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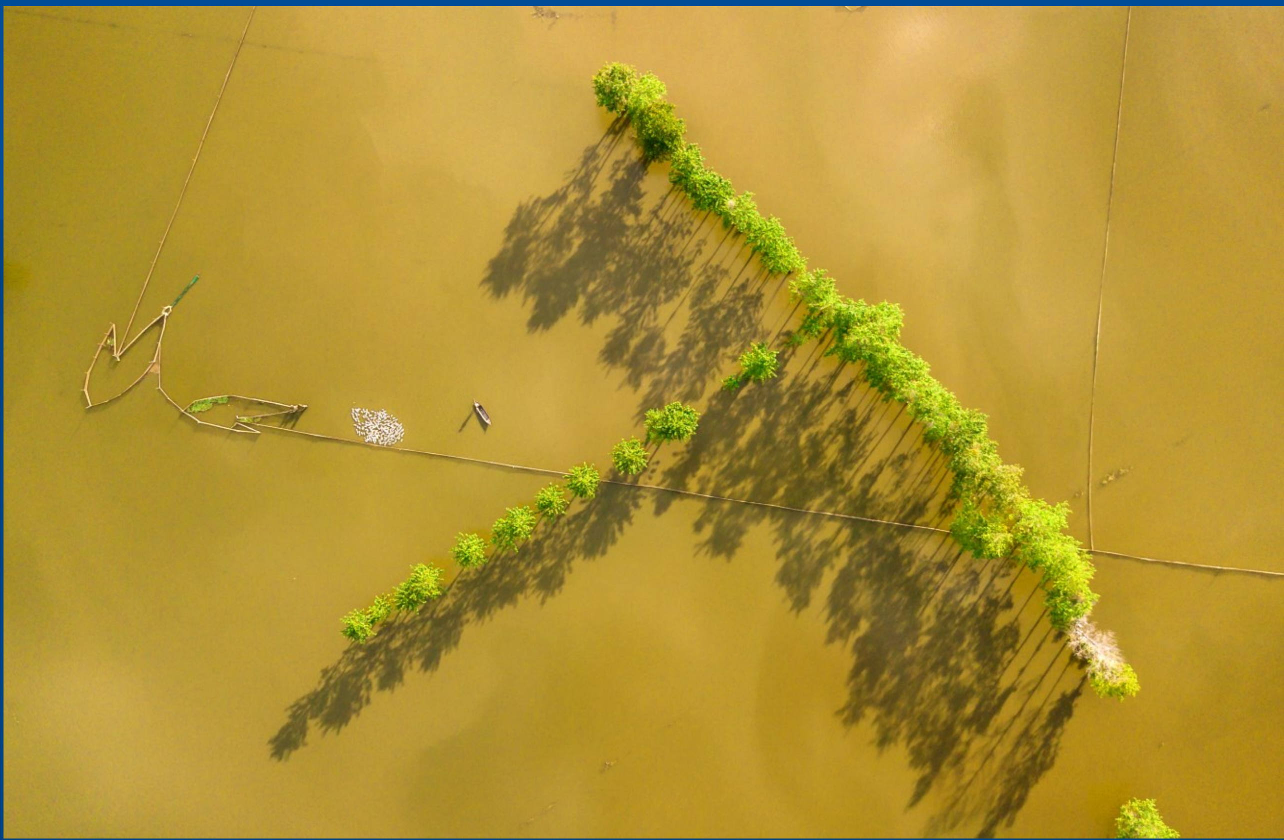

TECHNICAL GUIDANCE

for Fisheries Yield Assessment at the Landscape Scale in the Lower Mekong Basin

TECHNICAL GUIDANCE FOR FISHERIES YIELD ASSESSMENT AT THE LANDSCAPE SCALE IN THE LOWER MEKONG BASIN

December 2023

The Mekong River Commission (MRC) is funded by contributions from its Member Countries and Development Partners, including Australia, the European Union, Finland, Flanders/Belgium, France, Germany, Japan, Luxembourg, the Netherlands, New Zealand, Sweden, Switzerland and the United States of America.

First published (2023)

Title: Technical guidance for fisheries yield assessment at the landscape scale in the Lower Mekong River Basin

DOI: 10.52107/mrc.bgu8bl

Keywords: Technical Guidance/fisheries/habitat type/Lower Mekong Basin/Mekong River Commission

For bibliographic purposes, this volume may be cited as:
Mekong River Commission. (2023). *Technical guidance for fisheries yield assessment at the landscape scale in the Lower Mekong River Basin*. Vientiane: MRC Secretariat. DOI: 10.52107/mrc.bgu8bl

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CITATION

Mekong River Commission (2023). *Technical guidance on fisheries yield assessment at the landscape scale in the Lower Mekong River Basin.* Vientiane: MRC Secretariat. DOI: 10.52107/mrc.bgu8bl

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ABBREVIATIONS AND ACRONYMS

CPUE	Catch per unit effort
DAGAP	Data Acquisition and Generation Action Plan
FADM	Fish Abundance and Diversity Monitoring
FAO	Food and Agriculture Organization of the United Nations
FT	Full-time
GIS	Geographical Information System
GPS	Global Positioning System
IFReDI	Inland Fisheries Research and Development Institute
LMB	Lower Mekong River Basin
MRB-IF	Mekong River Basin Indicator Framework
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
OAA	Other aquatic animal
Occ	Occasional
PT	Part-time
SIMVA	Social Impact Monitoring and Vulnerability Assessment
YPUA	Yield per unit area

EXECUTIVE SUMMARY

In 2019, the Mekong River Commission (MRC) developed the Mekong River Basin Indicator Framework (MRB-IF) (MRC, 2019) to provide a consistent and streamlined approach to data collection, analysis and reporting. The MRB-IF has defined four fisheries-related parameters: (i) fisheries yield from rivers and major flood zones; (ii) fisheries yield from rainfed zones; (iii) fisheries yield from large water bodies including reservoirs; (iv) capture fisheries prices, which need to be monitored to evaluate the economic value of capture fisheries as well as to measure the economic performance of Lower Mekong River Basin (LMB) water-related sectors.

The MRC has carried out periodic assessments of the total catch of fish and other aquatic animals (OAAs) from the LMB to inform policy in 2000, 2010 and 2020. These studies used Geographical Information System (GIS) areal yield per unit of habitat area and household consumption studies to estimate the yield of fish and OAAs from the LMB. The 2000 and 2010 studies used literature-based assessments of the yield per unit habitat area, while the 2020 used a novel fisher catch-based approach to determine the yield per unit habitat area and to extrapolate the catch from the Basin.

Given the differences in methodologies between surveys, the aim of this Technical Guidance is to provide a more systematic approach to data generation, acquisition and analysis for fisheries yield assessment by habitat type to provide greater certainty for all stakeholders on roles and responsibilities in joint fisheries initiatives, especially in transboundary areas. The specific objectives are to:

- provide a standardized approach and robust methodology for conducting field surveys, data analysis and reporting on fisheries yield assessments at the landscape level;
- support the MRC to assess the status and trends in capture fisheries yields and production in the LMB and inform decision-making and planning for basin-wide sustainable fisheries management; and
- support the Member Countries to collect and share up-to-date data and information with relevant stakeholders for adaptive management planning and coordination of transboundary management.

Global fisheries monitoring strategies are first reviewed and related to the existing fisheries monitoring network in the LMB, to identify methodologies that can potentially be used to assess fisheries yield by habitat type while making full use of existing monitoring programmes in the LMB. The most appropriate data available are from national fisheries statistical surveys, household consumption surveys and GIS-based areal habitat yield models. Applying these three data sources allows triangulation of the results and the opportunity to intercalibrate the methodologies and improve accuracy.

Firstly, FAO fisheries data were downloaded and compared with national fisheries statistical data compiled from national statistical agencies. These data can be used as the baseline values against which to triangulate the consumption and GIS-based areal habitat yield models.

The aim of the GIS-based areal habitat yield component is to estimate the yield (catches) and value of fish and other aquatic animals (OAAs) from the main types of habitat that support fisheries and aquatic production. Total catch is estimated from the relationship between yield per unit area (*YPUA*) determined from interrogation of catch rates by different fishing gears in specific habitat types and *AREA* of habitat for different types of water bodies using *Catch=AREA*YPUA*. A Geographical Information System (GIS) approach is used to determine the *AREA* of habitat for different types of water bodies. Fisheries yield (the amount of fish harvested from a particular ecosystem/water body) is a product of the exploitation rate (catch per unit area of habitat) and fishing effort (number of fishers and time spent fishing). Catch rates are derived from targeted surveys of fisher households. These HH surveys are structured to collect a wide range of data on fisheries, including catch and consumption, and specifically data on catches regarding the habitat where the fish was caught and the type of fishing activity (full-time, part-time or occasional fishers). These data are further complemented by information from MRC Fisheries Abundance and Diversity Monitoring. Procedures for collecting, analysing and reporting the data are provided. In addition, it is recommended that the previous methodology that uses literature-based assessment of the yield per unit area is also carried out for comparative reasons.

The final component uses fish consumption data collected during the household and Social Impact Monitoring and Vulnerability Assessment (SIMVA) surveys. During the surveys, HHs are asked to estimate the total animal-based foods eaten each week (kg/hh/week), including all meals, and the proportion of fish and OAAs in this diet. They are also asked to estimate how much of the fish and OAAs is caught, purchased from the market or from other fishers, purchased or produced from aquaculture sources, as well as the percentage of meat and other protein sources eaten. These data are used to estimate the weekly consumption of each animal food source and can be upscaled to determine the total amounts of animal protein consumed from various sources across the LMB. Again, procedures for collecting, analysing and reporting the data are provided.

Finally, procedures determining the value of inland fisheries resources along the value chain are provided. Basically, field officers should collect information on first sale value of wild aquatic species caught by fishers at fish landing sites and fish (aquatic) farmers at aquaculture farms. The same information can also be collected from fishers who complete logbooks for the Fish Abundance and Diversity Monitoring (FADM) Programme. Other data collectors should collect market prices from fish retailers at fresh markets in the target provinces. The total value of the fish caught and OAAs harvested is then estimated from the product of the total catch weight in each country and the mean first sale price and final retail price of the fish and OAA products.

To ensure the robustness of the data, quality control procedures regarding fish catches, data checking, and method calibration and validation are described. The structure of national and regional reports is also provided.

1 INTRODUCTION

The Mekong River system is one of the most diverse and prolific inland capture fisheries in the world (MRC, 2018a). Capture fisheries play an important role in securing livelihoods and food nutrient for millions of people within the Lower Mekong River Basin (LMB) countries of Cambodia, Lao PDR, Thailand, and Viet Nam. The yield of capture fisheries, i.e. fish and other aquatic animals (OAAs), in the LMB was estimated at around 2.3 million tonnes per year, valued at approximately USD 11.15 billion in 2010 (So et al., 2015), but has subsequently fallen to 1.51–1.71 million tonnes per year, valued at between USD 7.13 billion and USD 8.37 billion annually in 2020 (MRC, 2023a).

This is arising because pressures on the fisheries are increasing, and fishers commonly report that their catch (per fisher) and average sizes of fish caught are declining, and some species have become rare at some locations (MRC, 2010, 2021a). These pressures are occurring because the Basin's human population is increasing, and there is a wider diversity of developments, such as hydropower, irrigated agriculture and urbanization, which impact fisheries. Consequently, information on status and trends is required to understand the impacts of such developments to provide input for planning, management and impact mitigation. Ongoing MRC monitoring of the fish and fisheries aims to provide such information in a practical, timely and cost-effective way, but there is a need to understand the size and value of the basin-wide capture fisheries in the LMB. Such information is crucial to inform regional and national strategies, policies and development plans, as well as improving coordination among the Member Countries for transboundary fisheries management.

2 RATIONALE

Fisheries monitoring is a core activity of the MRC Secretariat (MRCS), the operational arm of the MRC, now under the jurisdiction of the Environmental Management Division (ED). The ED has been working with the fisheries line agencies of LMB countries to conduct field surveys every five years to estimate the yield of capture fisheries in the LMB landscape from different major habitat types, namely: major flood zones, rainfed zones, large water bodies, including reservoirs, and estuaries/brackish water zones. The first basin-wide fisheries assessment was for 2000 (Hortle, 2007), the second for 2010 (Hortle & Bamrungrach, 2015), and the third for 2015–2016 (Hortle, 2017, unpublished). These studies used the same approach and methodology applied in the 2015 assessment and a draft procedure specifically for village and household sampling. However, concerns have been raised about whether this methodology was still applicable for assessing the yield of fisheries and other aquatic animals (OAAs) in the LMB and makes full use of available data.

In 2019, the MRC developed the Mekong River Basin Indicator Framework (MRB-IF) (MRC, 2019) to provide a consistent and streamlined approach to data collection, analysis and reporting. The MRB-IF has defined four fisheries related parameters: *(i) fisheries yield from rivers and major flood zones; (ii) fisheries yield from rainfed zones; (iii) fisheries yield from large water bodies including reservoirs; (iv) capture fisheries prices*, which need to be monitored to evaluate the economic value of capture fisheries (MRB-IF/Assessment indicator no. 24) as well as to measure economic performance of LMB water-related sectors (MRB-IF/Strategic indicator no. 8).

To implement the MRB-IF, the Data Acquisition and Generation Action Plan (MRC DAGAP, 2021b) provides clear direction to Member Countries and the MRCS on the data requirements. The DAGAP has phased the strategy to acquire the economic value of capture fisheries into two steps:

Step 1: Apply the methodology using yield assessments from the literature as described in 2015 technical report.

Step 2: Design and trial methodology for field surveys of different habitat types to update habitat yield estimates and take into account regional differences at smaller spatial scales.

While the DAGAP concluded that the data required to implement the MRB-IF largely exist, the systematic procedures for their collection and analysis for status and trends evaluation is missing.

The overall aim of this Technical Guidance is to provide a more systematic approach to data generation, acquisition and analysis for fisheries yield assessment by habitat type to provide greater certainty for all stakeholders on the roles and responsibilities in joint fisheries initiatives, especially in transboundary areas.

3 OBJECTIVES

The overall objective of fisheries and OAA monitoring at the landscape level in the LMB is to measure yield indicators contributing to the interpretation of the production and economic value of basin-wide capture fisheries. Accordingly, this ***Technical Guidance for Fisheries Yield Assessment at the landscape scale in the Lower Mekong Basin***, based on previous MRC assessments, the 2020 Fisheries Yield Assessment (MRC, 2023a) and other relevant MRC products, such as routine Fish Abundance and Diversity Monitoring (FADM), Social Impact Monitoring and Vulnerability Assessment (SIMVA) and the State of Basin Report (SOBR), has been developed to align with the MRB-IF and DAGAP. The specific objectives of the Technical Guidance are to:

- provide a standardized approach and robust methodology for conducting field surveys, data analysis and reporting on fisheries yield assessments at the landscape level;
- support the MRC to assess the status and trends in capture fisheries yields and production in the LMB and inform decision-making and planning for basin-wide sustainable fisheries management; and
- support the Member Countries in collecting and sharing up-to-date data and information with relevant stakeholders for adaptive management planning and coordination of transboundary management.

4 MONITORING STRATEGIES

4.1 GLOBAL PERSPECTIVE

The fundamental aim of fisheries monitoring and assessment is to understand the status and trends of capture fisheries yields and production, in this case, in the LMB. A wide diversity of stock assessment methodologies is currently in use to undertake this type of assessment (Bonar et al., 2002; Lorenzen et al., 2016). These range from detailed, long-term assessments of single species in single water bodies through rapid appraisal of multi-species, multi-gear floodplain fisheries in the tropics to broader simulations of the interactions between fisheries and other components of the aquatic system (Table 4.1).

Table 4.1. Approaches considered for assessing yield by habitat

Method	Advantages	Disadvantages
Depletion sampling of specific habitats	Provides accurate data on standing crop (biomass per unit area) within defined habitats.	Does not provide data on yield.
	Provides accurate data on species and sizes.	Can only cover small areas, typically less than a few hectares.
	Supports yield estimates, if production/biomass ratios can be assumed.	May be misleading as an indicator of production because fish and other aquatic animals (OAAs) move through a range of habitats.
Conventional catch assessment based on effort x catch per unit effort (CPUE)	Is useful in simple fisheries where all fishers and gears can be identified and catches estimated.	Not very effective in complex inland fisheries with many fishers and gear types, including illegal gears.
	Is most appropriate for well-regulated and managed fisheries, and typically applied in commercial marine fisheries.	Effort and catch estimates are subject to large errors; respondents will not report accurately.
Household and fisher surveys	Is convenient because fisher logbook surveys already exist under the FADM Programme.	Coverage of sites is limited to 38 locations and does not cover all the habitat types fully or account for habitat relationships.
	Can integrate all sources of fish and OAAs over large areas and by habitat.	Details on species and sizes may be error-prone.
	It is useful because the units to survey (households) are well-documented by census data, so are relatively error-free.	Requires interviewers with experience in working with households, and fisheries agencies may lack such experience.
	No need of information on gears for an estimate.	Results of interviews need cross-checking against other data.
	Practical because many countries have experience in household surveys of this type.	Logbook monitoring can be time-consuming, may be of variable quality, and requires oversight and auditing.

The traditional approach is to adopt fisheries dependent methodologies, such as fisheries catch assessment surveys (Lorenzen et al., 2016). These provide an assessment of the status of the existing fishery; however, the quality of the output is strongly dependent on the input information, which can be highly variable depending on its source, for example, scientifically collected or provided by fishers. In commercial and artisanal fisheries, fishers are typically requested to report their harvest and effort in logbooks, such as in the FADM surveys, or submit to observers or inspectors at various stages through the market chain, usually at the point of first sale. These catches are then upscaled to account for the whole fishing effort through frame surveys, which determine total fishing effort in the system (Bazigos, 1974; Caddy & Bazigos, 1985; Lorenzen et al., 2016). Catch assessment surveys typically involve observers visiting a high proportion of the fishing villages or landing sites on a regular basis or using logbook returns, and collecting as much information on the fishing operations and catch as possible.

Data are also collected at fish markets. Due to the volume of fish passing through markets, and the products often having been processed by smoking, salting or drying, they only provide coarse statistics, such as processed weight and dominant species type. However, the processed weights can be adjusted through conversion factors to wet weight of the original products. Market surveys also carry the danger of double counting because the same fish may appear more than once in the same market or in successive markets in the chain (Welcomme, 1999).

Problems arise in the LMB using this approach because many fishery products are not marketed or traded, but rather are consumed by the fishers and their families, sold locally in the community or bartered for other products. Consequently, this approach can underestimate a large part of the yield. Licensed traders may also under-report sales to avoid taxes or other costs. Unreported cross-border trade in the LMB is also likely to be common, but impossible to monitor.

Another source of information commonly used is government statistical, agricultural and household surveys. These surveys can be used to quantify harvest from fisheries where a substantial share of the catch is neither marketed nor landed at defined landing sites, or a substantial contribution of the fish consumed is from aquaculture. The same methodology can be adopted for OAAs.

However, carrying out fisheries assessments in large river systems with highly dispersed fisheries, such as found in the Mekong, is problematic and rarely, if ever, successful, largely due to the many biases that need to be addressed. Consequently, accuracy is normally impossible to estimate, simply because it requires a set of the real population parameters with which to compare. This would require sampling the entire population, which is rarely possible in either natural or experimental populations. When aware of any definite biases and noise in the sampling, it may be possible to correct for this, or if not, accept some of the biases. Possible causes of bias when sampling natural fish populations include:

- *Gear selection*: Most fishing gears and sampling devices are selective, i.e. the catches are not representation for the whole population even when the entire population is present in the volume sampled. A measure of selectivity can be obtained by comparing catches from different or modified gears.

- *Distribution*: When parts of the population concentrate in certain areas (e.g. spawning or nursery grounds) or in different parts of the fishable area in different seasons. These patterns must be known or examined by sampling at different localities, seasons and habitat types.
- *Target habitats*: Fishers exploit different types of habitats depending on access and profitability of the catch (both terms of the size of the catch and value), diversity of fishing gears and opportunities for use and availability of markets.
- *Sampling artefacts*: When sub-sampling from a catch, for example, there is a tendency to select the larger specimens present. Another situation is when an unknown fraction of the catches is consumed or unreported, for example, subsistence fishing or bartering.

Assuming that the amount of bias has been reduced to an acceptable level or that the population has been redefined, the aim shifts towards obtaining estimates of precision. This requires replication to be built into the sampling scheme. Some standard sampling designs used for yield estimates in natural fish populations that may be applicable to the LMB are:

Simple random sampling. If the distribution of the population is relatively homogeneous throughout the geographical area to be sampled, then simple random sampling is appropriate. Technically, this procedure divides the area into equal-sized sub-units and selects the desired number of sub-units at random. The methodology used in 2015 (Hortle, 2007; Hortle & Bamrungrach, 2015) adopts this approach to some extent by selecting village/commune areas as the sub-sample, but does not specifically relate the sub-sample to the larger basin area sub-units. It assumes the selected sub-units are representative of the wider basin units, but does not randomly select sub-samples against the three major habitat types (rainfed wetland zones, major flood zones and major water bodies) being considered.

Systematic sampling. This method is based on the selection of equally spaced sampling units within the grid pattern. The first unit is chosen at random (e.g. No 4) and hereafter every multiple of this number is selected (every 4^{th}). Thus, systematic sampling is spread evenly over the population. This can sometimes improve the precision, such as in situations where the causes for stratification are poorly understood. Systematic sampling is suitable when the population is heterogeneous without periodicity in time or space, for example, selecting fish from a conveyor belt, where you take every fifth number, but biased when the units are homogenous relative to the population variance, i.e. any cyclic variation. The problem is that the variance cannot be determined, since the systematic sampling is in reality equivalent to stratified random sampling with only one sample from each stratum. This is a critical shortcoming of systematic sampling.

Multiple step sampling or sub-sampling is used in connection with big, highly dispersed fisheries, using multiple gears, and fishing a wide diversity of habitats, or sampling from the commercial fishery. The procedure is to randomise within different levels, for example, gears, catches, habitat types or seasons, to estimate variance within and between sampling levels, thus improving coverage and the amount of information obtained per unit of sampling effort. An example of this is provided in Figure 4.1.

