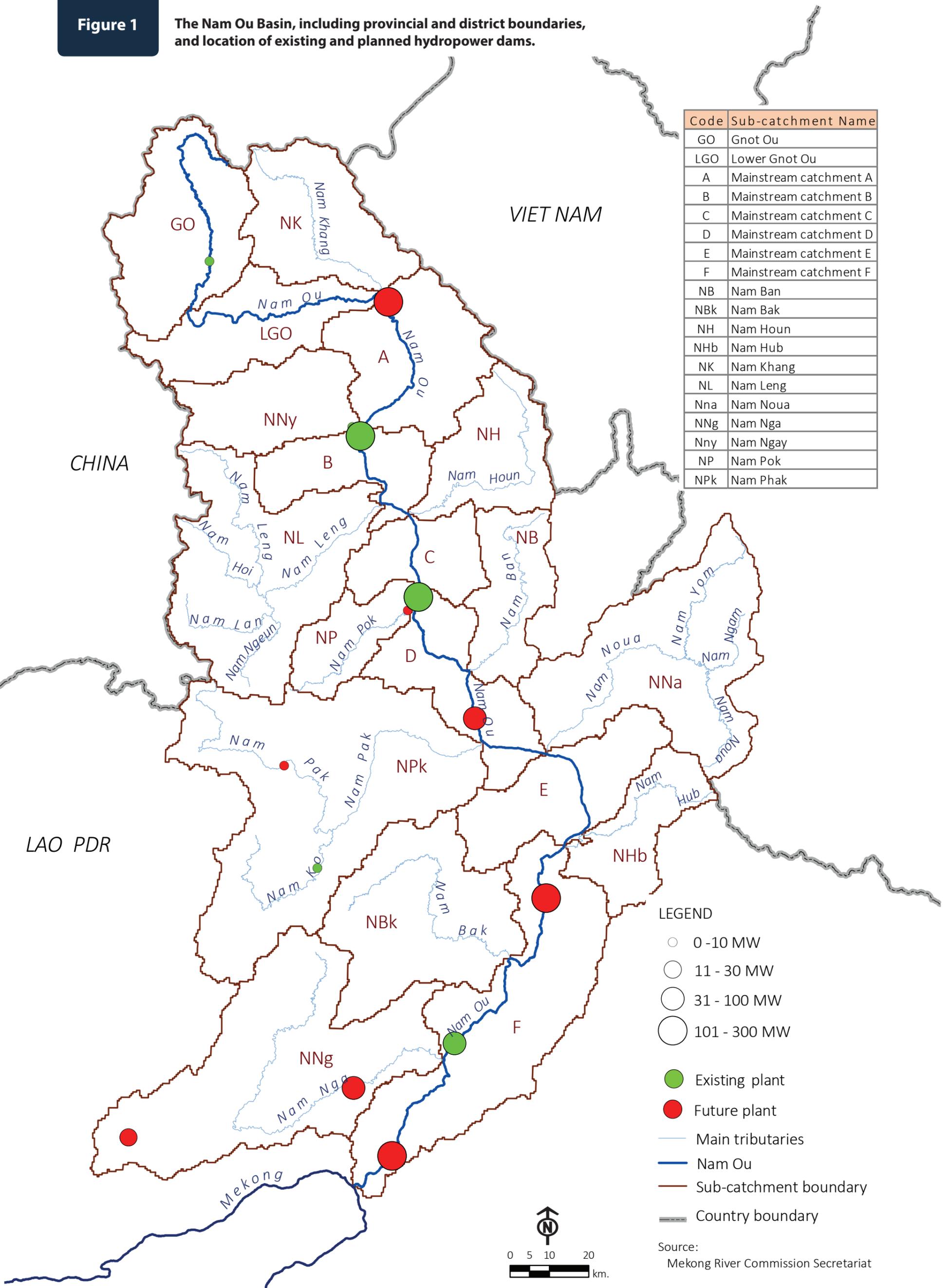
- ✓ Provide a greater understanding of the characteristics of the whole basin, including sub-basins.
- ✓ Provide documentation for river-basin planners.
- ✓ Enable the Government of Lao PDR, the private sector, local authorities, and communities to better manage the river and its resources for future generations.

The hydropower potential of the river is being developed. Out of a cascade of seven large hydropower projects, three became operational during 2016 and the remaining four will be completed by 2020. The projects will have a combined reservoir length of 350 km and an installed capacity of 1,272 megawatts (MW). The Nam Ou hydropower cascade and other planned developments will result in significant changes to the natural state of the river, which will impact the livelihoods and cultures of people in the basin. The Nam Ou River Basin Profile is a timely effort to document the current status of the river and provide the required baseline information for future river basin planning and management.



Figure 1

The Nam Ou Basin, including provincial and district boundaries, and location of existing and planned hydropower dams.

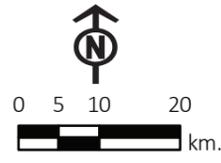


Code	Sub-catchment Name
GO	Gnot Ou
LGO	Lower Gnot Ou
A	Mainstream catchment A
B	Mainstream catchment B
C	Mainstream catchment C
D	Mainstream catchment D
E	Mainstream catchment E
F	Mainstream catchment F
NB	Nam Ban
NBk	Nam Bak
NH	Nam Houn
NHb	Nam Houb
NK	Nam Khang
NL	Nam Leng
Nna	Nam Noua
NNg	Nam Nga
Nny	Nam Ngay
NP	Nam Pok
NPk	Nam Phak

LEGEND

- 0 - 10 MW
- 11 - 30 MW
- 31 - 100 MW
- 101 - 300 MW

- Existing plant
- Future plant
- Main tributaries
- Nam Ou
- Sub-catchment boundary
- Country boundary



Source: Mekong River Commission Secretariat

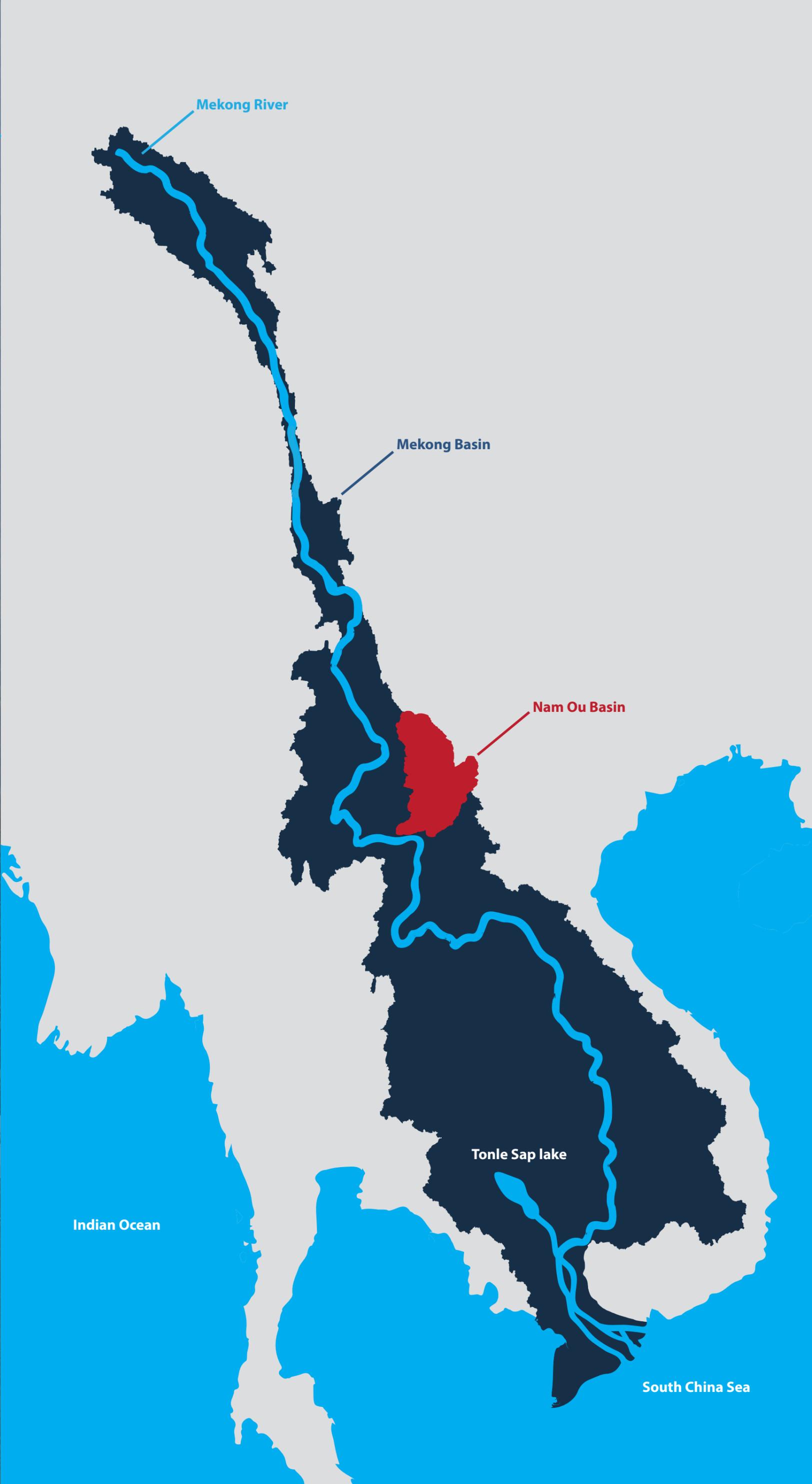
Box 2

Significance of the Nam Ou in the Mekong

In 2009, the Mekong River Commission (MRC) initiated a series of studies to consider the significance of the tributaries of the Mekong. The findings confirmed the importance of the Nam Ou based on the following criteria:

- **Catchment size and transboundary nature** – The Nam Ou, with a total area of nearly 26,000 km², is the 10th largest river basin in the Lower Mekong. Approximately 95% of the river basin lies in Lao PDR and the remaining 5% is in Vietnam on the Nam Noua, a tributary of the Nam Ou. The source of the Nam Ou arises in Lao PDR very close to the Chinese border.
- **Geology** – The Nam Ou has the fifth-highest proportion of limestone among Mekong tributaries, after the Nam Suong, the Nam Khan, the Nam Kading, and the Se Bang Fai. It also has a very high density of cave formations.
- **Flows** – Its mean annual flow ranks seventh among Mekong tributaries, contributing about 3.5% of the Mekong's total flow, including 3.5% during the wet season and 2.5% during the dry season.
- **Sediment load** – The Nam Ou contributes about 4.8% of sediments in all the catchments of the Lower Mekong Basin, second in Lao only after the Nam Ngum.
- **Aquatic health** – According to the MRC's aquatic health index, the Nam Ou is in the top 80th percentile in terms of overall river health, second only to the Nam Khan and above the Nam Ngum.
- **Aquatic ecology** – The Nam Ou ranks eighth in terms of protected areas with more than 7% its catchment within the Phou Den Din and Phou Hippi National Protected Areas (NPA). It is a recognized biodiversity hotspot with a variety of endemic and threatened fish species and serves as an important migration corridor providing key fish spawning, nursery, and feeding grounds.
- **Hydropower potential** – Its hydropower potential, in terms of gigawatt hours produced per year, ranks fourth among the Mekong tributaries, after the Sekong, the Nam Kading, and the Nam Ngum. It represents 7.8% of the potential installed capacity of the Mekong tributaries.
- **Fisheries yield** – The Nam Ou places 13th in terms of fisheries and other aquatic organisms (OAA) yield per year. However, this may be the result of a lack of accurate fish harvest data and relatively lower numbers of people in the basin compared to other major river systems in Lao PDR; expected fish and OAA yields are likely much higher than currently reported.
- **Land use** – The Nam Ou ranks fourth in terms of natural land cover, after the Sekong, the Tonle Sap, and the Nam Mun. Its percentage of agricultural land is 14th among all the Mekong tributaries.
- **Navigation** – The Nam Ou ranks second in terms of navigation importance, after only the Sekong. Local residents can transport up to 2,000 kg per boat in the wet season and 500 kg per boat in the dry season.

Sources: MRC (2007), MRC (2009), Meynell (2012).





“ Five kilometers from the river does not sound remote, but in some cases it was very challenging for our team to access target villages. Getting the information needed to understand these communities’ water resource needs means walking up to three days in mountainous terrain. ”

Sitthasone Luanglath,
lead Nam Ou Profile surveyor

ການສ້າງເອກະສານສະພາບລວມອ່າງຮັບນ້ຳອູ
Nam Ou River Basin Profile



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METHODOLOGY FOR DEVELOPMENT OF THE NAM OU RIVER BASIN PROFILE



The Profile was developed in 6 steps:

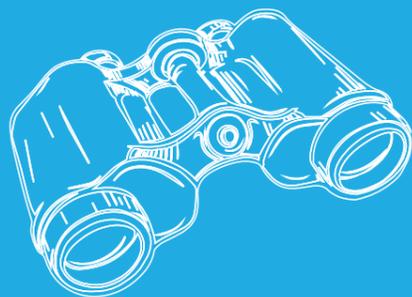
1



Establishing the team comprising representatives from the national, provincial, and district water resource management agencies as well as IFC and its consultants.

while meter readings for pH, temperature (°C), dissolved oxygen (DO; mg/L), and electrical conductivity (µS/cm) were taken at the habitat survey sites. Benthic macroinvertebrates were collected and analyzed based on the South African miniSASS system (<http://www.groundtruth.co.za/river-health-and-water-quality.html>); the sensitivity of different taxonomic groups – ranging from the least sensitive such as the Diptera, worms, and leeches to the most-sensitive mayflies, caddisflies, and the stoneflies – was used to determine overall general health of the river.

2



Background (desktop) research and review of available literature from relevant agencies and organizations at both the central and local levels.

This Profile was developed based on information presented in the Environmental and Social Impact Assessments (ESIA) and Cumulative Impact Assessment (CIA) that Earth Systems Lao (ESL) carried out for the seven hydropower projects in 2010 on behalf of Sinohydro Corporation (HKEC 2009, ESL 2011). It has also drawn on a number of publications prepared by the MRC, including MRC (2015), MRC (2009), and MRC (2007). Additional data were obtained from the Government of Laos National Statistics Bureau under the Ministry of Planning and Investment, including the Lao Expenditure and Consumption Survey 4 and 5 (LECS4, 5), Lao Population Census (2015), Agricultural Census (2011), Statistical Year Book (2014), and other sources.

4



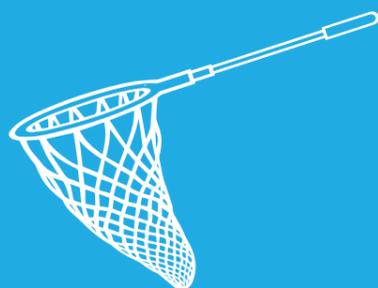
Field survey of 1,500 households in 75 villages along a five-kilometer corridor of the Nam Ou in five zones, and detailed case studies of eight villages.

5



Data analysis and reporting, including review and interpretation of the field data collected to determine trends in aquatic resource use over time, and writing the Profile document.

3



Designing tools for primary data collection, including: developing questionnaires, household surveys, and habitat surveys; water-quality analysis; collection of benthic invertebrates; and, GIS/mapping.

The Nam Ou was mapped using GIS techniques and Google Earth imagery to identify the key geomorphological features of the basin, according to the method developed by Baran (2014) and Meynell (2014) for the Sesan and Sekong Rivers. Livelihood dependence on water resources was mapped within a 5-, 10- and 15-km distance from the river. Key features such as river length, width, depth, habitat types, and vegetation were mapped and verified in rapid-river surveys and habitat surveys during the field program and case studies. Water samples were collected at eight water monitoring sites on the Nam Ou established by PONRE and DWR,

6



Review and approval of the Profile by key Government of Lao PDR (GoL) stakeholders at the national, provincial and local levels through consultation workshops, discussions, and meetings. Capacity building for GoL staff was an integral part of the Profile development process. IFC provided on-the-job training to the central, provincial, and district water resources departments on how to collect and analyze data and information for river basin Profile development. IFC also produced a video to describe the methodology used in developing the Profile: <https://www.youtube.com/watch?v=sg7-jjN-GVs&feature=youtu.be>

Household surveys and case studies were conducted between December 2015 and February 2016. A total of 1,500 households were randomly selected from 75 sample villages within 5 km of the Nam Ou and the Nam Phak (15 villages per zone, 20 households per village for a total of 300 households per zone). Focus group discussions (FGD) with village heads and key local representatives were held in eight villages as case studies to obtain general information on communities, livelihoods, and trends in resource use. Social issues examined included: history of change in livelihoods in the village; livelihood dependency on water resources, including fisheries and OAA; water sources for agriculture and domestic uses; resilience (livelihood options); and local extreme events (floods and drought).

Staff members from the DWR, three provincial PONREs, and 17 district DONREs participated in all field activities and stakeholder consultations. These organizations played key roles in the preparation of the Profile, including training, data collection, data entry, data review, analysis, and report writing.

Box 3

The Nam Ou Fish Poster

Dr. Phouvin Phousavanh from the NUOL compiled an illustrated book and poster to introduce fishes of the Nam Ou as a supporting document to the Profile. This book and poster was based on a series of fisheries surveys he conducted on the Nam Ou between 2007 and 2011.

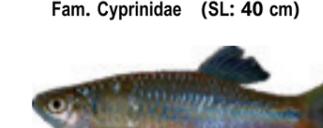
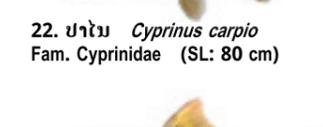
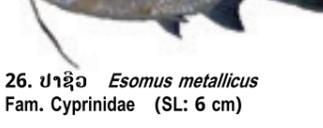
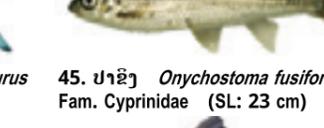
A total of 139 species found in the Nam Ou and its tributaries were identified and photographed. An analysis of all 139 species recorded in the Nam Ou and represented in the Fish Poster shows that they fall into nine orders and 24 families. Thirty-five of these species are endemic to the Mekong basin, 86 are native, and five are exotic or introduced species.

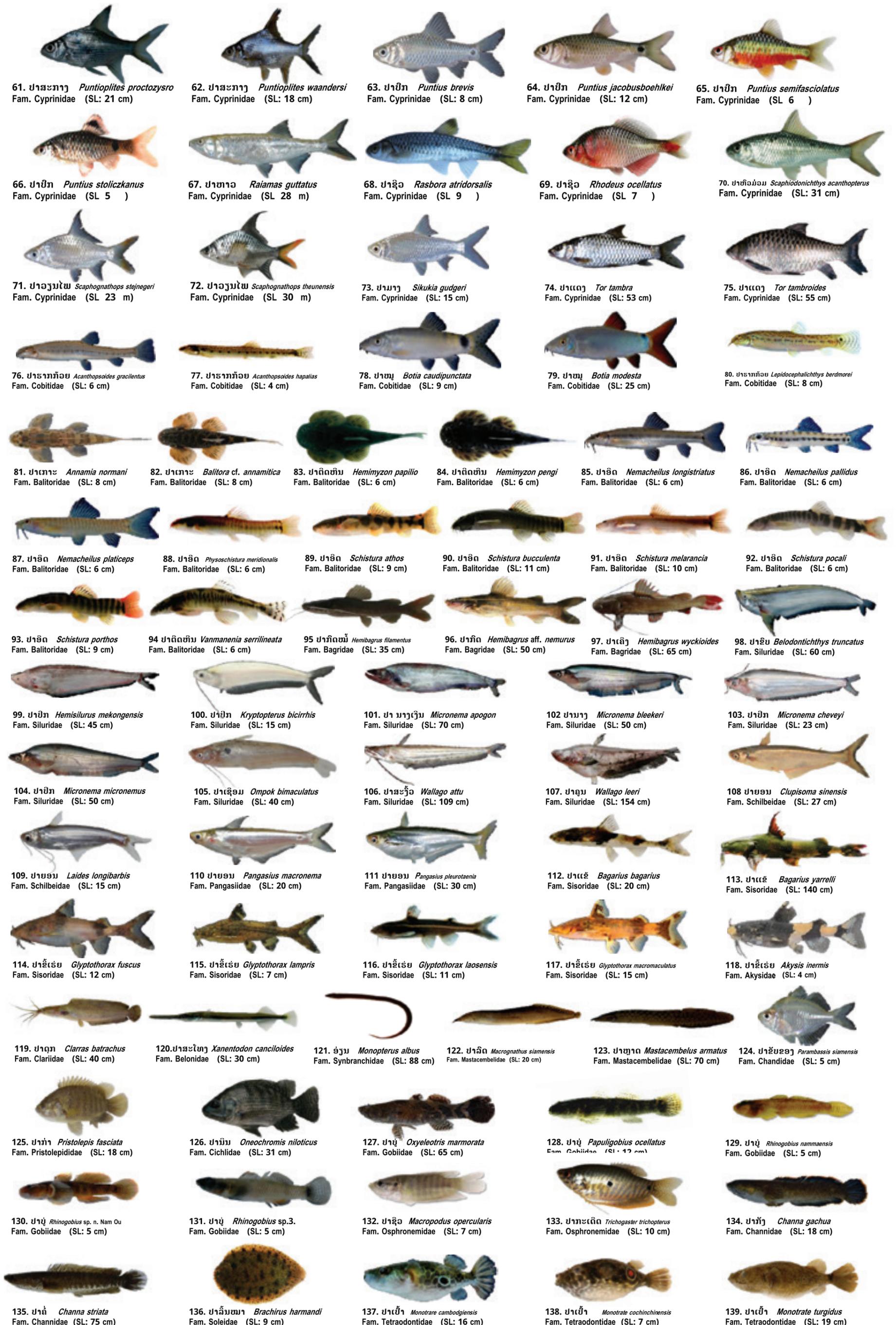
Five species (6% of the known fish fauna of the drainage) are known from no other drainage and are possibly endemic to the Nam Ou river basin. The highest numbers of endemic species were reported in the upper reaches (Ban Nagnao, Ban Pakban, and Ban Bouamsom [Nam Phak]), and fewer species were found in the downstream reaches such as Ban Paknga and Ban Pak Ou.

The team showed the poster to villagers in the case studies to help them identify fish species from their part of the river and the types that were most commonly captured. The poster was also used in discussions about fisheries resources and other issues with local communities.



