Mekong River Commission
For Sustainable Development

# Assessment of Fisheries Yield in the Lower Mekong River Basin 2020

# ASSESSMENT OF FISHERIES YIELD IN THE LOWER MEKONG RIVER BASIN 2020

December 2023

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This publication was developed based on collaboration with relevant line and implementing agencies, and National Mekong Committee Secretariats in each Member Country.

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CPUE | Catch per unit effort |
| EIA | Environmental Impact Assessment |
| EMMP | Environmental Management and Monitoring Plan |
| FADM | Fish Abundance and Diversity Monitoring |
| FAO | Food and Agriculture Organization of the United Nations |
| GPS | Global Positioning System |
| GIS | Geographical Information System |
| GDP | Gross domestic product |
| JEM | Joint Environment Monitoring |
| LMB | Lower Mekong River Basin |
| MC | Member Country |
| MDS | Multi-dimensional scaling |
| MRC | Mekong River Commission |
| MRCS | Mekong River Commission Secretariat |
| NMCS | National Mekong Committee Secretariat |
| OAAs | Other aquatic animals |
| FT/PT | Full-time/part-time |
| TbEIA | Transboundary Environmental Impact Assessment |
| SOBR | State of the Basin Report |
| SIMVA | Social Impact Monitoring and Vulnerability Assessment |
| YPUA | Yield per unit area |

# EXECUTIVE SUMMARY

The Mekong River Commission (MRC) has carried out periodic assessments of the total catch of fish and other aquatic animals (OAAs) from the LMB to inform policy and to understand trends in catches and the value of aquatic living resources over time and between different regions of the LMB. The previous assessments were carried out for 2000 and 2010, and this report summarizes the findings from the 2020 assessment using two approaches to estimate the total catch and compares them with national harvest estimates. These were Geographical Information System- (GIS) based modelling and fisher household surveys aimed at determining the total catch based on the product of average harvest per unit area of wetland areas from the total area of different habitat types, and an extrapolation of catch from fish consumption surveys.

Available data suggest that annual finfish yield from the LMB ranges between 1.51 and 1.71 million tonnes based on GIS habitat yield modelling compared with an estimate based on consumption studies, which falls within this range at 1.65 million tonnes, and that of OAA harvest is around 443,000 tonnes. The estimate is within the range but at the lower end of that provided in the State of the Basin Report (SOBR) 2018 (1.3–2.7 million tonnes). These data show a considerable decline in catches of around 25–30% since the 2000 and 2010 assessments. Most of this yield is harvested from rainfed and flooded habitat, contributing 53% and 25% of the catch, respectively. In addition, the brackish-water estuarine zone in Viet Nam, contributes around 18% of catch. This distribution of catch highlights the importance of protecting and preserving these key habitats to sustain fish stocks.

Comparison of the total 2019–2020 catch from the LMB countries using different assessment approaches

| | Inland fish yield – official statistics (t) | Inland fish yield – household surveys (t) | Inland fish yield – consumption surveys (t) | Value household surveys based on final retail price $ million | Value consumption surveys based on final retail price $ million |
|---|---|---|---|---|---|
| Cambodia | 413,200 | 486,916 | 292,614 | 2,022,484 | 1,215,420 |
| Lao PDR | 70,001 | 105,998 | 141,007 | 645,860 | 859,174 |
| Thailand | 67,873 | 489,674 | 732,802 | 3,407,994 | 5,100,097 |
| Viet Nam | 451,009 | 427,751 | 485,436 | 1,055,530 | 1,197,876 |
| LMB | 1,002,083 | 1,510,340 | 1,651,858 | 7,131,869 | 8,372,566 |

The estimated value of the fish catch varied between USD 7.13 billion and USD 8.37 billion annually. In addition, the estimated value of the OAA harvest was around USD 1.13 billion, which is approximately 17% lower than the estimate in SOBR 2018. While these catches show a significant contribution to gross domestic product (GDP) and food security in the countries of the LMB, the value has declined since the 2015 assessment, which is due to a lower fish catch and possibly the impact of environmental change in the LMB on aquatic productivity. A number of factors contribute to this change in capture fisheries production, including alterations of flooding patterns caused by dam development and prolonged drought periods, as well as the application of enhanced estimation methods, including a more conservative GIS assessment of the flooded zone.