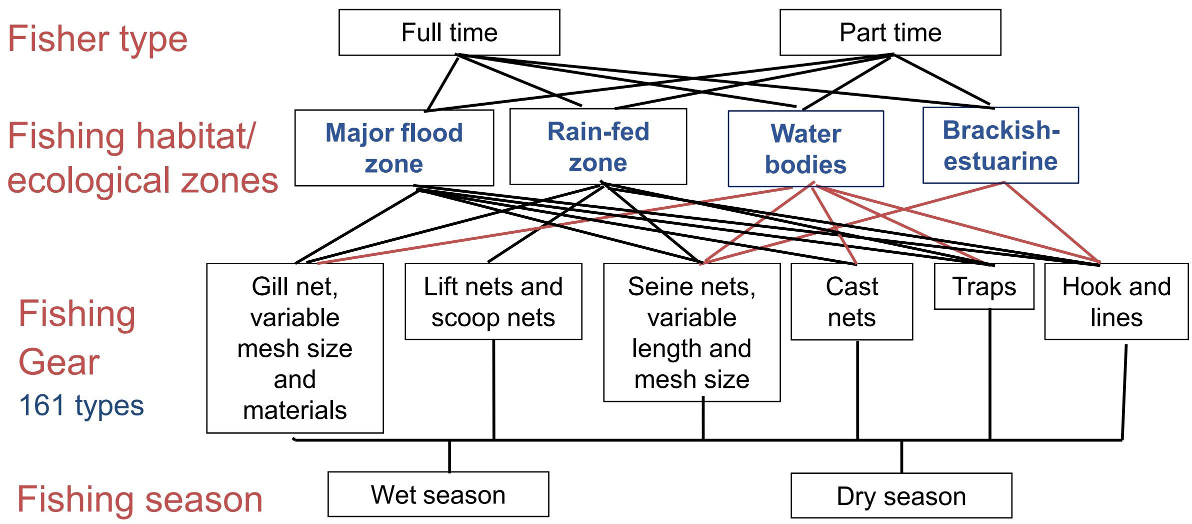

Figure 4.1. Hypothetical example of a multi-step, random sampling approach for small-scale fisheries in the LMB

4.2 MONITORING STRATEGIES IN THE LMB

The main methodologies is used in the LMB to determine the trends in catch and total catch and value of that catch are as follows:

- Fisheries Abundance and Diversity Monitoring (FADM);
- Dai fisheries monitoring in Cambodia;
- Official catch statistics from national surveys;
- Consumption and yield statistics;
- Derivation of yield from habitat extent using GIS;
- Social Impact Monitoring and Vulnerability Assessment (SIMVA).

The FADM and Dai fisheries monitoring typically report abundance (numbers and biomass) of each species in catches or in samples, expressed as catch per unit effort (CPUE). CPUE is assumed to reflect underlying changes in fish stocks, after taking into account other covariates. Reporting of diversity usually includes estimates of the number of species present (richness) and their contribution to catch (some measure of evenness or dominance), i.e. the extent to which the fish species assemblage is dominated by one or a few species. Basic data are often analysed further to provide derived parameters related to population and community trends. The aim of FADM fisheries monitoring is to determine the status and trends of basin-wide capture fisheries, as well as provide an effective means of monitoring and assessing the effects of water management and basin development activities. To assess these changes, a range of parameters that reflect potential changes are required. These parameters are in line with the Mekong River Basin Indicator Framework and can be used to cross-validate outputs from the Fisheries Yield Assessment by Landscape level approaches.

Each country carries out annual or biennial national statistical production and consumer surveys that provide information on bioeconomic and social status and trends to support government decision-making. These also feed into international reporting to organizations such as the World Bank and Food and Agriculture Organization of the United Nations (FAO).

Most of the data are online and provide information of livelihoods and income, agriculture production data, fish and OAA catch data, fish and OAA consumption rates and aquaculture production, all of which can be used to validate and cross-check data collected by the MRC monitoring programmes.

In addition, socioeconomic data are collected every five years as part of the MRC SIMVA programme; the latest survey was for 2018 (MRC, 2021b). SIMVA is designed as a regional study of rural villages and households (HHs) located within a 15-km buffer zone on each side of the Mekong mainstream and around major floodplains in Cambodia and in the Mekong Delta. Key informants in 200 villages are surveyed and 2,800 HHs, evenly split across the four LMB countries are interviewed. It provides information on the percentage of HHs with members who engaged in fishing activities in the previous 12 months, the main fishing habitats exploited in the previous 12 months, the per capita income from fish and OAA sales and the percentage of HHs that sold, bought and consumed fish and OAAs. Critically, it provides key information of consumption rate of HHs across the LMB.

Globally, scientists and managers are increasingly exploiting remotely accessed information (e.g. Geographic Information Systems, or GIS) to fill knowledge gaps for fish production or habitat productivity, often through development of predictive models (Fisher, 2013). Although GIS layers cannot directly assess fish productivity, abundance and density, models (e.g. Kriging[1]) can be developed that estimate fish productivity, abundance and density based on habitats revealed in GIS coverages (Pereira, Schultz & Auster, 2014; Rivoirard et al., 2000). For example, land cover within the watershed can be used to predict the productivity of fish in reservoirs (De Silva et al., 2001; Vanni et al., 2005) or rivers (Creque, Rutherford & Zorn, 2005). This approach has been used in the LMB where the MRC has used GIS layers to determine the extent of different fisheries habitat types that is related to potential productivity to estimate the yields of capture fisheries (Hortle et al., 2007; Hortle & Bamrungrach, 2015; Hortle, 2017 unpublished). A similar approach was used in the Mekong Delta study (DHI, 2015). These Technical Guidelines describe the application of this approach to achieving this outcome.

[1] Kringing is a geostatistical method that can be implemented in GIS for estimating fish abundance and density.

5 FISHERIES YIELD ASSESSMENTS AT THE LANDSCAPE SCALE

5.1 INTRODUCTION

It is imperative to determine the total harvest of fisheries and OAAs (yield) from the Mekong to manage the resources effectively in the face of development and other factors affecting the ecological integrity of the Basin. Given the complexities in determining the catches from large rivers and lakes, a number of assessment strategies need to be applied to cross-reference the results and improve the accuracy of the results. The most appropriate tools available to compare the results are national fisheries statistical surveys, HH consumption surveys and GIS-based areal habitat yield models (Figure 5.1).

Applying these three methods allows triangulation of the results and the opportunity to intercalibrate the methodologies and improve accuracy. This intercalibration will also allow an estimate of the "Hidden Harvest" (FAO, Duke University & WorldFish, 2023) between reported FAO statistics and actual catches.

The following sections provide guidance on each strategy for assessing the fisheries (including OAAs) yield from the LMB.

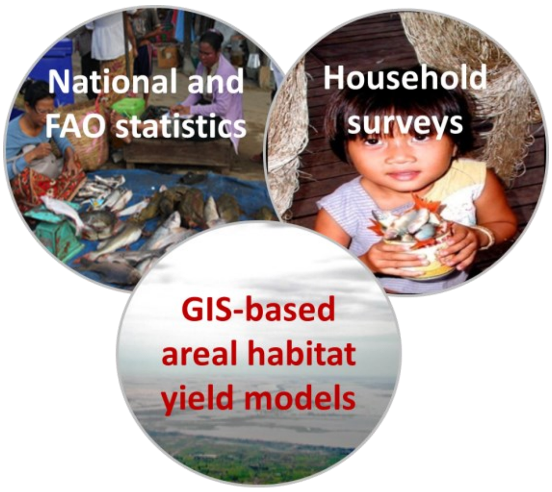

Figure 5.1. Mekong fisheries yield assessment strategies

5.2 FISHERIES AND AQUACULTURE DATA AND SURVEYS

Fisheries and aquaculture yields are usually referred to as 'production' in published official national statistics, a convention followed in this section. The two main sources of fisheries data are: (i) 'official' statistics for each country published by the FAO (FishStatJ); and (ii) surveys or monitoring carried out in each country. The utility of data from these sources is examined below.

5.2.1 FAO data

Fisheries and aquaculture data are collated by FAO to report to the FAO Committee on Fisheries. Official FAOStat data are usually available two years after their collection date; i.e. data up to 2020 are available in 2022. These statistics are compiled by the agency responsible for fisheries in each country and are provided to FAO. However, despite being commonly used to inform policy, there are known problems with the reporting, especially for inland capture fisheries (FAO, 2019).

All fisheries and aquaculture data are available on an online or downloadable database (FishStatJ:www.fao.org/fishery/en/topic/166235) and can be searched by country, continent, major fishing area, species (although many species are reported as NEI – i.e. Not elsewhere included) and environment (marine, freshwater, brackish). The database also holds information on global fish trade by partner country – quantities and values, global fish processed products and fishery food balance sheets.

FAO's statistics for the LMB (Figure 5.2) tend to grossly underreport catches from inland capture fisheries (Fluet-Chouinard, Funge-Smith & McIntyre, 2018; Ainsworth, Cowx & Funge-Smith, 2023), but are a reasonable indication of trends. This is because capture fisheries in the LMB are primarily artisanal or subsistence, with a small percentage (<10%) of full-time (FT) fishers in most places. A consider amount of fish and OAAs are consumed by the HHs that catch or grow them, so are not recorded in any official data; moreover, a large proportion of what is sold is also not recorded in any official systems. Furthermore, only national-level figures for inland fisheries and aquaculture are available because FAO data are not disaggregated by river basin (Ainsworth, Cowx & Funge-Smith, 2023). Most of Lao PDR and Cambodia are within the LMB so the national figures would be similar to FAO figures. In Thailand and Viet Nam, more accurate data are generated at the provincial level (see Section 5.1.2), but in Thailand, most of the inland capture fisheries data are from reservoirs, and data from large rivers such as the Mekong and Chao Phraya are poorly represented. Importantly, however, FAO statistics can be interpreted by reference to what is known of their origin and by cross-reference to other data that are likely more reliable (e.g. Ainsworth et al., 2023).

Irrespective of the underlying problems with FAO data, they are a valuable source of trends in catches and should be reported, as illustrated in Figure 5.2, as the baseline for any yield assessment. It is therefore recommended that these data are explored in conjunction with the national statistical reporting of fish catches as the first step in the triangulation of the fish catch assessment procedures described in this technical guidance.

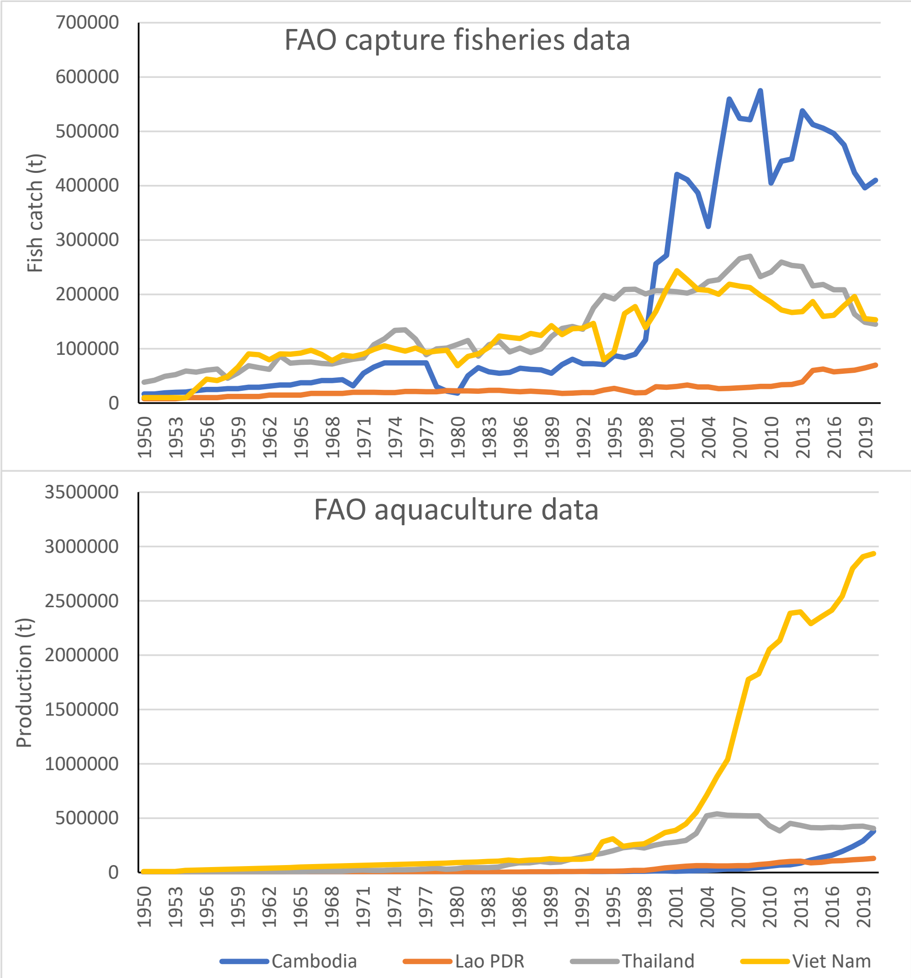

Figure 5.2. FAO FishStatJ records of annual fish catch and aquaculture production in Cambodia, Lao PDR, Thailand and Viet Nam

5.2.2 Official statistics

Each country prepares official statistics to report to Government and FAO in different ways, but usually carry out periodic HH surveys to determine social and economic characteristics of the population. These data can be reliable sources of information on livelihoods, food consumption and dependence of fisheries as a food source, and should be used to cross-validate against other approaches of determining the status and trends in fisheries.

In Cambodia, data are collated by the Central Statistics Office, Cambodian Fisheries Administration (http://camstat.nis.gov.kh), and IFReDI (Inland Fisheries Research and Development Institute. These surveys interview representative HHs across the whole country and provide valuable information on consumption levels of different parts of society. Fisheries statistics are collected as part of routine activities by government agencies, especially IFReDI and the Fisheries Administration. These include catch data, especially in the Tonle Sap Lake and catches from the Dai fisheries on the Tonle Sap River (e.g. Touch & Meas, 2021). Cambodia also regularly carries out national HH surveys to determine consumption of food products.

Official statistics for Lao PDR fisheries and aquaculture are prepared by the Government of Lao agencies based on estimates of water surface areas and assumed YPUA, rather than upon any field data collection. These same data are published by the FAO. The Government also carries out national HH surveys every five years, the Lao Expenditure and Consumption Surveys (LECSs), collated by the Lao National Statistics Bureau, which cover more than 8,000 representative HHs during each survey, and include both purchased and self-produced goods and services (LSB, 2019). Fish from capture and from aquaculture are combined in the summary data, and do not include OAAs. The survey is based on questionnaires that are filled by interviewers based on the recall of quantities and prices by respondents. As such the accuracy of responses is unknown, but because each survey has been carried out in the same way it can be assumed that any biases are consistent, thus any apparent temporal trends should reflect real trends. Adding more questions on the origin of fish, whether self-produced or from capture or culture, would aid in interpretation and the understanding required for policy formulation and cross-validation from alternative habitat yield surveys.

Official catch statistics in Thailand are compiled from an annual survey of commercial catches at landing sites on large reservoirs and some large rivers (FAO, 2019). They do not include most of the wild capture fisheries in Thailand, which are dispersed across a vast array of habitats, and thus likely represent only a small part of the inland fishery. The LMB contributes about half of the national figures and catches vary little from year to year, suggesting they are collected in a robust manner. Thai national figures for aquaculture production are more reliable than capture fisheries production, because aquaculture operations are licensed and regulated, and surveyed in a representative manner each year.

In Viet Nam, official inland capture fisheries production figures are reported for commercial catches, estimated based on locally registered gears or boats fishing in inland waters (www.gso.gov.vn). Most of the catches are from the Viet Nam Mekong Delta, but there is no official breakdown available for the LMB provinces which is consistent with the reported total national inland catches. Importantly, the Government conducts annual statistical surveys (GSO surveys) based on HH surveys, which provide valuable information on HH commodity dynamics and livelihoods, number of fishers, catch rates, and fish consumption rates by village, district and province. These data can be upscaled from the HH level to determine annual yield. In Viet Nam, official national figures for aquaculture production are more accurate than capture production figures, because aquaculture operations are licensed and regulated, and relatively easy to survey each year.

The following information should be collected from national statistics and provided to the MRC as part of the country reporting procedure on fisheries yield assessment:

- Population size;
- Number of HHs;
- Average household size;
- Number of full-time, part-time and occasional fishers in the household;
- Trends in fisheries catch and aquaculture statistics;
- Total fisheries and OAA catches and value of the catches;
- Average fish consumption and sources of fish consumed.

Where possible, these data should be reported by province.

The MRC should then summarize the national statistics, and account, where possible, the proportion of the area of each country and the contribution of the total population of each country within the LMB boundary (e.g. Table 5.1). These data can then be used to determine the fishing community demographics and consumption of fish and OAA products in the region.

In addition, the MRC should collate the annual fish catch and aquaculture production data for each country and the contribution from the LMB (Table 5.2). These data should be compared with the FAO statistical data but explicitly identify the contribution from the Mekong. They will be used as the baseline values against which to triangulate the consumption and GIS-based areal habitat yield models (Figure 5.1).

Table 5.1. Population of countries in the Lower Mekong River Basin countries in 2020 based on national statistics

Country	Whole country	LMB population	Percentage in LMB (%)	Number of households	Average household size
Cambodia	16,589,023	11,421,458	95.1	2,038,000	4.20
Lao PDR	7,231,000	4,850,765	93.0	1,296,980	5.57
Thailand	69.950,000	22,528,171	37.2	820,000	2.99
Viet Nam	77,635,400	17,505,470	22.5	4,794,200	3.85 in the Delta and 4.36 in the Central Highlands

Table 5.2. Summary of inland fish production (t) in 2020 in the Lower Mekong River Basin countries based on national statistics

Country	Whole country			LMB		
	Total fish production	Inland fish production	Aquaculture	Total fish production	Inland fish production	Aquaculture
Cambodia	826,300	413,200	400,400	813,600	413,200	400,400
Lao PDR	200,022	70,001	130,021	200,022	70,001	130,021
Thailand	2,769,035	451,009	2,318,026	199,929	67,873	132,056
Viet Nam	5,696,400	1,062,400	4,634,000	2,768,035	451,009	2,318,026
Total	9,491,757	2,110,709	7,482,447	3,981,586	1,002,083	2,980,503

5.3 HOUSEHOLD SURVEYS FOR FISHING ACTIVITIES, CATCH AND SOCIOECONOMIC INFORMATION AT THE LANDSCAPE SCALE

5.3.1 Background and objectives

Household surveys are the chosen methodology for collecting catch and socioeconomic information on fisheries and OAA harvest in the LMB. Household surveys have been successfully implemented in the region in a range of studies (Sjorslev, 2000; Sjorslev, 2002; Singhanouvong and Phouthavongs, 2003; Phan et al., 2003; Hortle and Suntornratana, 2008) and have be used in the MRC SIMVA data collection procedures as well as national statistical surveys.

The objectives of HH surveys to collect information at the landscape scale are:

- to update information regarding fishing gears, fish/OAAs catch estimates by habitat types, main species caught and consumed, and market prices of fish/OAAs from the major types of fish habitat in the LMB;
- to provide demographic and occupational information on fishing communities down to the district levels adjacent to major habitat types;
- to provide local perspectives about imports, exports, aquaculture and animal feed related to capture fisheries in the region.

The areas that should be surveyed are districts that are entirely or mainly classified as one of the main habitat classes. Districts that include flood-zone habitats will typically also include some rainfed habitat. Inclusion of villages located in this type of habitat in the survey ensures that catches by fishers who are likely to travel to and fish in, the nearby flood zone (i.e. the flood-zone fishery) are considered.

5.3.2 Village and household selection

A two-stage approach, as described by CDC (2007) and United Nations (2005), should be used to select sample villages and HHs, local authority staff's judgement of villages having the most fishing activities may be used to adapt the choice. Also, where possible, it is desirable to select the same villages and HHs used in previous surveys (see Annex 5 for list of villages used in 2020 surveys).

Irrespective, the survey should be based on a sample frame that includes all villages and HHs within a district from which a random sample of villages and HHs within the village should be selected using probability proportional sampling when establishing the sample frame. The methods for selecting villages and HHs are set below.

First, a number of districts are selected that represent the different major habitat types in each country. Previously, four districts were chosen in Lao PDR, three in Thailand, two in Cambodia, and three in Viet Nam (Table 5.3, Figure 5.3). These were chosen based on national census data and considered to be representative of the different habitat types in the countries. It is recommended that the same districts are chosen as in the past and in all subsequent studies for comparative reasons, but considerations should be given to integrate fisher HHs from FADM and SIMVA studies or asking supplementary questions in the government statistical surveys.

Village surveys

The aim of village surveys is to obtain background information, including the number of HHs in the village, fishing areas, trends in catches, and other complementary information to that obtained in the HH survey. Data can be used to cross-check data from the HH survey.

To undertake this approach, census data on villages and HH numbers must be obtained in advance from the National Statistics offices in the various countries, so representative samples can be selected for surveying. In the field, up-to-date data should be obtained from district offices. Extrapolation of results from the survey requires this census data.

If villages surveyed were not used in previous studies, then the selection of villages to be surveyed should use a two-stage cluster sampling approach as described by CDC (2007) and United Nations (2005). A sample of villages is chosen from within the target survey district using probability proportional sampling, a method in which the chance of a village being selected is proportional to the number of people in the village. As larger villages have more chance of being selected, the sample is self-weighting. The coverage for the survey areas should be between 25 km^2 and100 km^2 to ensure that a sufficiently large area is surveyed. The steps used to select the study villages are as follows:

1. In Excel, create a table with villages, listed alphabetically, and number of HHs in each. Note: the number of HHs may need to be estimated from the village population size divided by the mean HH size.
2. Add a third column listing the cumulative number of HHs.
3. Count and record the total number of all HHs in all villages in the district N.
4. Calculate the sampling interval [SI], i.e. the proportion of villages (N) in the district to be sampled based on the number of villages that can be sampled using the resources available. This is achieved by dividing the total number of HHs by the number of villages to be sampled (n). For example, in District 1, there are six villages with a total of 2,010 HHs. In order to sample two villages, then SI=N/n, SI=2010/2. Thus, the SI=1,005.
5. Select a random number between 1 and SI (i.e. 1,005 in the example) for the first village to be surveyed, called Random Start (RS) by using the Excel function =RANDBETWEEN(1,SI) (i.e. [=RANDBETWEEN(1,6) in the example). In the example, the RS is 923. The selected village will have a range containing 923, which is village D. The next village to be surveyed will contain number RS+SI (923+1005=1928), which is village F.
6. Continue to add the SI (i.e. 1,005 in the example) to each number until numbers of all villages to be surveyed are selected.