NAM OU FISH

- | | | | | |
|---|--|---|---|--|
| 
1. បារតា <i>Notopterus notopterus</i>
Fam. Notopteridae (SL: 60 cm) | 
2. បារតា <i>Chitala blanci</i>
Fam. Notopteridae (SL: 60 cm) | 
3. បារតា <i>Chitara lopis</i>
Fam. Notopteridae (SL: 100 cm) | 
4. បារតា <i>Chitara ornata</i>
Fam. Notopteridae (SL: 100 cm) | 
5. បារតា <i>Clupeichthys aesamensis</i>
Fam. Clupeidae (SL: 5 cm) |
| 
6. បារតា <i>Sundasalanx mekongensis</i>
Fam. Sundasalangidae (SL: 3 cm) | 
7. បារតា <i>Acheilognathus deignani</i>
Fam. Cyprinidae (SL: 6 cm) | 
8. បារតា <i>Bangana behri</i>
Fam. Cyprinidae (SL: 45 cm) | 
9. បារតា <i>Bangana lippus</i>
Fam. Cyprinidae (SL: 25 cm) | 
10. បារតា <i>Barbonymus gonionotus</i>
Fam. Cyprinidae (SL: 30 cm) |
| 
11. បារតា <i>Barbonymus schwanefeldii</i>
Fam. Cyprinidae (SL: 34 cm) | 
12. បារតា <i>Cirrhinus cirrhosus</i>
Fam. Cyprinidae (SL: 100 cm) | 
13. បារតា <i>Cirrhinus molitorella</i>
Fam. Cyprinidae (SL: 44 cm) | 
14. បារតា <i>Cosmochilus harmandi</i>
Fam. Cyprinidae (SL: 60 cm) | 
15. បារតា <i>Crossocheilus reticulatus</i>
Fam. Cyprinidae (SL: 11 cm) |
| 
16. បារតា <i>Cyclocheilichthys apogon</i>
Fam. Cyprinidae (SL: 16 cm) | 
17. បារតា <i>Cyclocheilichthys armatus</i>
Fam. Cyprinidae (SL: 18 cm) | 
18. បារតា <i>Cyclocheilichthys enoplos</i>
Fam. Cyprinidae (SL: 55 cm) | 
19. បារតា <i>Cyclocheilichthys furcatus</i>
Fam. Cyprinidae (SL: 40 cm) | 
20. បារតា <i>Cyclocheilichthys heteronema</i>
Fam. Cyprinidae (SL: 9 cm) |
| 
21. បារតា <i>Cyclocheilichthys repasson</i>
Fam. Cyprinidae (SL: 23 cm) | 
22. បារតា <i>Cyprinus carpio</i>
Fam. Cyprinidae (SL: 80 cm) | 
23. បារតា <i>Cyprinus rubrofuscus</i>
Fam. Cyprinidae (SL: 28 cm) | 
24. បារតា <i>Danio laoensis</i>
Fam. Cyprinidae (SL: 6 cm) | 
25. បារតា <i>Danio roseus</i>
Fam. Cyprinidae (SL: 4 cm) |
| 
26. បារតា <i>Esomus metallicus</i>
Fam. Cyprinidae (SL: 6 cm) | 
27. បារតា <i>Garra cambodgiensis</i>
Fam. Cyprinidae (SL: 10 cm) | 
28. បារតា <i>Garra cyclostomata</i>
Fam. Cyprinidae (SL: 15 cm) | 
29. បារតា <i>Hampala macrolepidota</i>
Fam. Cyprinidae (SL: 60 cm) | 
30. បារតា <i>Hemibarbus maculatus</i>
Fam. Cyprinidae (SL: 34 cm) |
| 
31. បារតា <i>Hypsibarbus lagleri</i>
Fam. Cyprinidae (SL: 35 cm) | 
32. បារតា <i>Hypsibarbus malcolmi</i>
Fam. Cyprinidae (SL: 41 cm) | 
33. បារតា <i>Hypsibarbus pierrei</i>
Fam. Cyprinidae (SL: 25 cm) | 
34. បារតា <i>Hypsibarbus vernayi</i>
Fam. Cyprinidae (SL: 22 cm) | 
35. បារតា <i>Hypsibarbus wetmorei</i>
Fam. Cyprinidae (SL: 20 cm) |
| 
36. បារតា <i>Labeo chrysopekadion</i>
Fam. Cyprinidae (SL: 60 cm) | 
37. បារតា <i>Luciocyprinus striolatus</i>
Fam. Cyprinidae (SL: 150 cm) | 
38. បារតា <i>Mekongina erythrospila</i>
Fam. Cyprinidae (SL: 30 cm) | 
39. បារតា <i>Metzia bounthobi</i>
Fam. Cyprinidae (SL: 7 cm) | 
40. បារតា <i>Mystacoleucus atridorsalis</i>
Fam. Cyprinidae (SL: 7 cm) |
| 
41. បារតា <i>Mystacoleucus cf. marginatus</i>
Fam. Cyprinidae (SL: 15 cm) | 
42. បារតា <i>Mystacoleucus ectypus</i>
Fam. Cyprinidae (SL: 8 cm) | 
43. បារតា <i>Mystacoleucus greenwayi</i>
Fam. Cyprinidae (SL: 8 cm) | 
44. បារតា <i>Mystacoleucus lepturus</i>
Fam. Cyprinidae (SL: 9 cm) | 
45. បារតា <i>Onychostoma fusiforme</i>
Fam. Cyprinidae (SL: 23 cm) |
| 
46. បារតា <i>Onychostoma gerlachi</i>
Fam. Cyprinidae (SL: 27 cm) | 
47. បារតា <i>Onychostoma meridionale</i>
Fam. Cyprinidae (SL: 20 cm) | 
48. បារតា <i>Opsarius koratensis</i>
Fam. Cyprinidae (SL: 8 cm) | 
49. បារតា <i>Opsarius pulchellus</i>
Fam. Cyprinidae (SL: 11 cm) | 
50. បារតា <i>Osteochilus lini</i>
Fam. Cyprinidae (SL: 14 cm) |
| 
51. បារតា <i>Paralaubuca barroni</i>
Fam. Cyprinidae (SL: 18 cm) | 
52. បារតា <i>Poropuntius angustus</i>
Fam. Cyprinidae (SL: 12 cm) | 
53. បារតា <i>Poropuntius carinatus</i>
Fam. Cyprinidae (SL: 23 cm) | 
54. បារតា <i>Poropuntius laoensis</i>
Fam. Cyprinidae (SL: 21 cm) | 
55. បារតា <i>Poropuntius normani</i>
Fam. Cyprinidae (SL: 13 cm) |
| 
56. បារតា <i>Probarbus jullieni</i>
Fam. Cyprinidae (SL: 100 cm) | 
57. បារតា <i>Probarbus labeamajor</i>
Fam. Cyprinidae (SL: 120 cm) | 
58. បារតា <i>Pseudohemiculter dispar</i>
Fam. Cyprinidae (SL: 22 cm) | 
59. បារតា <i>Pseudorasbora parva</i>
Fam. Cyprinidae (SL: 8 cm) | 
60. បារតា <i>Puntioplites falcifer</i>
Fam. Cyprinidae (SL: 30 cm) |



Box 4

Case Studies & Zones in the Nam Ou Basin

To understand the dynamics of the river and its use, the Nam Ou Basin is divided into four key mainstream zones and one large tributary zone to represent the different geographic and biophysical features of the river and to better manage the case studies. These five zones are described below:

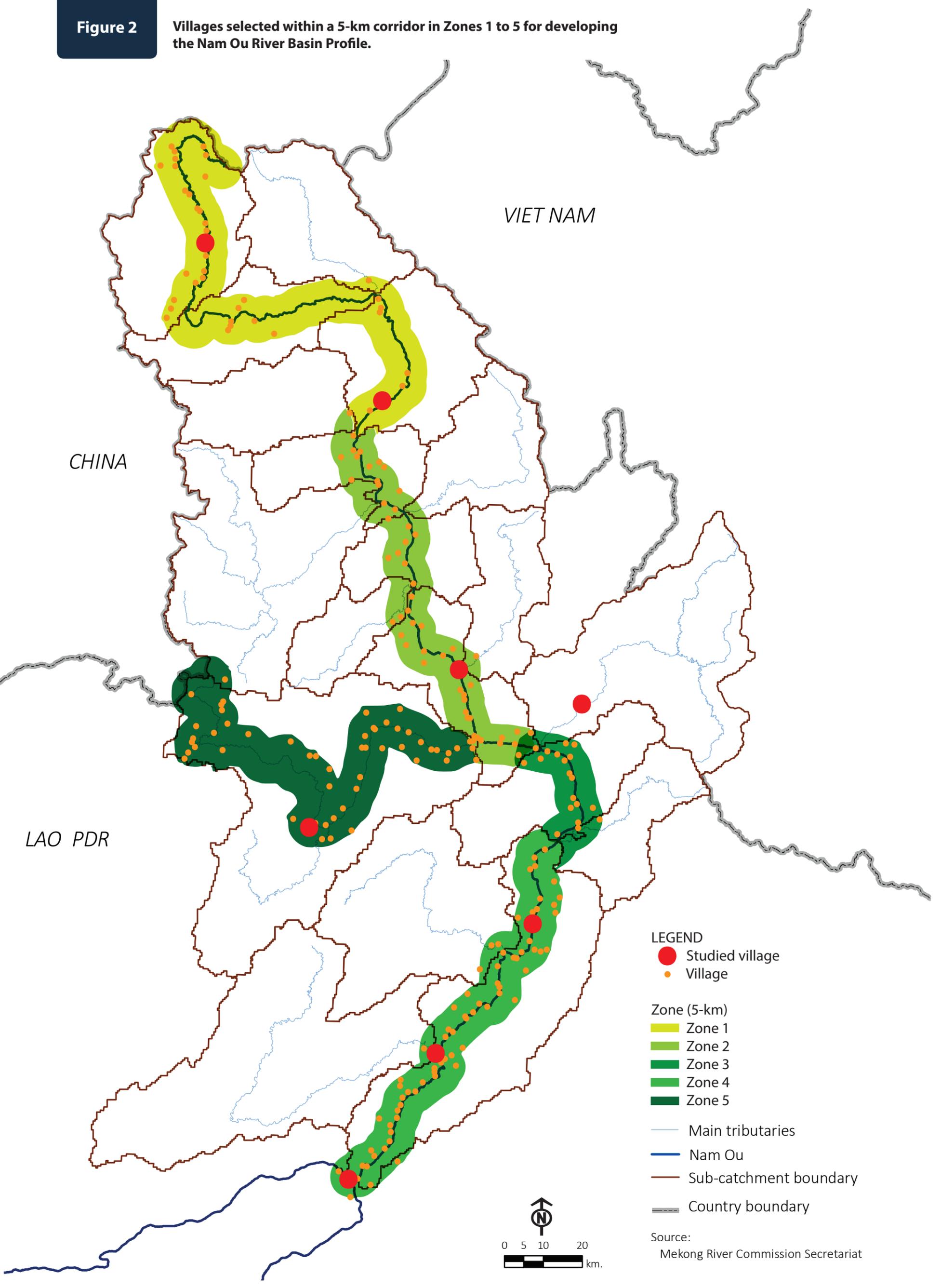
- **Zone 1:** Headwaters and upland river from the source to the confluence with the Nam Ngay, with a protected area covering the eastern tributary, the Nam Khang.
- **Zone 2:** Medium-sized, fast-flowing upland river, geologically-coherent sandstone, ecologically similar, from the confluence of the Nam Ngay to Muang Khoa, the confluence with the Nam Phak.
- **Zone 3:** Large, fast-flowing river with transition from sandstone to limestone, including the area from Muang Khoa (the Nam Phak) to the Nam Bak (Nong Khiaw); includes the tributary from Vietnam (the Nam Noua).
- **Zone 4:** Large, low-lying river flowing through mainly limestone karst landscape, from the Nam Bak confluence (Nong Khiaw) to the Pak Ou confluence with the Mekong.
- **Zone 5:** The Nam Phak, the largest tributary flowing through Oudomxay to Muang Khoa.

The field visits conducted in January and February 2016 aimed to familiarize the core team with the hydrological, environmental, and social conditions along the entire length of the Nam Ou and its main tributaries. The visits also helped validate the statistical and geographic information to be used in developing the Profile. The eight villages selected for case studies, along with their corresponding zones, were as follows (see also Figure 2):

- **Zone 1:** Ban Nagnao and Ban Phoumouang (now Ban Homsang).
- **Zone 2:** Ban Pakban and Ban Bouamsom (the Nam Phak, also in Zone 5).
- **Zone 3:** Ban Sobnao (the Nam Noua) and Ban Sopkong.
- **Zone 4:** Ban Paknga (the Nam Nga) and Ban Pak Ou.

Figure 2

Villages selected within a 5-km corridor in Zones 1 to 5 for developing the Nam Ou River Basin Profile.





“ This is all new information for us, a real learning experience. Local knowledge is key to understanding people’s relationship to and reliance on water resources. We are learning that in northern Lao PDR most people are still very reliant on the Nam Ou River and its tributaries for food security and livelihoods. ”

Lilao Bouapao,
IFC’s consultant on social development

3.0

RIVER BASIN CHARACTERISTICS (BASELINE DATA)



Physical characteristics

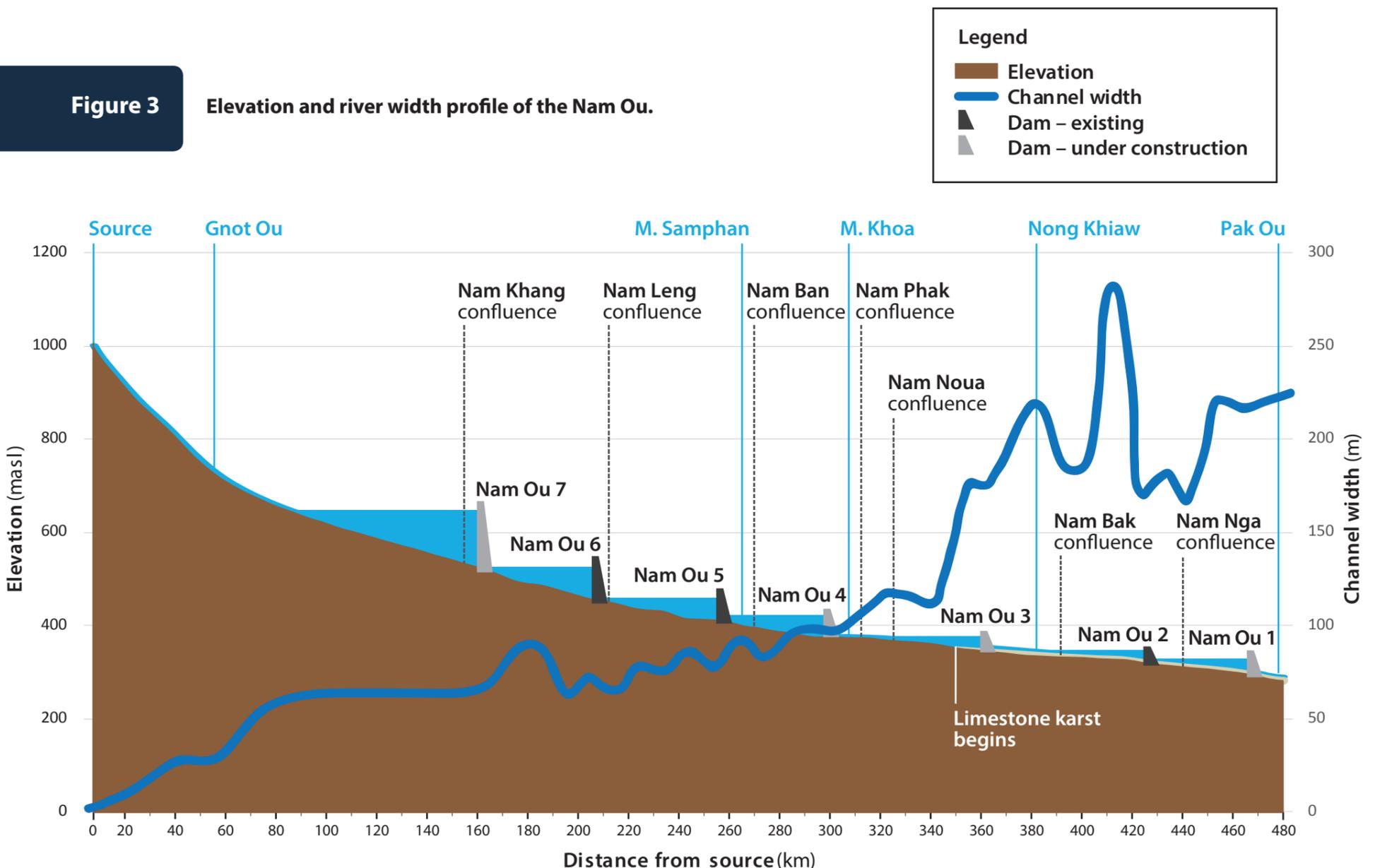
The Nam Ou Basin lies in three provinces of Lao PDR: Phongsaly, Oudomxay, and Luang Prabang. The basin is characterized by rugged, hilly, and sometimes mountainous terrain with steep-sided river valleys and fast-flowing rivers over rocky river bed and banks. In a classification of the watersheds of the Mekong, the MRC estimated the slopes and watershed classes of the Nam Ou as follows: 10% of the basin is very steep (>60% slope), 48.5% is steep (30-60% slope), and 24.3% is medium steep (15-30%). Only 2.2% of the basin is flat (0-2% slope) (MRC 2001).

The Nam Ou rises in the mountains of northern Lao PDR in Phongsaly Province, just south of the border with China. An elevation Profile of the Nam Ou shows that it rises at over 1,007 m above sea level (masl) and meets the Mekong at 290 masl, after a distance downstream of 485 km (Figure 3). During the early courses of the Nam Ou, it widens from a fast-flowing mountain stream with a rocky bottom about 2 m wide, to a recognizable river over 10 m wide within a few kilometers. The surrounding hill slopes are forested or have been cleared for cultivation of tea and banana plantations in some areas. A further 20 km downstream in one of these steeper stretches, a mini-hydropower plant has recently been constructed – the Nam Ou 9. This is a run-of-river plant that diverts water from a small headpond through about 700 m of headrace channel to the powerhouse; it has an installed capacity of 450 kW.

The river falls consistently from 527 masl at the Nam Khang confluence to 279 masl at Pak Ou. This is equivalent to a fall of 0.75 m per kilometer of the river. Changes in the river width shows a trend of widening with passage downstream from the confluence with the Nam Khang. The sites of the hydropower plants have been built near some of the narrowest points in the river.

The Nam Ou is characterized by its rapids interspersed with deep pools, which are present for more than a third of its total length. The sinuosity of a river (SI) is a measure of the extent to which the channel bends and turns. Alluvial rivers tend to be more sinuous than upland rivers, though this depends on the underlying geological formations. This highlights the fact that the Nam Ou is generally a very straight river (where the SI is between 1 and 2); there is at least one tributary entering on each side per 10 km for most of the length of the river, except between km 140-160, and at km 270. A few of the 10-km stretches have several streams and tributaries entering on both banks.

Figure 3 Elevation and river width profile of the Nam Ou.



Source: Google Earth survey for Nam Ou profile and Sinohydro.

The density of villages along the river increases in the lower end between km 120 and Pak Ou, and many of these lie on the right bank (see Figure 1). This distribution of villages is clearly influenced by the presence of the road along Road No 13 from Luang Prabang, with many villages on the right bank up as far as km 50, which is where the road diverts to follow the Nam Nga to Oudomxay. There are also large numbers of villages in Pak Bak and Nong Khiaw to Meung Ngoy (km 90 to km 120). The number of villages decreases upstream, but usually there is at least one village on both sides within each 10-km stretch. The larger number of villages around Meuang Khoa (km 180) and Meuang Samphan (km 220) also stand out.

River-bank gardens can be observed on Google Earth and it is evident that these tend to be associated with the villages, especially along the lower reaches of the river between Pak Ou and Meuang Ngoy. Above this there appear to be fewer river-bank gardens that can be seen on the imagery. This may reflect the steeper rocky banks, which are less favourable for cultivation.

The main soil types are Acrisols with four sub-types present (Ferric, Gleyic, Haplic, and Humic), making up 82.8% of the basin's area. Haplic acrisols are the predominant type. They tend to be acidic with a low-base status (<50% base saturation) and strongly leached. Most soils in the Nam Ou Basin are relatively infertile and, unless well-managed, liable to degradation; as a result, crop yields tend to be low.

Box 5

Karst & Caves in the Nam Ou Basin

There are five recognized karst areas with documented caves within the Nam Ou Basin. These are at Oudomxay, Nong Khiaw, Meuang Ngoi Neua, Nam Bak, and Pak Ou. There is no record of karst or caves in Phongsaly. The Nam Ou cuts through impressive karst peaks and massifs, at one point via a very deep limestone gorge. Caves occur both close to present river level and at 50-100 m above it. At the Nam Ngoy-Nam Ou confluence, the limestone mountains in the Meuang Ngoy Neua area are cut by a spectacular gorge with vertical rock walls up to 600 m high, where the village of Ngoy Neua is situated.

The Pak Ou Caves are located on the Mekong near the confluence of the Nam Ou with the Mekong, about 25 km upstream from Luang Prabang. Two of the caves contain large numbers of Buddha images and are an important tourism site.

Source: (Kiernan 2009)

The following are the Nam Ou's baseline sediment transport characteristics as described by HydroChina Kunming Engineering Corporation (HKEC) (ESL 2011):

- Sediment concentrations in the Nam Ou are low in the dry season but are relatively high during floods (mainly in the wet season).
- The average annual sediment flux at Meuang Ngoy is estimated at 233 tonnes/km² per annum, more than doubling the rate of 113 tonnes/km² per annum reported by the Water Quality Monitoring Network (1997).
- Meuang Ngoy's average annual sediment flux corresponds to a sediment flux of 142.4 kg/s and an average annual sediment concentration of 0.346 kg/m³. These figures represent suspended sediment loads.

At the average annual flow rate of 100-600 m³/s in the Nam Ou's cascade sites, the estimated bed load of 150-830 x 10³ tonnes/day would represent around 10-15% of the total sediment load, which is typical of mixed load streams (Lane and Borland 1951). Assuming an average sediment transport rate of 113-250 tonnes/year/km² and a bed load sediment flux equivalent to 5-15% of the total sediment load in the Nam Ou, it is estimated that the average total sediment load (suspended plus bed load) is around 120-290 tonnes/year/km².