# 1 INTRODUCTION

The Mekong River system is one of the most diverse and prolific inland capture fisheries in the world (MRC, 2019). Capture fisheries play an important role in securing livelihoods and food nutrients for millions of people within the Lower Mekong River Basin (LMB) countries of Cambodia, Lao PDR, Thailand and Viet Nam. In 2015, the capture fisheries yield (fish and OAAs) in the LMB was estimated at around 2.3 million tonnes per year (So et al., 2015), valued at approximately USD 11.15 billion. However, the Basin has been subjected to considerable change since then, and there is a need to update the status of the yield and value of the fisheries to take these changes into account. Information on the size and value of the basin-wide capture fisheries in the LMB is crucial to inform regional and national strategies, policies and development planning, as well as improving coordination among the Member Countries (MCs) for transboundary fisheries management.

In particular, pressures on the fisheries are increasing and fishers commonly report that catch (per fisher) and average sizes are declining, and some species have become rare at some locations (MRC, 2010; 2021). Moreover, the Basin's human population is increasing, and there is a wider array of developments, such as hydropower, irrigated agriculture and urbanization, which impact fisheries. Consequently, information on status and change in yield from the fisheries is required to understand the impacts of these developments and to provide feedback for planning, management and impact mitigation.

To achieve this, the Mekong River Commission Secretariat (MRCS) has been working with the fisheries line and implementing agencies of LMB countries to conduct field surveys every five years to estimate the yields of capture fisheries in the LMB landscape from different major habitat types: major flood zones, rainfed zones, large water bodies, including reservoirs, and brackish-water estuarine zones. The first basin-wide fisheries assessment was carried out for 2000 (Hortle, 2007), the second for 2010 (Hortle & Bamrungrach, 2015) and the third for 2015 (Hortle, 2017, unpublished report). Following a five-year cycle, similar studies were carried in 2020, but were severely hampered by the COVID-19 pandemic and the ability to undertake field surveys. Nevertheless, the surveys were carried out following, as closely as possible, the same strategy as the 2015 surveys (Hortle & Bamrungrach, 2015).

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 MRC-IF 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; and (iv) capture fisheries prices*, which need to be monitored to estimate the economic value of capture fisheries (MRB-IF/Assessment indicator no. 24) as well as to measure the economic performance of LMB water-related sectors (MRB-IF/Strategic indicator no. 8). Consequently, the 2020 surveys support the assessment needs to report against the MRB-IFs for fisheries, and update estimates of fisheries yield and value from previous studies.
The overall objective of the 2020 fisheries and OAAs assessment at the landscape scale in the LMB is to measure yield indicators contributing to the interpretation of the economic value of basin-wide capture fisheries.

# 1 METHODOLOGY

An array of methodologies is employed in the LMB to determine spatial and temporal trends in catch, and total catch and its value. These include:

- 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.

## 1.1 NATIONAL FISHERIES AND AQUACULTURE DATA

Each country prepares official statistics to report to the Food and Agriculture Organization of the United Nations (FAO) usually based on periodic household surveys to determine social and economic characteristics of the population. These data are considered reliable sources of information on livelihoods, food consumption and dependence on fisheries as a food source, and can be used to cross-validate against other approaches to determine 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 households 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 (Touch & Meas, 2021). Cambodia also regularly carries out national household surveys to determine consumption of food products.

Official statistics for Lao PDR fisheries and aquaculture are prepared by agencies of the Government of Lao PDR based on estimates of water surface areas and assumed yield per unit area (YPUA), rather than on any field data collection; these same data are published by FAO. The Government also carries out national household surveys every five years, the Lao Expenditure and Consumption Surveys (LECSs), which cover more than 8,000 representative households during each survey and include both purchased and self-produced goods and services (www.lsb.gov.la/en/home). Fish from capture fisheries and aquaculture are combined in the summary data, and they do not include OAAs. The surveys are based on questionnaires completed by interviewers based on recall of quantities and prices from respondents. As such, the accuracy of responses is unknown; however, since 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 interpretation and understanding as required for policy formulation and cross-validation of outputs 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. They do not include most of the wild capture fisheries in the country, which are dispersed across a vast array of habitats; consequently, these statistics likely represent only a small part of the inland fishery. The LMB portion of these official statistics represents about half of the national figures and catches vary little from year to year, suggesting that they are collected in a robust manner. Thai national aquaculture production data are more reliable than those for 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 is 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 Mekong Delta, but there is no official breakdown available for the LMB provinces that is consistent with the reported total national inland catches. Importantly, the Government conducts annual statistical surveys (GSO surveys) based on household surveys, which provide valuable information on household 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 household 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.