Village	No. of HHs	Cumulative	Range	Random	Selected village
A	100	100	1–100	923	D
B	200	300	101–300	1,928	F
C	300	600	301–600		
D	450	1,050	601–1,050		
E	550	1,600	1,051–1,600		
F	410	2,010	1,601–2,010		

Since HHs are the primary sampling unit (PSUs) used to extrapolate total catches in the district and the proportions of catch from each habitat, it is also important to ensure that the villages in the zones to be surveyed cover the range of habitats at sufficient scale to reduce edge effects, i.e. to obtain a representative or average proportion of the types of habitat, as well as the fishing effort and catches in the study areas. To achieve this, the head of each village as well individuals who have general knowledge of the village and fisheries, should be interviewed to gain information about the number of HHs engaged in fishing or other activities, and an approximation of where they fish.

Equally important when selecting the villages is that the majority (70%) of the villages are close to the fishing area. For example, in a district where 29% of the villages are far from the fishing area [FA] (i.e. around 2 km or more from the FA) and 71% are near to the area, we can assume that the 'Far from FA' villages also fish in the FA zone to some extent, so they need to be included in the survey.

For each selected survey area, updated maps would be prepared based on the new Information and Knowledge Management Platform (IKMP) GIS data, the MRC's flood layer, and villages and infrastructure. A more detailed map to allow for a finer resolution of smaller habitat patches should be prepared for each survey area based on any available aerial photos, satellite images and Google Earth imagery (at best, 2-m resolution, if available). The habitat classifications should be ground-truthed and photo-documented by project staff during site visits in both the dry and wet seasons.

Household surveys

The HH surveys are designed to gather catch data from representative HHs fishing different habitats. The data are then extrapolated to all HHs that are expected to be fishing in the study area based on the results of the village survey. Catch assessment is based on estimated effort (fishing days) multiplied by catch per day, but other data are also collected to support the estimates, including consumption data.

The section of HHs follows a systematic sampling procedure:

1. Using Excel, list all the HHs of each village, which is often provided by village authority. The list should be alphabetical or in a random sequence.
2. Calculate the sampling interval [SI], i.e. the proportion of HHs (N) in the village that need to be sampled based on the number of HHs that can be sampled using the resources available. This is achieved by dividing the total number of HHs (N) by the number of HHs we wish to sample (n). For example, if there are 289 HHs in the village and six of them need to be sampled, then SI=N/n, SI=289/6. Thus, the SI is rounded off to 48, i.e. every 48th HH needs to be sampled.
3. Select a random number between 1 and the SI (i.e. 48 in the example) for the first HH to be surveyed, by using the Excel function=RANDBETWEEN(1,SI) (i.e. [=RANDBETWEEN(1,48)] in the example).
4. Add the SI (i.e. 48 in the example) to the first HH number to obtain the second HH be surveyed (i.e. if the first HH randomly selected is no. 25, then the next house is no. 25 +48 = 73.
5. Continue to add 48 to each number until there are six HHs.

If for some reason a HH cannot be surveyed, choose an adjacent house and note that you did so on the sheet. If a chosen HH is uncooperative, choose an adjacent house and note that on the sheet.

Distribution of districts and households surveyed in 2020

The distribution of districts chosen for the 2020 survey is shown in Figure 5.3. The districts and number of HH surveyed for the 2020 Landscape level study are given in Table 5.3 (see Annex 5 for list of villages used in 2020 surveys).

Currently, the distribution of these districts and the selection of villages and HHs are under review, and consideration is being given to making better use of FADM monitoring in specific villages or asking supplementary questions in the government statistical surveys.

Table 5.3. Location and number of households surveyed for the 2020 landscape scale study

Country/province	Rainfed Rice fields and associated habitats – H1	Floodplain – large river – H2	Reservoir – H3	Brackish-estuarine -– H4	Total
Cambodia					180
Prey Veng	45	45			
Kompong Thom	31	29	30		
Lao PDR					180
Champasak	2	45	43		
Borrikhamxay	45	43	2		
Thailand					183
Ubon Ratchathani	22	19	20		
Si Sa Ket	61				
Nakhon Phanom	30	31			
Viet Nam					180
An Giang	8	54			
Tra Vinh	2			116	
Total	246	266	95	116	723

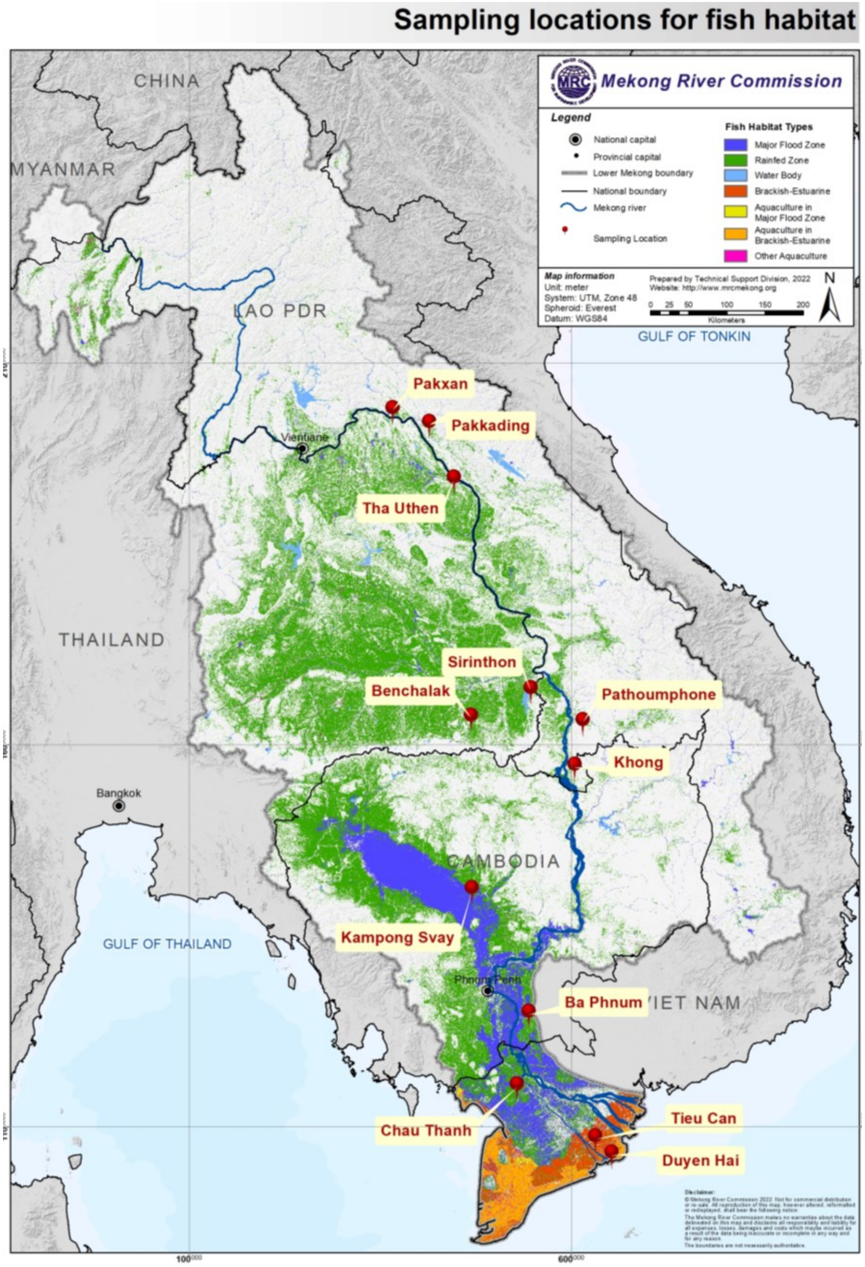

Figure 5.3. Distribution of districts surveyed in the 2020 landscape scale study regarding different fish habitat types in the LMB

5.3.3 Survey techniques

The village and HH/fisher surveys are based on structured interviews to collect data on HH/fisher's fishing gears, fish/OAAs catch estimates by season and by habitat types, main species caught and consumed, and market (first sale and retail) prices of fish from the major types of fish habitats in the LMB (Annex 3). Although the probability proportional sampling procedure was recommended earlier, HH/fishers selected for interviews should be from different backgrounds, and if possible, should include as many of the HH/fishers interviewed in previous surveys (Annex 5) to enable continuity and minimize biases associated with selecting different HHs. The HHs/fishers should also fish in as many different micro-habitats as possible. Further information can also be collected from the questionnaires targeting provincial fisheries management officers and focus group discussions organized in local/fisher communities.

The instructions for the village and HH/fisher surveys and questionnaires are provided in **Annexes 1, 2 and 3**.

A questionnaire for provincial fisheries management officers is based on semi-structured interviews to provide information on local perspectives about import, export, aquaculture and animal feed related to capture fisheries in the region. The questionnaire and instructions for the provincial fisheries management officer surveys are provided in **Annex 3 – Toolbox 2**.

Focus group discussions should also be organized in local/fisher communities of the same selected districts for each Member Country to validate the data and information collected from the HH/fisher surveys and reflect on different perspectives that would not be recorded during the HH/fisher interviews. Each focus group discussion should include 6–10 people, with a balance of men and women. Open-ended questions used for group discussions with local/fisher communities are provided in **Annex 3 – Toolbox 3**.

Photographs should be taken of the habitat types, fisheries products (raw and process) during the field surveys. Survey teams are encouraged to use cameras (or Smartphones) with the Global Positioning System (GPS) turned on when taking photos to record the coordinate of the location of the sites.

The following stepwise procedure is used to determine the fish and OAA catches and consumption by individual fishers/HHs. Note, it is assumed there is only one fisher per HH in the analysis, although it is known that several members of the HH may fish either full-time (FT), part-time (PT), or occasionally.

1. Initially, HH are asked to indicate the contribution of fishing to their livelihoods, as FT, PT or occasional. Occasional includes subsistence fishing or to supplement income on an ad hoc and possibly, a seasonal basis.
2. Fishers from each category are then asked to indicate the primary gear used, the main fishing habitat, and where possible, micro habitat fished, the main fishing season, or if fishing is conducted all year round, the proportion of time spent fishing, and the percentage of the catch according to the main fishing gear used.
3. The same questions are repeated for secondary gear or secondary habitat using the same gear, and if appropriate, for tertiary gear or habitat.
4. The same steps are repeated for OAAs to determine the total monthly and annual catches.
5. The total monthly catch of the fisher from the primary habitat is then enumerated by asking the fisher to recall his catches in each month.
6. The procedure is repeated for secondary and tertiary habitats and gears.
7. Steps 2–6 are repeated for OAAs to determine the total monthly and annual catches by each fisher/HH.
8. The total annual catches of fish and OAAs for each fisher/HH are calculated from the sum of the monthly catches.

9. The proportion of the annual catches of fish and OAAs sold on the markets or to friends and family should be determined.
10. Where possible, the main species caught and sold should be determined, and the average sale price of the fish and OAAs provided to derive the value of the overall fish catch and various groups of OAAs.

A limitation of the HH surveys carried out for the assessment of total yield for the LMB is that only a small number of HHs in a restricted number of districts covering a limited range of habitat types are surveyed (see Table 5.3). This limits the capacity to upscale the data to other districts or provinces, and to provide representation of catches from different habitat types across the LMB. The fisher logbook surveys carried out under the MRC Fisheries Abundance and Monitoring (FADM) programme are therefore used. Here, three fishers from 38 different locations across the LMB (see Annex 5 for details) complete daily logbooks of their catch. These data can be used to supplement the HH survey data and tune the annual catch data of different provinces.

5.3.4 Household surveys data analysis and reporting

Household survey data should analysed and reported for the following characteristics at both the national and regional levels. Examples are provided both for national reporting and regional summarising of the information collected. It is also important that the information be interpreted to help understand trends, and that cause and effects of changes found are described in full.

Demographic and socioeconomic characteristics of fishing villages

The demographic and gender characteristics of the majority of fishers and their families is important information to understand whether those engaged in fishing are ageing as is found elsewhere in the world and the proportion of women involved both directly in fishing and in ancillary, processing and marketing activities. Currently, most fishers are aged between 40 and 60, with an average age between 45 years old in Cambodia and 54 in Thailand (Table 5.4; Figure 5.4). The demographics suggest that the fishing communities in all countries are ageing, except perhaps in Cambodia, which has a higher proportion of younger fishers.

Table 5.4. Survey data collected by province, district and fish habitat type

Province	District	Habitat type	Sampled household /fisher	Age of fishers in sampled households			Number of family members in sampled households		
				Average	Min.	Max.	Average	Min.	Max.
Prey Veng	Ba Phnom	Rainfed Rice fields	45	49.1	15	64	4.8	2	12
		Flood-plains	45	42.8	22	74	5.1	2	10
Kampong Thom	Kampong Svay	Rainfed Rice fields	30	43.8	25	63	5.2	2	11
		Flood-plains	30	47.5	33	66	5.9	4	9
		Reservoir	30	42.1	15	64	4.4	2	7
Overall average			180	45.2	15	74	5.1	2	12

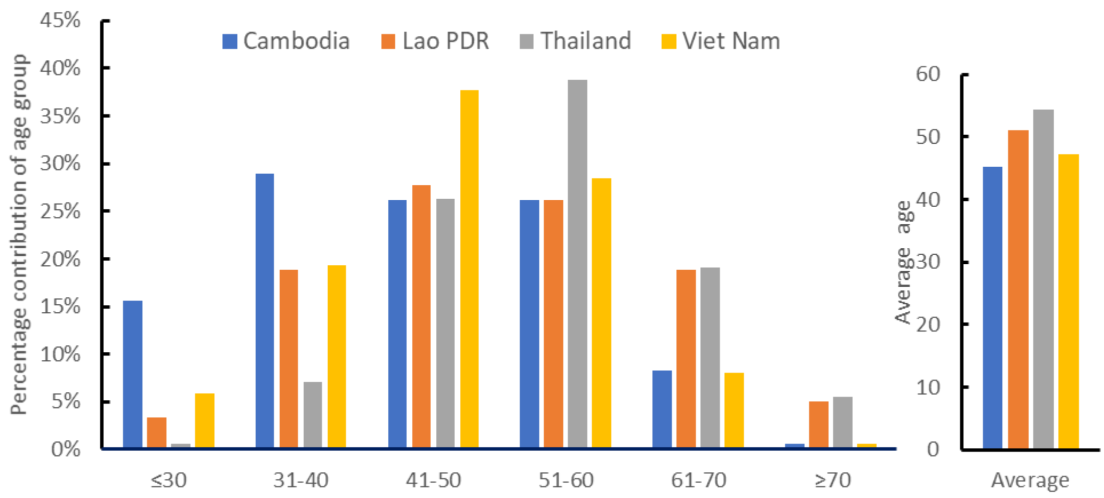

Figure 5.4. Age distribution and average age of fishers in villages surveyed in 2020 household surveys

The proportion of FT, PT and occasional fishers interviewed across countries is an valuable indicator of the importance of fishing to livelihoods and income in the region (Table 5.5). It is important that the data be collected for each habitat type bot only to show the variability in fisher category between habitat types, but highlight the importance for different types of habitat for fishing. For example, major flood zone areas (H2) are more important for FT fishers in Cambodia, while rainfed zones (H1) are more important for PT fishers (Table 5.5). These data should be compared with the latest SIMVA and Government statistical data, which have a wider distribution of surveys across the Basin. It should be recognized that the SIMVA surveys (MRC, 2021b) appear to misrepresent the number of FT and PT fishers in the overall population, but attempt to determine the proportion of occasional (perhaps subsistence) fishers in the population. This is likely because the questions asked about fishing as a livelihood are related to income rather than time spent fishing. It is important to discriminate the main livelihoods of all persons surveyed and the proportion of FT, PT and occasional fishers in the population.

Table 5.5. Number of full-time vs. part-time fishers at the sampling sites

Country	Occupation	Rainfed zone	Major flood zone	Water bodies	Brackish and estuarine zone	Total 2020 surveys	Proportion of fisher categories, from SIMVA 2018 (%)
Cambodia	Full-time	5	40	13		58	7.9
	Part-time	71	34	17		122	7.6
	Occasional						33.8
Lao PDR	Full-time	18	17	10		45	0
	Part-time	28	72	35		135	6.5
	Occasional						8.7
Thailand	Full-time	1	7	6		14	1.6
	Part-time	112	43	14		169	9.9
	Occasional						41.9
Viet Nam	Full-time	44	43		59	146	2.3
	Part-time	28	6			34	5.8
	Occasional						3.6

The ratio of female to male fishers in the communities (Table 5.6) should be determined to understand the gender roles in the fishing communities and the contribution of women to HH activities and livelihoods.

Table 5.6. Fisher characteristics by gender of sampled household/fisher across fish habitat types

Province	District	Habitat types	Sampled HH/fisher	Female %	Male %
Cambodia					
Prey Veng	Ba Phnom	Rainfed Rice fields	45	11	89
		Floodplain	45	27	73
Kampong Thom	Kampong Svay	Rainfed Rice fields	30	40	60
		Floodplain	30	30	70
		Reservoir	30	3	97
Lao PDR					
Bolikhamxay	Pakkading	Rainfed	45	7	93
	Paksan	Floodplain	45	0	100
Champasak	Khong	Floodplain	45	27	73
	Pathoum phone	Reservoir/permanent water body	45	22	78

Fishing activities

Although there are some 160 recognized fishing gears used in the LMB, of which 58 were reported as being used in the 2020 surveys (MRC, 2023a), it is recommended that only the ten most important fishing gears used by fishing season across different fish habitat types be reported (e.g. Figure 5.5), although the full list of usage can be reported in supplementary material. It is also important to determine the proportion of the catch taken by each of the gears (Figure 5.6) as it provides a good indication of the main sources of exploitation and can help define fishing regulations.

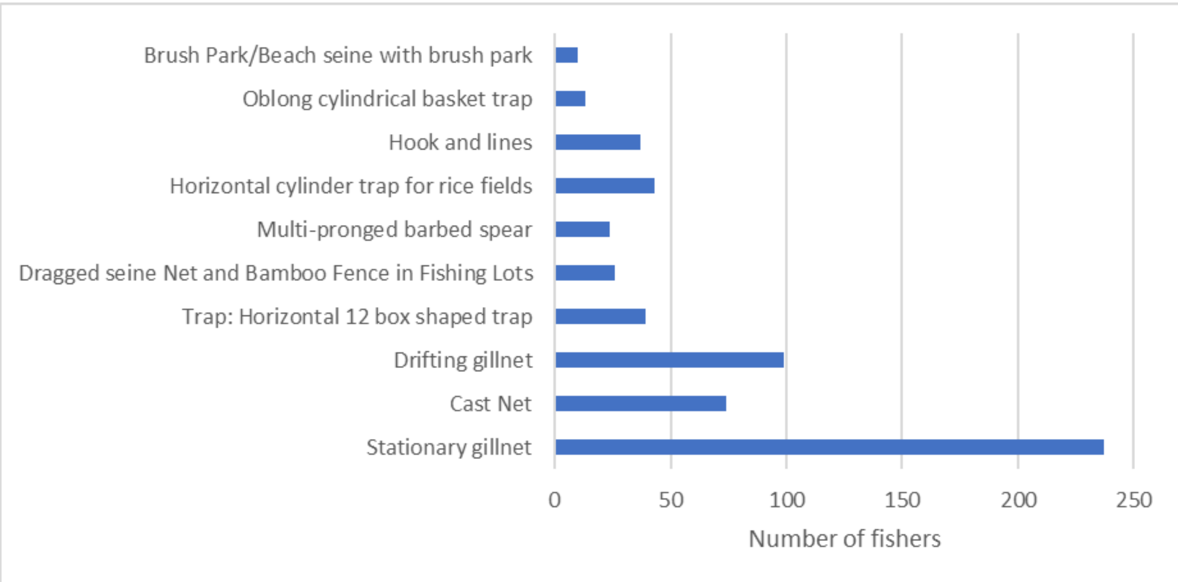

Figure 5.5. Main fishing gear used by fishers in household survey

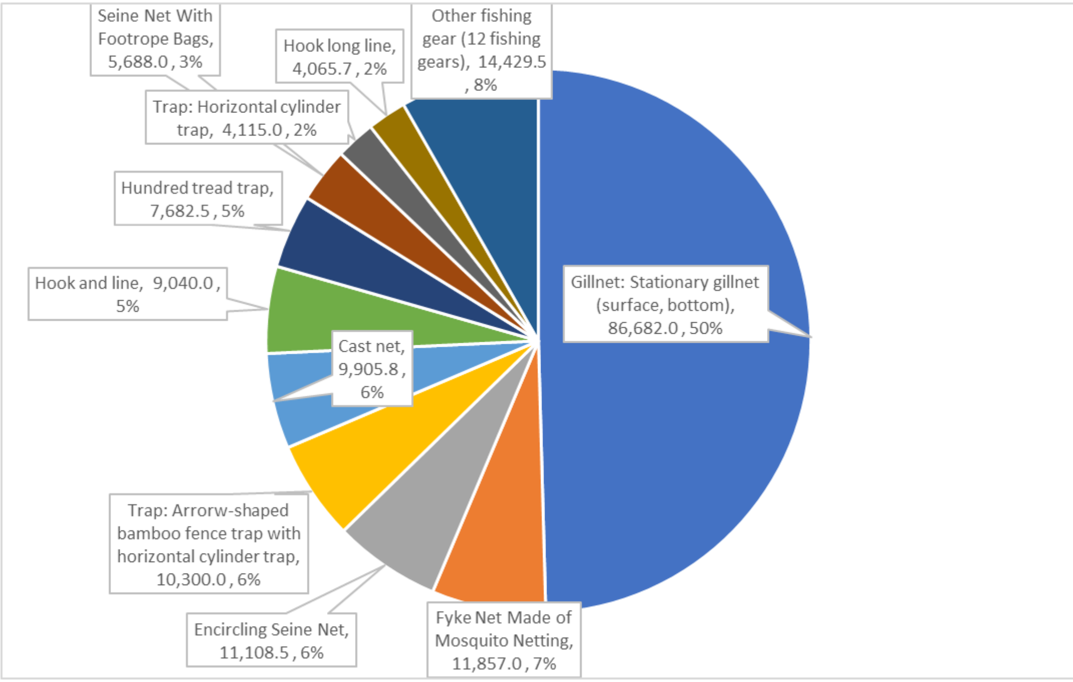

Figure 5.6. Contribution to catch (%) by the top 10 fishing gear used in Cambodia

Another important attribute of fishing activities that needs to be presented is the distribution of effort between seasons by fishers (Table 5.7). This helps manage fishing effort, especially regarding breeding seasons of key species, should it be required.