The average total sediment load of 120-290 tonnes/year/km² estimated for the Nam Ou Basin is likely to be higher than various estimates of the natural (pre-clearing) sediment yield from catchments in the humid tropics, which range from 80 to 150 tonnes/year/km² (Yu 2005). Furthermore, the sediment load could be significantly higher based on erosion events triggered by land clearing, mining, dredging, and hydropower construction in the catchment.

Climate & Meteorology

The Nam Ou catchment has a tropical monsoonal climate, with a distinct wet season between May and October and a pronounced dry season for the rest of the year (Figure 4). Average annual rainfall within the catchment ranges from around 1,250 mm (Luang Prabang) to 1,750 mm (Meuang Ngoy). In 2009, annual rainfall was 1,752 mm at Phongsaly, 1,340 mm at Oudomxay, and 1,260 mm at Luang Prabang, while evaporation rates represented 43% (747.8 mm), 66% (879 mm), and 67% (847 mm) of rainfall at these stations, respectively (ESL 2011). Around 84% of the total rainfall occurs during the wet season, with the highest rainfall occurring in the months of July and August.

From 1971 to 2006, average maximum temperatures at Luang Prabang ranged from 34°C to 44°C, while Phongsaly recorded average maximum temperatures of 26°C to 35°C from 1988 to 2006. The hottest months are from April to June. Average minimum temperatures range from 3.4°C to 20°C at Luang Prabang and 0.4°C to 12.4°C at Phongsaly. Temperatures are lowest in December and January. Spatial temperature trends exist across the Nam Ou catchment, with average monthly temperatures becoming increasingly cooler in the north (toward Phongsaly) and warmer in the south (toward Luang Prabang).

In December and January, temperatures in the north of the basin can drop significantly, even down to 0°C. Prolonged periods of up to 10 days of cold weather have been recorded in several years, most recently in 2016, and can lead to livestock mortality. In January 2016, cold weather caused the deaths of large numbers of fish, especially *Puntioplites proctozystron* (61), in the Nam Noua, according to villagers in Ban Sopnao.

Rainfall distribution is even more distinct. Between May and October, most of the upper (northern) parts of the Nam Ou Basin receive between 1,200 mm and 1,500 mm of rainfall, while the lower parts of the basin (effectively Luang Prabang) receive between 1,100 mm and 1,200 mm. In the dry season, the lower rainfall range of 200-300 mm appears to follow the river valley from a drier area around Gnot Ou and then an increasingly wider area from the Nam Phak confluence down to the Mekong. Outside of these drier areas (on the higher ground), rainfall in the dry season ranges from 300-400 mm.

Box 6

Flood Events & other Disasters

Key flood characteristics of the Nam Ou at Meuang Ngoy are summarized below (HKEC 2009):
Flood hydrographs are typically unimodal, with a duration of 5-15 days, with major floods occurring in 1994 and 1996.

- August 15-19, 1996 Heavy monsoon rainfall from the east gave rise to a peak flood discharge of 7,017 m³/sec, damaging agricultural crops. The maximum average daily discharge was 9,290 m³/s.
- July 15-20, 1994 A monsoon typhoon caused damage to agricultural crops and livestock. The storm rainfall was 1,090 mm, giving rise to a peak flood discharge of 7,771 m³/sec.
- July 26, 1992 Minimum average daily discharge was 1,660 m³/s.

In Phongsaly, three major floods have taken place since 2001:

- 2016 Nam Lan and Nam Leng in Boun Tai.
- 2011 Meuang Mai and all tributaries of the Nam Neua.
- 2001 In Meuang Gnot Ou, the urban area close to the river was flooded with significant damage, including the concrete irrigation water pipe.

Meuang La appears to be the district most affected by flash flooding, with three big recorded events in 1975, 1991, and 2008. In 1991, 17 people were killed and 20 injured, but no casualties were recorded in the other floods. Drought, in terms of water supply and agriculture, has not occurred in the Nam Ou Basin. (Source: Provincial validation workshops)

Nam Ou Water Resources

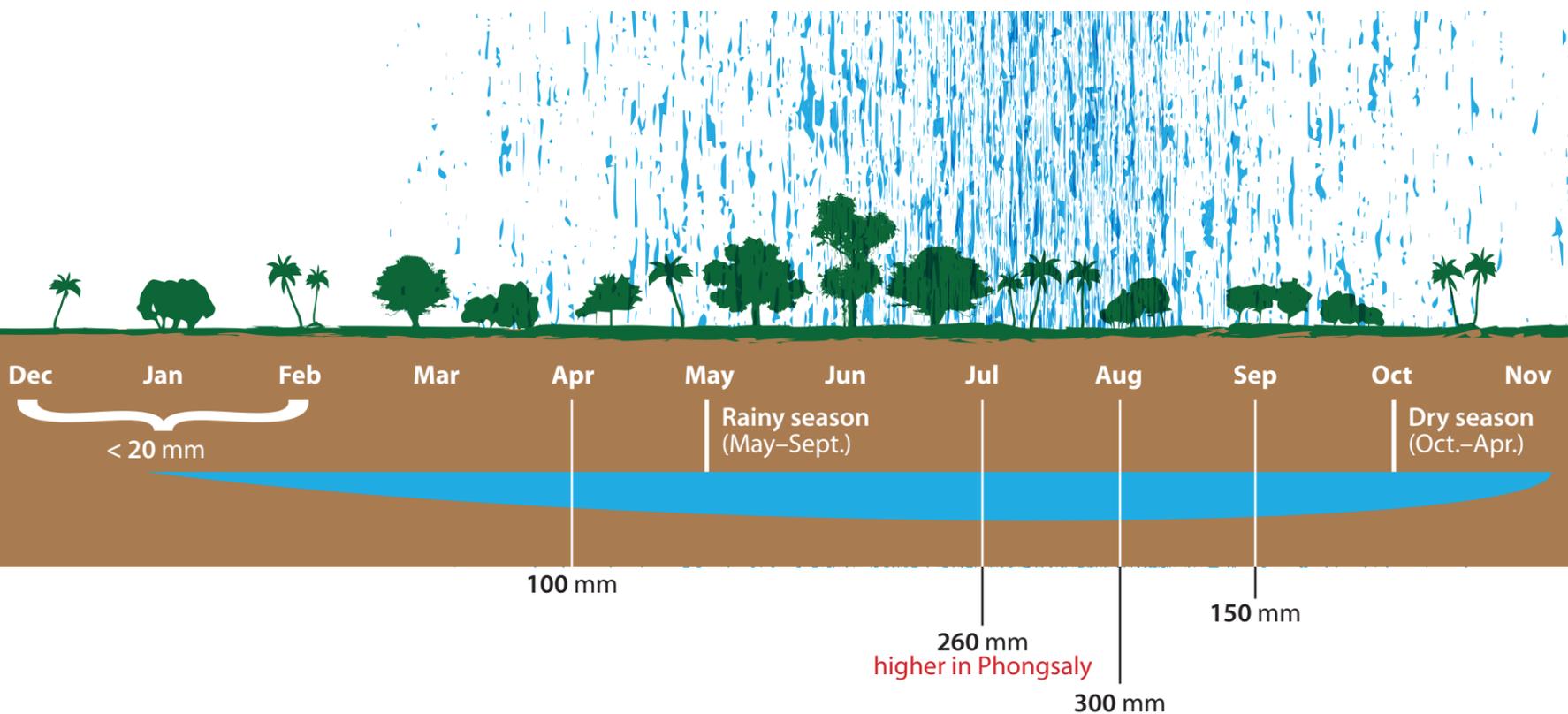
Tributaries and Catchment Area

The Nam Ou has 11 major tributaries. The size and ranking of their catchment areas are shown in Table 1. The Nam Phak, the Nam Nga, and the Nam Leng are the top three tributaries by catchment area and percentage of the river basin, with the Nam Noua being the fourth-largest tributary.

Hydrology

Information on the Nam Ou's surface water hydrology was obtained from the official hydrological gauging station at Meuang Ngoy (20°42'38.01"N, 102°40'25.52"E), which had records dating back to the 1970s. Several other hydrological stations have been put in place recently for other purposes such as hydropower development, but the records for these are either unavailable or are not of long duration. Daily flow data from 1987 to 2003 were used to generate hydrological estimates for the design of the seven-dam cascade (HKEC 2009) and the IDOM training study between 1999 and 2003 (IDOM 2014, ESL 2011).

Figure 4 Long-term mean monthly rainfall in Nam Ou Basin.



Box 7

Hydrology – Key characteristics (HKEC 2009):

- The average discharge of the Nam Ou at Meuang Ngoy was 440 m³/s, based on data collected from 1987 to 2003.
- The maximum average annual discharge was 710 m³/s (1971) and the minimum was 221 m³/s (1992).
- Runoff increases each year from May, peaking between July and September, and decreases from November to April.
- Around 83.6% of the annual runoff occurs in the wet season (June to November), while only 16.4% occurs in the dry season (December to May).
- The lowest average monthly discharge occurs around March to April, with a minimum of 57 m³/s observed in April 1979.
- Based on an average annual rainfall of 1,650 mm and an average annual runoff depth of 721 mm, the runoff coefficient for the catchment is estimated at 44%.

Surface Water Quality

The Mekong River Commission has been collecting monthly water-quality data from different sites on the Mekong since 1985, including one location on the Nam Ou at Ban Hat Kham downstream from the Pak Ou bridge (Station Name and ID: Ban Hat Kham, H100101). Figure 5 shows general trends in water quality observed at this station over time.

When compared to the United Nations Economic Commission for Europe (UNECE)'s river-quality standards regarding DO, chemical oxygen demand, manganese, Total P, Total N, pH, and alkalinity, most of the samples (collected since 1985) fall into Aquatic Health Classes 1 and 2 (UNECE 1994). Historically, the aquatic health of the Nam Ou waters at Ban Hat Kham before discharge to the Mekong was generally very good to good, especially for DO, pH, and chemical oxygen demand. Upstream waters in Phongsaly have better water quality than downstream in Luang Prabang near the confluence with the Mekong.

Table 1

Catchment area (km²) and estimated average annual flow rate (m³/s) for the Nam Ou Basin and its main tributaries.

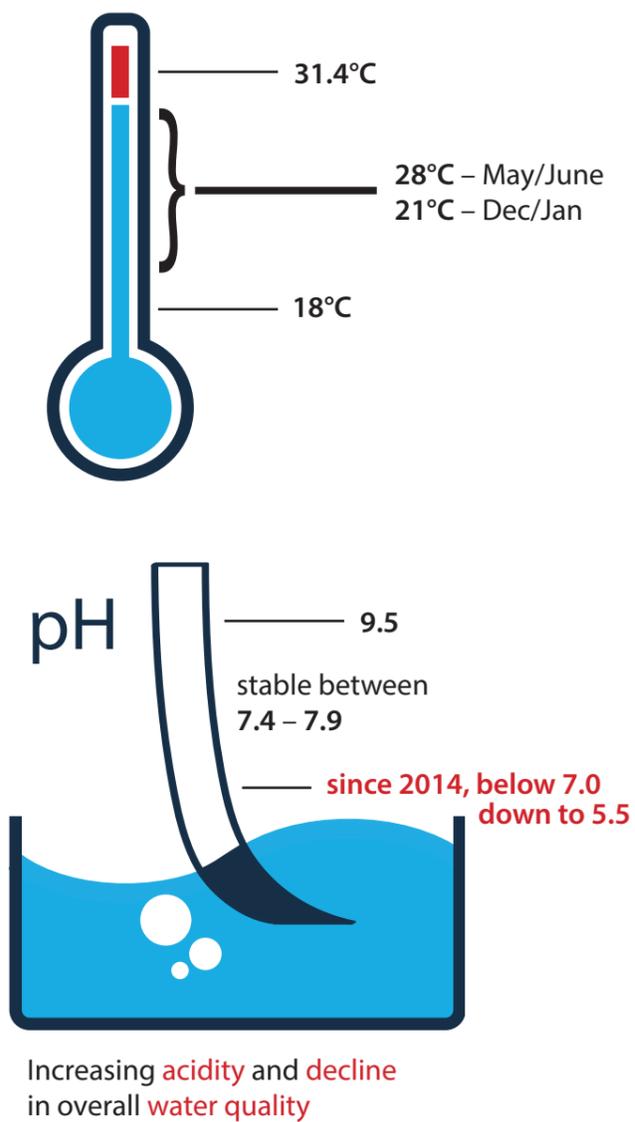
Tributary	Code	Catchment area (km ²)	% of basin area	Annual Avg. flow (m ³ /s)	Rank*
1. Nam Khang	(NK)	1,097	4.2	21.7	6
2. Nam Ngay	(NNy)	879	3.4	18.6	8
3. Nam Leng	(NL)	2,092	8.1	40.9	3
4. Nam Houn	(NH)	881	3.4	19.5	7
5. Nam Pok	(NP)	517	2.0	10.0	11
6. Nam Ban	(NB)	742	2.9	15.3	9
7. Nam Phak	(NPK)	3,342	12.9	68.4	1
8. Nam Noua	(NNa)	2,089	8.1	32.1	4
9. Nam Hub	(NHb)	713	2.8	12.9	10
10. Nam Bak	(NBk)	1,722	6.6	15.8	5
11. Nam Nga	(NNg)	2,677	10.3	47.1	2
Total Tributary area (km ²)		16,752	64.7		
Nam Ou Basin total area (km ²)		25,910			

Source: GIS analysis and (HKEC 2009)

*Ranked by catchment area and flow contribution

Figure 5

Average monthly water temperature and pH at Ban Hatkham since 1985 (Source MRC).



In recent years, there has been an increase in nutrient levels such as Total P and Total N (perhaps indicating a tendency toward eutrophication) and lower alkalinity, suggesting that the water has less potential for buffering acidity. There are some marked peaks in COD up to 16 mg/l between 2012 and 2014. These figures all point toward a general decline in the Nam Ou's water quality in recent years, especially in downstream areas, probably coinciding with large infrastructure construction activities upstream of Ban Hat Kham.

Key sources of water pollution include: industrial discharges in urban areas, untreated sewage, hydropower development, sand and gravel dredging, gold mining (including use of mercury), and overuse of agricultural chemicals on banana and rubber plantations. To date, no comprehensive surveys of toxic chemicals, including persistent organic pollutants, have been conducted on the Nam Ou, and there are limited data on heavy metals and other parameters of concern.

Wetlands & Associated Waterbodies

The total area of water bodies found in the Nam Ou is estimated at 5,554 ha. This includes the river itself and standing bodies of water, lakes, ponds, and reservoirs. As a very steep-sided and rather narrow valley, the Nam Ou Basin is generally not suitable for the formation of natural lakes and wetlands; there is little floodplain area where such wetlands could form. However, floodplain areas on the banks of the main river and tributaries are important spawning areas for many fish species and are used as riverbank gardens during the dry season.

Ecological Characteristics of the River

Box 8

Ecological Characteristics of the Nam Ou Basin

The Nam Ou Basin lies within the Northern Indochina sub-tropical terrestrial ecoregion as defined by World Wide Fund For Nature (WWF) (Olson and Dinerstein 2002). The basin also lies within the moist, sub-tropical broadleaf forest biome and is recognized to have special karst features. Under the classification system for river reaches developed for the Greater Mekong sub-region (Lehner and Ouellet Dallaire 2014), which uses three groups of classes, the following may be noted about the Nam Ou Basin's hydrologic, physio-climatic, and geomorphologic features:

Hydrologic:

- The tributaries of the Nam Ou can be classified as medium-sized rivers based on their mean annual flow of 10-100 m³/sec.
- The Nam Ou mainstem from the Nam Khang confluence to Pak Ou can be classified as a large river with a mean annual flow of 619 m³/sec (range 100-1,000 m³/sec).
- The peak monthly discharges are about three times the mean annual flow, which put the tributaries in the category of high seasonal flow variability. The upper reaches have a slightly lower flow variability because of the lower rainfall compared to the lower reaches and tributaries.

Physio-climatic:

- The tributaries and the mainstem are in the high (above 750 masl) and low (below 750 masl) moist broadleaf forests.
- There is significant presence of karst in the lower parts of the river.

Geomorphologic:

- The tributaries and the mainstem have high stream gradient.
- The tributaries and the mainstem have presence of sediment but no floodplain.

Habitat Surveys

Box 9

Habitat Survey – Ban Vangle, Pak Ou

A detailed habitat survey was carried out on the sand and gravel island upstream of Ban Vangle, near Pak Ou (see also Figure 6). The Google Earth image of the area shows the widening of the river channel at this point with two channels, both of which are fast-flowing. The left-bank channel is wider with exposed rocks and shrubs at the upstream and downstream ends. This channel has some small rapids and riffles. The right-bank channel is about 30-40 m wide with a sharp bend at the end of the island where it rejoins the main channel. There is an area of rock and sand deposition at this point, used extensively by the small village on the right bank.

The island itself is 580 m long by 190 m wide, consisting of deposited sand, gravel, and pebble beds, laid down in channels that are inundated in the high flow season. The higher banks of the island are vegetated with tall grasses and shrubs, especially *Mimosa pigra*. The left bank of the river has larger trees and shrubs, while the right bank has riverbank gardens and smaller trees and shrubs.

A macroinvertebrate survey of the sand, gravel, and bank vegetation on the island showed relatively sparse populations of Crustacea (crabs and shrimps), mayflies, bugs and beetles, molluscs, and small fish. The biodiversity index showed a score of 6.5, indicating a moderately modified stretch of the river in fair condition. The populations of macro-invertebrates in the upper bank layers sampled were probably depressed because of changes in water level due to a recent storm and flow changes from upstream dams.

Figure 6

Google Earth image of the island opposite Ban Vangle (top), overlay of aquatic habitats, bank type, and bank vegetation types on island upstream of Ban Pak Ou (bottom).



Fisheries & Aquatic Resources

Box 10

Fisheries Resources in the Nam Ou Basin

There have been several studies of the fishes of the Nam Ou Basin, notably by Kottelat (2009) for WWF. Surveys were conducted for the environmental impact assessment (EIA) of the Nam Ou cascade and noted that because of the diverse range of aquatic habitats, the Nam Ou supports a high diversity of fish species that have adapted to fill the different ecological niches in the river (Warren 2010).

Kottelat (2009) identified a total 84 fish species of 23 different families in the Nam Ou Basin. At least three species are exotic, having been introduced for aquaculture, such as the Nile Tilapia (*Oreochromis niloticus*), or for stocking, such as Rohu (*Labeo rohita*) and Common Carp (*Cyprinus carpio*). Golden Barb (*Puntius semifasciolatus*) and Spotted Steed (*Hemibarbus maculatus*) may also have been introduced into the basin through the Nam Noua from Vietnam (Kottelat, 2009). Dr. Phouvin Phousavanh (NUOL) conducted a series of fisheries surveys between 2007 and 2011, identifying a total of 139 species in the Nam Ou and its tributaries.

The Mekong Giant Catfish (*Pangasianodon gigas*), a critically endangered species, is reported as being present in the area of the confluence with the Mekong but not in the Nam Ou itself. The lower part of the Nam Ou from Meuang Ngoy to Pak Ou is listed as a key biodiversity area (KBA) by the International Union for Conservation of Nature (IUCN) (<https://www.iucn.org/key-biodiversity-areas>) because of the presence of another critically endangered species, the Giant Barb (*Catlocarpio siamensis* or *Pba Chok*). Respondents at provincial validation workshops held in Phongsaly and Luang Prabang in 2017 confirmed that this species is found in the Nam Ou as far up as Pak Ban where fish of up to 10 kg have been caught, but it is not found in Oudomxay Province.

Two other endangered fish species, the Mekong Freshwater Stingray (*Dasyatis laosensis*) and Seven-striped Barb (*Probarbus jullieni*), are also found throughout the Nam Ou. A spawning ground of the Seven-striped Barb and its spawning behaviors have been recorded at Ban Hatkhe, which is 41 km upstream from the confluence with the Mekong and 27 km upstream of the proposed Nam Ou 1 hydropower project site.

Respondents at the 2017 provincial validation workshops also noted the presence of one of the longest distance migratory species, *Pangasius krempfi*, which migrates from the Mekong Delta to spawn and returns with its young. It was noted as far upstream as Meuang Samphan where fish of up to 30 kg have been caught. By contrast, the Marbled Eel (*Anguilla marmorata*) is the only truly catadromous fish of the Mekong migrating from the river to breed in the sea.

Fish migrations are an important part of the seasonal cycle. Fish move upstream from the Mekong into the Nam Ou and from the Nam Ou mainstream into the tributaries to breed. There are two main migration seasons: late in the dry season when the waters and flow rates are low and the smaller fish can move upstream easily; and in the flood season, when there is more water and the larger, stronger swimming fish, such as catfish, migrate. At the end of the flood season, many fish migrate back downstream again (Poulsen, et al. 2004, Warren 2010).

Table 2 shows the number of species falling into different fish guilds (or groupings) as described by (Welcomme et al. 2006). There are 28 rhithron resident guild species, which are typical of fast-flowing rocky, mountainous rivers. There are 48 main channel migratory species, including one migratory main channel and tributary resident guild species (*Bangana behri* [8]), 27 migratory main channel spawner guild species, and 20 migratory main channel refuge seeker guild species. Generally known as white fish species, they migrate from the Mekong mainstream into the tributaries such as the Nam Ou and from there into its tributaries, either to spawn or to seek refuge during the dry season.

Thirty species are characterized as generalists, which live and breed under wide ecological conditions. Six species are floodplain residents, generally known as black fish species. Only one species, the Marble Goby (*Oxyeleotris marmorata* [127]), is semi-anadromous (living both in brackish and estuarine conditions). There are no catadromous (moving back down to the sea to breed) or marine species, as is to be expected. There are five non-native species and six whose guild is not known. Three exotic species reported are widely distributed throughout the basin.

This analysis of fish guilds found in the Nam Ou shows that it is dominated by species that are characteristic of fast-flowing rocky mountain rivers as well as migratory species that move from the Mekong mainstream into the Nam Ou and its tributaries. The proportion of generalist species and black fish species is lower than in some other tributaries where there are greater lengths of slower-moving lowland rivers.

Table 2
Distribution of fish species by fish guilds in the Nam Ou Basin.