## 1.2 VILLAGE AND HOUSEHOLD SURVEYS

### 1.2.1 Selection of villages and households

The household (HH) survey was the chosen methodology for collecting catch and socioeconomic information on fisheries and OAAs harvesting in the LMB. The objectives of field surveys in collecting information at the landscape scale were:

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

The areas surveyed are districts that were entirely or mainly classified as one of the main fish habitat classes. Districts that include flood-zone habitats typically included some rainfed habitat. The inclusion of villages located in this type of habitat in the survey ensured that catches by fishers likely to travel to, and fish in, the nearby flood zone (i.e. the flood-zone fishery includes people who live in or near it as well as people from nearby rainfed areas in the same district) are considered. The distribution of districts chosen for the 2020 surveys is shown in Figure 2.1. The villages (Table 2.1) were selected based on the local authorities' assessment of those that had the most fishing activities, and may not necessarily be the same

as those used in previous surveys in 2000, 2010 and 2015, although most villages and fisher households surveyed were the same.

It should be noted that the distribution of these districts and the selection of villages and households are currently under review, and consideration is being taken to more effectively use Fish Abundance and Diversity Monitoring (FADM) monitoring in specific villages or asking supplementary questions in the government statistical surveys.


**Figure 1.1.** Distribution of districts surveyed for the 2020 assessment of different fish habitat types in the LMB

**Table 1.1.** Location and number of households surveyed for the 2020 assessment

| Country/province | Rainfed rice fields and associated habitats – H1 | Floodplain – large river – H2 | Reservoir – H3 | Brackish-water 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 |

#### *1.2.1.1 Village surveys*

The aim of the village surveys is to obtain background information, including the number of HHs in the village and fishing areas, the trends in catches, and other information complementary to that obtained in the HH survey. Data are also used to cross-check information from HH surveys. A sample of approximately 30 villages was chosen from within each survey district.

#### *1.2.1.2 Household surveys*

The aim of the household surveys is to gather 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 fish consumption data.

### 1.2.2 Survey techniques

The household/fisher surveys (Table 2.1) were based on structured interviews to collect data on fishing household demography, household/fisher's fishing gears, fish/OAAs catch estimates by season and by habitat types, main species caught and consumed, and first-sale prices of fish from the major types of fish habitats in the LMB. In the 2020 surveys, households actively fishing a range of habitats were chosen by district staff. The households selected in the 2020 surveys were mostly from fishing households, and adjustments were required for the analysis to account for this bias. It is recommended that the proportional probability sampling procedure be used to select households for interviewing on a random basis in future

surveys (MRC, 2023), but where possible, include as many of the households/fishers interviewed in previous surveys to enable continuity and minimise biases associated with selecting different households. The households/fishers should also fish in as many different micro-habitats as possible. Further information was also collected from questionnaires targeting provincial fisheries management officers, and focus group discussions were organised in local communities.

The questionnaire and instructions for the HH/fisher surveys are provided in Annex 1.

The questionnaire for provincial fisheries management officers was based on semi-structured interviews to provide local perspectives on import, export, aquaculture and animal feeds related to capture fisheries in the region. The questionnaire and instructions for the fisheries management officer surveys are provided in Annex 1.

Focus group discussions were organized in local communities of the same selected districts for each MC to validate the data and information collected from the household/fisher surveys and reflect on different perspectives that would not be recorded during the household/fisher interviews. Each focus group discussion included 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 1.

During the field surveys, photographs were taken and graphs drawn on the habitat types, fishery products (raw and processed) and interviews were carried out. Survey teams were encouraged to use cameras (or Smartphones) with GPS turned on when taking photos to record the coordinates of the sites.