Table 5.7. Seasonal distribution of fishing activities in the LMB based on household surveys

Country	Both seasons	Dry	Wet
Cambodia	67	17	96
Lao PDR	141	26	13
Thailand	95	42	46
Viet Nam	150	6	30
Total	453	91	185

Fishing catch and effort

One of the key outputs of the fisher/HH surveys is the determination of mean catch rates (kg/fisher/year) for fish and OAAs. These are derived from fisher catches in the different countries and different habitat zones (Table 5.8), as described in Section 5.3.3. A similar assessment of catch rates can be undertaken for OAAs (kg/fisher/year).

Table 5.8. Mean fish catch per fisher in different habitat types in the four countries of the LMB

		Rainfed zone (H1) Mean ± SD	Major flood zone (H2) Mean ± SD	Water bodies (H3) Mean ± SD	Brackish and Estuarine zone (H4) Mean ± SD
Cambodia	Full-time	1,704 ± 745	2,273 ± 2,412	2,063 ± 1,815	
	Part-time	222 ± 243	742 ± 829	469 ± 335	
Lao PDR	Full-time	819 ± 540	1032 ± 605	935 ± 555	
	Part-time	452 ± 317	829 ± 615	428 ± 389	
Thailand	Full-time	383 ± 785	1,357 ± 1,246	645 ± 779	
	Part-time	387 ± 1,027	463 ± 389	634 ± 733	
Viet Nam	Full-time	3,263 ± 4,729	2,696 ± 2,707		12,021 ± 12,344
	Part-time	311 ± 379	238 ± 144		

Consumption of inland fish products

Fish consumption rates should be derived from fishers exploiting different habitat zones (e.g. Figure 5.7). It is likely that only marginal differences will be found between zones, although it is expected that consumption rates may be higher in fisher HHs exploiting the more productive habitat types, e.g. major flood zone (H2) in Lao PDR or the brackish-water estuarine zone (H4) in Viet Nam. It is imperative that more in-depth analysis of the type of fish consumed be carried out to understand any differences in consumption rates between habitats and countries.

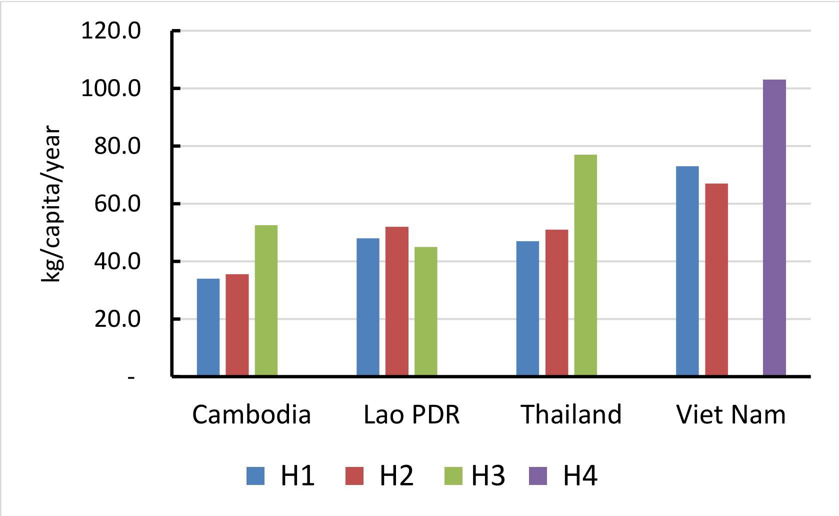

Figure 5.7. Average fish consumed by HH/fishers (kg/capita/year) exploiting different habitat types in the four countries of the LMB

Fish prices

During the HH surveys, fishers were asked the first sale price of their catch according to three length categories (<25 cm, 25–50 cm and >50 cm), as well as the price of similar sized fish on the market (Figure 5.8). As expected, the median prices of different sizes of fish and categories of OAAs vary between major habitat types fished and between countries, with the value of larger fish higher than smaller fish. Combining these data with retail sale value (mark-up) and market surveys will provide valuable information on the added value of the fish and OAA products in the market and to GDP. This information will enable managers to understand if the price is driven by market demand or local economic drivers.

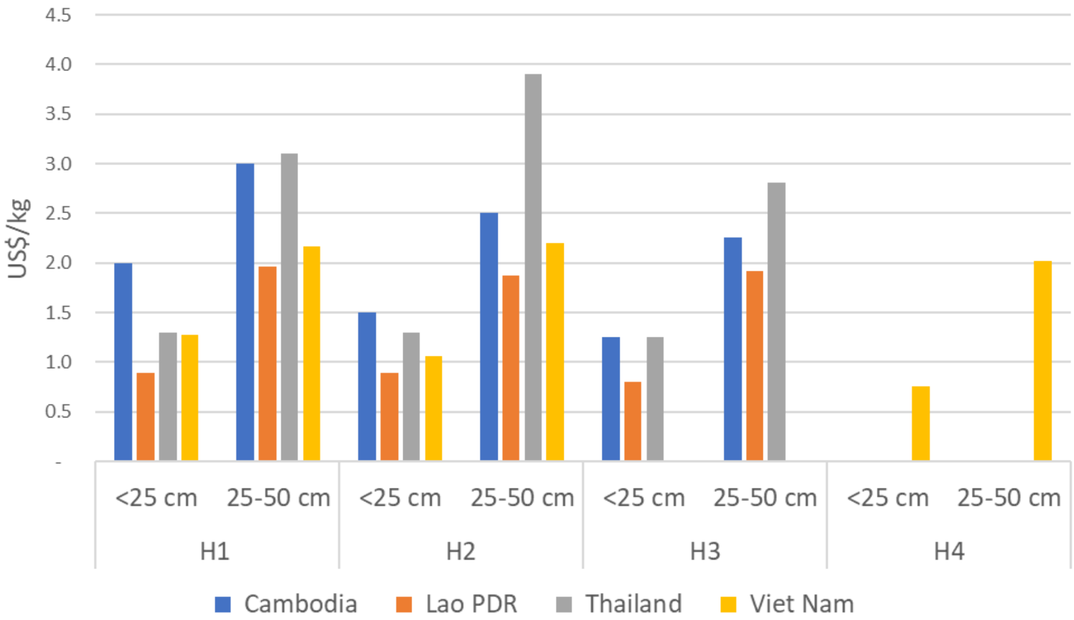

Figure 5.8. Average market price of small- (<25 cm) and medium- (25–50 cm) sized fish caught in different habitat types in the four countries of the LMB

Finally, the mean first sale and final retail values will allow an approximation of the total value of fisheries and OAA harvest to be estimated, and highlight the importance of the services provided by the fisheries sector for comparison against other sectors such as agriculture or aggregate extraction.

5.4 FISHERIES YIELD BY HABITAT AT THE LANDSCAPE SCALE

5.4.1 Introduction

The aim of this component is to estimate the yield (catches) and value of fish and OAAs from the main types of habitat that support fisheries and aquatic production. Total catch can be derived from the relationship between *YPUA* determined from interrogation of catch rates by different fishing gears in specific habitat types and *AREA* of habitat for different types of water bodies using *Catch=AREA*YPUA*. A GIS approach is used to determine the *AREA* of habitat for different types of water bodies (Figure 5.9). And the fisheries yield, the amount of fish harvested from a particular ecosystem or water body, is the product of exploitation rate (CPUA of habitat) and fishing effort (number of fishers and time spent fishing). What are important here are to obtain an accurate assessment of the coverage of the different habitat types and an estimation of the yield per habitat type to determine the total production from the system.

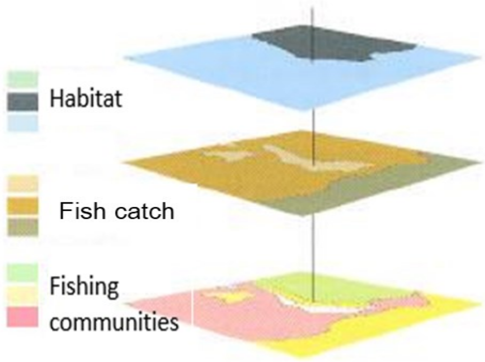

Figure 5.9. Illustration of steps/layers used to determine inland fisheries yield from a landscape perspective

5.4.2 Challenges with yield per habitat assessment

Inland fisheries yield assessment and forecasting pose challenges that differ from the marine environment, where the main stock assessment models were developed, and this is true for the LMB. Fishery-dependent data in the LMB are difficult to generate because many fisheries are subsistence, informal, unregulated and there is no formal monitoring scheme. Furthermore, major fisheries operate in the larger river channels associated with migratory species. Other challenges are:

- sheer number and diversity of fisheries and the gears used;
- weak institutional capacity and financial and human resources for assessment;
- anthropogenic impacts other than fishing;
- frequent use of active enhancement measures such as stocking that affect stock dynamics.

As a consequence, accurate assessment of the production or yield from the LMB and other large tropical rivers is elusive. This is further exacerbated by the considerable environmental and geomorphological changes that the river is experiencing as a result of infrastructural and economic development in the Basin.

It is fundamental to ensure that robust data are collected on the fisheries exploitation patterns to account for changes in fishing pressure and environmental changes in the LMB. It is necessary to know the volume, value or other measures of the contribution of the fisheries to understand their importance to livelihoods and food security. There is thus a need to capture real-time consumption data and fisheries resource uses to advocate for their protection and conservation when integrating into wider basin policy development. The next sections outline the procedures for collecting data on the ground for a better understanding of the yield and value of fisheries in the LMB.

5.4.3 Land-cover datasets and maps

GIS mapping tools are used to determine the coverage of the major aquatic habitat types (in the LMB. Although there is a wide diversity of aquatic habitat types, it is reduced to four main categories, defined broadly as follows:

Major flood zone: land that is subject to flooding in most years to depths >0.3 m by water from adjacent rivers. Based on the 2010–2019 annual flood maps, the flood zone represents the area inundating at least 50% of the maximum annual flood extent. Most of this area consists in floodplains, covered by recession rice fields, forest or scrub, streams, swamps and water bodies, and also includes the Tonle Sap–Great Lake system. Note: floodplains may be modified so there is little flooding now, especially in Thailand. Floodplains can also be termed 'water resource-rich' habitats; they may not flood every year, but there is relatively abundant surface water most of the time.

Rainfed zone: land that is inundated in most years by rainwater or local diversion to shallow depths up to about 0.5 m; this mainly includes rainfed rice fields as well as smaller streams, channels and swamps located outside major flood zones.

Large water bodies: all water bodies outside major flood zone, including:

- Large rivers;
- Artificial reservoirs;
- Large canals.

Note: if the areas of the large water bodies are small, they may be included in the rainfed zone because of the resolution of GIS (30-m pixels). They may be viewed by people as independent of other habitats.

Brackish-water estuarine zone: brackish-water habitats located in zones where fresh water meets seawater, including mangrove area. These are exclusively in the southern Viet Nam Delta.

In addition, distinct **aquaculture** production areas in each of the major fish habitat types can be determined.

The procedure to define these major wetland and aquaculture habitat areas is described in Simons (2022) and summarized below:

1. The maximum annual flood extents were determined for the 2010–2019 period from the Joint Research Center (JRC) Yearly Water Classification History data accessed through the Google Earth Engine[2]. Based on this dataset (10 maps), all

[2] http://code.earthengine.google.com

pixels with at least one observation of inundation in a given year were included in the maximum flood extent for that year.

2. The 10 maps of maximum annual flood extent were examined to identify the pixels that are included in at least half of the maps (i.e. flooded for at least 1 month during at least five of the years in the 2010–2019 period).
3. To differentiate reservoirs and other water bodies detached from the mainstream or major tributaries, a segmentation procedure was applied using the (Orpheo Toolbox (OTB) in QGIS v3.22. The OTB segmentation process creates clusters of connected pixels with the same value, and assigns to each cluster a unique ID. In this way, a single cluster was produced consisting of the major river network as well as all connected permanent and seasonal surface water included in the map created in Step 2. All other clusters comprised surface water that is permanently present or frequently recurring, but detached from the major flood zone, and was therefore excluded from the major flood zone from this step onwards. The water bodies located outside the major flood zone represent Class 3.
4. In the previous steps, some reservoirs were erroneously classified as major flood zone rather than water bodies. These were converted to water bodies based on a shapefile of reservoirs provided by the MRCS (generated for the Second Basin Development Plan).
5. Isolated pixels were removed using the sieve function in QGIS v3.22.
6. Built-up areas and all other lands based on the 'urban class' in the MRC Technical Support Division (TD) Land Use/Land Cover (LU/LC) product for 2020 (MRC TD, 2021), which are not part of the major flood zone, nor of any of the other habitat types (i.e. aquacultures), were removed. The output represents the major flood zone (Class 1).
7. Paddy fields and marsh and swamp areas outside the flood zone were extracted from the MRC TD LU/LC 2020 product and added to the rainfed flood zone to represent the rainfed habitat (Class 2). Special attention was paid to triple rice cropping systems that have effectively resulted in the conversion of former major flood zone land to rainfed zone land.
8. The intertidal estuarine (EI), subtidal estuarine (ES), and marine-coastal/intertidal (MI) Level 3 classes were extracted from the wetland database, and collated in a single brackish-water estuarine habitat class (Class 4).
9. Aquaculture in the major flood zone and in brackish-water estuarine habitats was subtracted from the respective major habitat types to produce Classes 5 and 6. All aquaculture that is located outside the classes included in the major fish habitat map were designated Class 7.
10. Finally, minor manual adjustments were made to correct for obvious errors in the source datasets:

All datasets were produced in GeoTIFF format with a 30-m spatial resolution. The coverage of these different habitat types in 2020 are illustrated in Figure 5.10 and values given in Table 5.9.

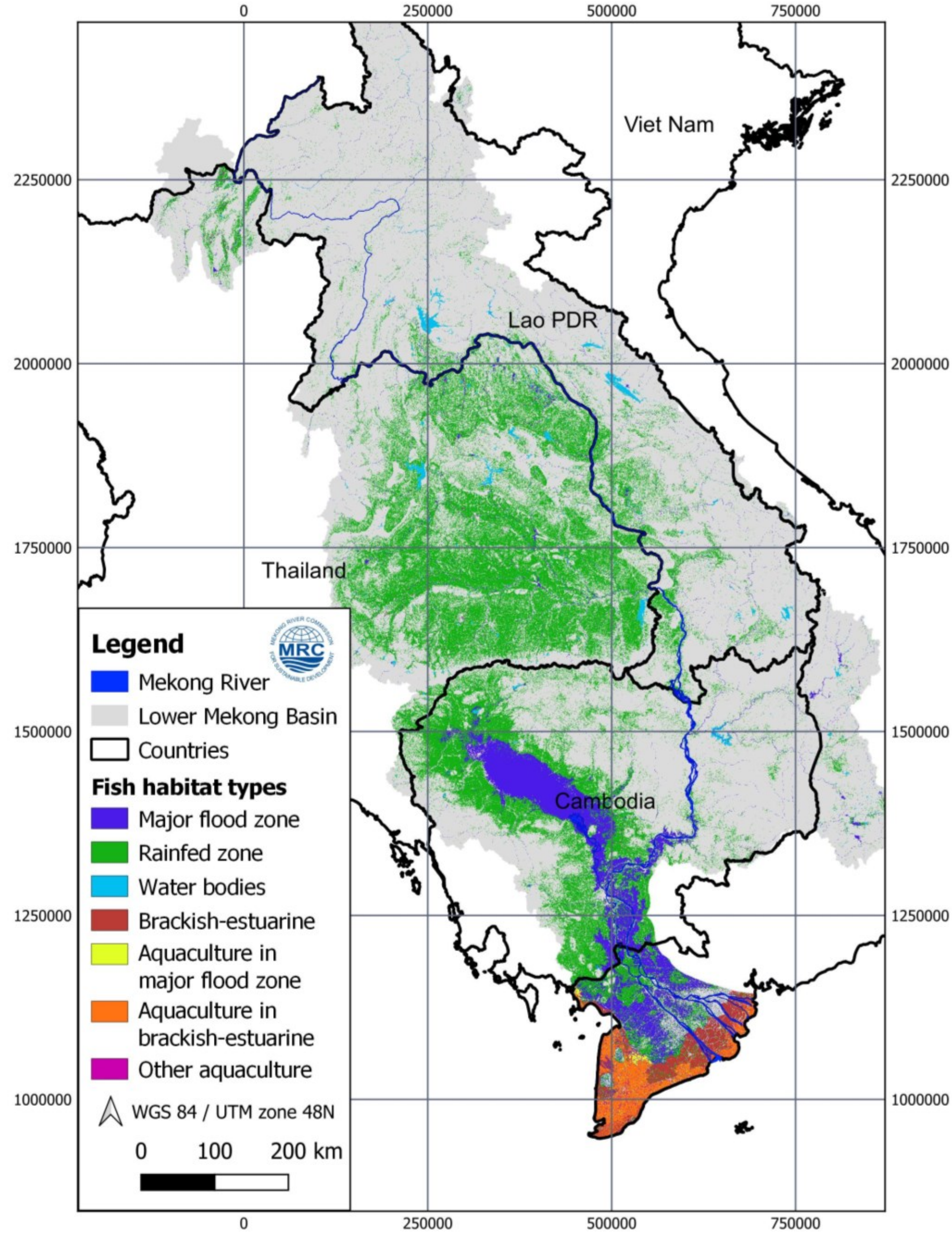

Figure 5.10. Coverage of different fish habitat types in the LMB

Table 5.9. Area (km²) of broad classes of aquatic or wetland habitats based on MRC's GIS data (Simons, 2022)

Habitat Zone	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam Highlands	TOTAL LMB
Wetland area						
Major flood zone: permanent water bodies including most major rivers, the Tonle Sap – Great Lake system, and seasonally flooded land and recession rice fields.	19,069	2,740	2,278	8,957	553	33,597
Rainfed zone: mainly rice fields, other wetland crops and associated habitats not within the major flood zone. Most is former forest.	36,867	13,556	74,947	6,706	1,033	133,109
Large water bodies outside the flood zone, including reservoirs, and canals in the southern delta.	529	2,010	2,422	7	283	5,251
Brackish-water estuarine	18	0	0	12,995		12,995
Total wetland area	56,483	18,305	79,648	28,665	1,869	184,970
Aquaculture habitat area						
Major flood zone	64.4	36.7	110.0	834.8	7.6	1,054
Brackish-water estuarine	11.0	0	0.6	6,518.8		6,590
Other	154.3	182.3	944.6	889.1	77.6	2,267
Total aquaculture outside flood zone, not considered in yield figures	228.6	215.9	1,069.5	8,396	-	9,910
Total aquatic habitat area	56,713	18,524	80,703	36,908	1,954	194,881

Note: Small areas (-) are not delineated by the GIS data.

It should be noted that major changes in the habitat areas were found between the 2000, 2010 and 2020 assessments (Table 5.10). Data for 2003 are also shown to give an example of change in wetted area resulting from a strong flood year. These differences in categories are largely caused by isolating brackish-water estuarine areas from major water bodies and the substantial decline in flooded areas in the 2020 assessment. This latter point becomes more prominent because the updated definition of major flood zone is more conservative and it does not look at a single major flood season but is based on the median of maximum annual flood levels during the 2010–2019 period. In addition, water levels during the flood season in the LMB have decreased in the past decade, which is likely reflected in a smaller major flood zone (MRC, 2018b). There is also a decline in major wetted area between 2000 and 2020, which is partly the result of shift in land use to cropland, mostly of flooded forest, and conversion of wetland to other uses. **As a result of the issue over defining the area of different habitat types, it is recommended that the approaches to assessing the extent of each habitat type and GIS algorithms used to carry this out are standardized for future studies.**

Table 5.10. Changes in major habitat areas in the LMB derived by GIS

Habitat type	2000	2003	2010	2020
Major flood zone	57,197	58,017	57,196	27,093
Rainfed	126,547	129,835	124,037	133,118
Water bodies	6,533	7,512	8,260	5,276
Brackish-water estuarine				13,421
Total	190,276	197,737	189,494	178,908
Aquaculture	2,095	2,373	6,792	9,910

5.4.4 Fisheries yield per habitat type

Fisheries yield, the amount of fish harvested from a particular ecosystem/water body, is based on the product of exploitation rate and biological production. Biological production of fish represents the total amount of living material (biomass) that is produced from the ecosystem at all trophic levels during a defined period of time, but accumulated in fish at different trophic levels. This production is important because it is a direct measure of total ecosystem processes, and it sustains biological diversity. The yield of the fish is critical to understand the total harvest from the ecosystem, in this case the LMB. It is therefore critical to understand the yield from each type of habitat in the LMB to extrapolate the data from the habitat scale to the basin scale.

In the Mekong, aquatic productivity, and thus fish yield, is largely dependent on the extent, duration and depth of inundation by water, as well as other factors such as the quality of the inundated habitat, the nutrient levels and the amount and quality of inundated terrestrial organic material. Although some permanent water is found, typically in the river channels, lakes and permanent wetlands, temporary seasonal water bodies are more extensive than permanent water bodies during the flood pulse and contribute extensively to the production. It is therefore important to understand the contribution of both the permanent and temporary water bodies to overall production and yield.