Guild	Description	No. of species	% of species
Guild 1	Rhithron resident guild	28	22.6
Guild 2	Migratory main channel and tributaries resident guild	1	0.8
Guild 3	Migratory main channel spawner guild	27	21.8
Guild 4	Migratory main channel refuge seeker guild	20	16.1
Guild 5	Generalist guild	30	24.2
Guild 6	Floodplain resident guild (Blackfish)	6	4.8
Guild 7	Estuarine resident guild	0	0.0
Guild 8	Semi-anadromous guild	1	0.8
Guild 9	Catadromous guild	0	0.0
Guild 10	Marine guild	0	0.0
NG	No Guild appropriate	0	0.0
NK-NI	Not Known or No Information	6	4.8
NN	Non-Native	5	4.0
Total		124	100.0

A number of threatened fish species are found in the river, according to the IUCN Red List of Threatened Species (Red List). One species, *Scaphognathops theunensis* (71), is considered critically endangered; three are endangered, including *Luciocyprinus striolatus* (37), *Probarbus jullieni* (56), and *Probarbus labeamajor* (57); and five are considered vulnerable, namely *Bangana behri* (8), *Crossocheilus reticulatus* (15), *Hypsibarbus lagleri* (31), *Mystacoleucus lepturus* (44), and *Pseudohemiculter dispar* (58).

The critically endangered *Scaphognathops theunensis* is only found in the Nam Theun and Nam Gnouang rivers, which are a long way from the Nam Ou. Identification of specimens collected from the Nam Ou is being conducted to confirm that this species is indeed more widespread than reported in the IUCN Red List, and/or if villagers had erroneously identified the fish. Another similar species found in the Nam Ou, *Scaphognathops stejnegeri* (72), was recorded in two locations – Ban Pakban and Ban Paknga – and is of least concern on the IUCN Red List.

When the Nam Ou 4 dam is built, the five endangered species identified by villagers at Ban Pakban will probably disappear. When the Nam Ou 1 dam is built, the two endangered species at Ban Paknga will also likely disappear, especially *Probarbus jullieni* (56), which has a recognized low-flow spawning area at Ban Hatkhe that will be inundated after the construction of the dam.

Table 3 lists the distribution of fish guilds reported by villagers in the eight villages for case studies.

Table 3
Number of fish species reported at 8 villages from the Nam Ou and associated tributaries. Fish species are grouped based on their guilds¹, and their origin. Number of Species of Concern (IUCN/Red List)² are listed.

Village	Waterbody	Fish groups (guilds) ¹					Origin			IUCN (Red List) ²			Total
		A	B	C	D	E	Endemic	Native	Exotic	CR	EN/VU	NT	
1 Ban Nagnao	Nam Ou	19	12	14	4	3	19	35	3		3	3	52
2 Ban Homsang ³	Nam Ou	14	12	7	4	3	10	29	3	1		2	41
	Reservoir	1	3	3		2	2	4	2				9
3 Ban Pakban	Nam Ou	16	25	14	1	3	18	40	3	1	5	6	59
	Nam Ban	4	5	2			4	7	0			2	11
4 Ban Buamsom	Nam Phak	11	11	16	3	1	16	29	1	1		2	42
5 Ban Sopnao	Nam Noua	7	9	8	3	2	9	19	2	1		2	29
6 Ban Sopkhong	Nam Ou	9	18	14	6	2	13	36	2	1	1	2	49
	Nam Nga	2	3				3	2	0				5
7 Ban Pak Nga	Nam Ou	12	21	11	2	3	14	35	3	1	2	4	49
	Nam Nga	2	3				3	2	0				5
8 Ban Pak Ou	Nam Ou	1	20	10	2	2	7	26	2	1	2	4	35
Total		28	48	30	6	5	35	86	5	1	8	8	117

¹ Fish grouping: (A) Rhithron resident (guild-1); (B) Migratory main channel, resident, spawner, and refuge seeker species (Guild 2-4); (C) Generalist (Guild-5); (D) Floodplain resident/blackfish (Guild-6); and (E) Non-Native.

² IUCN Red List species of concern: (CR): Critically Endangered; (EN/VU): Endangered or Vulnerable; & (NT) Near Threatened.

³ Ban Homsang: a relocated village previously known as Ban Phoumuang.

Fisheries & Fishing Gear

The fishery specialist report for the EIA of the Nam Ou cascades included surveys with fishermen in 18 villages along the length of the river (Warren 2010). The surveys revealed that a single fisherman could on average catch between 0.5 kg and 3.0 kg of fish per day using whatever gears appropriate to the time of year. During the upstream fish spawning migrations between April and June, daily landings can rise considerably, and reports of individual fishermen catching in excess of 10 kg per day are not uncommon (sometimes as high as 30 kg per day). When fish landings exceed what is necessary for daily household consumption, fish are sold for cash if they are medium-sized (1 or 2 kg) or large (>5 kg) and processed –fermented, smoked, or sun-dried – if they are small (Warren 2010).

In December and January, men from the Luang Prabang districts of the Nam Ou may catch 5-10 kg of fish per day using a cast or scoop net and women may catch 2-5 kg per day using different gear. The transition to wet season is the most productive period, with about 70% of the catch sold and 30% used domestically.

Further upstream in Phongsaly, fish catches tend to be lower in Gnot Ou. A fisherman normally catches around 2-3 kg per day during dry season. Most fish are consumed domestically rather than sold. Before the impoundment of the Nam Ou 5 hydropower project, fish catches in Ban Pak Ban between February and March could be as high as 20-30 kg per day, while fewer fish were caught between August and October. During impoundment, when the river levels were very low, they caught many fish including large ones. Now fish catches have been reduced to less than 0.5 kg per day. In Ban Homsang, during the impoundment of the Nam Ou 6 reservoir, they caught 10-20 kg of fish per day and sold 70% of them in Ban Hatsa and Meuang Khoa markets while consuming the rest.

The main fishing gears used include fixed and drift gillnets, beat-nets, cast-nets, "Jun" traps, long-lines, single hooks, "Sai" traps, "dtawn", "Oo" traps, home-made spear guns, "Son", "Dtoom", and "Scoup-nets". Some of the gears are seasonal and others are used year-round (Warren 2010).

Fish conservation zones (FCZ) have been established with assistance from WWF at several villages along the Nam Ou and its tributaries. These zones are sections of the river that are recognized by local fishermen as important habitats for fish; usually they are deep pools that provide refuge for fish during the dry season and serve as spawning areas or fish nursery grounds. Participating fishermen from surrounding villages agree to abide by the rules and regulations restricting fishing activities in these zones, which are often marked with a string of flags across the river at the beginning and end of the reach that may be 500-m or 1-km long. Most fishermen agree that FCZ are effective in helping to protect and increase fish stocks.

Warren (2010) identified 15 villages with established FCZ on the Nam Ou mainstem. In the Luang Prabang districts of the Nam Ou Basin, there are 30 FCZ, with 25 on the Nam Ou (Ngoy – 10, Nam Bak – 11, Pak Ou – 4) and five on the Nam Nga as of 2016. In the Oudomxay districts along the river, more than 90 villages have 35 conservation pools and 101 protection pools, figures from the 2017 provincial validation workshops show. Local regulations prohibit the use of explosives, electrofishing, and biocides (poison) to catch fish; however, these activities are still undertaken in some communities

Other Aquatic Animals (OAA)

Several OAA species, especially freshwater prawns, river weed (*Cladophora* spp.), amphibians, and reptiles are important in the local subsistence economy and in livelihoods of communities along the Nam Ou. However, no systematic studies of OAA, which include benthic invertebrates, zooplankton, phytoplankton, molluscs, crustaceans, and aquatic insects, have been conducted in the Nam Ou Basin.

A few turtle species are found in the basin, many of which are captured for sale and consumption. Some species are critically endangered, including the Asian Box Turtle (*Cuora amboinensis*) and the Indochinese Box Turtle (*C. galbinifrons*) – both of which have been captured in Phongsaly. There is one endangered amphibian species, the Yunnan spiny frog (*Nanorana yunnanensis*). These species are threatened primarily by human consumption and habitat loss.

Box 11

Littoral macroinvertebrates bio-survey

Littoral (shoreline) macroinvertebrates are good indicators of a river's general health because different taxonomic groups respond differently to changing flow and chemical conditions in the river. During field studies conducted in developing this Profile, the South African miniSASS system was used to sample and analyze macroinvertebrates. Littoral macroinvertebrates are probably the easiest aquatic fauna to sample from the banks and can be sorted on site, preserved, and identified at leisure. However, the choice of sampling sites is important: usually banks and river beds with gravel, pebbles, and boulders are the most effective for sampling, as sand and mud tend to be too dense for many species.

The bio-survey index results showed that three sites in the upper river – the Nam Ou source stream, a natural site above Gnod Ou, and the Gnod Ou Bridge – are considered the most natural, despite some disturbance from agricultural runoff and pollution from Gnod Ou town. Stoneflies were found in all three sites, which increased their scores.

Downstream sampling was not possible until Ban Sopkhong, which was considered to have a good macroinvertebrate index despite a rather low number of groups and indicators showing higher sensitivity. Below Ban Paknga, Ban Hatkhe, and Ban Vangle, the macroinvertebrate index revealed fair to poor conditions possibly due to a combination of high rainfall, drying-up, occasional releases from the dams, and sediment releases as a result of dam construction.

Three sites were sampled in the tributaries of the Nam Kor, the Nam Phak, and the Nam Nao. The first two were in poor to fair conditions largely because of sewage releases from Oudomxay town. From the macroinvertebrate sampling results, the Nam Noua appeared to be in fair condition though the diversity of species was relatively low (see Table 4 for detailed results).

Table 4

Stream health assessment – littoral macro-invertebrate sampling (miniSASS) conducted on the Nam Ou Basin and tributaries.

Stream Health Indicator (macro-invertebrates)	Score	Nam Ou (source)			Nam Ou u/s-> d/s				Tributaries u/s-> d/s			
		S1	S2	S3	B1	B2	B3	B4	T1	T2	T3	T4
1. Flat worms	3											
2. Worms	2											
3. Leeches	2											
4. Crabs and shrimps	6		6		6	6		6	6	6	6	
5. Stoneflies	17	17	17	17								
6. Minnow mayflies	5			5					5	5	5	5
7. Other mayflies	11	11	11	11	11	11		11	11	11	11	11
8. Damselflies	4											
9. Dragonflies	6	6	6	6	6		6		6		6	6
10. Bugs and Beetles	5	5	5	5	5	5	5	5	5	5	5	5
11. Caddis flies	9	9	9		9		9		9		9	9
12. True flies, Diptera	2	2							2		2	2
13. Molluscs	4		4	4	4	4	4	4	4	4	4	
14. Megaloptera	9		9							9		
i. Tadpoles		×			×					×		
ii. Fish		×		×	×	×	×	×	×			
Total score	85	50	67	48	41	26	24	26	48	40	48	38
Average score (Index)	6.1	8.3	8.3	8.0	6.8	6.5	6.0	6.5	6.0	6.7	6.0	6.3

Note: 'x' - Tadpoles and fish are not included when calculating stream health index, yet, the presence of both organisms was recorded as this is indicative of a healthy aquatic ecosystem.

Legend:

Stream Health Index values for rocky type rivers

	Index
Unmodified (Natural/pristine condition)	>7.9
Largely natural/few modifications (Good condition)	6.8-7.9
Moderately modified (Fair condition)	6.1-6.8
Largely modified (Poor condition)	5.1-6.1
Seriously/critically modified (Very Poor condition)	<5.1

Sampling locations:

1. Nam Ou Source	S1
2. Gnot Ou Town upstream ('pristine' site)	S2
3. Gnot Ou downstream of bridge	S3
4. Ban Sopkong FCZ	B1
5. Ban PakNga	B2
6. Ban Hatkhe	B3
7. Ban Vangle (island)	B4
8. Nam Kor – fast water	T1
9. Nam Kor – slow water	T2
10. Nam Kor (confluence with Nam Phak)	T3
11. Ban SopNao	T4



Box 12

Freshwater Prawn Fishery in the Nam Ou

An important prawn fishery is found in the limestone karst mountainous areas near Meuang Ngoy. Several limestone caves in this area have streams flowing out into the Nam Ou mainstream, especially the Tham Paho caves near Ban Sopchem. The waters found in these streams are cool-cold and are very clear. There is a species of prawn (*Macrobrachium yui*) that lives in the Nam Ou where it grows to sexual maturity (Kounthongbang et al. 2015). When the mainstream becomes turbid at the beginning of each wet season, prawns move up and into the clear-water streams issuing from the caves. According to researchers at the Living Aquatics Research Center in Vientiane, the prawns reside in this area during their spawning migration. During this seasonal migration period, certain villages close to these caves are able to exploit the fishery by setting special traps to catch the prawns as they move into the caves. Most landings are made at night. Following capture, the prawns are either eaten by villagers or sold to local restaurants and traders who have specialized marketing outlets in large cities such as Luang Prabang.

There are four villages active in the prawn fishery: Huay Chong, Nong Khiaw, Meuang Ngoy, and Sopchem. From July to September, the villagers may catch up to 50 kg of prawns per day, with individuals reaching a size of 0.5 kg. An estimate of the total prawn catch has been put at 170,000 kg per year, according to information presented at the 2017 Luang Prabang provincial validation workshops.

Box 13

River Weed in the Nam Ou

River weed (*Cladophora* spp.) is a freshwater alga collected throughout the main channel and the tributaries of the Nam Ou Basin. There are several different algae species that grow on underwater rocks and thrive in clear, shallow water. River weed is collected during the dry season when flows are low and the water has less sediment. Known as “Mekong weed” in English, it is dried in flat sheets and eaten as a delicacy. Most families living in riverside villages harvest river weed; for example, there are 80 such families in Ban Pak Ou and each could collect up to 25 kg of weed in wet weight per day between January and May. In recent years, however, river weed collection has become more difficult and less productive because of river-level fluctuations and increased sediment due to hydropower construction.

Families in the Nam Ou tributaries in Oudomxay collect 10-15 kg of river weed per day from January to May. This yields 2-3 kg of dry river-weed sheets, which measure 40x80 cm each. There are about three to five sheets per kg and each sheet sells for 3,000 kip (or 8,000-10,000 kip per kg). Thus, a full day's collection of river weed in Oudomxay might provide an income of 45,000 kip per day. This can make a significant contribution to household income in the villages.

Terrestrial Resources

Land Use/Cover

The most recent comprehensive land cover/land use assessment for the Lower Mekong sub-basin was carried out by the MRC in 2014 using satellite imagery from 2010 and ground-truthed throughout the basin, including the Nam Ou Basin in both Lao PDR and Vietnam (Vo, et al. 2015).

The land cover reflects both the terrain, geology, and land uses in the basin. The predominant land cover is broadleaved deciduous forests, followed by shrubland; together, they make up 86% of the total land cover in the basin. The combined natural forest lands (deciduous, evergreen, bamboo, and coniferous) make up 14,596 km², contributing 56% of the total. The industrial plantations in the northern sub-catchments reflect the recent developments of rubber plantation. Agriculture makes up 6.5% of the total land area, including annual crops, paddy rice, orchards, and shifting cultivation, which makes up 4.0% of the total. Compared to the rest of the basin, the Nam Noua sub-catchment in Vietnam stands out with much more intensive land use such as paddy, annual crops, and orchards.

Forest Cover/Vegetation

The main forest types in the Nam Ou Basin are as follows:

Upper mixed deciduous forest is small patches of relatively undisturbed primary forest with a dense canopy of around 10-20 m in height. This is the most biologically diverse vegetation type in the Nam Ou Basin. Deciduous tree species represent more than 50% of the stand and bamboo occurs in some areas.

Unstocked forest refers to areas that were once upper mixed deciduous forest, but the primary tree crown density in these areas has been reduced to less than 20% because of selective logging or shifting cultivation activities.

Riparian forest identifies dense forest along creeks and rivers. Most of the riparian forest along the Nam Ou and its tributaries is unstocked due to selective logging. Large emergent trees are often present above a dense mid-story and understory. Riparian forest usually does not extend further than 50 m from the creek or river edge.

Bamboo forest is widely distributed across the region and occurs primarily in areas previously subject to shifting cultivation. Areas classified as bamboo forest have at least 80% composition of bamboo species with canopy heights of up to 15 m.

In-channel vegetation occurs within the Nam Ou itself and the channel of major tributaries such as the Nam Khang. This vegetation occurs on sandbanks, sandbars, and rocky outcrops within the river channel.



In Lao PDR, protection and conservation forests are defined by the Forestry Law (2008) as follows:

- **Protection forest** is forest and forestland classified for the purposes of protecting water sources, soil quality, the environment, and strategic areas for national defense; preventing soil erosion; protection from natural disasters and so on.
- **Conservation forest** is forest and forestland classified for the purposes of conserving nature and preserving plant and animal species, forest ecosystems, and other valuable sites of natural, historical, cultural, tourism, environmental, educational, and scientific importance.

In Phongsaly, there is one national conservation forest (Phou Den Din), five provincial-level conservation forests, and four district-level conservation forests covering a total area of 327,518 ha. There are five national protection forests and two district protection forests covering a total area of 797,409 ha, and two production forests covering a total of 158,573 ha.

The Phou Pha Provincial Conservation Forest is located on forested mountain slopes adjacent to the provincial administrative center of Phongsaly and covers around 200 ha. The area is protected primarily to conserve the township's water resources. The area is also managed as a district protection forest by the Phongsaly District Agriculture and Forestry Office.

The Phou Tasan Provincial Conservation Forest is located adjacent to the Nam Ou within the Nhot Ou District. The forest covered over 14,000 ha before it was reclassified by the Ministry of Agriculture and Forests – Forest Inventory and Planning Department (FIPD) as Phu Sen National Protection Forest covering 9,495 ha.

The Phou Taleng Provincial Conservation Forest is located within the Boun Nua District. The forest currently covers around 14,310 ha, but its boundaries have been reclassified by the Ministry of Agriculture and Forests – FIPD, expanding its area to about 16,000 ha.

The Nam Lan Provincial Conservation Forest is located in the southwest corner of Phongsaly Province, adjacent to the Lao PDR-China border. Covering around 15,200 ha, the forest is a mountainous area with altitudes from 600 masl to 1,900 masl and reportedly contains significant areas of primary forest and supports a wide range of amphibian species. Tourism in this area is promoted by the Phongsaly Forest Conservation and Rural Development Project.

Oudomxay has 130,000 ha of protection forests, 133,000 ha of reservoir forests, and 64,000 ha of production forests lying within the Nam Ou Basin. In Luang Prabang, there are 198,923 ha of national protection forest, 57,540 ha of district protection forest, and 8,028 ha of district reservoir forestry.

**Fauna –
Threatened Species, including Wildlife & Birds**

Box 14

**Animals of Conservation Significance
(Endangered Species) in the Nam Ou Basin**

Critically Endangered

- Northern White Cheeked Gibbon, *Nomascus leucogenys*

Endangered

- Francois’s Langur, *Trachypithecus francoisi*
- Phayre’s Langur, *Trachypithecus phayrei*
- Banteng, *Bos javanicus*
- Sunda Pangolin, *Manis javanica*
- Chinese Pangolin, *Manis pentadactyla*
- Large Antlered Muntjac, *Muntiacus vuquangensis*
- Indochinese Tiger, *Panthera tigris corbetti*
- Fishing Cat, *Prionailurus viverrinus*
- Green Peafowl, *Pavo muticus*
- Elongated Tortoise, *Indotestudo elongata*
- Big-headed Turtle, *Platysternon megacephalum*

Source: ESL. (2010). Nam Ou Cascade Terrestrial Biodiversity and Forest Resource Use Study.



Lao PDR has 27 important bird areas (IBA; BirdLife International 2004), with only one located in the Nam Ou Basin – the Phou Den Din Important Bird Area (IBA No. LA008). This area covers around 126,880 ha and comprises the upper Nam Ou and its catchment within the Phou Den Din NPA. To be classified as an IBA, the site must fulfil at least one of the three criteria: 1) The area holds significant numbers of one or more globally threatened species, 2) is among a set of sites that together hold a suite of restricted-range species or biome-restricted species, and 3) has exceptionally large numbers of migratory or congregatory species.

A second KBA is in the lower Nam Ou from above Meuang Ngoy to Pak Ou because the critically endangered Siamese Giant Barb (*Catlocarpio siamensis*) is found there. Villagers attending the 2017 provincial validation workshops confirmed its presence in the area.

Non-Timber Forest Products (NTFP) in the Nam Ou

Box 15

**Non-Timber Forest Products (NTFP) in the
Nam Ou Basin**

The collection of NTFP is an important livelihood activity for all villagers living in the Nam Ou Basin, whether it is for food for home consumption or sale, or as medicinal plants. Many species have high commercial value and are sold for cash income.

NTFP species were reported as being collected in many areas of the Nam Ou River Basin; these are listed in order of widespread use:

Most widespread

- Galangal (*Alpinia galanga*)
- Bamboo shoots (*Bambusa* spp.)
- Fern (*Diplazium esculentum*)
- Cardamom (*Amomum krervanh*) (not in lowest area)
- Centella (*Centella asiatica*) (not in highest area)

Common

- Paper mulberry (*Brousonetia papyrifera*)
- Broom grass (*Thysanolaena maxima*)
- Acacia (*Acacia* spp.)
- Amorphophallus (*Amorphophallus rhizomatosus*)
- Elephant’s ear fig tree (*Ficus auriculata*)
- Melientha (*Melientha suavis*)

Several tree species are used by villagers mostly for house-construction purposes. Two tree species are used throughout the Nam Ou Basin: *Duabanga grandiflora* (Maiten) and *Toona sureni* (Mai ngom). Two species are found throughout the basin except in the north: Grape myrtles (*Lagerstroemia* spp.) (Mai yen) and *Mechelia* (*Paramechelia baillonii*) (Mai sai). Two are mainly found in the middle sections of the basin: Beechwood (*Gmelina arborea*) (Mai so) and Island longan (*Pometia pinnata*) (Mai kha). Four have a less even distribution: Leichhardt tree (*Nauclea orientalis*) (Mai kan luang) is found mainly in the north, Fijian longan (*Pometia eximia*) (Mai kuang leng) and *Protium serratum* (Mai mak faen) in the middle reaches, and *Schima wallichii* (Mai ta lo) mainly in the south.

National Protected Areas (NPA) in the Nam Ou Basin

Box 16

National Protected Areas

With 222,000 ha, Phou Den Din covers about 8.6% of the Nam Ou Basin and is the oldest NPA. Phou Den Din represents about 1% of Lao PDR's total land area and about 6.4% of all 23 NPA in the country.

According to Berkmüller and Southammakoth (1995), Phou Den Din has the following characteristics:

- A mid-ranking NPA in terms of biological importance. Although being the only NPA in biogeographic sub-unit 10c, surveys of birds and herptiles to date suggest it is not particularly distinct from other northern Lao sites.
- Three bird species are not recorded from any other National Biodiversity Conservation Area (NBCA,) but none of them are key species.
- Elephants (*Elephas maximus*), gibbons (including *Nomascus leucogenys*), and a high density of Lesser Fish-eagles (*Ichthyophaga humilis*) live in the area.
- High densities of deer, otter, and water-monitor tracks around the Nam Ou, upstream of the Nam Khang, suggest that this area is little affected by hunting, almost certainly due to its difficulty of access. The extent of disturbance in the other remaining block of old forest, near the Vietnamese border, is unknown.
- Reports of several species of large mammals; more extensive surveys may well yield appreciable numbers of additional species (Berkmüller and Southammakoth 1995).

In 2013, a second NPA was created in Oudomxay Province by upgrading the Phou Hippi conservation area (MONRE, 2016), covering 87,000 ha in the area on the east bank of the Nam Kor. The Nam Kat, a tributary of the Nam Kor, flows through the center of this new NPA. It contains a mixture of pristine old-growth forest with giant dipterocarps (nyang oil tree), limestone outcrops, and mountains surrounding the eastern side of Oudomxay town.

Immediately adjacent to Phou Den Din but outside of the Nam Ou Basin is the Muong Nhe National Nature Reserve in Vietnam, covering nearly 300,000 ha. It has 47,400 ha of forest (mostly evergreen and bamboo), 204,200 ha of grassland, and 44,000 ha of shifting cultivation and scrub.

There is one Vietnamese NPA lying within the Nam Ou Basin: Muong Phang. It is an ecological and historical protected area known for being the location of General Vo Nguyen Giap's headquarters during the Dien Bien Phu campaign against the French in 1954. Lying at around 1,000 masl, Muong Phang covers an area of 92 km² mainly comprising forests with centuries-old trees. It surrounds the Pha Khoang Lake with two hydropower plants, Thac Bay and Na Loi.

People of the Nam Ou Basin

Administration

The Nam Ou Basin is located within the boundaries of three provinces – Phongsaly, Oudomxay, and Luang Prabang – but not all of their areas fall within the hydrological boundaries of the Nam Ou Basin. There are 17 districts within the basin: seven in Phongsaly, six in Oudomxay, and four in Luang Prabang. All districts and nearly all villages in Phongsaly are in the Nam Ou Basin. The mainstream Nam Ou and territories within the 5-km corridor of the river lie within Phongsaly and Luang Prabang provinces; only tributaries of the Nam Ou are in Oudomxay Province.

Population

In 2015, the total population of the three provinces was **885,200**, with an estimated **404,094** people (45.7%) living within the watershed boundaries of the Nam Ou Basin (Table 5). About 96% of Phongsaly's population live in the basin, but only one-third

of Oudomxay and Luang Prabang residents live in the basin. Compared to the other two provinces, Luang Prabang has the largest population but a majority of its residents live in urban areas. Over the last decade, population density has increased in all three provinces: Oudomxay recorded the biggest change with its population density rising from 17.3 persons/km² in 2005 to 20.0 persons/km² in 2015, while Phongsaly was the lowest (Figure 7).

Between 2005 and 2015, the population growth rate in the three provinces of the Nam Ou Basin has been uneven. Almost three-quarters of the people live in rural areas of the provinces; most of them engage in subsistence agricultural activities and depend heavily on natural resources for their livelihoods. A high percentage of the rural population does not have road access. In Phongsaly, for example, over 21% of the population live in rural areas without roads.

From the Agricultural Census (2011), over a quarter of farming households live within a 5-km corridor of the mainstream Nam Ou and the Nam Phak. Results of the 2016 household survey indicated that most households (around 96%) within 5 km of the Nam Ou are headed by men.

Table 5

The Nam Ou Basin demographics (based on the availability of data from the Population and Housing Census 2015) – Phongsaly, Oudomxay, and Luang Prabang; number inside basin by district and total number outside the Nam Ou Basin.

	Number of Households	Household Size	Total Population	Population Inside Basin (est.) ¹	% of Total Population
Phongsaly	33,800	5.1	171,400	163,858	95.6%
Oudomxay	55,200	5.4	295,800	101,459	34.3%
Luang Prabang	80,900	5.2	418,000	138,776	33.2%
Total	169,900	5.2	885,200	404,094	45.7%

¹ The number of population within the basin is estimated based on Data of the Agricultural Census 2010/11, however in terms of distribution.

Ethnic Groups/Ethnicity

The 2005 population census shows that residents of the Nam Ou Basin are ethnically diverse. In Phongsaly, the Akha account for the largest percentage of the provincial population (27%), followed by the Khmu (22%), and the Songsiri (18%). In Oudomxay, the Khmu is the largest (59%), followed by the Hmong (14%) and the Lue (around 10%). The Khmu makes up almost half (47%) of Luang Prabang Province's population, followed by the Lao ethnic group (29%) and the Hmong (16%).

The Akha

The Akha originally settled in the area from Kuaichao and Yunnan, which are part of China today. Akha villages are usually situated on hillsides 600-1,000 masl and have 40 to 50 households per village. Their houses are made of materials from the forest such as bamboo and wood planks. Most Akha villages are located far from rivers. Qualitative information on the Akha suggests that they would be little affected by changes in water-resource availability in the Nam Ou Basin because they mainly practice upland agriculture with little reliance on fishing.

The Lao ethnic group

The Lao ethnic group has been in Lao PDR for hundreds of years. They usually live in lowland areas near river/streams and have followed Theravada Buddhism for centuries. The Lao practice lowland paddy and upland agriculture, growing crops such as vegetables, tobacco, cotton, fruit, and cassava. They also raise buffalo, cattle, pigs, poultry, and dogs. Fish are an important source of food and income for the Lao who fish in rivers, streams, lakes, and other areas. They will be significantly affected by changes in Nam Ou water resources because lowland agriculture, including paddy and riverbank gardening, is highly dependent on water and they rely on fish as a food supply and income source.

The Hmong

The Hmong migrated from the Tibetan region in China into Lao PDR in the mid-19th century. The Hmong practice mainly shifting cultivation, including rice and maize. They are skilled at animal husbandry, raising cattle, buffalos, horses (historically), goats, pigs, dogs, and chickens. Handicrafts form an important part of their livelihoods, including blacksmithing, baskets, jewelry, and embroidery. They fish only occasionally; as a result, changes in water resources in the Nam Ou Basin will affect them less as they mostly practice upland agriculture.

The Khmu

The Khmu are one of the oldest inhabitants in northern Lao PDR. Khmu villages are found near streams in lower mountainous areas, varying in size from 10 to 90 houses. The Khmu practice shifting cultivation, growing crops such as cassava, maize, peanuts, other vegetables, and tobacco. They raise buffalo, goats, pigs, and chickens; they also fish, hunt, catch rodents, and collect NTFP for cash and food. The Khmu are skilled at working with metal and weaving with bamboo and rattan, making baskets, fish traps, and other tools and utensils, which are sold or traded. Qualitative information on the Khmu suggests that they would be significantly affected by changes in Nam Ou water resources because of their reliance on fisheries and belief in the Hom Spirit.

The Singsily

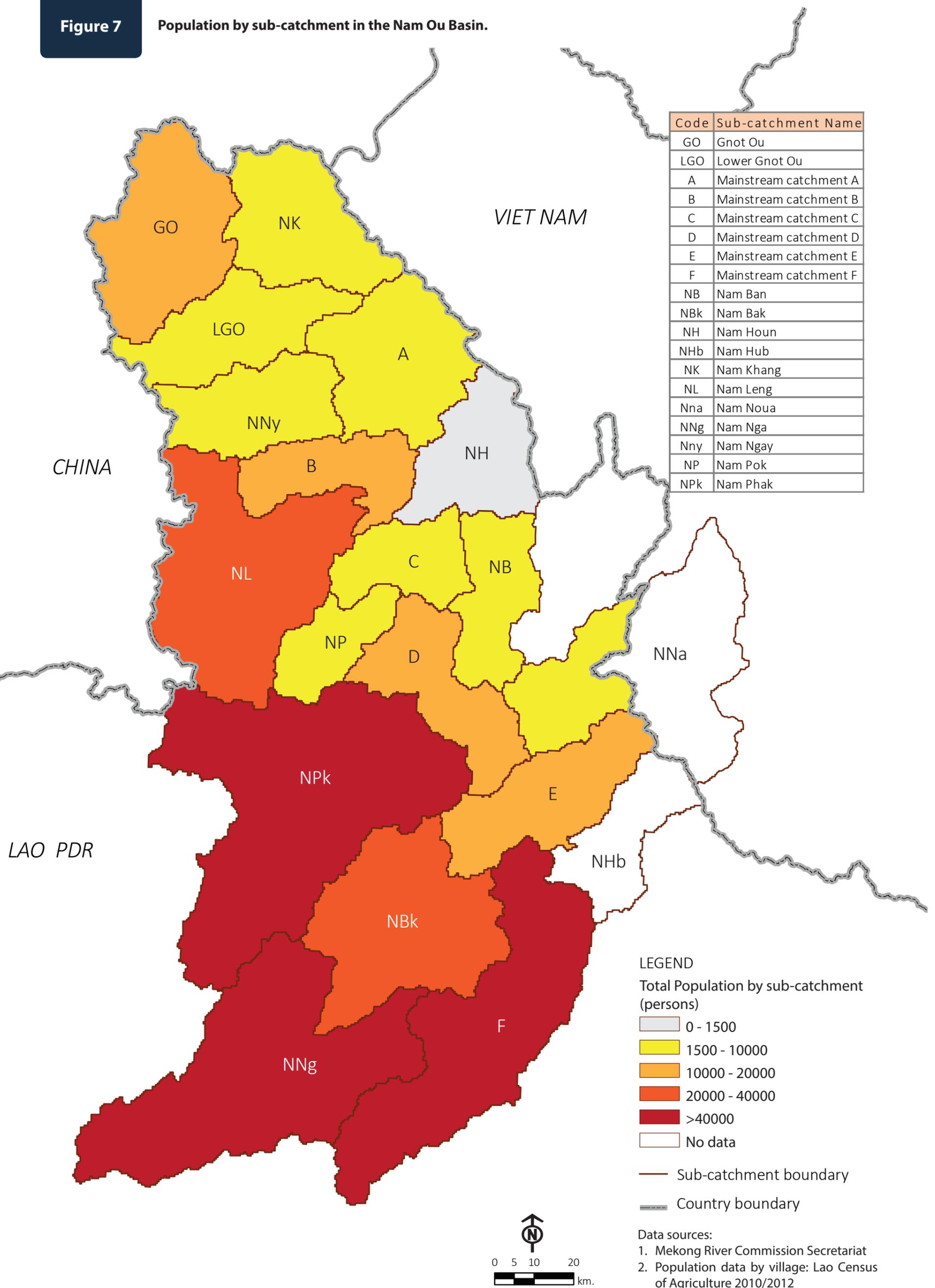
The Singsily have lived in Lao PDR for centuries near streams in mountainous areas 600-1,000 masl. Singsily villages range from 20 to 100 households in size. They grow both dry and wet rice in upland/shifting cultivation areas, with glutinous rice being the most common; other crops include corn, cucumber, sugar cane, cabbage, lettuce, and some tobacco. Chicken, pigs, and buffalos are the livestock often raised. Singsily women are skillful in sewing clothes, while men can make simple tools such as knives, axes, machetes, and crossbows. They also weave baskets, fish traps, and storage baskets. Singsily households would be significantly affected by changes in Nam Ou water resources as their villages are located close to streams/rivers and they believe water spirits influence the results of harvests.

The Lue

The Lue originally came from China's Guangdong Province. Their villages are located at altitudes 150-400 masl near rivers/streams. They grow mostly glutinous rice as a staple food and other crops such as corn, tobacco, cotton, fruits, and vegetables. They raise buffalo, pigs, and poultry. They work with silver, weave baskets, and make sarongs, handbags, and other handicrafts. If there are changes in Nam Ou water resources, the Lue would be affected because of their dependence on rivers/streams for farming.

Figure 7

Population by sub-catchment in the Nam Ou Basin.





Remy Rossi © 2016

Baseline vulnerability

Life expectancy is higher for women than men in all provinces of the Nam Ou Basin. Phongsaly has the highest life expectancy, followed by Luang Prabang, for both sexes despite having the lowest percentage of population with access to health services; only 5.3% of its population has access to a licensed pharmacy. More than half of the population in the three provinces have access to midwives and health volunteers.

Overall, less than 5% of the total sampled heads of households are females. Women aged between 15 and 49 in Phongsaly and Oudomxay give birth to nearly four children on average, while women in the same age group in Luang Prabang give birth to just over 3 children.

Literacy rates for women are lower than men in all three provinces. In Phongsaly, less than half of its population is literate, with a literacy rate of 53% for men and 34% for women; in Oudomxay, 73% of men and 40% of women are literate; the figures are 80% for men and 55% for women in Luang Prabang (National Statistics Center 2007).

A low percentage of the Nam Ou Basin's population has completed secondary education or higher. If people's livelihoods in these provinces are affected by changes in access to natural resources, less than 13% of Luang Prabang's population may be able to find better opportunities elsewhere and less than 7% in Phongsaly and 9% in Oudomxay can do so.

Water resources, such as fish, other aquatic animals and plants, and riverbank gardens, are an important part of people's nutrition in the Nam Ou Basin. A food security study found that wild meat and aquatic resources, especially wild fish, were the biggest source of animal protein in rural parts of the country (World Food Programme, 2007). The 2016 household survey within the 5-km corridor of the Nam Ou and the Nam Phak showed that the value of water resources, including irrigated rice, fish, and other aquatic animals, makes up 15-28% of the total monetary value of daily consumption. Changes in water resources will directly affect the nutrition of people in the basin. Fish have been the basis of subsistence livelihoods for rural people in the country and will remain important in the years to come.

Dependency ratio is defined as the number of individuals aged below 15 or above 64, divided by the number of individuals aged 15 to 64, expressed as a percentage. The higher the dependency ratio, the more difficult it is for a household to adapt to changes that may be required by a decline in livelihood resources. Phongsaly and Oudomxay share the same, high dependency ratio of 0.8. This means that people in Oudomxay would be more vulnerable to negative changes because they are poorer and have more unproductive household members to feed compared to people in the other two provinces.

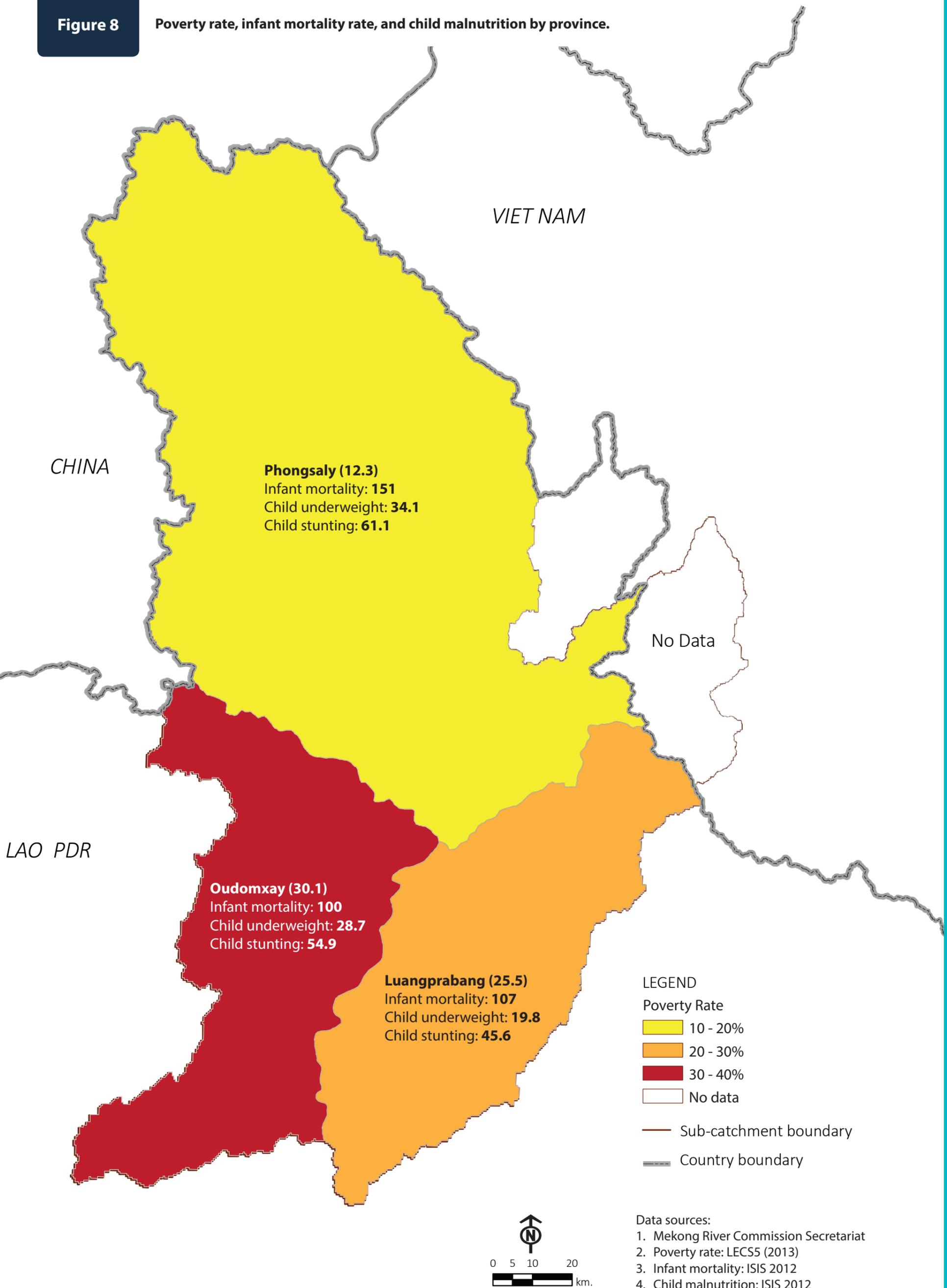
Poverty in rural areas is caused by factors such as limited opportunities for skill development, lack of investment in the area, a high dependence on rain-fed farming, the collection of NTFP, and fisheries, which are highly seasonal. Communities are therefore vulnerable to any changes in livelihoods or access to natural resources. Vulnerability in this context is not fixed, but highly dynamic. Poverty distribution in the Nam Ou Basin shows that the poorest province is not the remotest; Phongsaly, a mountainous province, has the highest percentage of population employed in the agricultural sector, but the other two provinces with larger urban centers – Meuang Xay and Luang Prabang – are in fact poorer (Figure 8).

More than half (53.9%), of the villages surveyed in Phongsaly had access to electricity. Although access is much higher in Oudomxay (74%) and Luang Prabang (71%), the electrification rate in these provinces is among the lowest in the country. However, LECS4 data indicate that the percentage of villages with electricity has increased between the LECS 2002/03 and 2007/08 surveys. In the northern provinces, including three in the Nam Ou Basin, access to electricity increased from 22% to 51% over this period.

The percentage of people living in villages with piped water supply is low in all three Nam Ou Basin provinces, ranging from under 15% in Phongsaly to just over 25% in Luang Prabang. Within the 5-km corridor in 2016, most households (93%) obtained water from piped water sources, often connected from small streams running from hills or mountains near the villages. Less than 7% of Phongsaly's population has access to markets, while the figures are 13% in Luang Prabang and 11% in Oudomxay.

Figure 8

Poverty rate, infant mortality rate, and child malnutrition by province.



Livelihoods

Key Livelihood Activities of Nam Ou Basin Residents

Households in the three provinces of the Nam Ou Basin undertake different livelihood activities around the year, including paddy cultivation, upland cultivation of rice and other crops, fishing, collection of OAA and plants, riverbank gardening, raising livestock, hunting, collection of NTFP, and planting of industrial trees such as teak (Table 6). Households interviewed in 2016 said their most important livelihood activities include, but are not limited to, those pertaining to rice cultivation and livestock. Fishing is also important, particularly during the dry season and the onset of the wet season.

Close to 93% of the working-age population in Phongsaly is self-employed in owner-operated farms. In Oudomxay, the percentage is just 73.2%, while Luang Prabang was lowest (66.9%). This means Phongsaly would be most affected if significant changes occur in its farming systems or access to local resources.

Results of the 2016 Household Survey indicate that a substantial proportion of the working-age population in the 5-km corridor of the Nam Ou engage in rice cultivation in upland (45%) and paddy (26%) areas as their main livelihood activity. The high percentage of people undertaking upland rice cultivation as their main livelihood activity is partly because only 2.2% of the basin is flat and the rest of the area has steep slopes.

The 2016 survey results show that over 70% of all respondents said their household members went fishing within the past year. Fisheries are important to the local subsistence economy for many communities along the Nam Ou as fish can both be eaten and traded/sold. Several previous studies conducted in Lao PDR and the Lower Mekong Basin have clearly demonstrated that fish are a critical source of food and protein for local communities throughout the country. This is also true for residents of the Nam Ou Basin.

Table 6

Main livelihood activity of working-age population by zone in the Nam Ou Basin.

Livelihood	Zone				
	1	2	3	4	5
Not working	0.8%	2.3%	1.8%	1.2%	1.3%
Paddy	43.9%	0.2%	20.0%	21.2%	37.3%
Fishing	0.3%	0.6%	0.2%	0.3%	0.0%
Temporary worker	0.2%	0.7%	2.3%	3.6%	0.4%
Permanent employee	1.8%	1.4%	4.5%	8.0%	4.4%
Students/pupil	7.7%	10.9%	10.6%	10.3%	13.9%
Business/Trading	1.1%	2.5%	3.9%	7.4%	4.1%
Housewife	3.3%	1.1%	1.5%	1.3%	0.8%
Other	0.0%	1.9%	0.4%	0.4%	0.3%
Upland rice	37.9%	70.9%	46.5%	40.2%	35.2%
Other crops (not rice)	1.9%	6.6%	5.9%	4.4%	1.6%
Livestock	1.1%	0.7%	2.2%	1.5%	0.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Agriculture

Only around 40% of villages within the 5-km corridor of the Nam Ou ranked upland rice as the most important livelihood activity, according to the 2016 Household Survey. Close to 30% of people living in the 5-km corridor do not have enough rice to eat throughout the year and experience shortages for about five months a year.

Few households in the Nam Ou Basin have land suitable for cultivation of dry-season paddy or second crops; only nine households out of 1,499 sampled said they grew a second rice crop (naxeng) in irrigated paddy within a year before the survey.

Non-rice crops grown by Nam Ou villages include: maize, starchy roots, peanut, soybean, vegetables, mung bean, tobacco, cotton, sugarcane, coffee, and tea. According to the Lao Statistical Bureau (2015a), productivity in Phongsaly is lowest among the three provinces for most crops, except for maize, sugarcane, and coffee. Riverbank gardens are an important source of household food and

income in the Nam Ou Basin. One-third (33.2%) of the total sampled households along the 5-km corridor said they grew vegetables in riverbank gardens within a year before the survey.