Previous assessments of the yield per habitat area (Hortle, 2007; Hortle & Bamrungrach, 2015) used mean values of catch per area of habitat based on the literature (Tables 5.11, 5.12). These are averaged from a range of studies both within and outside the LMB. (See Annex 4 for list of studies used to derive average values of yield per habitat area.) While they may remain valid, the Mekong ecosystem form and functioning, and in particular the flooding regime, are changing, and the values may no longer be representative of conditions of the system. Further, the values are generalized for each country and considerable variability may be found between different regions. Therefore, these guidelines will provide a revised methodology for assessing yield per habitat and testing against the values used by Hortle (2007) (Table 5.11) and Hortle & Bamrungrach (2015) (Table 5.12), to obtain more up-to-date values to reflect recent changes. In doing so, it should also be recognized that the source of catches in the target habitats is often distant from that which provided the biological production to support the harvest of aquatic animals. This is largely because fish and OAAs migrate upstream, downstream and laterally within the LMB (MRC, 2015), thus production, and hence yield, must be determined for the total basin area to account for this redistribution of production.

In 2017, this was further refined to add fisheries yield for brackish-water estuarine habitats (Table 5.13). These data are then extrapolated to determine the mean catch per unit area of habitat (Table 5.14), although the methodology used was not well described. Yields for the flood zone districts in Lao PDR and Cambodia are close to the expected low value of 100 kg/ha/year, Thailand is above the expected high value of 200 kg/ha/year and the value for Viet Nam is much higher than expected high values. Yields for rainfed sites in Lao PDR and Cambodia are within the expected range whereas Thailand and Viet Nam have apparently high and very high yields, respectively.

Table 5.11. Estimated fisheries yield per unit area in the LMB based on literature (from Hortle, 2007)

Estimated yield (kg/ha/year)	Cambodia	Lao PDR	Thailand	Viet Nam
Low estimate				
Fish	40.0	20.0	20.0	40.0
Other aquatic animals (OAA)	10.0	5.0	5.0	10.0
Total fish and OAA	50.0	25.0	25.0	50.0
Medium estimate				
Fish	80.0	40.0	40.0	80.0
OAA	20.0	10.0	10.0	20.0
Total fish and OAA	100.0	50.0	50.0	100.0
High estimate				
Fish	160.0	80.0	80.0	160.0
OAA	40.0	25.0	25.0	50.0
Total fish and OAA	200.0	100.0	100.0	200.0

Table 5.12. Assumed mean fisheries yields per hectare across broad habitat classes in the LMB (after Hortle, 2007 and Hortle & Bamrungrach, 2015)

	Assumed yield (kg/ha/year) in each country					LMB weighted mean yield (kg/ha/year)
Zone	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam Highlands	
Year 2000 assumed yields (kg/ha/year) (after Hortle, 2007)						
1 Major flood zone	200	200	150	200		194
2 Rainfed zone	100	90	75	100	100	82
3 Large water bodies	300	300	300	300	300	300
Weighted mean yield	164	145	88	166	128	123
Year 2010 assumed yields (kg/ha/year) (after Hortle & Bamrungrach, 2015)						
1 Major flood zone	180	100	150	165.0		165
2 Rainfed zone	90	50	75	82.5	100	76
3 Large water bodies	270	300	300	247.5	300	292
Weighted mean yield	139	86	91	147.5	161	112

Table 5.13. Estimated fisheries yield per unit area in the LMB based on the literature (from Hortle & Bamrungrach, 2015 and updated by Hortle, 2017)

Annual fish yield	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam highlands	LMB
Major flood zone	180	100	150	165		165
Rainfed	90	50	75	83	100	76
Water bodies	270	300	300	247.5	300	292
Brackish-water estuarine	300			300		300
Mean	139	86	91	147.5	161	112

Table 5.14. Yield per unit area estimates from the 2016 survey (from Hortle, 2017, unpublished)

Country	Province	District	Habitat class	Yield of fish (kg/ha/yr)	Yield of OAAs (kg/ha/yr)	Yield of fish + OAAs (kg/ha)/yr	Percentage of fish (%)
Cambodia	Kampong Thom	Kampong Svay	Flood	86	2	88	97.5
	Prey Veng	Ba Phnom	Rainfed	75	21	96	77.9
Lao PDR	Savannakhet	Champhone	Flood	77	15	92	83.6
	Savannakhet	Outhomphone	Rainfed	39	17	56	69.9
Thailand	Sisaket	Rasi Salai – 5 sub-districts	Flood	210	4	214	98.4
	Surin	Non Narai	Rainfed	103	19	122	84.1
Viet Nam	An Giang	Chau Thanh	Flood	531	1,318	1,849	28.7
	Tra Vinh	Tieu Can	Rainfed	124	69	192	64.3
	Tra Vinh	Duyên Hải	Brackish	60	40	100	60.1

Comparison of these two data sources (based on the literature [Hortle, 2007] and HH surveys (Hortle, 2017)) suggests some complementarity between studies, although Hortle (2017 unpublished) indicated a considerably higher catch of fish per unit area in the major flood zone around Chau Thanh in Viet Nam than average and range values, at 531 kg/ha/year,. In addition, there is considerable yield of OAAs at the same site, which appears to be mainly molluscs. The other important asset of the Hortle (2017 unpublished) data is the breakdown of the yield into fish and OAAs, which suggests that fish make up 80–90% of the catch in Lao PDR, Thailand and Cambodia, but the contribution is considerably lower (around 60%) in Viet Nam.

Given the potential inaccuracies and biases with the literature-based methodologies (Hortle, 2007; Hortle & Bamrungrach, 2015) identified above, a modified GIS-based areal approach is suggested to determine the yield in the LMB.

Traditionally, determination of catch per unit area (kg/ha/yr) is based on extensive monitoring of the defined area using catch assessment and frame survey methodologies (see Section 4.1). This is not viable in the LMB because of the sheer scale of the Basin, and it is difficult to relate the catch per HH data to a defined area fished. Consequently, a stratified approach is necessary.

Among the possible methods for estimating yield by habitat (Table 4.1), HH surveys linked to logbook surveys are considered the most appropriate. These studies are designed to collect a wide range of data on fisheries, including catch and consumption, and some surveys also included data on catches related to types of habitat fished (see Section 4.2). Household surveys are usually complemented by collecting data at the village level and by interviewing individual fishers. Information on habitat types, and effort and catch by habitat can be used to apportion catches by habitat. These data can be further complemented by information from logbook surveys (FADM) as well as a visual censuses of actual fishing effort and catches throughout the study areas over short periods.

The number of villages and HHs to be interviewed are selected based on resources available and the stratified sampling procedure outlined in Section 5.3. Once the sampling frame is established, interviews are held with the village head or other key personnel, and with the HHs using the adapted questionnaires for village and HH surveys (Annex 3), with a special focus on fishing activities.

The main data that must be collected in each interview are as follows:

- Village level: Census data, HH and population numbers, number of fishing HHs, land-use and habitat mapping.
- Household level: Number of fishers, habitats fished and main gears used, effort and catch related to habitat fished and gear used, main species caught, and where possible, sizes of fish caught, use or disposal of fish and OAAs, HH consumption and origin of fish and OAAs.
- Fisher level: Details of fish species, seasonality of catches, catches related to sub-habitats.

Information on habitat types, and effort and catch by habitat is used to apportion catches by habitat, as outlined in Table 5.15. Essentially, the total fish and OAA catches for all the HHs surveyed are collated and divided by the total number of HHs surveyed to provide a mean catch per HH per year. This figure is then multiplied by the total number of HHs in the survey area to estimate the total fish and OAAs catch from the defined area. To determine the yield per habitat type (kg/ha/year) from the surveys area, the total catch is divided by the area of habitat. Other information to support the catch estimates could include catch for any large gears as well as a visual censuses of actual fishing effort and catches throughout the study areas over short periods; an example is provided in Table 5.15.

Table 5.15. Summary of fish and OAA catch and yield

No.	Description	Village 1	Village 2
1	Survey area (ha)	1,050	1,082
2	Wetland area (ha)	476	460
3	Total fish catch (kg/year)	40,048	27,345
4	Total OAAs (kg/year)	7489	10,727
5	Total fish and OAAs (kg/year)	47,537	38,072
6	Number of HH surveyed	180	180
7	Mean fish catch (kg/HH/year) [3 / 6]	222	152
8	Mean OAAs catch (kg/HH/year) [4 / 6]	42	60
9	Mean fish and OAAs (kg/HH/year) [7 + 8]	264	212
10	Number of HH in survey area	16,174	12,472
11	Total fish catch from survey area (t/ha) [10 x 7]	3,599	1,895
12	Total OAAs catch from survey area (t/ha) [10 x 8]	673	743
13	Total fish and OAAs catch from survey area (t/ha) [11 + 12]	4,271	2,638
14	Yield of fish (kg/ha/year) [11 / 2]	76	41
15	Yield of OAAs (kg/ha/year) [12 / 2]	14	16
16	Yield fish and OAAs (kg/ha/year) [14 + 15]	90	57
17	Percentage of fish	84%	72%
18	Percentage of OAAs	16%	28%

The procedure can be improved considerably by defining the type of fisher (FT, PT or occasional) and the type of habitat fished (major flood zone; rainfed; water bodies and brackish-water estuarine). Additional information on the distribution of catch according to three fish size categories (<25 cm; 25–50 cm; >50 cm) and OAAs according to frogs, crustaceans (crabs and prawns) and snails, plus others (e.g. snakes, crocodiles) would improve the accuracy of the assessment.

The catch per unit area data was updated for the 2020 study (MRC, 2023a) using information from fisher HH surveys carried out in 2019/2020. The information gained from the house surveys on fishing practices, catch and fish habitat (Section 5.3) was used to determine the overall catch and update the YPUA. Using this approach, HH surveys are complemented by collecting data at the village level and by interviewing individual fishers.

The following stepwise procedure was used to determine fish catch and yield from each province in the LMB. The procedure is illustrated in Table 5.16. Note: the same step number used in Table 5.16 is used in the description below.

1. The land area within and outside the LMB in each province is determined from GIS modelling, although these data are also mostly available from existing reports and previous yield assessments and vary little between surveys.
2. The area of each major wetland habitat type in each province is determined using GIS as described in Section 5.4.3.

3. The most recent population data for each province are obtained from the national statistics offices, and where appropriate, proportionally allocated to the area of the province in the LMB (Section 5.2.2). Here, it is assumed the population is distributed evenly across the province, although it is recognized that many people may be living in urban centres in some provinces. Once the populational size is determined, the number of HHs in the province is obtained by dividing the total population by the average HH size in the country at the time of the population census.
4. The number of fishers in each province is determined from the most recent Social Impact Monitoring and Vulnerability Assessment (SIMVA) datasets that categorize HHs in villages surveyed in each province into FT, PT, occasional and non-fishing HHs. The proportion of each category is multiplied by the total number of HHs in the province to determine the number of HHs engaged in each level of fishing activity. It is important to note that the SIMVA data appear to underestimate the number of HHs engaged in fishing in some districts, and thus theyneed to be cross-checked and adjusted against data from the HH surveys (Section 5.3), or data from the national statistics office census data where available. SIMVA also only surveys communities within 15 km of a major water bodies, and thus some transient fishers in remote HHs may be omitted. Where no data are available for a province, data from geographical similar and adjacent provinces should be used as proxy information.
5. This step allocates the number of fishers of each fishing category to the different wetland habitat types in each province derived from the GIS modelling (Section 5.4.3). Here, the distribution of each category of fisher is apportioned to each habitat type based on the percentage contribution of each habitat type to the total wetland area. This follows the assumption that more fishers will exploit the more extensive wetland habitat types, although it is recognized that fishes will move to more productive habitats, especially those associated with seasonal changes in flooding, or to target migratory fish. There are also potential issues with large areas of open water such as Tonle Sap Lake that technically have no inhabitants according to the census data, although there are numerous floating villages that do not appear to be recorded. To account for this habitat, the area of the Tonle Sap was allocated to each province that boarders the lake area, and the mean catch per unit area of open water was derived and added to the total catch for each province.
6. The total annual catch for each HH is determined from the HH surveys or FADM surveys. In the HH surveys, specific questions are asked of the HH to determine the total catch of fish each year and the attribution related to specific major habitat types (see Section 5.3 for details).
7. The total catch for each habitat type in each province is derived from the product of the catch rates (kg/fisher/yr) and the total number of fishers of each category (FT, PT. occasional) exploiting each habitat type. It is assumed that the catch rate of occasional fishers is 20% of a PT fisher, although this needs to be verified ~~justifying~~. Total catch is determined by upscaling the information for all HHs fishing in the defined area of habitat as:

$$\sum \sum_{i}^{1} (FYi * Ai)$$

8. The total catch per country and in the LMB are the sum of the catches in each of the provinces and the sum of the country catches, respectively.
9. Yield per unit habitat per year for the different habitat types in each province is calculated by dividing the total catch for each habitat type by the area of habitat in the province. These data can be cross-checked against the YPUA of habitat used in the original method by Hortle (2007) and Hortle & Bamrungrach (2015).
10. The whole procedure is repeated for OAAs to determine the total harvest of these products. Where possible, it is preferable to break down the OAA estimates into crustaceans, amphibians, molluscs, snakes and other OAAs.
11. Finally, the percentage contribution of fish and OAAs to the overall catch is then determined.

Table 5.16. Example of the methodology to determine fish catch and yield from each province in the LMB

No.	Description	Attapeu	Bokeo
1	Determine area of province inside LMB (km^2)	9,542	6,967
2	Determine area of different wetland habitats in province (ha)	26,226	9,204
3	• Access recent population data for number of people living in the province. • Divide by average population size to determine the number of households (HH) (average HH size of4.7 in Lao PDR) [3/4.7]	157,00 33,404	200,000 42,553
4	Determine the percentage of FT, PT and occasional (Occ) fishers in each province from SIMVA and household surveys	FT – 0.78% PT – 3.9% Occ – 11.7%	FT – 0.36% PT – 2.38% Occ – 28.6%
5	Allocate the number of fishers of each category to the different wetland habitat types in each province [2/4].	Total fishers: 5,466 e.g. major flood zone FT – 33 PT – 167 Occ – 501	Total fishers: 13,323 e.g. major flood zone FT – 52 PT – 235 Occ – 4,136
6	Determine the total annual fish catch for each fisher category for each habitat type from the household surveys or FADM surveys (kg/fisher/year)	e.g. major flood zone FT – 678 PT – 542 Occ – 108	e.g. major flood zone FT – 400 PT – 320 Occ – 64
7	Determine total fish catch (t/yr) for each habitat type in each province [5 x 6].	e.g. major flood zone 167,463 kg	e.g. major flood zone 395,722 kg
8	Determine total fish catch per country and in the LMB (t/yr)	Sum total values for each province and habitat type	Sum total values for each province and habitat type
9	Derive the fish yield per unit habitat per year (kg/ha/year) for the different habitat types in each province [7/2]	16.53	42.14
10	The whole procedure (1-9) is repeated for OAAs		
10	Percentage of fish (and OAAs)	84% (16%)	72% (28%)

Note: Values in [#] represent step number

To support this GIS-based method, and for comparability reasons, it is suggested the literature-based method of Hortle & Bamrungrach (2015) using updated mean and range catch per unit area data from Hortle & Bamrungrach (2015) and Hortle (2017 unpublished) (Table 5.13) are also applied. While the yield of these systems is likely to have changed over time, especially due to changes in flooding extent and fishing pressure, they are considered a reasonable reflection of the catch rates in the LMB. These data on YPUA of habitat are multiplied by the area of the main habitat types in each country to determine the total yield and the country totals are summed to obtain the total yield for the LMB.

5.4.5 Data reporting

Initially, fish YPUA from the HH surveys should be presented (Table 5.17). These estimates should be supported by data from the SIMVA and FADM surveys to adjust what are considered unrealistically high yield per unit habitat estimates for the habitat types (Table 5.18).

The total fish yield for each country and the LMB as a whole (Table 5.19) are determined as the product of YPUA of specific habitat types in each country (Table 5.18) and the area of the specific habitats in each country (Table 5.9). This can be compared with the same method, but using the LMB average yield per unit habitat against totals of each habitat type in the LMB. These data can also be compared with outputs derived from yield per unit habitat type based on literature surveys (Table 5.11) from Hortle & Bamrungrach (2015) (Table 5.20).

Table 5.17. Estimated fisheries yield per unit area in the LMB based on 2020 household surveys

Country/province	District	Habitat class	Yield of fish (kg/ha/yr)	Yield of OAAs (kg/ha/yr)	Yield of fish + OAAs (kg/ha)/yr	Percent-age of fish (%)	Percentage of OAAs
Cambodia							
Kampong Thom	Kampong Svay	Flood	86	2	88	97.5	2.5
Prey Veng	Ba Phnom	Rainfed	75	21	96	77.9	22.1
Lao PDR							
Savannakhet	Champhone	Flood	77	15	92	83.6	16.4
Savannakhet	Outhomphone	Rainfed	39	17	56	69.9	30.1
Thailand							
Sisaket	Rasi Salai – 5 sub-districts	Flood	210	4	214	98.4	1.6
Surin	Non Narai	Rainfed	103	19	122	84.1	15.9
Viet Nam							
An Giang	Chau Thanh	Flood	531	1,318	1,849	28.7	71.3
Tra Vinh	Tieu Can	Rainfed	124	69	192	64.3	35.7
Tra Vinh	Duyên Hải	Brackish	60	40	100	60.1	39.9

Table 5.18. Estimated fisheries yield per unit area (kg/ha/yr) in the LMB based on SIMVA and FADM surveys

Annual fish yield	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam highlands	LMB
Major flood zone	128.74	88.2	83.08	105.39	74.05	87.7
Rainfed	64.62	43.8	60.10	73.33	47.40	56.2
Water bodies	53.65	111.69	83.80	32.81	143.98	93.1
Brackish-water estuarine	208.62			208.62		208.6
Total	113.91	81.22	75.66	105.04	88.47	111.38

It is recommended to begin by comparing the contribution of different habitat zones to the total catch from each country with previous surveys (Figure 5.11). However, it should be recognized that the previous surveys were based on literature-based values for catch per unit habitat area and are not necessarily comparable.

Table 5.19. Estimated total inland capture fishery yields in each LMB country (t) based on SIMVA and household surveys

Annual fish yield	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam highlands	LMB
Major flood zone	245,466	24,156	18,930	94,398	4,092	294,549
Rainfed	238,235	59,394	450,447	49,178	4,896	747,550
Water bodies	2,836	22,448	20,297	23	4,076	48,868
Brackish-water estuarine	379			271,091		271,469
Total yields for area of each habitat type in each province	486,963	105,998	489,674	414,689	13,064	1,510,388
Total based on mean yield per area of each aquatic habitat type in each country	643,384	148,680	602,633	301,090	16,533	1,712,320

Table 5.20. Estimated total inland capture fishery yields in each LMB country (t) based on yields per unit area according to Hortle (2017)

Annual fish yield	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam highlands	LMB
Major flood zone	343,245	27,398	34,176	147,796	0	552,615
Rainfed	331,800	67,778	562,104	55,328	10,330	1,027,339
Water bodies	14,274	60,298	72,661	171	8,493	155,897
Brackish-water estuarine	544	0	0	389,843	0	390,388
Total	689,864	155,474	668,940	593,138	18,823	2,109,688

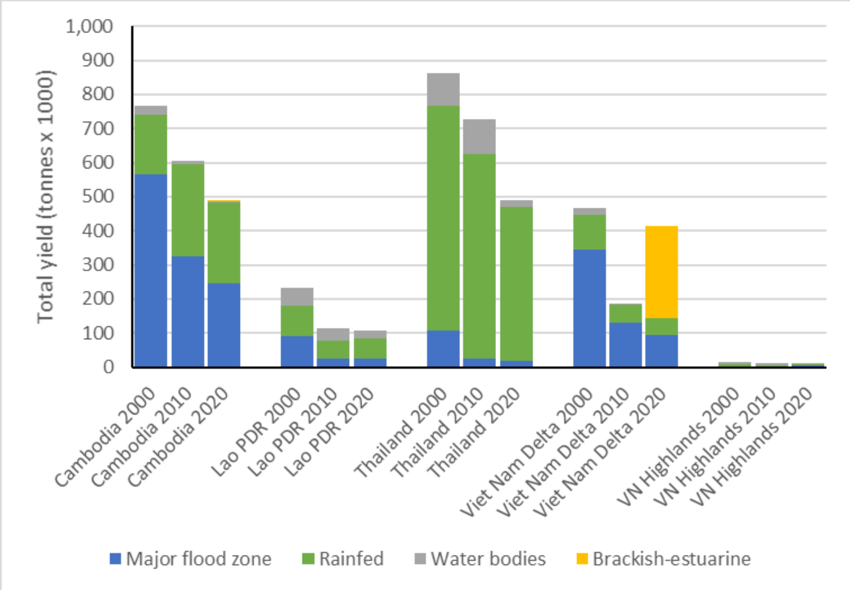

Figure 5.11. Comparison of total catch from habitat zones in each of the LMB countries between 2000, 2010 and 2020

Note: 2020 data are based on SIMVA and HH surveys.

In addition to exploring the contribution of different countries to the total catch from the LMB, the data can be broken down into provinces of each country to understand the contribution from different regions (e.g. Figure 5.12). In all cases, catch from rainfed water bodies dominated the contribution to overall catches, with the exception of Viet Nam, where brackish-water estuarine habitat dominated. The provinces making the greatest contribution were also driven by human population density as well as the proportion of the HHs that engaged in fishing full-time and part-time.