Livestock

Livestock, especially buffalo and cows, are an important livelihood asset that enhances household capacity to withstand or recover from shock. Experience in Lao PDR shows that losing livestock has the most serious impact on long-term livelihoods and household security. The sale of livestock is an important source of funds when a disaster strikes or medical emergency arises. In rural areas of the country, the income from the sale of a buffalo can provide enough cash to buy rice for four to five household members for an entire year (World Food Programme, 2001). Livestock is therefore ranked by some villages for case studies as one of the most important livelihood activities.

Fisheries

Over 70% of the sampled households in the 5-km corridor indicated that they went fishing in the Nam Ou or one of its tributaries within a year before the survey. Over 90% of households in Zone 1 were engaged in fishing, and nearly 80% of households in Zones 2 and 3 did the same. Almost two-thirds (64.4%) of sampled households said they collected OAA; in Zone 1, over 90% of households collected OAA, and households headed by women noted that OAA collection was a more common activity for them compared to fishing.

The amount of fish and OAA captured increases as one moves from north to south along the Nam Ou; the total population also increases the further along downstream. The number of fishing households within the 15-km corridor of the Nam Ou Basin is higher in Phongsaly than Luang Prabang (Table 7).

Table 7 Number of fishing households in the Nam Ou Basin.

	0-5km	5-10km	10-15km	Total
Oudomxay			1	1
Nga			1	1
Phongsaly	5,352	2,676	84	8,112
Boun-tai	43	89	3	135
Gnot-ou	2,641	983	12	3,636
Khoa	704	263	12	979
Mai	249	261	18	528
Phongsaly	679	319	25	1,023
Samphan	1,036	761	13	1,810
Boun-neua			1	1
Luang Prabang	5,340	1,341	47	6,728
Nambak	465	686	32	1,183
Ngoy	2,751	222	9	2,982
Pak-ou	2,100	265	2	2,367
Phonthong	24	168	4	196
Total	10,692	4,017	132	14,841

Importance of Nam Ou Water Resources to Local Livelihoods

Water resources play an important role in food consumption. Results of the 2016 Household Survey show that on average, 20.6% of the total food consumption value is derived from aquatic items, including irrigated rice, fish, and OAA. The share of consumption value from water resources can be as high as 28% in Zone 1; this does not include vegetables from riverbank gardens due to difficulties in separating sources of vegetables in the survey, and the results presented are therefore conservative. Overall contribution of water resources to cash income in villages in the basin is about 7% overall but much higher in specific zones (for example, over 24% in Zone 5 and 13% in Zone 3).

Changes in livelihood activities

Information obtained through FGD and household surveys conducted in 2016 suggests that fish catches have declined on the Nam Ou in recent years. In the eight villages selected for case studies, women and children who used to catch small fish and collect OAA and plants can no longer do so; this is the result of the hydropower developments and creation of reservoirs with steep slopes in the natural river.

Villagers said the number of fish species collected has also declined. For example, villagers of Ban Phoumeuang (near Nam Ou 6) identified 41 fish species that they used to catch in the Nam Ou; following their move to the new resettlement village of Ban Homsang, they report that they are only catching nine fish species in the reservoir, two of which are exotic – Tilapia (*Oreochromis niloticus*) and Common Carp (*Cyprinus carpio*). The experience of other areas of Lao PDR and Southeast Asia show that species diversity is reduced with the inundation of a reservoir; migratory fish species and rhithron resident species move away, allowing generalist and exotic species to take their place. If there is insufficient suitable habitat remaining, these species are likely to die out. It is, however, possible that the villagers of Ban Phoumeuang have not yet adapted to alternative fish-capture methods required in a deep, steep-sided reservoir.

In some of the case-study villages, villagers from Ban Pak Ou, Sop Kong, and Phou Meaung said they could no longer collect river weed following the construction of hydropower dams.

People in the Nam Ou Basin focus on upland rice as their main livelihood, and this has changed little over time. Only 68 of 1,500 households surveyed in 2016 reported a change in their livelihood activity in the last five years; many of them live in Zone 3, where hydropower developments have taken place.

A significant proportion of the people living along the Nam Ou and its main tributaries would be highly vulnerable to negative changes in water resources availability or access because of their reliance on fisheries and riverbank gardens. Overall, resilience capacity is low.



“ How dams are built and managed will be vital for the people who rely on the Nam Ou. A sustainable economic growth model for the river, with integrated and inclusive management, can minimize the potential negative impact on the economy and local communities. It will also contribute to long-term development and sustainable growth in the region. ”

Ounheuan Saiyasith, a native to the Nam Ou Basin and Senior Program Officer (Water Resources) for the Australian Aid Program

4.0

WATER RESOURCE USE & MANAGEMENT CHALLENGES



Agriculture, Land use, Irrigation, & Livestock

The Nam Ou Basin has 112,409 ha of agricultural land and 34,249 ha of non-agricultural land, representing 4.6% and 1.4% of its total land area, respectively. The amount of agricultural land in each province increases with passage downstream, from 2.8% in Phongsaly to 6.2% in Oudomxay and 17.7% in Luang Prabang.

Cereal cultivation in the basin has been divided into four main crops: lowland rice, upland rice, sweetcorn, and Job's tears (Poaceae). In the wet season, there are nearly 19,000 ha of lowland paddy rice (rain-fed and irrigated), 29,000 ha of upland rice, 4,500 ha of sweet corn, and 1,000 ha of Job's tears. In the dry season, there are only 1,460 ha of irrigated rice and small areas of other cereals cultivated.

In recent years, there has been a marked expansion in crop production during the dry season, with a total of 4,621 ha being cultivated in Phongsaly in 2016. The main fruits cultivated in the basin are longan (368 ha), mangos (205 ha), custard apple (184 ha), and lychee (171 ha). Banana plantations have rapidly developed for export to the Chinese market, especially in Phongsaly and northern parts of Oudomxay; hillsides of banana plantations are becoming a characteristic feature of the agricultural landscape in some parts.

In 2010, there were 16,020 ha of rubber plantations in the river basin, of which 10,394 ha (65%) were in Phongsaly. Five districts in Phongsaly have similar areas of rubber plantations ranging from 1,300 to 2,700 ha, but Mai and Samphan Districts have much smaller areas of rubber. The 2010 Agricultural Census showed that 462 ha of tobacco was cultivated in the wet season, with 60% in Luang Prabang and 30% in Oudomxay.

Only 110 ha of coffee were cultivated as of 2010, with under 50% in Phongsaly and about 40% in Luang Prabang. However, recent (2016) newspaper articles have indicated that concession agreements with a Chinese company will develop up to 3,000 ha of coffee plantations in Phongsaly. The province has long been known as a tea-growing area: 1,227 out of 1,928 ha of tea plantations were in Phongsaly District, according to data from the 2010 census. The total area of tea in the Nam Ou Basin is 2,026 ha, with Oudomxay and Luang Prabang having about 50 ha each.

According to the MRC Irrigation Database (2009), there are 178 existing irrigation schemes in the Nam Ou, of which 57 are fully operational, 98 are partially operational, and 14 are not operational. A total of nine schemes planned for construction between 2009 and 2016 have been included, of which eight are in the Nam Phak and one in the Nam Nga. These schemes provide irrigation for a total of 7,440 ha, including 3,416 ha during the dry season.

There are 492 planned irrigation schemes in the Nam Ou Basin covering a total of 20,031 ha with 5,675 ha for dry-season irrigation. The schemes will have an average size of 63.7 ha, with the smallest one at 30 ha and the biggest at 400 ha. Together, they will irrigate a total of 11,998 ha including 6,996 ha in the dry season throughout the Nam Ou Basin. These figures roughly double the 6,339 ha of total irrigated areas and 3,347 ha of dry-season areas presented in the MRC irrigation database (2009).

There are over 39,000 cattle, 37,000 buffalo, and 121,000 pigs in the Nam Ou Basin, with a smaller number of goats and sheep. The proportion of buffalo (18,000) to cattle (13,000) is higher in Phongsaly, but there are more cattle than buffalo in Oudomxay and Luang Prabang. Animal densities strongly correlate with human densities and are highest in areas with the most agricultural activities, especially in and around irrigation systems.

When these animal numbers are converted into Tropical Livestock Units (TLU) (1 cow=250 kg=1 TLU; 1 buffalo=2 TLU; 1 pig=0.2 TLU; 1 goat/sheep=0.1 TLU), there are 135,795 TLUs in the Nam Ou Basin with a density of 5.52 TLUs per square kilometer. This is much lower than the average for Southeast Asia, which has a density of 17.7 TLU per square kilometer (Peden, et al. 2007). Every year, some 1.276 million cubic meters are required as drinking water for the livestock to keep them alive without weight loss, and some 60.7 million cubic meters are required for fodder production (Peden, et al. 2007).

Aquaculture & Fisheries

In the Nam Ou Basin, there are 54,748 households participating in the capture fishery and 5,496 households engaged in aquaculture, usually fish ponds (Agricultural Census 2010). In Mai, Khoa, and Xai Districts, around 11 to 16% of households are engaged in aquaculture.

According to 2016 provincial data, there are 2,324 households engaged in aquaculture in Luang Prabang, roughly double the number of households recorded since 2009. Each household usually has one pond with an average size of 0.2 ha.

Most agricultural households also participate in the capture fishery. In Pak Ou, 66% of agricultural households engage in the capture fishery. In Nam Ou mainstream districts, over 90% of households are engaged in fishing, with the highest number in Gnot Ou (97%), Samphan (92%), and Khoa (99%); further downstream, the percentage of households engaged in fishing is lower (71% in Ngoy and 66% in Pak Ou). The districts furthest away from the Nam Ou mainstream have the lowest proportion of households going fishing, including Nam Bak (49%), Xai (52%), Phongsaly (57%), and La (66%).

Assuming that each agricultural household goes fishing about three times a week, the total fish catch in the Nam Ou Basin is estimated at around 42,500 tons per year (ranging from 21,000-64,000 tons per year), of which 18,600 tons are caught in Phongsaly, 10,200 tons are captured in Oudomxay, and 13,600 tons are caught in Luang Prabang.

Energy Sector / Hydropower Development

The Nam Ou has one of the highest potential for hydropower development among the tributaries in the Lower Mekong Basin. Three of Sinohydro Corporation's seven hydropower plants – Nam Ou 2, 5, and 6 – have been constructed in the cascade on the Nam Ou mainstream. Before these were built, there were six small hydropower plants in the Nam Ou Basin:

- Nam Kor hydropower plant – 1.5 MW; built in 1996 on a tributary of the Nam Phak.
- Nam Ngay hydropower plant – 1.2 MW; built in 2002 but has now been submerged with the filling of the Nam Ou 6 reservoir.
- Nam Ou 9 – 454 kW; funded by the government of Japan and came into operation in 2013 on the Nam Ou above Gnot-Ou.
- Nam Boun – 110 kW in M. Boun Neua, Phongsaly; came into operation in 1997
- Nam Ngam – 110 kW in M. Mai, Phongsaly; funded by Japan's New Energy and Industrial Technology Development Organization in 2010; undergoing improvement
- Nam Mong – 70 kW in M. Nam Bak, Luang Prabang; operated by EDL.

There are two hydropower plants in Vietnam in the headwaters of the Nam Noua:

- Na Loi hydropower plant – 9.3 MW; completed in 2003 on the Pa Khoang Lake.
- Thac Bay hydropower plant – 2.4 MW; completed in 1984 and repaired and upgraded in 2002.

The total installed capacity of the Nam Ou cascade will be 1,272 MW, generating 5,044 gigawatt hours per year (Table 8). Each hydropower plant will operate for an average of 10.8 to 11.2 hours per day. The top dam in the cascade (Nam Ou 7) is the main regulating dam, storing water (1,060 Mm³) during the wet season for release in the dry season. Nam Ou 6 and 5 have smaller regulating capacities of 246 Mm³ and 142 Mm³, respectively, while the lowest four dams (Nam Ou 1-4) have very little regulating or storage capacity and essentially act as run-of-river plants. They each have about 2 m draw-down, which enables them to balance daily power-generation schedules.

For most of the cascades, the reservoirs back up almost to the foot of the dam above, apart from the headwaters of the Nam Ou 2 reservoir to the Nam Ou 3 dam where there is about 30 km of free-flowing river, and the headwaters of the Nam Ou 3 reservoir to the Nam Ou 4 dam where there is 15 km of free-flowing river. Therefore, most of the mainstem Nam Ou will be transformed into a series of reservoirs through the construction of these projects.

A total of 64 villages have been affected by the three dams, with 804 households being resettled from 22 of these villages. Roughly 509 ha of land have been acquired for dam construction and 5,189 ha of land have been inundated.

Table 8 Specifications for the 7 Sinohydro hydropower projects in the Nam Ou Basin.

Nam Ou Hydropower Project	1	2	3	4	5	6	7	Total
Distance from Mekong (km)	18	53	112	171	215	283	327	392
Distance from d/s dam (km)	–	35	68	59	44	53	47	–
Reservoir length (km)	35.4	67.3	59.7	45.1	53.2	46.9	65.3 ¹	373
Reservoir area (km ²)	9.6	15.7	13.3	9.4	17.2	17.0	38.2	120
Area of stream channel inundated (km ²)	7.1	13.5	8.6	4.2	4.1	3.5	5.4	46.4
Regulating storage capacity (Mm ³)	22	25	24	16	142	246	1,060	1,536
Installed capacity (MW)	180	120	210	132	240	180	210	1,272
Annual output GWh	710	448	826	519	977	726	838	5,044

¹ Reservoir length on the Nam Ou, main arm. The reservoir will also extend for 44.4 km along the Nam Khang (Sources: Sinohydro 2016, ESL 2010, CIA of Nam Ou cascade) Profile document source: 2 tables in Profile (Tables 6-22 & 6-23).

Other Industrial Sectors

Of all the river basins in Lao PDR, the Nam Ou Basin has among the lowest number of industries. In 2013, the Asian Development Bank Core Environment Program carried out a study of industrial pollution in the country (ADB Core Environment Program, 2013). Most of the industries are in Oudomxay, especially in Meuang Xai; industries in Luang Prabang Province are concentrated in the urban areas and not in the Nam Ou Basin.

Riverine sand and gravel dredging in the basin occurs in many locations. A total of 22 sand extraction licenses have been granted: 14 on the Nam Kor, four on the Nam Muan, three on the Nam Phak, and one on the Nam Ngao – together, they extract 13,823 tons of sand per day. Sand and gravel extraction is usually a dry-season activity, when the flows and river levels are lower and the sediment transport is reduced.

Artisanal gold mining occurs in many villages and is usually conducted by women and children. Impacts from these small local operations are likely minimal and restricted to small areas. However, in the middle sections of the river, there are large gold mining operations, which may significantly affect water quality and fisheries habitats (i.e., pools and riverbed).

Navigation & Tourism

River transport on the Nam Ou has historically been very important. Boats move people and goods up and down the full length of the mainstem, bringing them to villages and towns that would have been difficult to access by land. Most parts of the river are navigable, except in some areas where rapids restrict movements of smaller vessels, especially during the dry season. Boats can carry up to 2,000 kg of people and cargo when river conditions are ideal (and 500 kg per boat in the dry season). The connectivity of the river enabled trade and socialization between different villages and ethnic groups in the basin.

The construction of the Nam Ou dams 2, 5, and 6 has dislocated some of the boat routes. To address the issue, boat landings were built on the reservoirs above the dam wall. Villagers now have to portage around the dam sites, using local roads. To some extent, the reservoirs have made navigation easier and safer compared to the river, which was sometimes difficult to navigate, especially at low water levels. However, the dams are expected to pose significant and negative impacts on trade and overall vessel movement between communities.

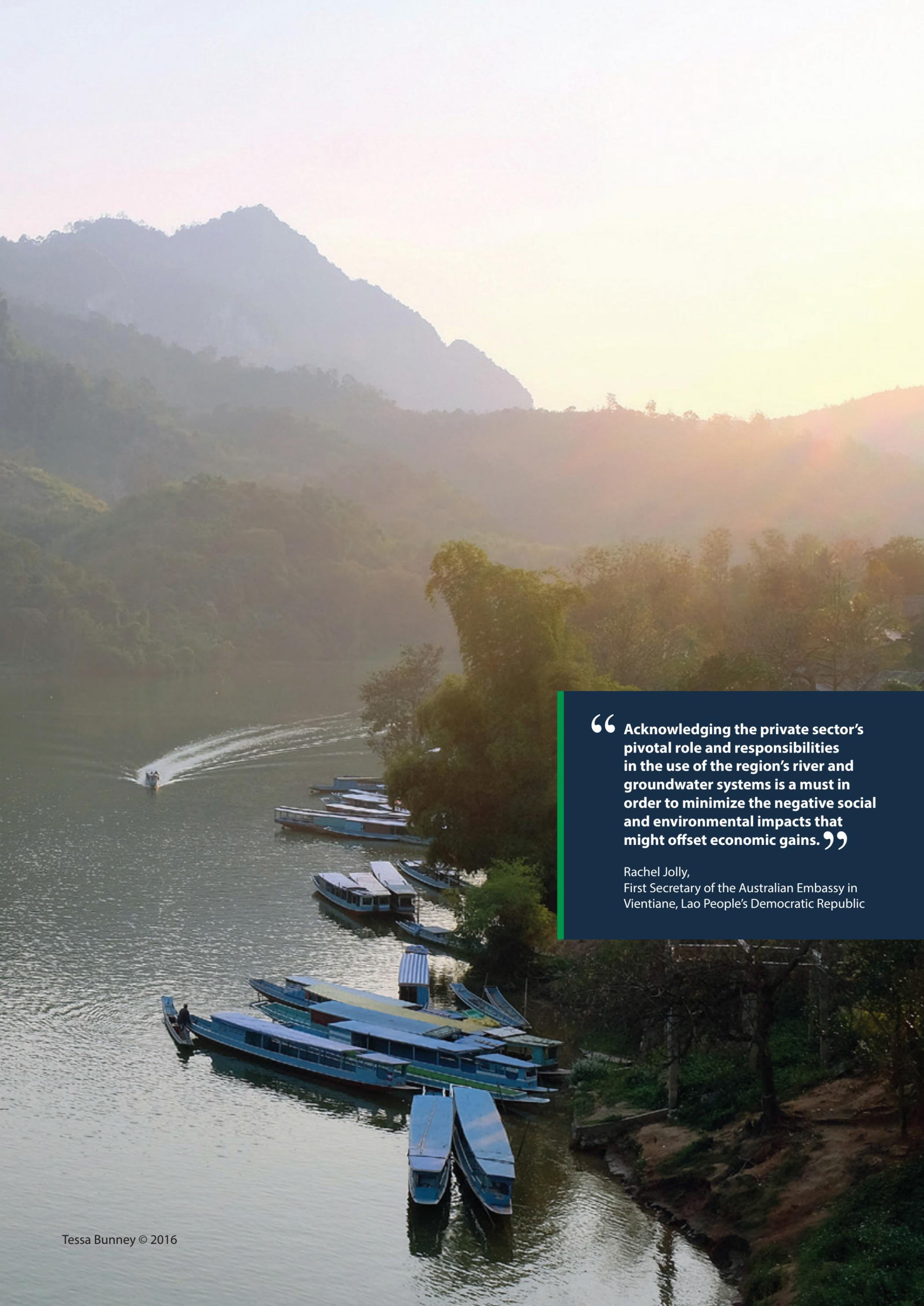
Tourism is an important economic sector in the Nam Ou Basin, especially in the lower reaches of the river between Meuang Ngoy through Nong Khiaw to Pak Ou. These include the areas with dramatic limestone-karst landscape, caves, and river transport to the Mekong. In 2015, there were 13,541 domestic visitors and 38,863 foreign tourists visiting the Nam Ou according to data presented at the Luang Prabang provincial validation workshop. Tourism also depends on boat transport on the river, especially from Meuang Khoa to Nong Khiaw and Pak Ou. The construction of Nam Ou 3 and 4 within the main tourist area will likely have a significant impact on tourism.

Urban & Rural Water Supply

Urban areas in the Nam Ou Basin are relatively small. The largest is the provincial capital of Oudomxay, which has a population of around 25,000 people, followed by Phongsaly provincial capital. The district headquarters have smaller populations of under 5,000 people. Total urban water usage in the Nam Ou Basin, including Vietnam, is likely to be in the range of 12,000-19,000 m³/day. In Vietnam, the town of Dien Bien Phu has an estimated population of 100,000 people, making it the largest urban area in the basin.

There are many rural water supply schemes. In M. Pak Ou, 50 villages are supplied with water, five of which come from springs and the rest from streams and rivers; a total of 27,634 people are served by these schemes. Eight schemes have problems with the water source drying up and not producing sufficient quantity, while the water is too hard for two of these schemes.