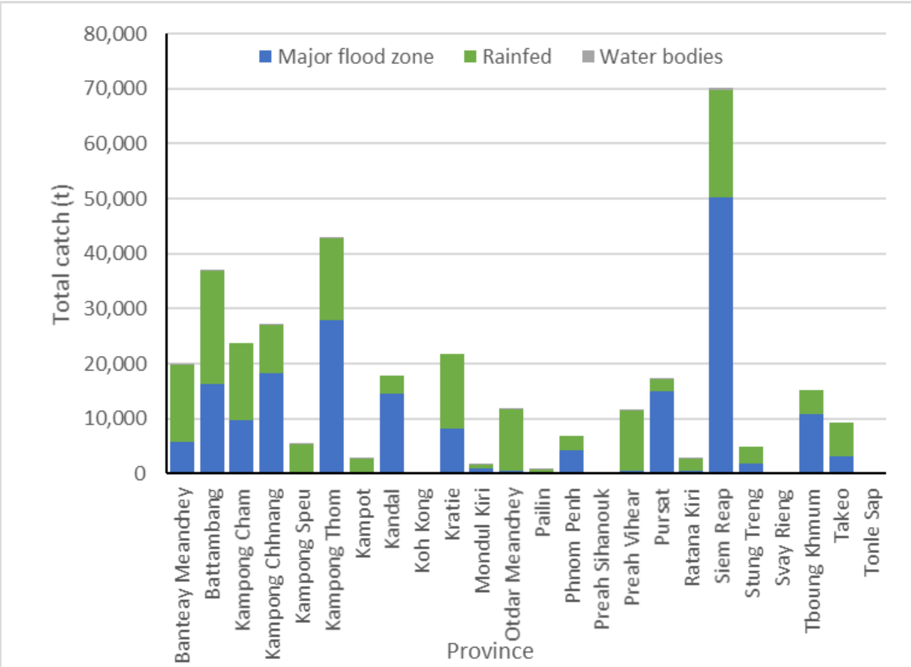

Figure 5.12. Comparison of total catch from different habitat zones by province in Cambodia in 2020 based on SIMVA and household surveys

Finally, the same approach to estimating fish yield from the LMB using catch per unit habitat should be applied to estimate the total harvest of OAAs (Table 5.21). Again, comparison with previous surveys **is recommended.**

Table 5.21. Estimated total inland OAAs yields in each LMB country based on literature-based yields per unit area (after Hortle & Bamrungrach, 2015)

Annual OAAs yield	Cambodia	Lao PDR	Thailand	Viet Nam	LMB
Major flood zone	2,712	4,020	934	85,173	92,839
Rainfed	77,403	23,028	142,421	53,508	296,360
Water bodies	0	0	0	0	0
Brackish-water estuarine	0	0	0	53,611	53,611
Total	80,116	27,048	143,355	192,292	442,810

5.5 ASSESSMENT OF FISH CONSUMPTION AND YIELD IN THE LMB

5.5.1 Data collection and analysis

A complementary method to determine the total fish catch from the LMB is using fish consumption data collected during the HH and SIMVA surveys. Critical to the HH surveys is that a random sample of fishing and non-fishing HHs are selected for the surveys, commensurate with the proportion of HHs with FT, PT and occasional fishers, as well as those not fishing. This is important because consumption in fishing villages tends to be higher than the national average.

During the surveys, HHs are asked to estimate the total animal-based foods eaten each week (kg/hh/week), including all meals, and the proportion of fish and OAAs in this diet. It is imperative that all types of fish consumed are taken into account, including fresh, dried, smoked, pickled, and pastes and sauces. Descriptions of the different fish and OAA-based foods, as well as conversion factors to upscale to wet weight of fish are provided in Hortle (2007).

Households are also asked to estimate how much of the fish and OAAs is caught, purchased from the market or from other fishers, and purchased or produced from aquaculture sources, as well as the percentage of meat and other protein sources eaten. These data are used to determine the weekly consumption of each animal food source, and can be upscaled to determine the total amounts of animal protein consumed from various sources across the LMB.

To supplement the HH and SIMVA consumption surveys, additional catch and consumption data can be obtained from national statistical surveys and can be used to cross-validate against other studies.

The total consumption is calculated using the following steps:

1. The most recent population data for each province are obtained from the national statistics offices, and where appropriate proportionally allocated to the area of the province in the LMB (see Section 5.4.3). As with the fish catch survey, it is assumed that the population is distributed evenly across the province. Once the population size is determined, the number of HHs in the province is obtained by dividing the population size by the average HH size in the country at the time of the population census.
2. To determine the consumption rate, during the HH surveys, individuals in the family are asked the amount of fish they consume in a typical day in all meals, if possible, during previous meals. It is imperative that all fish types are identified, including fresh, smoked, dried and pickled, as well as sauces and pastes.
3. The mean weight and standard deviation of the weight of fish consumed at an average meal is determined. The wet weight equivalent of preserved fish and sauces should be derived from the conversion factors developed by Hortle (2007).
4. The next step is to determine the source of the fish consumed. Each individual, and the HH as a whole, are asked to break down the source of the fish consumed into percentage contributions from their own catch, from their own aquaculture production, purchased (or bartered) from the market or from other fishers, or from other sources, for example, marine fish, frozen fish originating from outside the country.
5. The HHs are then asked to define the frequency of consumption of fish in meals over the duration of the previous week and then estimate relative consumption patterns over the year. Consumption frequency is divided into over 3 times/week, 2–3 times/week, once/week and “other”, which generally refers to much a lower frequency of consumption.
6. The consumption for each province is determined from:
   Weight of fish consumed at a typical meal x frequency of consumption per week x proportion of population consuming fish at that frequency x province’s population size.
7. The procedure is repeated for the different frequencies of consumption of fish in typical meals each week.
8. The total consumption of fish caught is then determined by multiplying the consumption by the percentage of the meal contributed by wild caught fish from the LMB (all sources).
9. The total annual consumption in the country is determined by summing the consumption of wild caught fish from all provinces and all countries.
10. The whole procedure is repeated for OAAs to determine the total harvest of these products. Where possible, it is preferable to break down OAA estimates into crustaceans, amphibians, molluscs, snakes and other OAAs.

An alternative method to determine the total fish catch from the LMB is to use national fish consumption data. Inland fishery yield (i.e. all fish and OAAs caught and collected in LMB waters within each country) has previously been estimated from consumption studies, as described in Hortle (2007, 2017), using:

$$Yield = C - I + E + A + F + W$$

Where:

C = consumption by people
I = imports (inland fish and OAAs imported to the LMB)
E = exports (inland fish and OAAs exported from the LMB)
A = aquaculture feed (inland fish and OAAs used to feed aquaculture fish)
F= animal feed (inland fish and OAAs used to feed poultry and livestock)
W= wastage (losses of fish post-harvest and subsequently in the supply chain to domestic consumers).

Total consumption is determined by multiplying the average annual consumption of the population derived from SIMVA or national surveys by the total population size. This may be a slight overestimate because children do not necessarily consume fish at a young age.

For the LMB, imports of inland fish from adjacent basins or from overseas would be minor relative to exports, although it is recognized that fish are exchanged between countries, especially over international borders in the Basin. Animal feed and waste quantities are unknown, but would probably be at least an additional 10% per year, which may approximately balance the small component of consumption derived from aquaculture.

The use of inland trash fish for aquaculture feed is insignificant in Lao PDR or Thailand (a few thousand tonnes per year) since most trash fish is marine-derived (Ingthamjitr, Mattson & Hortle, 2005). By contrast, inland trash fish are important in Cambodia; So et al. (2005) estimated that about 55,000 tonnes per year is used in aquaculture. In Viet Nam, most trash fish are marine-derived, and althougharound 13% of fresh fish that is fed to catfish and snakeheads comes from inland waters (Anh Tuan & Quynh Maim, 2005). In 2000, the use of inland fish in aquaculture in the Viet Nam Delta was estimated at 55,000 tonnes/year. It is assumed that these proportions of fish have remained constant over time.

5.5.2 Data reporting

Mean annual consumption rates should be determined from the HH and SIMVA surveys (Table 5.22) and compared with national reported consumption data. Differences may be found between the different studies, such as in the 2020 surveys data between HH and SIMVA results (Table 5.22), and need to be accounted for. For example, consumption rates reported for the 2020 HH surveys were considerably higher (almost double) than those reported in the SIMVA-based results, and both differ from nationally reported consumption rates. This is likely because the 2020 HH surveys were based on fishing villages only, where access to fish is high, while the SIMVA-based results were based on HHs living within 15 km of the main water bodies, and the national figures are representative of the entire population of the country living in the LMB land area.

Table 5.22. Mean annual fish consumption rates of fish, OAAs and aquaculture products derived from the SIMVA-based and 2020 household surveys (kg/capita/year)

	SIMVA			Household surveys		
	Capture fisheries	OAAs	Aquaculture	Capture fisheries	OAAs	Aquaculture
Cambodia	21.10		0.54	35.32		5.58
Lao PDR	21.10		0.54	49.80		8.06
Thailand	76.61		1.43	96.61		31.04
Viet Nam Delta	36.12		5.50	78.29		15.63
Viet Nam Highlands	18.37		1.84	42.88		8.23

The total consumption of inland fish, OAAs and aquaculture-produced products were estimated from the mean consumption rates and the populations in each country of the LMB (Table 5.23).

Table 5.23. Total annual fish consumption of fish, OAAs and aquaculture products derived from the SIMVA-based household surveys

	SIMVA		
	Capture fisheries	OAAs	Aquaculture
Cambodia	292,614		22,697
Lao PDR	141,007		3,638
Thailand	732,802		13,675
Viet Nam Delta	422,416		82,057
Viet Nam Highlands	63,019		6302
Total	1,651,857	0	128,369

Where feasible, trends in consumption rates and total consumption should be explored through a comparison with previous studies (Figure 5.13), and where possible, comparisons between different provinces in each country (e.g. Figure 5.14) should be described to highlight the variability of contribution of fisheries and aquaculture products to the diet of communities in different regions of the LMB.

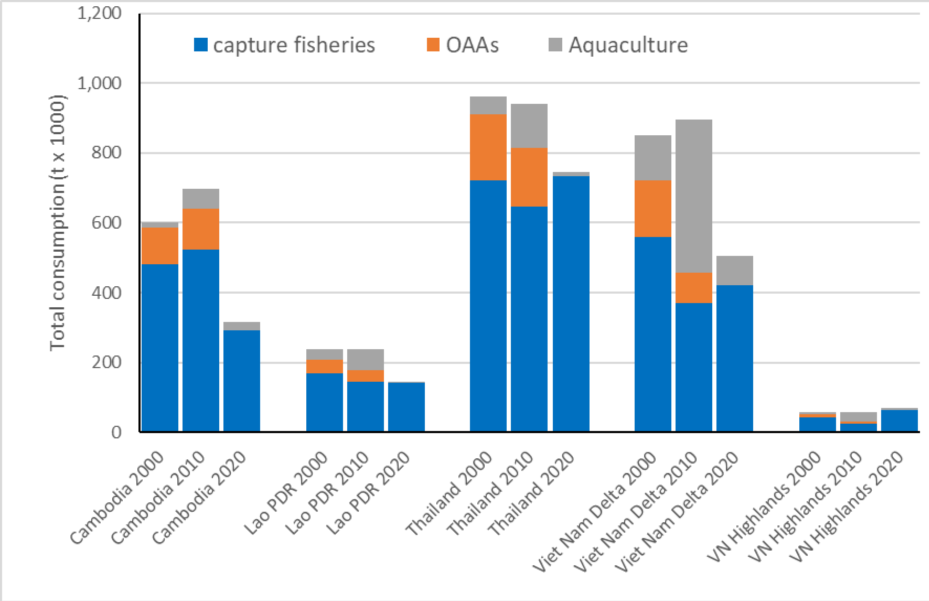

Figure 5.13. Total consumption of inland fish, OAAs and aquaculture products based on household consumption studies in the LMB, i.e. Cambodia, Lao PDR, Thailand and Viet Nam, 2000, 2010 and 2020

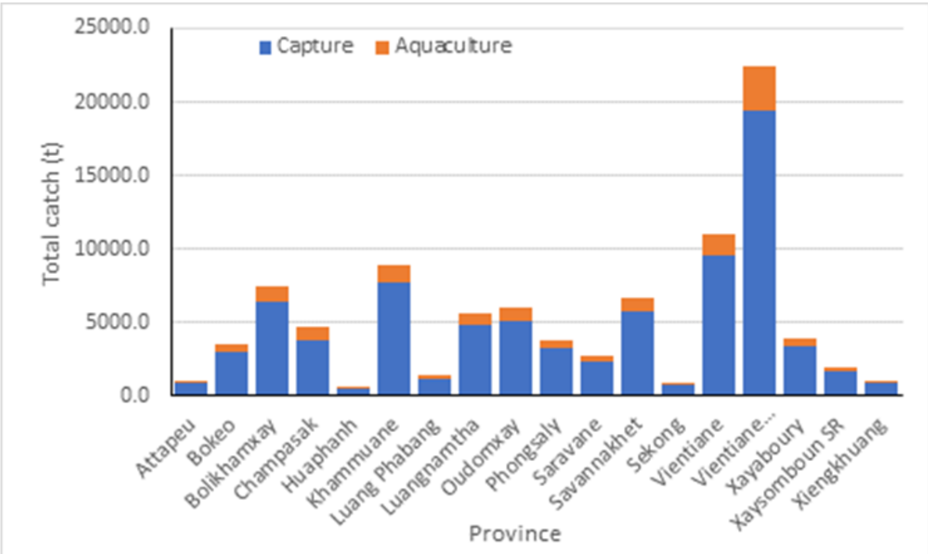

Figure 5.14. Total consumption of fish and aquaculture production based on household consumption studies by province in Lao PDR

5.6 VALUE OF FISH AND OAA PRODUCTS

5.6.1 Data collection and analysis

One key outputs of the capture fisheries and OAA yield assessment from the LMB is the economic value of the products along the value chain. This information, together with other components, will enable an estimate of the first sale and retail market values of inland capture fisheries and OAA harvest in the region. This information is vital to show the economic importance of fisheries and aquatic resources to livelihoods and food security in the LMB, and to underpin the protection of the resources against other economic sector developments in the Basin.

The aims of the component are to:

- collect data and information on first sale price, either directly from the fishers or at landing sites, and aquaculture farmgate prices of key aquatic species and sizes of fishes;
- collect information on the proportion of the catch either sold, bartered or consumed by the fisher HH;
- collect data and information on market prices of key aquatic species at selected fresh markets;
- make use of the survey results to estimate the total value of the fisheries and other aquatic animals in the LMB.

The surveys should be carried out as part of the FADM monitoring or as independent HH and market surveys, or in conjunction with SIMVA or other targeted surveys. Surveys should be carried out by national line/implementing agencies or data collectors that are properly trained. Regular QA/QC backstopping services should be provided during the period of data recording. It is recommended that specific questionnaires be designed to target the following stakeholders:

- Fishers (FT and PT)
- Traders (middlemen or fish collectors, wholesalers and retailers)
- Aquaculture farmers.

The questionnaires should cover several periods of time to account for variability of catch and thus sale price in different seasons, and cover a range of provinces, associated with the FADM or HH surveys, as well as variation in the value of fish and OAAs from the three main habitat types. The questionnaire should be limited to market prices and most of the effort focused on measuring first sale price of fish by fishers and final retail market prices. There is no need to develop a full value chain analysis with the partitioning of the earnings along the value chain, nor is a complete analysis required of the interactions between stakeholders or the flow of fish trade volumes through the region.

Basically, the data collectors should use the questionnaires to collect first sale value of wild aquatic species caught by fishers at fish landing sites and fish farmers at aquaculture farms. The same information can also be collected from fishers who complete logbooks for the FADM Programme. Officers who collect the logbooks should ask the fisher the first sale value of his/her catch according to fish species size or category of OAAs, as well as the proportion of each sold, bartered or consumed by the HH.

Other data collectors should collect market price from fish retailers at fresh markets in the target provinces. The data collectors should interview the respondents and record data on the questionnaire and note relevant information from their observations during the interviews.

In principle, the data collectors should record all information about fish and OAA prices that he or she encounters at the selected landing sites, fish farms, or markets during the time of surveys. However, each Member Country, in close coordination with line agencies, should also identify and select five fish species of small-sized fish (<25 cm), five fish species of medium-sized fish (25–50 cm) and five fish species of large-sized fish (>50 cm) according to three main criteria:

- Common for local consumption or food security
- High commercial value
- Abundance.

The completed questionnaires should be collected and submitted to the national team leader to enter the data and information into a national database or MS Excel spreadsheet located at the fisheries line/implementing agency. To ensure that the database format of regional and national teams is consistent, a standardized database template should be designed by the regional team at MRC ED and used by each national team for data entry.

Before analysis, the datasets should be reviewed, quality assured and checked as appropriate. The national team leader should provide feedback to each data collector according to the findings of the revision/review process so as to improve data collection in the future. The completed questionnaires should be stored at least until the cleaning process is completed, certified and copies of the database are made and securely stored.

5.6.2 Data reporting

Fishers are asked the first sale price of the fish they caught according to three size groups: > 25 cm, between 25 cm and 50 cm, and fish larger than 50 cm. These data are used determine the mean first sale price of the different size categories for each district and each country Table 5.24, and the weighted mean first sale value of fish according to:

Weighted mean value = $((Y_{<25} \times V_{<25}) + ((Y_{25–50} \times V_{25–50}) + ((Y_{>50} \times V_{>50}))/ (Y_{<25} + Y_{25–50} + Y_{>50})$

Where Y_i and V_i are the catch and value of the different size groups.

Table 5.24. Mean first sale price ($/kg) of different sized fish in different provinces in 2020 surveys

	Mean first sale price ($/kg)			Weighted mean first sale price ($/kg)
	Fish <25 cm	Fish 25–50 cm	>50 cm	
Cambodia	1.88	2.96	7.50	1.88
Ba Phnum	2.06	3.72	7.50	2.06
Kom pong Svay	1.70	2.55		1.70
Ny pech kor	1.70	2.00		1.70
Lao PDR	1.04	2.13	3.23	1.55
Kong	1.11	1.78	2.78	1.50
Pakkading	1.09	2.50	3.35	1.79
Paksan	1.09	2.37	3.65	1.64
Patoumphone	0.89	1.87	2.50	1.13
Thailand	1.35	3.38	3.30	1.69
Benchalak	1.23	3.28	3.10	1.62
Sirindhorn	1.33	3.04	3.59	1.59
Tha Uthen	1.50	3.75	2.81	1.93
Viet Nam	1.30	2.66	3.89	1.94
Chau Thanh	1.22	2.18	2.26	1.46
Duyen Hai	0.95	2.33	5.45	1.73
Tieu Can	1.63	3.61	2.66	1.90
LMB average	1.40	2.64	3.41	1.90

Note: First sale value determined for 2015 (So et al., 2015) is provided for comparison

The total value of the fish caught is then derived from the product of the total catch weight in each country and the mean first sale price and final retail price of the fish (Table 5.25).

The same procedure can be followed for the retail price of different sized fish obtained from the market surveys, and a similar procedure can be adopted for OAAs. Here, the OAAs are divided into Crustacea, Mollusca and Amphibia (Table 5.26), although the latter tend to be exclusively frogs. The weighted mean value of OAAs is also calculated based on the proportional contribution the different OAAs groups to the catch using the same procedure as used of sizes of fish. These values can then be used to estimate the total value of OAAs in the LMB.

Table 5.25. Total value of capture fisheries ($ million) in the LMB, based on 2020 household and consumption surveys

	Fish production based on household surveys (t)	Fish production based on consumption surveys (t)	Weighted mean first sale price 2020 ($/kg)	Value first sale price based on household surveys 2020 ($ million)	Value first sale price based on consumption surveys ($ million)
Cambodia	486,916	292,614	1.88	915	550
Lao PDR	105,998	141,007	1.55	164	218
Thailand	489,674	732,802	1.69	827	1,238
Viet Nam	427,751	485,436	1.94	829	941
LMB	1,510,339	1,651,858	1.9	2,737	2,948,

Note: The value is based on the final retail sale price (based on So et al., 2015), which has been provided for the purposes of comparison.

Table 5.26. Mean first sale price ($/kg) of OAAs in provinces of Cambodia, Lao PDR, Thailand and Viet Nam, in 2020 surveys

	Mean sale price of crustacea ($/kg)	Mean sale price of molluscs ($/kg)	Mean sale price of frogs ($/kg)	Weighted mean sale price of OAAs ($/kg)
Cambodia	1.57	0.98	3.37	2.04
Kompong Thom	0.70	0.59	2.74	1.53
Prey Veng	1.93	1.59	3.95	2.54
Lao PDR	1.41	0.54	1.88	0.77
Borrikhamxay	1.29	0.27	2.86	1.09
Champasak	1.45	0.57	1.85	0.72
Thailand	7.69	1.43	1.91	5.14
Nakhon Phanom	4.61	1.67	2.03	2.07
Si Sa Ket		0.94	1.72	1.33
Ubon Ratchathani	8.14	1.35	1.72	6.53
Viet Nam	2.37	1.00	2.40	2.17
An Giang	2.81	0.81	2.55	2.42
Tra Vinh	2.25	1.07	2.38	2.09
Total	2.74	0.91	2.78	2.27

The total value of the OAAs harvested (Table 5.27) can be derived from the product of the total catch in each country (Table 5.21) and the weight mean first sale price of the OAAs (Table 5.26).

Table 5.27. Total value of capture fisheries ($ million) of capture fisheries in the LMB, based on 2020 household and consumption surveys

	Weighted mean first sale price of OAAs ($/kg)	OAA production household surveys (t)	Value of OAAs based on household surveys ($ million)
Cambodia	2.04	80,116	163,437
Lao PDR	0.77	27,048	20,827
Thailand	5.14	143,355	736,845
Viet Nam	2.17	192,292	417,274
LMB	2.27	442,811	1,338,382

6 DATA MANAGEMENT AND REPORTING

6.1 OBJECTIVES

Fisheries data are highly variable and provided in a range of formats, quality and accuracy.

- Quantitative: e.g. species abundance or catch statistics, water depth and flow
- Semi-quantitative: abundance scale or CPUE, species composition
- Nominal/categorical: presence or absence.

Data collected under the yield per habitat programme are held in the MRC Fisheries database and need to be extracted to an Excel spreadsheet and sorted to create tables that allow analysis to meet defined research objectives or test research hypotheses.

It is important to recognize that biological - catch – social-economic data are characterized by large numbers of zero values and are often highly skewed. Socioeconomic data are often missing or of differing scales, a mixture of nominal (numerical) and categorical (abundance classes). All these parameters need to be taken into account when undertaking analyses.

6.2 QUALITY CONTROL PROCEDURES

Changing the sample procedure or sampling under varying conditions, or with different staff or field crews may cause large variations in results, so it is important to follow the guidance on surveying villages and HHs above, and fill field data sheets accurately. On any occasion, if it is necessary to modify the procedure at a location, full details should be recorded for future reference and for possible adjustment at other locations.

After all sample processing is completed several quality checks should be carried out.

6.2.1 Data check

The final computerized data are cross-checked against the contents of the field sheet and against the notes of each interview, in terms of:

- number of villages and HHs;
- the demography of the persons interviewed;
- gears used and habitats fished;
- the catch of fish and OAAs, including species reported.

The data should also be checked against the historical data for the location, and if any major changes are evident (i.e. large increases in catches or changes in habitat fished), the field book data and photographs should be re-checked.

6.2.2 Calibration and validation

Periodically, responsible agencies may replicate surveys to calibrate and validate catch and consumption data with other HHs in the village. Calibration of the method ensures consistent results under given conditions, especially of catch and habitats fished. Spatial variation in fishing area is a large source of bias and error (related largely to habitat variation and abundance of fish), but it is assumed that the use of replicate HHs in the village reduces such variation.

6.2.3 Data quality monitoring

Institutions and researchers responsible for implementing the monitoring programme should take measures to ensure that the data recorded in the surveys are unbiased and as accurate as possible by regularly overseeing and checking data recording activities. Institutions should encourage Interviewers to report any problems they experience and provide further training or additional equipment as necessary.

6.2.4 Data quality scores – judgment of respondents by the survey team

The Interviewers should study the respondents' attitude and behaviour, their willingness to help, their level of interest, the time they take to answer questions, and their apparent knowledge of the village situation and fisheries, and the subject of each question. Also, it should be considered whether the respondents are merely providing answers to satisfy the Interviewer or if they may have reasons to mislead the Interviewer s or be biased. The aim is for the team to judge the likely quality of the answers overall for each question, as a guide to whether it is necessary to ignore the results for some questions, or to re-design or repeat some parts of the survey.

The classifications should be based on the following factors:

- Average: Respondents are willing to help and mildly interested. Respondents take some time to think about the questions. They sometimes ask the Interviewers for clarification, and they seem to have some basis or reason for their answers. They seem to have reasonable knowledge about the village situation and fisheries. They have an average understanding of numbers and units.
- Above average: Respondents are very interested and willing to help. They take more time to think about the questions. They often ask the Interviewers for clarification, and they seem to have a clear basis or reason for their answers. They seem to have a good knowledge about the village situation and fisheries. They have an above-average understanding of numbers and units.
- High quality: Respondents are enthusiastic; they understand and are supportive of the overall purpose of the survey to manage and conserve fisheries. They discuss the questions, seek clarification and may even offer suggestions for improvement. They are very experienced and knowledgeable about the village situation and fisheries. They have a very good understanding of details and of numbers and units.
- Below average: Respondents seem slightly reluctant to help and are not very interested. They are impatient and want to complete the survey quickly; they answer

questions quickly, often without much thinking. They rarely ask the Interviewer s for clarification, and they may seem to be inventing answers or just providing an answer to get the interview over with. They seem to be lacking some knowledge about the village situation or fisheries. They may be confused about numbers and units.

- Poor quality: Respondents are reluctant to participate in the interview and may even be hostile. They are quite impatient and want to complete the survey quickly; they answer questions quickly without much thinking. They do not ask the Interviewer s for clarification, and they appear to be inventing answers or providing quick ones. They seem to have little knowledge about the village situation or fisheries. They have no interest in the details or in numbers and units.

In all interviews, the Interviewer s should rank the likely quality of the responses to each set of questions by ticking the box as shown below. The rankings -2 to +2 correspond to the classifications summarized above.

Poor quality	Below average	Average	Above average	High quality
-2	-1	0	1	2

6.3 DATA STORAGE

As soon as possible, data from field sheets should be entered into standardised databases or customized Excel spreadsheets until the databases are available. Ideally, data are entered in the field on tablet computers, or immediately upon return to the office. The staff that carried out field sampling should enter the data or supervise data entry. Field sheets should be photocopied or scanned for a backup and then stored systematically in separate files. Databases should be backed up each day to a separate external hard disc.

6.4 REGULAR FISHER FEEDBACK

The reliability and sustainability of any monitoring programme will largely depend on fishers' understanding and them remaining interested in the monitoring activities. *It is therefore very important that research institutions or researchers take the necessary time to explain to participating fishers the purpose of the data collection and to regularly provide feed back on the results of the survey programme in a readily understandable format.* Fishers or organized fisher groups need to see the results of their hard work and to understand how the data they collect contribute to better management of fisheries resources. Providing regular feedback helps to maintain motivation and to ensure that the data continue to be collected effectively (FAO's 'Guidelines on Designing Data Collection Systems', pp. 79–81).

6.5 DATA SHARING

MRCS ED has a central role in compiling the data submitted by national partners and synchronizing them into a regional database platform for regional sharing. It also has a central role in synthesizing all of the data and providing a regional analysis of the data in a report according to the structure provided in Annex 6.

6.6 TECHNICAL REPORTS

National line agencies who are involved in monitoring fisheries yield assessment by habitat types will prepare technical reports describing the survey activities and the results of the surveys in their respective countries. Reporting guidelines and contents of the national annual report are provided in Annex 6. National technical reports will be submitted to the MRCS ED, which has the central role to synthesize and perform further regional analyses of monitoring data (if required) for a regional report and MRC Technical Paper publications. These reports should follow the instructions for analysis as above, but also include an explanation of the information provided. Examples of the way to present the data are provided in the various sub-sections of Section 5. The report should then undertake a review of the changes in catch and CPUE per habitat type and of fishers' effort and status over time, i.e. between sampling periods. The same analyses as described above should be used to show trends in fisher and HH demography, habitats fished, gears used, catch rates of fish and OAAs and their value, and consumption information, and ultimately derive an estimate of the annual catch of fish and OAAs and their value from the LMB.

MRC will compile the contents of the national reports to provide a LMB regional synthesis (Annex 6). They will combine all data from the reports and follow the same structure and format as for the national reports, but should provide a more detailed regional analysis and comparison with previous yield assessment studies. Where possible, data from other programmes should be included in the regional review.

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ANNEXES

ANNEX 1. VILLAGE SURVEYS

The aim of the village surveys is to obtain background information, including number of households (HHs) in the village, fishing areas, trends in catches and other complementary information to that obtained in the HH survey. Data are also used to cross-check data from the HH survey.

From within the survey area (a district), a sample of 30 villages is chosen using probability proportional sampling (PPS), a method in which the chance of a village being selected is proportional to the number of people in the village. As larger villages have more chance of being selected, the sample is self-weighting.

Annex 1.1. Before travelling to the field survey area

Prepare a map from Google Earth and/or other sources, with the planned survey area and the villages in or near that area, and upload the layer access roads and other features. The ED team will assist or provide guidance.

Obtain a copy of the most recent national census data and locate the villages in the survey area and enter their details and population data on the village form prior to the field trip, i.e. pre-prepare the forms for each village. The ED team will assist or provide guidance.

Plan your road route to make efficient use of your time each day.

Contact province or district officials to explain the objective and arrange the visit.

Annex 1.2. In the village

The interview should be with the village chief and others (respondents) who have general knowledge of the village and fisheries. There would ideally be 2–3 men and 2–3 women in the group interviewed. If there are fewer men or women, the interview can still be conducted since there is an opportunity to follow-up on later visits.

The team should provide drinks and snacks, or some small incentives to participate.

At the start of the interview, note down the date and time of the interview and other details on page 1.

Introduce the team and explain the overall purpose of the study (i.e. to improve fisheries management) and the village survey (i.e. to understand the fishery and get data for a HH survey). Be respectful, and before talking about the interview, ask questions about the village. Explain that the interview could take 30–60 minutes, and if the respondents do not have time, offer to come back later.

Ask if there is a village register available that shows HHs and other data, and use it to answer as many questions as possible.

Show the respondents the map of the study site, with main habitats and villages. Show them where their village is located and then ask them to provide any details that are missing in the questionnaire.

Explain that you mainly want to obtain information about fishing and its importance in the village, the number of people fishing, where they go fishing, and their gear and catches, and ask them to provide any other supporting information.

Explain the terms that will be used, as follows:

- A household is usually the same as a family, but can be consist of two or more families who live in the same house or houses on one property.

It is important to classify all HHs in the village into the three main groups.

- FT fishing HHs: HHs in which one or more HH member captures fishes or other aquatic animals (OAAs) most days; usually, some of the catch is sold. These HHs include commercial fishing HHs.

- Commercial fishing HHs: A subset of FT fishing HHs. One or more members captures fishes or OAAs most days, and the HH derives most income from selling fish or OAAs.

- PT fishing HHs: One or more members captures fishes or OAAs – typically for a few hours or 1–2 days per week, or occasionally for longer periods but a few times per year. Most or all of the catch is for HH consumption; only minor quantities are sold or given away. Most HHs in rural areas are found in this category.

- Occasional fishing: members of the household go fishing occasionally or short time to catch fish for household consumption or to give to friends and relatives. Occasional barters the fish for other food products.

- Non-fishing HHs: HHs in which no one ever captures fishes or OAAs. This is uncommon in traditional rural areas. Make sure that women, children and elders are included in the interviewing of HHs.

- In this context, fishing includes any activities regarding catching fish and/or collecting OAAs (other aquatic animals). OAAs include all other kinds of aquatic animals that live in or associated with water:

  - Tadpoles, small frogs, big frogs
  - Molluscs (bivalves and gastropods)
  - Shrimps
  - Crabs
  - Aquatic insects

- Snakes (caught in water)
- Turtles
- Water birds
- Eels (Note: eels are fish but many people call them OAAs; they need to be separately mentioned).

Work through each set of questions:

- Explain the purpose of each question.
- Take time to make sure that the respondents understand each question.
- Work from the bottom up and the top down to obtain a reasonable answer. For example, the respondents might calculate a total catch by multiplying up average catches, but then think the result is much too high for a total figure.
- If respondents do not want to provide an answer or do not know, this is OK, just record DN.
- If they provide a range (e.g. 50–100 kg), record it.
- Do not insist on personal details if they do not wish to provide them.
- The aim is to know how many people are actually residents in a village; the questions about fishing and catches relate to the actual situation for HH members who were there most of the time over the last 12 months.

Annex 1.3. Completing the forms

When the interview is finished, work through each question again and recheck it; try to ensure that there are no gaps or contradictory answers.

Note: It is OK if there are some discrepancies between answers – just write down an explanation – e.g. there could be disagreement between two people in the interview, or some questions may need to be re-worded.

Any blank responses on the form should be filled in with DN (don't know) or NR (non-response – the respondent does not want to answer), or another explanation.

The form can be modified to make it more suitable. You can re-word questions to make them less ambiguous, or you can add questions that are relevant. Any changes can be discussed at the regional meeting after the first field visit for the village survey.

At each village, the team leader should check and sign each form before proceeding to another village.

When each survey is completed, photograph or scan each page and keep a digital copy.

At the end of the interview, note down the date and time of the interview and other details on the final page.

Annex 1.4. Photographing each village

Each surveyed village should be photographed systematically.

Ideally, the camera records GIS data for each photograph (lat./long./elevation).

The following photos should be taken with the photograph numbers recorded on a GPS:

- Photos (4) looking in each main direction away from the HH towards the surrounding landscape: North, South, East and West, or intermediate angles depending upon HH orientation.
- Photos in the village (2), looking both directions along the main street.
- Photos of the village interview location (1–2).
- Photos of any nearby particular fishing areas for that village.
- Photos of any large gears in or near the village.
- Photos of any markets, or fish or OAAs being sold in or near the village.
- Photos or any fish processing equipment.
- Photos of any aquaculture facilities or ponds in or near the village.

Digital photos should be catalogued in folders by village name and date.

ANNEX 2: HOUSEHOLD SURVEYS

Annex 2.1. Objectives of the household surveys

The household (HH) surveys are aimed at obtaining data for representative HHs on their catch from different habitats. The data are then extrapolated to all HHs that are expected to be fishing in the study area based on the results of the village survey. Catch assessment is based on estimated effort (fishing days) multiplied by catch per day, but other data are also collected to support the estimates, including consumption data.

Six HHs should be selected randomly within each of the sample villages. Households provide information on fishing effort and catches, habitats fished, as well as various other supporting information. They are the primary sampling units (PSUs) used to extrapolate total catches in the district and the proportions of catch from each habitat.

Annex 2.2. Before going to the field

The number of households (HHs) from each village is determined based on the sample frame data from the village survey, statistical criteria, expected non-responses, and within the limits of the available resources. Please note the following:

- The head of each village should be notified well in advance of the expected date of the visit and the number of HHs planned to be interviewed.
- Province or district officials should be contacted to explain the objectives and arrange the visit and their schedule.

Annex 2.3. In the village

Households (HHs) should be selected randomly from a complete list of HHs in the village. Random sampling allows every household (HH) in the village to have an equal chance of being selected for survey. See Appendix 1.

The interviews at each HH should be organized through a request in advance with the village chief.

Annex 2.4. In the household

The interviews should include as many people as possible from the HH and their presence should be noted on the questionnaire.

Questions should be directed at the person who has most knowledge of that subject.

Most of the questions are directed at the HH head and/or the main people who capture fishes and/or OAAs.

Questions regarding food consumption should be directed at the main person responsible for food purchasing and its preparation.

The team should provide drinks and snacks, or some small incentives to participate.

At the start of the interview, note down the date and time of the interview.

Introduce the team and explain the overall purpose of the study (i.e. to improve management of fisheries) and this HH survey (i.e. to understand the size and value of the fishery and the sources of catches). Be respectful, and before talking about the interview, ask questions about the village. Explain that the interview could take 30–60 minutes, and if the respondents do not have time, offer to come back later.

Important: explain that your work only concerns fisheries and that the data collected will not be used in any way that identifies the respondents. This will prevent respondents from understating the number of catches or other quantities for fear of taxation or other issues. Explain also the importance of the fisheries should not be overstated.

Show the respondents the map, with the main habitats and villages. Ask them to indicate their house and make sure that they understand the target area of the study. Remind that the aim is to obtain knowledge about all of their catches and to separate the proportion according to the location of the catches.

Explain that we want to obtain information, such as the number of people fishing, where they go fishing, and their gear and catches. In addition, provide other supporting information.

Explain the terms that will be used.

- A household is usually the same as a family, but can consist of two or more families who live in the same house or houses on one property.

Tables 2 and 3 are used mainly to classify a HH into one of the main categories.

- FT fishing HHs: HHs in which one or more HH member fishes or collects OAAs most days; usually some of the catch is sold. These HHs include commercial fishing HHs.
- Commercial fishing HHs: A subset of FT fishing HHs. One or more members captures fishes or OAAs most days, and most of the HH income comes from selling fish or OAAs.
- PT fishing HHs: One or more members captures fishes or OAAs– typically for a few hours or 1–2 days per week, or occasionally for longer periods but a few times per year. Most or all of the catch is for household consumption; only minor quantities are sold or given away. Usually most HHs in rural areas are in this category.
- Non-fishing HHs: HHs in which no one ever fishes or collects OAAs. This is uncommon in traditional rural areas. Make sure that women, children and elders participate in the survey.

In this context, fishing includes any activities regarding capturing fishes and/or OAAs. All members in the HH should be included, including women, children and elders. Even if only one person captures fishes or OAAs occasionally then the HH is a ‘fishing HH’. Generally, most rural HHs are ‘fishing HHs’ but usually only a few are FT or commercial.

OAAs include all other kinds of aquatic animals that live in or associated with water.

- Tadpoles, small frogs, big frogs
- Molluscs (bivalves and gastropods)
- Shrimps
- Crabs
- Aquatic Insects
- Snakes (caught in water)
- Turtles
- Water birds
- Eels (Note: eels are fish but many people call them OAAs; they need to be separately mentioned).

Work through each set of questions.

- Explain the purpose of each question.
- Take time to check if the respondents understand each question.
- Work from the bottom-up and the top-down to get a reasonable answer. For example, they might calculate a total catch by multiplying up average catches, but then think the result is much too high for a total figure.
- If respondents do not wish to provide an answer or don't know, that is OK, just record DN.
- If they provide a range (e.g. 50–100 kg), record it.
- Do not insist on personal details if they do not want to provide them. Just leave that question blank and write non response (NR).
- The aim is to find out how many people capture fish; the questions about fishing and catch relate to how many members of the household practiced fishing over the last 12 months.

For question 11 on the Household Form (Annex 3), the names of fermented fish products names in LMB countries are provided in the table below.

Name of fermented fish products in LMB countries

Language	Fermented fish products			Dried fish, salted/dried fish	Smoked fish
	Fish paste	Fish sauce	Other fermented fish products		
Thai	Pla Ra	Nam Pla	Ka Pi Pla, Pla Jom, Pla Som, Pla Jao	Pla Heng	Pla Yang
Khmer	Prahoc, Mam	Teuk Trey	Pa 'ok	Trey Ngiet, Trey Hal, Trey Pra Laak	Trey Ch'au
Lao	Pa Dek	Nam Pa	Ka Pi Pa, Som Pa, Pa Jao	Pa Heng	Pa Lon Fai
Vietnamese	Cha Ca, Mam Linh	Nuoc Mam	Mam Ca, Mam Nem	Ca Kho	Ca Xong Khoi
Typical usage time	6–12 months	6 months to several years	Up to 6 months		

Note: Mam in Khmer is fish with papaya half ripe. Papaya is removed after 10 days and sold with some adhering fish.

Annex 2.5. Completing the forms

When the interview is finished, work through each question again and recheck it; try to make sure that there are no gaps or contradictory answers.

Note**:** It is OK if there are some discrepancies between answers – just write an explanation – e.g. there could be disagreement between two people in the interview, or some questions may need to be re-worded.

Any blank responses on the form should be filled in with DN (don't know) or NR (non-response should the person does not wish to answer), or write down another explanation.

The form can be modified to make it more suitable. You can re-word questions to make them less ambiguous, or you can add questions that are relevant.

At each HH the team leader should check and sign each form before proceeding to another village.

When each HH interview is finished, photograph or scan each page and keep a digital copy.

At the end of each interview, note down the date and time of the interview and other details on the final page.

Annex 2.6. Taking photos of households

Each surveyed HH should be photographed systematically, but ask permission to photograph people.

Ideally, the camera would record GIS data for each photograph (lat./long./elevation).

The following photos should be taken with the photograph numbers recorded on a GPS:

- Photos (4) looking in each main direction away from the HH towards the surrounding landscape: North, South, East and West, or intermediate angles depending upon HH orientation.
- Photos of any nearby particular fishing areas for that HH.
- Photos of the HH (2), from front and back.
- Photos of fishing gears.
- Photos of any fish or OAAs in or near the HH.
- Photos or any fish processing equipment.
- Photos of any aquaculture facilities or ponds.

Digital photos should be catalogued in folders by village – then HH name and date.

ANNEX 3: QUESTIONNAIRE FOR HOUSEHOLDS/FISHERS AT KEY MAJOR HABITATS IN THE LOWER MEKONG RIVER BASIN

Toolbox 1: Questionnaire for households/fishers at key major habitats in the Lower Mekong River Basin

Instructions for interviewer.

A clean version of questionnaire for the survey is provided separately.

1. HOUSEHOLD AND INTERVIEW DETAILS

Table 1. Information of respondents (the person who oversees the fishing activities should be interviewed): an example of a filled in survey

Name	Age	Gender[1]	Number of family mem-bers[2]	Occupation[3]		Address (village, district/province)/phone number
				Last 5 years	Last 12 months[4]	
Nguyen Van A	45	M	4	Full-time	Part-time	Chau Thanh - An Giang VN - 0918425999

Purpose: The most important information from this table is 'occupation', which later contributes to understanding on the family fishing activities and catches. Any change in occupation over the last 5 years also highlights social aspects related to the catches and values. For example, in the Mekong Delta, there are not many full-time fishers now since the catches have declined and the economic incentives from fishing are much lower than other opportunities such as aquaculture or services.

Instructions for the interview and to fill in questionnaire:

- [1]Gender: **M**: Male; **F**: Female
- [2]Number of family members: Number of family members who physically live in the house for last 12 month.
- [3]Occupation: **Full-time**: if total income in a year is >70% from capture fishery including fish and OAAs; otherwise **part-time or occasional**.
- [4]Last 12 months: any change in activities or circumstances.

2. FISHING GEARS

Table 2. Fishing gears, habitats, relative effort and catch per year. Example of a filled in survey

Most frequently used gear[1]	Gear name[2]	Habitat[3]	Distance from HH (km)[4]	Season[5]	Percentage of fishing days (%)[6]	Percentage of catches (%)[7]
First	Trawl	H1	1	B	70	80
Second	Gill net	H1	3	W	30	20
Third						
Fourth						
Total					100	100

Purpose: To provide information on gear efficiency and on the likely habitat boundary where the HHs fish, which are likely to be the most productive habitats. Fishers tend to utilize the most efficient gear and go to where they can catch the most fish. Therefore, the information in this table will help to identify the likely habitat boundary where HHs capture fish or OAAs and to understand and explain which habitat is likely to be the most productive.

Instructions:

- [1]Note down the most frequently used gear. ordering it from the most frequently used (first) to least often (second, third, fourth).
- [2]Gear name: Refer to common gear types in the LMB in **Annex 2**. If any gear has any particular feature, describe it or take a photo. Also take photos of gears used in the field if possible.
- [3]Habitat: Where the gear is used. Either use codes or habitat names below for input into questionnaires

H1: Rainfed rice fields and associated habitats
H2: Floodplain – large river
H3: Reservoir
H4: Brackish-water estuarine

- [4]Distance from HH (km): Distance from home to fishing locations/grounds.
- [5]Season: when the gear is used. Either use codes or names below for input into questionnaires

D: Dry season (from December to May)
W: Wet season (from June to November)
B: Both seasons

- [6]Percentage of fishing days: number of days using each kind of gear divided by total fishing days in a year. The interviewer should double-check to make sure that the total percentage of fishing days by gear types is **100%.**
- [7]Percentage of catches: weight of catches using each kind of gear divided by total catches in a year. The interviewer should double-check to make sure that the total percent of catches by gear types is **100%**.

3. FISH CATCH ESTIMATED BY THE HOUSEHOLDS

Table 3. Estimated fishing effort and **fish catches** from each habitat by the HHs over the last 12 months

Most frequently visited habitat[1]	Habitat[2]	Parameter	Month												Total (kg/year)
			1	2	3	4	5	6	7	8	9	10	11	12	
First	H1	Fishing days/month[3]													
		Catches (kg/day)[4]													
		Catches (kg/month)[5]													
Second	H2	Fishing days/month													
		Catches (kg/day)													
		Catches (kg/month)													
Third	H3	Fishing days/month													
		Catches (kg/day)													
		Catches (kg/month)													

Purpose: The information in this table will provide an estimate of the possible total catch per HH/fisher/year in each habitat type by averaging catches per HH. Multiply this figure with total number of fishers, then divide by areas (hectare) of habitat will provide likely a catch/yield per ha per year. Double-check with habitat information in Table 2 to make sure that the habitat information is consistent.