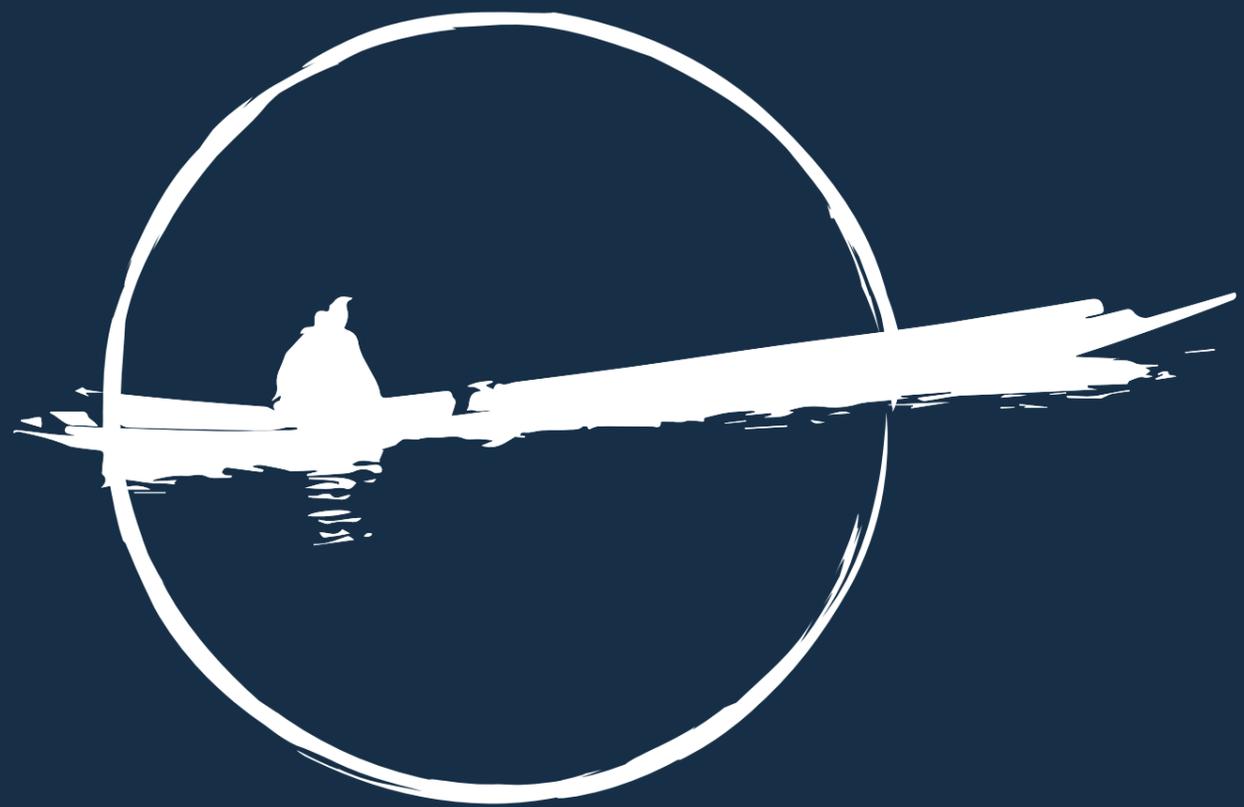


“ Acknowledging the private sector’s pivotal role and responsibilities in the use of the region’s river and groundwater systems is a must in order to minimize the negative social and environmental impacts that might offset economic gains. ”

Rachel Jolly,
First Secretary of the Australian Embassy in
Vientiane, Lao People’s Democratic Republic

5.0

THE FUTURE OF THE NAM OU BASIN



5.1

CHANGES IN WATER FLOW PATTERNS

Flow patterns in the Nam Ou experienced significant changes in 2015 mainly because three of the dams in the cascade (Nam Ou 2, 5, and 6) were constructed and the associated reservoirs filled. This resulted in very low water levels downstream. After the dams became operational in April 2016, flow patterns throughout the basin became more regular, with increased flows in most of the dry season and slightly reduced peaks in the wet season. Construction of the other four dams in the cascade (Nam Ou 1, 3, 4, and 7) is expected to be completed by the end of 2020.

During the dry season, the outflows will increase by more than 20% compared to the baseline flows in January, rising to 73% in April. By contrast, the outflows are 13% lower than the baseline flows in June and July; they return to the baseline level or above from October to December.

Flow patterns also change daily among all seven dams as the plants are operated for 10 to 12 hours a day. During the night, the plants will only release minimum flows; the turbines will be brought up to full flow in the morning with peaking operation. Ramping rates, or actual changes in flow over time, can have significant environmental impacts on aquatic biota and ecosystem health. For example, excessively fast ramping of flow rates can result in fish stranding or isolation, leading to a loss of habitats critical for fish; rapidly rising water levels can also pose health and safety issues for local communities living downstream of the dams.

In terms of water availability, the Nam Ou cascade will not affect the flows in the tributaries, where most of the offtakes for irrigation and water supply are located. The potential of irrigation projects in the basin is large: 492 schemes have been proposed, with 20,031 ha of irrigation in the wet season and 5,675 ha in the dry season. This is a significant increase from the current 3,979 ha of irrigated area in the dry season and will require discussions among various stakeholders, including the hydropower developers, on ways to achieve this.

Under baseline conditions, the Nam Ou on average contributes about 16.1% to the flows in the Mekong at Luang Prabang. The monthly contributions vary from 21.6% in July to 11.5% in April. The overall annual flow contribution will remain the same at 16.1% following dam construction, but in the dry season from January to April, the flow contribution will increase from 11-15% to 18-22%; for example, the flow rate for March will rise from 137 m³/sec to 229 m³/sec. In the wet season, the Nam Ou's contribution to Mekong flows would drop from 20.6% to 17.9% in July (from 1,370 m³/sec to 1,136 m³/sec), and from 21% to 19.5% in August (from 1,844 m³/sec to 1,712 m³/sec).

5.2

CHANGES IN LAND USE & SOIL EROSION

The Nam Ou Basin stands out with a very high degree of land cover change of more than 60% (Vo, et al. 2015). These changes in land use have been largely driven by the patterns of upland cultivation and the conversion of shifting-cultivation areas into rubber and banana plantations, especially in the northern parts of the basin in Phongsaly.

Changes in land use often lead to severe soil erosion: degraded forests have more than 10 times the erosion rate of virgin and regrowth forests, and crops like cassava and upland rice also have significantly higher erosion rates. Industrial plantations of rubber and coffee also cause soil erosion, especially in the early stages of establishment.

Since the Nam Ou Basin is characterized by steep and very steep slopes with over 80% of the land having slopes of more than 15 degrees, the potential for erosion with changes in land use is very high. Soil erosion will likely decrease when the rubber plantations mature, as this land has been converted from shifting cultivation and upland rice/corn. In 2010, there were 1,064 km² of shifting cultivation, 94 km² of industrial plantations (mainly rubber), 33,174 ha of upland rice and corn, and 16,020 ha of rubber plantation. Although only 110 ha of coffee were cultivated in 2010, the prospect of an additional 3,000 ha of coffee will potentially increase soil erosion in Phongsaly.

Box 18

Environmental Flows in the Nam Ou

Environmental flows refer to “the quantity, frequency, timing, and quality of water and sediment flows necessary to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems” (amended from The Brisbane Declaration (2007)). Environmental-flow assessments require the collaboration of engineers, lawyers, ecologists, economists, hydrologists, sociologists, resource economists, water planners, politicians, stakeholders, and communicators. Environmental flows are negotiated through a process of data analysis and discussion of the physical, chemical, biological, social, resource-economic, economic, biodiversity, and land-management implications of water-resource developments. Because of their wide reach, environmental flows have become a central component of integrated water resources management (IWRM), which “promotes the coordinated development and management of water, land, and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Global Water Partnership 2010).

Information on minimum flow releases or environmental-flow requirements is not available for the Nam Ou. The timing and volume of water released from the Nam Ou hydropower projects will be determined by the operational requirements to meet power demand; these water releases are expected to vary significantly on a daily and seasonal basis. Changes in flows downstream from the hydropower projects will affect fish habitat by altering channel features as well as geomorphological and biological processes; the flows’ alteration in volume, depth or velocity may result in the fish’s behavioral or physiological needs not being met. This can lead to changes in a fish community’s abundance, age structure, and/or species composition. During periods of high precipitation, water is retained in the reservoir, leading to lower than normal levels of downstream flows; flows will be higher when water is released later. Rapid daily flow fluctuations from hydropower peaking requirements can result in reduced fisheries production in tailwaters and the presence of fewer aquatic plants and benthic invertebrates that are important for fish. Altered flow regimes can reduce a habitat’s abundance and quality for critical life-history stages, impede fish migrations, affect food chains that support fish (for example, algae, benthos, and macrophytes), and change the community structure of fish and other aquatic biota.

The reservoir’s operation can cause chemical and physical changes that may significantly affect water quality downstream. The temperature and DO levels of released waters may vary drastically at different periods of the year; the waters may also contain suspended solids and other compounds such as hydrogen sulfide and ammonia. Sediment deposition will be significantly reduced – this can have positive short-term effects for phytoplankton and some fish and invertebrate species but will generally lower productivity in downstream areas. This could alter the abundance and composition of organisms on which fish feed, including algae, other plant life, and benthic invertebrates. The extent of the impact from reduced sediment deposition will depend on planned sediment releases during dam operation.

Stream benthic invertebrate communities downstream of the hydropower projects will be affected by changes in flow patterns, temperature, substrate-particle size and stability, and water depth; this will likely result in reduced species diversity for a substantial distance downstream of the dam.

Some Nam Ou fish species rely on inundated floodplains for breeding and feeding. Lower flows in the wet season, including reduced peak flow conditions, will prevent several fish species from accessing these floodplains and tributaries downstream of the dam, which are important habitats at critical life stages of these species. Several other species that rely on access to spawning areas upstream of the dams will be eliminated.

The operation of the dams brings more even flows throughout the year compared to the baseline, but other changes include increased dry-season flows, reduced wet-season flows, delayed and lower flood peaks, and diurnal variation in water level of up to 3 m, which will significantly affect the livelihoods of people living downstream of the dams. Key anticipated impacts include changes in navigation patterns and access routes to communities, loss of aquatic resources and riverbank gardens, declines in migratory and resident fish species biodiversity (and replacement with primarily introduced species), and reductions in fish, OAA, and river weed harvests. As a result, several communities have been relocated from the vicinity of the dam construction areas.

5.3

CHANGES IN SEDIMENT TRANSPORT

With the construction of the first three dams on the Nam Ou mainstream, the sediment transported by the river will increase and sediment trapping will rise significantly following the completion of all seven dams (Shrestha 2013). During the construction of the dams, associated roads and other infrastructure, some of the sediment will settle in the river and some will be transported into the Mekong. Similarly, sand mining and alluvial-gold mining in the river also releases considerable quantities of sediment from the banks and riverbed, which increases the sediment load and concentration of suspended solids in the river for many kilometers downstream.

With the completion of the three dams, much of the sediment in the river, especially bed loads (that is, the rocks, stones, and gravel that move down the river during times of high flows), will be trapped in the reservoirs, especially at the top end where the rate of water flow slows down as it enters the reservoirs, forming a delta.

The net effect will be a significant decrease in annual sediment transport rates downstream of Nam Ou 1. However, sediment loads will tend to increase with distance downstream of Nam Ou 1 because of increasing contribution of flows (and sediment) from tributaries and increased entrainment of sediment within the Nam Ou. Seasonal changes to the erosion and sediment transport regime of the Nam Ou could affect the channel morphology and thus have an impact on aquatic ecosystems and fisheries downstream of Nam Ou; for example, scouring may reduce fish habitat during the dry season.

The annual total sediment load of about 140 million tons (Mt) per year in the Mekong comes from two principal areas: the upper basin in China and the Central Highlands of Vietnam. The former, sourced from less than 20% of the overall basin, produces some 700 t/km²/yr or 60 Mt per year representing about 50-60% of the regional total, while the latter produces an estimated 30% of the total sediment load reaching the delta. The remaining 10% comes from all the other tributaries combined, of which the Nam Ou is the largest contributor with a historic total of about 6.7 Mt per year. This is about 4.8% of the total sediment load added to the Mekong. With the seven Nam Ou dams in place and only 1.94 Mt per year being released, the contribution of sediment from the Nam Ou will drop significantly to about 9% of the sediment transported at Luang Prabang.

5.4

CHANGES IN FISHERIES RESOURCES & AQUATIC HABITATS

As a result of the hydropower cascade development, one of the biggest changes in the Nam Ou will be the alteration of aquatic habitats from a free-flowing river (with regular alternation of rapids, runs, and pools as deep as 20 m) to a series of slow-moving or semi-stagnant reservoirs ranging from 40 to 60 m deep near the dam walls.

With the completion of all seven dams in the cascade by 2020, the total length of the reservoirs will extend almost continuously from the bridge over the Nam Ou at Ban Tang, on the road to Gnot Ou (forming Arm 2 of Nam Ou 7), and down to Nam Ou 1 (18 km upstream from the confluence). The total reservoir length will be 417 km, with 372 km of the Nam Ou mainstream being converted into reservoirs. These reservoirs will be long and thin following the river valley of the Nam Ou and its tributaries; they will be generally 200-300 m wide with steep sides. Apart from the Nam Ou 7 reservoir, which has significant storage and drawdown, the inundated area is relatively small.

The transformation from a free-flowing river into deep, steep-sided reservoirs will have profound implications for the river's overall productivity and the different species living in the aquatic habitats, including fish, amphibians and invertebrates, and aquatic plants and algae. In general, a free-flowing river has greater biodiversity and productivity than steep-sided, deep upland reservoirs, which tend to be oligotrophic. The spawning habitats of many fish species will be lost, and the dams will prevent fish migration both from the Mekong and the Nam Ou mainstream to its tributaries, resulting in a decline in biodiversity. This is already evident from observations by villagers of Ban Phoumeuang, who stated that fewer fish species are caught in the new Nam Ou 6 reservoir compared to what they were able to catch in the river.

Areas with ecological features can be classified as of global, national, provincial, and local importance. The reach of the Nam Ou mainstem from above M. Ngoy to Pak Ou is viewed as globally important because it is a KBA within a karst-limestone landscape with many caves and serves as a spawning area for the endangered Giant Barb (*Catlocarpio siamensis*). The other large sets of river reaches of national and provincial importance are: (i) the mainstem from M. Khoa to M. Samphan and up to the confluence with the Nam Leng; (ii) the reaches within the Phou Den Din NPA in Phongsaly; and (iii) the tributaries of the Nam Nga and the Nam Bak because of their karst landscape and caves.

The entire mainstem of the Nam Ou is already heavily compromised by completed dams (Nam Ou 2, 5, and 6) and those under construction (Nam Ou 1, 3, 4, and 7). It is anticipated that most of the river's important reaches will come under pressure from human activities.

Box 19

Mapping ecologically sensitive areas & human pressures on the Nam Ou

An analysis of the ecologically sensitive river reaches in the Nam Ou Basin affected by existing and planned human activities has been applied following the method developed by the MRC – Initiative on Sustainable Hydropower 01 project (MRC, 2015). It uses the river-reach classification of the Nam Ou established by WWF (Lehner and Ouellet Dallaire, 2014) and assesses the ecological importance of different reaches based on the following criteria:

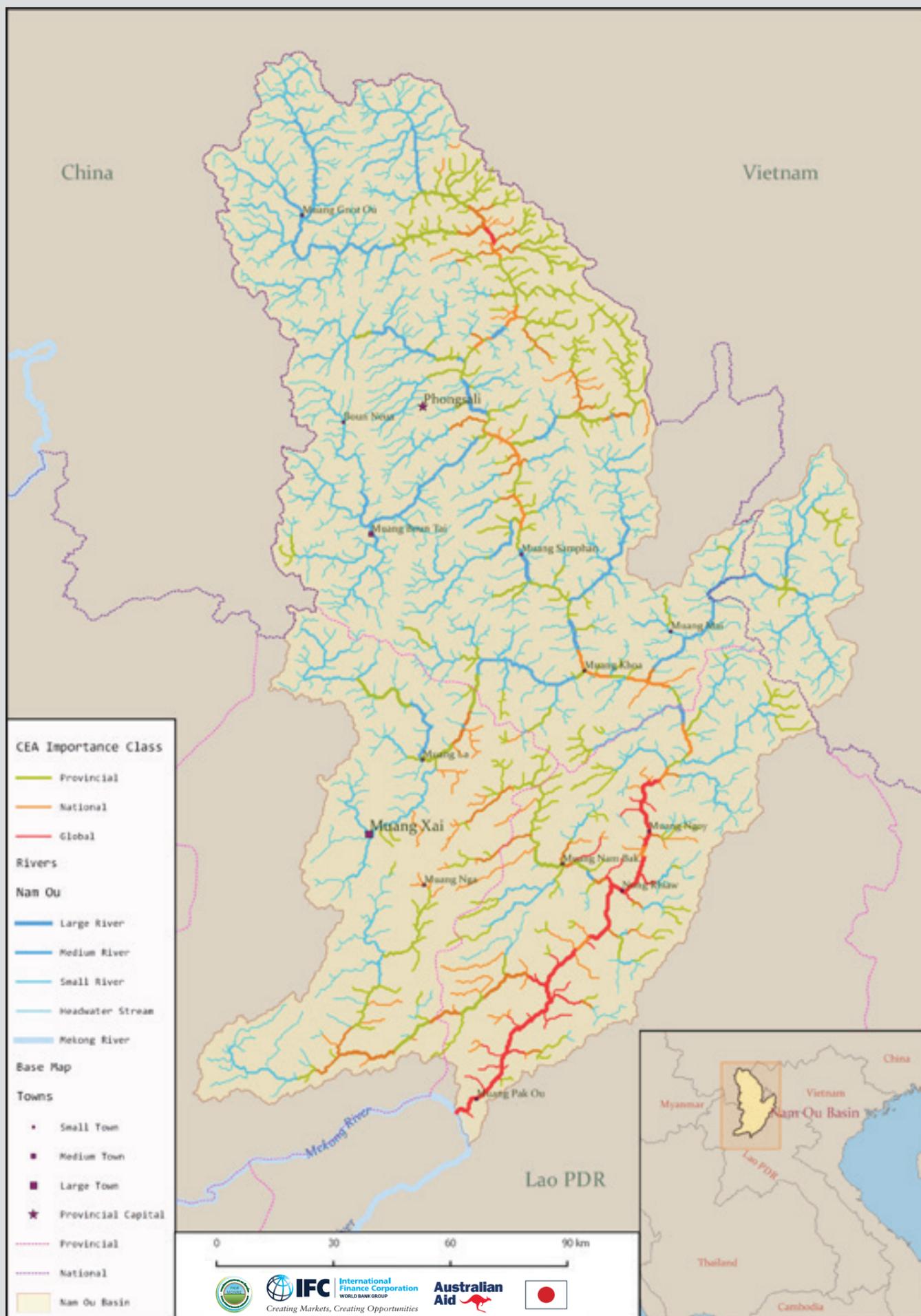
- River reach lies within a KBA and protected areas – national and provincial
- Scarcity of the river-reach type within the Nam Ou Basin, especially karst-limestone areas
- River reaches above and below major confluences
- Presence of hot springs and caves, culturally important areas
- Recognized spawning areas of endangered fish species and areas known for endemic fish species

Existing and planned pressures from human activities have been mapped, including urban areas (all the provincial and district centers), influencing water quality downstream, mining operations at the exploitation stage, sand and gravel extraction and alluvial-gold mining in the river, dry-season irrigation schemes, land use change (especially loss of forest cover), and existing and planned hydropower plants (Figures 9 and 10).



Figure 9

Ecologically Sensitive Reaches in the Nam Ou River Basin.



5.5

WATER QUALITY



The MRC has been measuring the Nam Ou's water quality at Ban Hat Kham since 1985 and the results generally ranged from good to very good. However, since the construction of the three dams in the Nam Ou cascade in 2013, the river's water quality has shown signs of deterioration. Water-quality analysis carried out by the MRC near the mouth of the Nam Ou shows a trend of decreasing pH and DO as well as rising COD. Results from the biomonitoring carried out during the 2016 field studies indicate that the upper reaches and some tributaries have good aquatic health, but the lower reaches (Ban Pak Nga, Ban Pak Ou, the Nam Phak, and the Nam Noua) are variable and in poorer condition. More detailed water-quality and aquatic-health monitoring data are needed to confirm these findings.

Factors that may be contributing to the deterioration of water quality include:

- Infrastructure construction activities, especially hydropower projects
- Changes in water levels and flow rates
- The release of reservoir water
- Sand and gravel extraction, and gold mining
- Increased urbanization, for example, around Meuang Xai town on the Nam Kor, a tributary of the Nam Phak
- Increased industrial activities
- Increased commercial agriculture and agro-forestry
- Poor waste disposal practices and lack of sewage treatment plants in the Nam Ou Basin.



5.6

CLIMATE CHANGE IMPACTS ON WATER RESOURCES



Climate-change downscaling and modelling projections for the whole of the Lower Mekong have recently been undertaken by the MRC, and some of the projections used in the Council Study have been applied to the Nam Ou Basin. Based on these studies, changes in temperature and rainfall are expected in the Nam Ou Basin, although the extent of change remains unclear and modeling results vary.

Modeling results suggest up to a 3°C shift in seasonal temperature and a 27% decrease to 41% increase in seasonal precipitation. The largest increase in temperature is observed in the dry season, while the largest change in precipitation is observed in the wet season.

Changes in annual stream discharges are likely to range from a 17% decrease to a 66% increase in the future, which will lead to predicted changes in annual sediment yield, ranging from a 27% decrease to about a 160% increase. Shrestha (2013) estimated that under current conditions, about 7 Mt of sediment per year are discharged from the Nam Ou into the Mekong. The final sediment discharge will be significantly influenced by the trapping of sediment in the Nam Ou cascade, which will reduce sediments to between 1 and 2 Mt per year regardless of which climate-change scenario is applied.





5.7

CHANGES IN LIVELIHOODS FOR PEOPLE LIVING ON THE RIVER

Community reliance on fisheries resources in the Nam Ou is significant, and fish play an important role in the local subsistence economy. The hydropower cascade developments will result in significant losses of fisheries and OAA resources used by local communities; this will have economic, health, and cultural implications. Livelihood changes are also expected for riverbank

gardens, river weed collection and harvesting, and artisanal mining in the mainstream Nam Ou. Key biological and social assets that will be impacted by hydropower developments are presented in Tables 9 and 10.

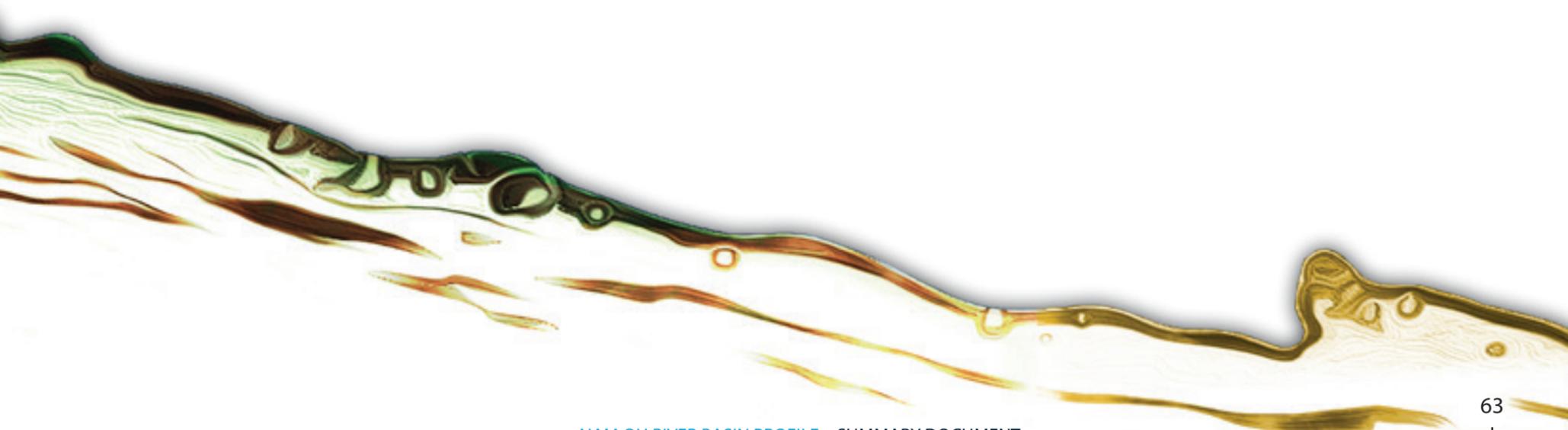


Table 9

Key Biological assets in the Nam Ou Basin which will be impacted by hydropower developments.

Assets	Description
Fish and fish habitat	<p>Over 139 fish species are known to be present in the Nam Ou Basin, of which 9 are listed as Endangered on the IUCN Red List (including 1 Critically Endangered species). Both resident and migratory fish species are present; some species migrate to the Nam Ou via the Mekong River from Cambodia and Viet Nam, so the fisheries resources are of transboundary importance (Poulsen, et al. 2002). Fish life cycles revolve around the natural flow regime, which include specific triggers to migration at the onset of the wet season; availability of dry season habitats, especially deep pools; and, connectivity of the different sections of the river with the tributaries, particularly during the wet season. Fish are important to local subsistence economies and to livelihoods throughout the basin.</p> <p>Some fish species will thrive in the new reservoirs, others will move away into the smaller rivers upstream and populations will decline. The diversity of fish species in the reservoirs is likely to be lower than in the original river as reported by the villagers from Ban Homsang on the Nam Ou 6 reservoir, with the commonest species caught being the exotic species, common carp and Tilapia.</p>
Plankton and zooplankton; and Other Aquatic Animals (OAAs)	Plankton, zooplankton, benthic invertebrates and other OAA form the basis of the aquatic food chain. OAA also provide an important source of food for local communities, particularly during the wet season.
Other amphibians and reptiles	The upper sections of the Nam Ou contain a number of rare amphibians and reptiles which are important for biodiversity conservation in the region, and are also used as a source of food for local communities.
Aquatic plants and ecosystems	Aquatic plants, especially algae (river weed) and macrophytes, are an important food source for many fish species. The upper sections of the Nam Ou contain a number of plants and ecosystems are important for biodiversity conservation in the region. River weed grows on rocks and pebble beds in relatively shallow, clear water during the dry season. In reservoirs and in reaches with fluctuating water levels and high sediment loads, river weed will not grow.

Table 10

Key Social assets in the Nam Ou Basin which will be impacted by hydropower developments.

Assets	Description
Fisheries and collection of OAAs	Local communities are highly dependent of fisheries and collection of OAAs for subsistence. Fish and OAAs are the main source of protein for most communities in Lao PDR and Cambodia. OAAs consumed included snails, frogs, shrimp, tadpoles and water insects and were important in both seasons. OAA are harvested mostly by women and children, especially in female-headed households. It is estimated that about 42,000 tons of fish are harvested from the Nam Ou and its tributaries each year.
Riverbank gardens	All communities located close to the river or streams develop dry season riverbank gardens. Seasonal variation in hydrology inundates areas and along the banks of the Nam Ou and its tributaries depositing sediment and nutrients and creating fertile alluvial soils. Local communities have developed strategies for maximizing harvests and working with natural hydrological conditions. For example, some riverbank crops are planted when water levels are high while others are planted when water levels have receded.
River Weed	River weed (<i>Cladophora</i> spp.) is collected throughout the Nam Ou Basin, both in the main channel and in the tributaries. Most families living in riverside villages engage in this activity, which makes a significant contribution to household income in the villages.
Gold panning	Artisanal gold panning undertaken by downstream communities will be impeded by the increased dry season flows and upstream communities through the inundation of the reservoir areas.





“ Proper water management is important to protect the environment, to preserve water usage for communities, and for economic purposes. ”

Chanthanet Boualapha, Director General of the Department of Water Resources

6.0

RIVER BASIN GOVERNANCE & MANAGEMENT



6.1

INSTITUTIONAL FRAMEWORK FOR NAM OU BASIN MANAGEMENT

The main policies and strategies pertaining to river basin management in Lao PDR include:

- The Water and Water Resources Law (2017);
- The 8th Five-year National Socio-economic Development Plan 2016-2020, officially approved at the VIIIth National Assembly's Inaugural Session, 20-23 April 2016, Vientiane; and
- Vision Until 2030 and the 10-Year Strategy (2016-2024) of the Sector of Natural Resources and Environment.

According to the Vision until 2030 and the 10-Year Strategy (2016-2024) of the Sector of Natural Resources and Environment, the following have been accomplished and/or are planned:

- Technical guidelines on IWRM have been created and tested.
- IWRM, including initial evaluation and management of groundwater, water quality, flood, drought, and impacts of climate change, has been developed and improved.
- River Basin Committees for six river basins have been established based on characteristics of each basin. For the Nam Ou Basin, a River Basin Committee has been set up by relevant provinces; the committee would proactively manage the basin with coordination between central and local levels.
- Integrated river basin management will be carried out to balance the use of water resources for socio-economic development, people's livelihoods, and protection of ecosystems.
- The Decree on River Basin Committees shall be improved.

According to the Decree No. 435/PM, MONRE is directly responsible for planning and implementing integrated river basin management for the Mekong River Basin, transboundary river basins, and main river basins, including the Nam Ou. Under MONRE, agencies responsible for river basin management are DWR, Division of Water Resources under PONRE, and the Water and Forest Resources Unit under DONRE.

DWR proposes the establishment of River Basin Committees and their secretariats for basins in the country. DWR guides, supervises, evaluates, and stimulates the activities of secretariats of River Basin Committees, Divisions of Water Resources at the provincial level, and the Water and Forest Resources Unit at the district level. The Division of River Basin Management and Development, under DWR, is responsible for planning and management of river basins. To date, no common approach is used across different river basins in Lao PDR. Management and development of river basins should be conducted based on the unique characteristics, strengths, and problems of each basin. Another important role of DWR is its Center for Data and Information on Water Resources, which creates and develops databases/networks on water resources at the central, river basin, provincial and district levels (Decree No. 3089/MONRE).

6.2

THE ROLE AND CAPACITY OF LOCAL AUTHORITIES

Based on the Ministerial Decree of MONRE No. 1467 dated 9 March 2012, PONRE manages and implements activities related to the conservation, protection, rehabilitation, development, and use of water and related resources. The Water Resources Division under PONRE is tasked with developing plans, programs, and detailed projects to implement the aforementioned activities in coordination with the Secretariat of the River Basin Committee and relevant stakeholders.

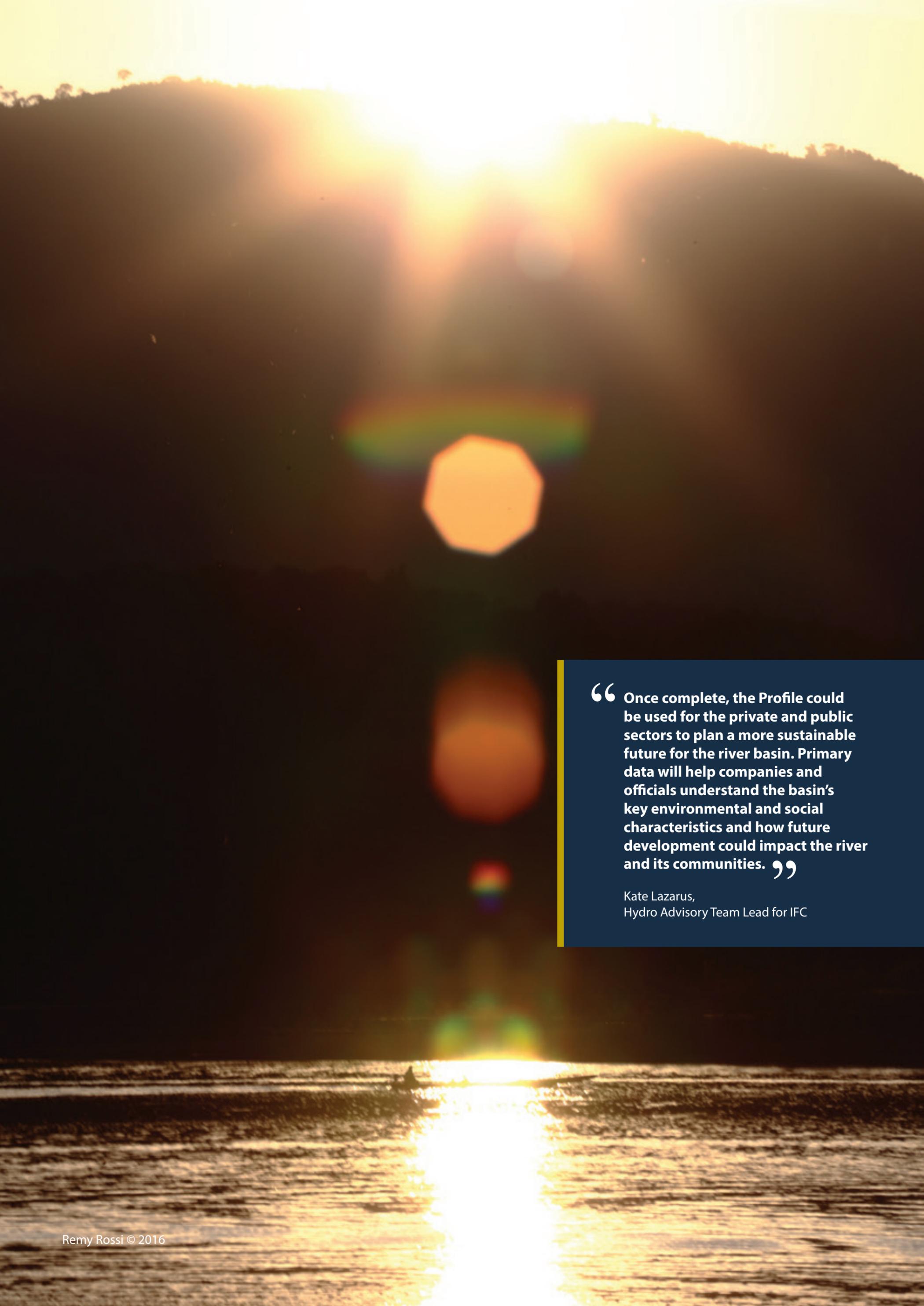
According to the Ministerial Decree of MONRE No. 4384, DONRE is to implement regulations, strategies, plans, programs, and projects for the management, conservation, protection, rehabilitation, use, and development of water resources within district boundaries.

Results of FGD and individual interviews undertaken during the validation workshops in Luang Prabang, Oudomxay, and Phongsaly in January 2017 indicate that implementation of these provincial strategies and plans has been challenging. Unclear coordination between relevant sectors, limited data/information, and lack of human, technological, and financial resources all contributed to the difficulties in implementation.

There are conflicting and sometimes duplication of laws. Roles and responsibilities of different sectors are ill-defined and coordination between departments and sometimes even within their own divisions is weak. There is ambiguity in the allocation of decision-making and management power between central and local authorities. Out-of-date legislation, such as the Law on Water and Water Resources (adopted in 1996), was also cited as a constraint to implementation.

Staff shortages are common at both the provincial and district levels, particularly the latter. Few newly-recruited staffers are knowledgeable in water resources or related fields through formal education. Technical work, such as monitoring water quality and ecological health, requires on-the-job training. However, most water monitoring and management activities associated with hydropower development projects are performed by the developer's staff, leaving little room for government officials to obtain on-the-job training. In writing proposals for new projects, the role of PONRE staff is limited to filling in forms of potential donors, such as the Environmental Protection Fund.

About 60 to 80% of the required budget is lacking for water-related projects at the national and local levels. Available funds come mainly from the state budget and private development projects (for example, water-quality monitoring for hydropower projects). The lack of technological resources is also constrained by insufficient funding for the purchase and maintenance of scientific equipment. Not many provinces have basic equipment such as water-quality meters, biological-sampling equipment, computers, cameras, and global positioning systems, and they are almost non-existent in the districts.



“ Once complete, the Profile could be used for the private and public sectors to plan a more sustainable future for the river basin. Primary data will help companies and officials understand the basin’s key environmental and social characteristics and how future development could impact the river and its communities. ”

Kate Lazarus,
Hydro Advisory Team Lead for IFC

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CONCLUSIONS & RECOMMENDATIONS

The Nam Ou is one of the most important tributaries in Lao PDR and the whole Lower Mekong Basin. For centuries, the river has been providing a stable water supply for domestic use and agriculture, fisheries, and OAA resources as well as serving as a transportation corridor for local communities. However, the river and surrounding watershed is rapidly changing because of hydropower and other developments. This Profile provides important background information on the Nam Ou and aims to assist water-resource managers in Lao PDR in future river-basin planning and management.



The following are key conclusions and recommendations:

Need for Improved Management of Nam Ou Basin Resources

Institutional mechanisms pertaining to water resource management in Lao PDR, including legislation and an administrative framework, are in place at the national, provincial, and district levels. The policy framework for water resource management in the Nam Ou Basin is based on the 8th Five-year National Socio-economic Development Plan, the Vision until 2030, the 10-year Strategy (2016-2024) of the Sector of Natural Resources and Environment, the 8th Provincial Socio-economic Development Plan, and the PONRE Strategic Plan. Mechanisms for planning and management of the basin are, however, limited to DWR. Furthermore, river-basin management guidelines and a river basin management committee have not yet been formalized for the Nam Ou.

Coordination between relevant sectors and stakeholders remains weak. PONRE and DONRE are facing other challenges in the implementation of strategies, programs, and projects related to water resources. These include, but are not limited to, a lack of relevant data/information and limited human, technological, and financial resources for effective river basin management.

Recommendations: Coordination between the private sector and GoL agencies at the national and local levels needs to be improved for management of the Nam Ou Basin. A River Basin Committee or Organization should be established to help manage water resources in the Nam Ou and address issues associated with hydropower and other developments. Adequate budget needs to be allocated for water resource management across the country, particularly in Phongsaly, Oudomxay, and Luang Prabang Provinces. Training and capacity building is needed for PONRE and DONRE staff in aquatic and social sciences as well as river basin management.

Need for Monitoring and Mitigation of Impacts from Hydropower and Other Developments

As part of the ESAs produced for the Nam Ou cascade, an Environmental and Social Management and Monitoring Plan (ESMMP), a Resettlement Action Plan, and other related documents were prepared. The developers are also required to follow the Environmental and Social Obligations (ESO) signed as part of their contract with GoL for operating the Nam Ou hydropower cascade. Monitoring programs aim to provide ongoing information for determining whether mitigative measures are effective, how environmental resources have been affected, and whether post-start-up corrective action is necessary. Monitoring must encompass all phases and components of the Nam Ou hydropower development project cycle, including pre-construction, construction, operation, and decommissioning.

Monitoring programs should include measures to enhance and support fisheries and aquatic resources in the Nam Ou Basin as well as regular monitoring of water quality and community use of fisheries and other aquatic resources. Given the lack of information, data need to be collected on minimum flow releases and environmental flow requirements in this area. Monitoring of social changes associated with hydropower developments is needed, especially for communities that have been relocated and/or rely heavily on the Nam Ou resources for their livelihoods. Changes from baseline conditions should be addressed through increased monitoring and appropriate compensation to villagers for lost livelihoods. Monitoring needs to be transparent and the information should be shared between the developer, GoL, and the international community.

Monitoring programs for the Nam Ou Basin should, at a minimum, include:

1. Aquatic biological surveys to determine the effect of dam placements and associated impoundments on fish species composition and abundance, both in the newly created impoundments and in tributaries;
2. Assessment of the effects of altered flow regimes on downstream fish and OAA populations, and local communities, including impacts on the Mekong;
3. Determinations of the effect of altered temperature, sediment levels, and water chemistry on fisheries, OAA, and aquatic habitats;
4. Assessments of the effect of the projects on community fisheries, navigation, and livelihoods of local populations;
5. Variables of dependence and resilience of people as stated in this Profile should be used as basic indicators for long-term monitoring to detect changes. Once changes are detected, linkages to the impacts of specific projects and human activities can be investigated and established.

Given the uncertainty and gaps in our understanding of the Nam Ou Basin, it is recommended that:

- Determinations of environmental flow values be made (for example, considering a habitat or holistic approach);
- A program of routine monitoring of stream flows should be initiated, including monitoring at a high frequency to measure current ramping rates;
- A long-term environmental monitoring program, including biological and geomorphology components, should be initiated to supplement baseline data; the program should continue through the construction and operation of all hydropower projects, covering the implementation of the ESMMP as well as ESO.
- An adaptive management program should be developed to consider existing and baseline monitoring data as well as specific conditions that trigger such adaptive management.

Recommendations: Monitoring requirements and mitigation plans, as stipulated in the Project ESMMP, ESO, and associated plans prepared for the Nam Ou hydropower cascade, should be implemented and enforced. Information sharing and data management systems need to be in place to help improve monitoring of the Nam Ou Basin. Monitoring results should be made available to local communities, GoL, and the international community.

Need for Protection of Livelihoods for People in the Nam Ou Basin

For centuries, people in the Nam Ou Basin have relied on the river for their water supply, fisheries and other aquatic resources, and as a transportation corridor. The hydropower cascade developments will result in significant losses of fisheries and OAA resources used by local communities; this will have economic, health and cultural implications. People living in the basin and their future generations will continue to rely on the river for their livelihoods. It is uncertain to what extent will the Nam Ou be able to continue to provide important ecosystem services and natural resources required by local communities. Overall, resilience capacity is low.

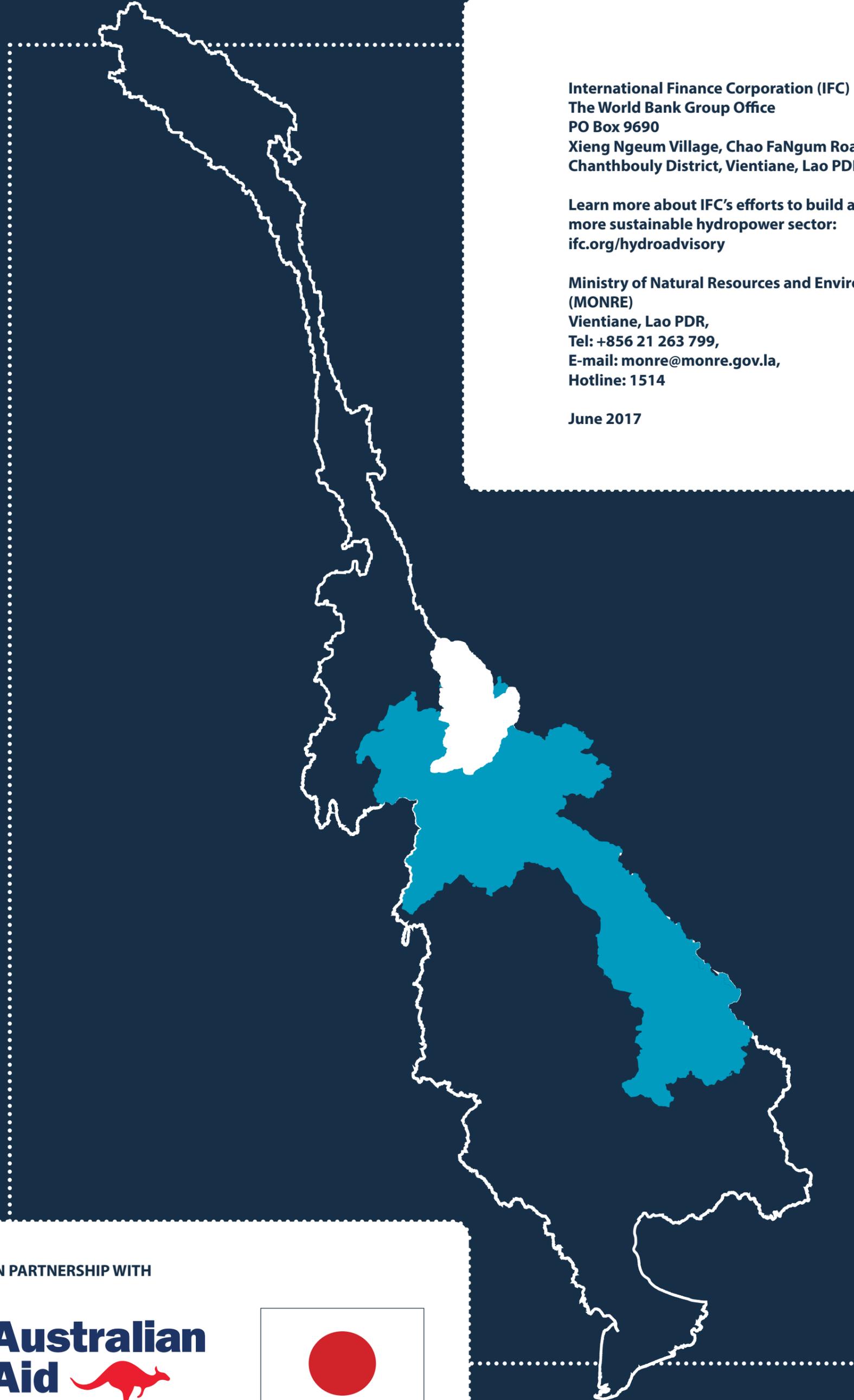
Recommendation: Monitoring and mitigation of social issues associated with the Nam Ou hydropower cascade is essential to ensure that local communities benefit from the developments, and that livelihoods are maintained or improved compared to before the developments.

This Profile has presented the key environmental and social characteristics of the Nam Ou River Basin; the next step is to use this information for water resource planning and management. However, the mechanism for planning and management at the basin level is limited to DWR and requires inter-ministerial coordination. To enable proper planning and management based on IWRM principles, the river-basin management guidelines should be finalized and applied to the Nam Ou Basin. The establishment of a Nam Ou River Basin Management Committee (at least at the technical level) is also recommended. These management plans will need to be guided by the 8th Five-year National Social-economic Development Plan (2016-2020), the Vision Until 2030, and the 10-year Strategy of the Sector of Natural Resources and Environment.

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**International Finance Corporation (IFC)
The World Bank Group Office
PO Box 9690
Xieng Ngeum Village, Chao FaNgum Road
Chanthbouly District, Vientiane, Lao PDR**

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**Ministry of Natural Resources and Environment
(MONRE)
Vientiane, Lao PDR,
Tel: +856 21 263 799,
E-mail: monre@monre.gov.la,
Hotline: 1514**

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