Instructions:

- [1]Most frequent visiting habitat: order of most frequent visiting habitat, from most often (first) to less often (second, third, fourth).
- [2]Habitat: where to go fishing. Use codes or habitat names below for input into questionnaires
  H1: Rainfed Rice fields and associated habitats
  H2: Floodplain – large river
  H3: Reservoir
  H4: Brackish-estuarine
- [3]Fishing days/month: the interviewer could ask the HH's fishing information in 2019 since the information in 2020 and 2021 could be biased due to COVID-19. Encourage the HH/fisher to remember the numbers of fishing day each month. All Member Countries should use the solar calendar.
- [4]Catches (kg/day): Estimate the average weight in kg of the fish caught per day each month. Interviewer should take note and convert local measuring unit into the standard unit **kg**.
- [5]Catches (kg/month): Multiply fishing days by average daily catch to obtain monthly catch. If the respondent cannot remember the number of catch per day, fill in the number of catch per month instead.

Table 4. Estimated fishing effort and OAAs catches from each habitat by the HHs over the last 12 months

Most frequent visiting habitat[1]	Habitat[2]	Parameter	Month												Total (kg/year)
			1	2	3	4	5	6	7	8	9	10	11	12	
First	H1	Fishing days/month[3]													
		Catches (kg/day)[4]													
		Catches (kg/month)[5]													
Second	H2	Fishing days/month													
		Catches (kg/day)													
		Catches (kg/month)													
Third	H3	Fishing days/month													
		Catches (kg/day)													
		Catches (kg/month)													

Instructions: Same as fish catches in Table 3.

Table 5. Example of survey form on the trend of fish and other aquatic animal catches, 2010–2019

Parameter	2010	2015	2019	Note
Catch of fish per year (kg)	1,000	900	1,500	
Catch of other aquatic animals (OAAs) per year (kg)	500	700	800	

Purpose: To understand the trend of fish and OAA catches in the area, from 2010 to 2019.

Instructions: The interviewer asks the HHs/fishers to remember the total catches of the household in each year. The HHs are asked to provide reasons explain why the trend increased or decreased. For example, the trend may drop due to water quality or less fish, or the trend may increase due to less fishers fishing in the area. The years chosen for the survey data are 2010, 2015 and 2019; however, please note that these years are flexible, i.e. they can be moved by one year before or after, in which case it should be noted.

4. MAIN SPECIES CAUGHT AND SOLD, AND PRICES

Table 6. Species caught and sold, and market data last 12 months

Parameters	Key species[1]	Total yearly caught (kg/year)	Total yearly sold (kg/year)	Most likely price (USD/kg)	
				Fisher price	Market price
Fish (total)					
1. Small-sized fish (<25 cm)					
2. Medium-sized fish (25–50 cm)					
3. Large-sized fish (> 50 cum)					
Crustaceans (total)					
1. Shrimps					
2. Crabs					
Molluscs (total)					
1. Clams					
2. Snails					
Amphibians and reptiles (total)					
1. Frogs					
2. Turtles					
3. Water snakes					

Purpose: To obtain an overview of the proportion of catch, sold and consumption, and the value of different fish species and OAAs. This information could provide an estimate of the economic values of fisheries in LMB. The consumption data (consumption = total caught - total sold) are obtained from the HHs' catches; other consumption data are further discussed in Table 7.

Note: [1]For the key species name, refer to the list of common species in the LMB in **Annex 3**.

Table 7. Consumption of inland fish products, and other aquatic animals

Average quantity (kg/HHs/week) consummned[1]	Percentage from different sources[2]				
	Captured fish/other aquatic animals (OAAs)		Aquaculture	Meat	Others
	Caught by the HH	Bought by the HH			

Purpose: The aim of this table is to record information on HH consumption from different kinds of animal protein sources. It should help estimating roughly the consumption of fish/OAAs (kg/HH/week). Multiply the quantity of animal protein consumption per week by 52 weeks to calculate kg fish or OAAs per HH per year. Interviewer should discuss with HHs to make sure that the consumption of fish orOAAs (kg/HH/year) makes logical sense. This figure could be double-checked later with national consumption survey data, which the survey team should obtain from the national statistical office. The entire study is based on the assumption that total inland capture fish or OAAs were consumed in the LMB, so that the information from this table could be used to determine the yield of fish in the LMB.

Instructions:

- [1]Estimate roughly how many kg of fish and OAAs the HH consumes per week.
- [2]Estimate the percentage of the animal protein consumption per week from different sources.

Toolbox 2: Questionnaire for fisheries management officers at selected provinces for the HHs interviews in the Lower Mekong River Basin

Instructions for the interviewer.
A clean version of the questionnaire for the survey is provided separately.

OFFICER INFORMATION

Table 1. Information of respondents: example of a filled in survey form

Name	Age	Gender	Official position	Department	Province
Nguyen Van B	45	M	Aquaculture extension	Department of Aquaculture and Rural Development	An Giang Province

USAGE OF CAPTURED INLAND FISH AND OAAs

Table 2. Example of survey form filled in with information on the usage of captured inland fish and OAAs in each Member Country in the LMB

Fisheries products[1]	Usage of captured inland fish and OAAs from within country [2]						Import quantity and country of origin	
	Quantity (t)[3]	Human consumption %	Aquaculture feed %	Animal feed %	Others %	Export %	Import (t)[4]	Country[5]
Fresh fish (whole weight)	4,500	70	10	20		10	50	Cambodia
Fresh trash fish (whole weight)	4,000	0	70	30	10		45	Cambodia
Fresh OAAs (whole weight)	500	50	40	10				
Preserved fish								
Fish paste	100	100	0	0	0			
Fish sauce								
Other fermented fish								
Dried/salted fish								
Smoked fish								
Total								

Instructions: Inland fisheries yields (i.e. all fish and OAAs caught and collected in LMB waters within each country) can be calculated as follows: *Yield = C +A + F + W + E – I*

Where:

C = consumption by people

A = aquaculture feed (inland fish and OAAs used to feed aquaculture fish)

F= animal feeds (inland fish and OAAs used to feed poultry and livestock)

W = wastage (losses of fish post-harvest and subsequently in the supply chain to domestic consumers)

E = exports (inland fish and OAAs exported from the LMB)

I = imports (inland fish and OAAs imported to the LMB.

[1]Products: list all products including fresh and processed fisheries products

[2]Usage: percent (%) of using the fisheries products, from within country sources, for each purpose

[3]Quantity (tonne): this information could be obtained from the National Statistics Office. Provide % of each usage, i.e. human consumption, aquaculture feed, animal feed, export, etc.

[4]Import: how many tonnes of each product are imported.

[5]Country: where the products are imported from.

Table 3. Information on aquaculture

Species	2010		2015		2019/2020		Remarks
	Production (t)	Total area (ha)	Production (t)	Total area (ha)	Production (t)	Total area (ha)	

Purpose: Many areas in the floodplain and rainfed rice fields are converted into aquaculture ponds. The information from this table will help remove these areas and production from the capture fisheries estimates, i.e. actual area of habitats used by wild fish and actual captured fisheries production.

OTHER INFORMATION RELATED TO IMPORT AND EXPORT OF INLAND FISHERIES AND OAAs

4. The following is the list of information that needs to be collected at the provinces selected for the HH interviews:
   - geographical data and information of survey sites (province and district surveyed);
   - detailed data on demographics and occupations at the survey sites (province and district surveyed);
   - data on other economic activities related to aquaculture and capture fisheries.
   - the importance of capture fisheries and fish products to food security, livelihoods and economics;
   - information from the national expenditure and consumption survey.

Toolbox 3: Open-ended questions use for group discussion with HHs/fishers

Instructions for the interviewer.

A clean version of questionnaire for the survey is provided separately.
Instructions: The purpose of the group discussion is to validate the results from the household (HH) survey and reflect on different perspectives that may not be recorded during HH/fisher interviews. Basically, the groups will be asked the same questions as in Toolboxes 1 and 2. The questions below are general guidelines only; interviewers are encouraged to come up with any questions to deepen our understanding about fish and fisheries in the area.

1. **Fishing gear**

1.1. What is the most popular fishing gear used in your area in dry or wet seasons and in different habitat types?
1.2. What is the most efficient fishing gear (catch most fish) used in your areas in dry or wet seasons and in different habitat types?

2. **Fish catch estimates in last 12 months**

2.1. What is the range of fish catches (kg/month and kg/year) per HH? In which months are the most/least fish caught? In which habitats (H1, H2, H3 or H4)?

2.2. What is the likely yield (kg/month/ha and kg/year/ha) of fish in each habitat (H1, H2, H3 or H4)?
2.3. What is the range of OAAs harvested (kg/month and kg/year) per HH? In which months are the most/least OAAs harvested? In which habitats (H1, H2, H3 or H4)?
2.4. What is likely yield (kg/month/ha and kg/year/ha) of OAAs in each habitat (H1, H2, H3 or H4)?

3. **How many HHs in your village are full-time fishers (>70% income from capture fishery) and part-time fishers?**

4. **Main species caught and market data for the last 12 months**

Fish species name	Small-sized fish/individuals (<25 cm) – likely catch (kg/HH/year)	Likely price asked by the fisher (USD/kg)	Medium-sized fish (25–50 cm) Likely catch (kg/HH/year)	Likely price asked by the fisher (USD/kg)	Large-sized fish (> 50 cm) Likely catch (kg/HH/year)	Likely price asked by fisher (USD/kg)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Instructions: [1]Key species name: please refer to the list of common species in the LMB in **Annex 3**.

5. **Consumption of inland fish products, and other animal proteins**

Average quantity of fish and OAAs consumed[1] (kg/HH/week)	Percentage of inland fish products from different sources[2]				
	Captured fish/OAAs		Aquaculture	Meat	Others
	Caught by the HH	Bought by the HH			

Instructions:

- [1]Estimate roughly how many kg of fish and OAAs the family consume per week.
- [2]Estimate the percentage of the consumption of fish and OAAs per week from different sources.

6. Do villages export fresh fish and OAAs to other countries? Further discuss this information with villagers.

7. Are there any fishing regulations applied in your fishing grounds? Describe the fishing regulation.

8. How often do you encounter law enforcement officers regarding fishing regulations? How do they operate?

Country	Location	Habitats	Flooded, irrigated or rainfed	Stocked (yes or no)	Yield all (kg/ha/yr)	Yield fish (kg/ha/yr)	Mid-range fish yield (kg/ha/yr)	Fish	OAA	Source
Cambodia	Battambang	Rice fields, single crop	Rainfed (and flooded)	N	119	92	92	0.77	0.23	Hortle et al. (2008)
Cambodia	Svay Rieng (L)	Rice fields, single crop	Rainfed	Y	40	30	30	0.75	0.25	Amilhat et al. (2009)
Cambodia	Takeo (U)	Rice fields, single crop	Rainfed	Y	5	3	3	0.54	0.46	Amilhat et al. (2009)
Cambodia		Rice fields		?		43				Ahmed et al. (1998)
Cambodia	Svay Rieng Theap District	Rice fields, single crop	Rainfed	?	100	82	82	0.82	0.18	Gregory et al. (1996) as cited by Guttman (1999).
Cambodia						51	51			Gregory & Guttman (1999) as cited by Gregory & Guttman (2002)
Lao PDR	3 provinces in southern Lao PDR	Rice fields, single crop	Rainfed and irrigated	Y		60	60			Nguyen Khoa et al. 2005
Thailand	Khu Khat	Rice fields, single crop	Rainfed	N		25	125	75		Fujisaka & Vejpas (1990) as cited by Little et al. (1996)
Thailand	Koh Wang District, NE Thailand	Rice fields, single crop	Rainfed	Y		33	33			Mang-Uphan et al. (1990) cited by Middendorp (1992)
Thailand	Koh Wang District, NE Thailand	Rice fields, single crop	Rainfed	Y		209	209			Middendorp (1992)
Thailand	NE Thailand	Rice fields, single crop	?	?		25	25			Spiller (1985) cited by Gregory &Guttman (1997)
Thailand	Yasothon (L)	Rice fields, single crop	Rainfed	Y	26	22	22	0.84		Amilhat et al. (2009)
Thailand	Sisaket (U)	Rice fields, single crop	Rainfed	Y	65	55	55	0.84		Amilhat et al. (2009)
Viet Nam	Hanoi (L)	Rice fields	Irrigated	Y	52	44	44	0.84		Amilhat et al. (2009)
Viet Nam	Phu Xuyen (U)	Rice fields	Irrigated	Y	151	127	127	0.84		Amilhat et al. 2009)
Cambodia	Tonle Sap	Floodplain, Rice field and	Flooded	N	243–532	310	310	0.8		Dubeau

		Permanent water bodies								
Cambodia	Tonle Sap	Entire floodplain	Flooded	N		230	230			Baran et al. (2001) cited by Hortle & Penroong (2009)
Cambodia	Tonle Sap	Entire floodplain (1995-99)	Flooded	N		139–190	164.5			Lieng & van Zalinge (2001) cited by Hortle & Penroong (2009)
Thailand	Songkhram	River floodplain system	Flooded, irrigated and rai	N		79	79	0.63		Hortle & Santornratana (2008)
Viet Nam	Mekong Delta	Floodplain Rice fields	Flooded	?	42–63	25	30	0.47	0.53	de Graaf & Chinh (2000) cited by Hortle & Suntornratana (2008)
Viet Nam	Mekong Delta	Floodplain Rice fields	Flooded	?	119	106	106	0.89	0.11	de Graaf and Chinh (2000) cited by Hortle & Penroong (2009)
Asia	Various	Floodplain river systems	Flooded			90	90			Halls et al. (2006)
Bangladesh	Pabna (NW)	Floodplains	Flooded	N		104–130	117			Halls et al. (1999)
Bangladesh	Tangail	Floodplains and Perm. w/bs	Flooded	N		165	165			De Graaf et al. (2001)
Bangladesh	Tangail	Floodplains	Flooded	N		83				De Graaf et al. (2001)
Bangladesh	Various	Floodplains and beels	Flooded	N			107			Ali (1997)
Asia		Rice fields	?			1.5–84	43			Gregory & Guttman (1997)
Malaysia		Rice fields, double crop	Irrigated			68–140	104			Tan et al. (1973) cited by Hortle & Suntornratana (2008)
Malaysia		Rice fields	?			Up to 150				Ali (1990)

ANNEX 5: NAMES OF LOCATIONS SELECTED FOR FISHERIES YIELD ASSESSMENT BY COUNTRY AND HABITAT

No.	Country	Province/City	District	Commune	Village	Standard habitat	Latitude (N)	Longitude (E)	Number of fishers	Agency	Remark
1	Cambodia	Stung Treng	Siem Pang	Tmar Keo	Pres Bang	Tributaries	14° 7'0.43"	106°23'23.99"	3	IFReDI	2003-2021
2	Cambodia	Ratanakkiri	Lumpat district	Chey Udom	Day Lo	Tributaries	13°28'18.08"	106°59'16.26"	3	IFReDI	2003-2021
3	Cambodia	Ratanakkiri	Veunsai	Banpong	Fang	Tributaries	13°57'43.14"	106°48'7.11"	3	IFReDI	2003-2021
4	Cambodia	Stung Treng	Talaborivat	Ou Svay	Ou Run	Mekong mainstream	13°52'0.13"	105°59'53.91"	3	IFReDI	2003-2021
5	Cambodia	Kratie	Sambo	Ou Krieng	Koh Khne	Mekong mainstream	13°08'9.15"	106°03'51.75"	3	IFReDI	2003-2021
6	Cambodia	Kandal	Ponhe Leu	Kampong Luong	Sang Var	Tributaries	11°49'9.52"	104°48'16.54"	3	IFReDI	2003-2021
7	Cambodia	Kampong Chhnang	Boribo	Chhnouk Trou	Chhnouk Trou	Floodplain/swamp/lake /tributaries	12°30'55.10"	104°27'26.91"	3	TSA	2011-2021
8	Cambodia	Pursat	Kor	Kompong Loung	Ti 2	Floodplain/swamp/lake /tributaries	12°36'21.09"	104°13'27.44"	3	TSA	2011-2021
9	Cambodia	Battambong	Ek Phnom	Prek Torl	Prek Torl	Floodplain/swamp/lake /tributaries	13° 6'1.48"	103°44'36.37"	3	TSA	2011-2021
10	Cambodia	Siem Reap	Siem Reap	Chong Khneas	Ti 3,4,5	Floodplain/swamp/lake /tributaries	13°12'54.07"	103°48'45.29"	3	TSA	2011-2021
11	Cambodia	Kampong Thom	Kompong Svay	Phat Sanday	Neang Sav	Floodplain/swamp/lake /tributaries	12°43'1.52"	104°25'45.64"	3	TSA	2011-2021
12	Lao PDR	Luangprabang	Luangprabang		Pha Oh village	Mekong mainstream	19°56'4.39"	102°12'21.97"	3	LARReC	2003-2021
13	Lao PDR	Vientiane Capital	Hatsaifong		Tha Mouang	Mekong mainstream	17°53'26.87"	102°44'45.86"	3	LARReC	2003-2021
14	Lao PDR	Bolikhamxay	Paksan		Sinxay	Mekong mainstream	18°20'51.40"	103°45'9.42"	3	LARReC	2003-2021
15	Lao PDR	Champasack	Phonthong		Hatsalao	Mekong mainstream	15° 4'28.16"	105°49'38.79"	3	LARReC	2003-2021
16	Lao PDR	Champasack	Khong		Hat	Mekong mainstream	14° 5'2.67"	105°50'42.54"	3	LARReC	2003-2021
17	Lao PDR	Bokeo	Houaysai		Houay Tab	Mekong mainstream	20°19'38.88"	100°22'51.08"	3	LARReC	New (2013-21)
18	Lao PDR	Bokeo	Houaysai		Donkhoun	Tributaries	20°22'3.73"	100°22'22.02"	3	LARReC	New (2013-21)
19	Lao PDR	Oudomxay	Pakbeng		Pak Ngeuy	Mekong mainstream	19°53'20.84"	101° 7'18.29"	3	LARReC	New (2013-21)
20	Lao PDR	Oudomxay	Pakbeng		Beng	Tributaries	19°53'29.72"	101° 8'17.65"	3	LARReC	New (2013-21)
21	Lao PDR	Luangprabang	Xieng Ngeung		Pha Nom	Tributaries	19°53'9.14"	102° 9'34.41"	3	LARReC	New (2013-14)*

21	Lao PDR	Xekong	Lamam		Gnai Nava	Tributaries	15°20'49.42"	106°44'29.17"	3	LARReC	New(2017-21)**
22	Lao PDR	Luangprabang	Pak Ou		Hat Nga	Tributaries	20° 5'6.33"	102°15'41.98"	3	LARReC	New (2013-14)
23	Lao PDR	Xayaboury	Xayaboury		Tha Dua	Mekong mainstream	19°25'52.93"	101°50'20.32"	3	LARReC	New (2013-14)
24	Lao PDR	Xayaboury	Xayaboury		Na Sam	Tributaries	19°13'47.50"	101°42'28.24"	3	LARReC	New (2013-14)
25	Lao PDR	Bolikhamxay	Paksan		Posy	Tributaries	18°25'29.64"	103°37'5.49"	3	LARReC	New (2013-14)*
25	Lao PDR	Attapeu	Samakhixay		Saphaothong	Tributaries	14°48'33.98"	106°47'18.35"	3	LARReC	New (2017-21)**
26	Lao PDR	Champasack	Pakse		Hae	Tributaries	15° 8'34.40"	105°48'7.43"	3	LARReC	New (2013-14)*
26	Lao PDR	Champasak	Khong		Hangsadam	Mekong mainstream	13°56'8.04"	105°57'31.84"	3	LARReC	New (2017-21)**
27	Thailand	Loei	Chiang Khan		Ban Noy	Mekong mainstream	17°54'38.64"	101°41'45.81"	3	DoF	2003-2021
28	Thailand	Nong Khai	Tha Bo		Thadaeng	Tributaries	17°53'10.62"	102°34'1.32"	3	DoF	2003-2021
29	Thailand	Nakhon Phanom	Tha Uthen		Woen Phrabat	Mekong mainstream	17°37'25.67"	104°31'2.71"	3	DoF	2003-2021
30	Thailand	Nakhon Phanom	Si Songkhram		Ban Tha Bho	Floodplain/swamp	17°39'21.42"	104°13'5.80"	3	DoF	2003-2021
31	Thailand	Ubon Ratchathani	Khemarat		Ladjalean	Mekong mainstream	16° 1'39.51"	105°21'0.17"	3	DoF	2003-2021*
31	Thailand	Ubon Ratchathani	Khong Chiam		Weonbuk	Mekong mainstream	15.321692	105.54645	3	DoF	New(2021)**
32	Viet Nam	Vinh Long	Vung Liem	Thanh Binh	Lang	Mekong mainstream	10°05’ 57.7	106°13’ 38.5	3	RiA2	2003-2021
33	Viet Nam	An Giang	Toai Son	Nui Sap	Tay Son	Floodplain/swamp	10°11'21.30"	105°15'27.62"	3	RiA2	2003-2021
34	Viet Nam	An Giang	Cho Moi	My Hoi Dong	My Thuan	Mekong mainstream	10°32’ 49.5	105°20’ 06.6	3	RiA2	2003-2021
35	Viet Nam	An Giang	An Phu	Phu Hoi	Ap 2	Canal	10°47'55.73"	105°04'46.79"	3	RiA2	2003-2021
36	Viet Nam	Tra Vinh	Tieu Can	Cau Quang	Khom 3	Estuarine	09°45'15.46"	106°07'09.88"	3	RiA2	2003-2021
37	Viet Nam	Can Tho	Phong Dien	My Khanh	My Thuan	Floodplain/swamp	10°00'27.82"	105°42'20.70"	3	RiA2	2003-2021
38	Viet Nam	Tra Vinh	Tra Vinh city	Long Duc	Long Trị	Estuarine	09°59’ 24.4"	106°21’ 11.7"	3	RiA2	2003-2021

Notes: * represented non-operated sites. ** represented newly selected sites in 2017.

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