The following stepwise procedure was used to determine the fish and OAAs catch and consumption by individual fishers/households. It should be noted that it was assumed that there was one fisher per household in the analysis, although it is known that several members of the household may be full-time, part-time or occasional fishers:

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

8. The proportion of the annual catches of fish and OAAs sold on the markets or to friends and family should be determined.
9. 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 household surveys carried out for assessment of total yield for the LMB is that only a small number of households in a restricted number of districts covering a limited range of habitat types are surveyed (see Table 2.1). This limits the capacity to upscale the data to other districts or provinces, and provide representation of catches from different habitat types across the LMB. The fisher logbook surveys carried out under the 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 were used to supplement the household survey data and tune the annual catch data of different provinces.

## 1.3 ASSESSMENT OF LOWER MEKONG RIVER BASIN FISHERY YIELD BASED ON HABITAT PRODUCTIVITY

Fisheries yield, the amount of fish harvested from a particular ecosystem/water body, is a product of exploitation rate and biological production. Yield can be derived from the relationship between *YPUA* derived from interrogation of catch rates by different gears in specific habitat types and *AREA* of habitat for different type of water bodies using *Catch=AREA*YPUA*.

### 1.3.1 Determining the major habitat zone areas

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

**Major flood zone:** This refers to 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 the area is floodplain, covered by recession rice fields, forest or scrub, streams, swamps and water bodies, and also includes the Tonle Sap-Great Lake system. It should be noted that 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:** This refers to land that is inundated by rainwater or local diversions to shallow depths in most years up to about 0.5 m; it includes mainly rainfed rice fields as well as smaller streams, channels and swamps located outside major flood zone.

**Large water bodies:** This refers to all water bodies outside a major flood zone, including:

- Large rivers
- Artificial reservoirs
- Large canals.

**Note:** If the areas of these water bodies are small, they may be included in the rainfed zone because of the GIS resolution (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 areas. These are exclusively in the southern Viet Nam Mekong Delta.

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

The procedure to determine 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[1]. Based on this dataset (10 maps), all 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 them (i.e. flooded for at least one month during at least five 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 or frequently present, but is 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 large water bodies (Class 3).
4. In the previous steps, some reservoirs were erroneously classified as major flood zones rather than water bodies. Hence, they were converted to water bodies based on a shapefile of reservoirs provided by 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) maps for 2020 (MRC TD, 2021) that 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.

[1] Google Engine. http://code.earthengine.google.com

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 habitats in the major flood zone and in brackish-water estuarine habitats were subtracted from the respective major habitat types to produce Classes 5 and 6. All aquaculture located outside the classes included in the major fish habitat map were designated Class 7.
10. 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.

### 1.3.2 Estimation of yield per habitat area

Having estimated the area of aquatic habitat in each province/country of the LMB using GIS (Section 2.3.1), the second step is to determine the catch per unit of area (CPUA) (kg/ha/yr) of fish and OAAs harvest for each major habitat type.

Previous assessments of yield per habitat area used mean values of catch per area of habitat (Hortle, 2007; Hortle & Bamrungrach, 2015) or estimates derived from surveys (Hortle, 2017 unpublished). In this approach, Hortle (2007) derived yield per habitat area from available literature on catch for large rivers systems, mostly across southern and South-East Asia. These data were subsequently revised by Hortle and Bamrungrach (2015) following a further review of the catch rates in specific habitats, and specifically for the three major habitat types, plus the area occupied by aquaculture outside the flood zone, but not considered in the yield figures, as follows:

- **Major flood zone:** Permanent water bodies including most major rivers, the Tonle Sap–Great Lake system and seasonally flooded land, which includes recession rice fields.
- **Rainfed zone:** Mainly rice fields, other wetland crops and associated habitats not within the major flood zone; most of which is former forest.
- **Large waterbodies:** These include reservoirs outside the flood zone.
- **Aquaculture:** Located outside flood zones, not considered in yield figures.

Hortle (2017, unpublished) recognized that the individual YPUA data used in the previous studies (Hortle, 2007 and Hortle & Bamrungrach, 2015) had possible errors in fish yield per unit area (YPUA) of habitat as high as ±50%, and carried out a new field data collection focused on improving yield-per-unit-area estimates. As a result, the YPUA values were further refined, and fisheries yield for brackish-water estuarine habitats were added (Table 2.2).

To update the current total catch for 2020, two approaches were tested. First, the updated mean and range catch per unit area data from Hortle and Bamrungrach (2015) and Hortle (2017, Table 2.2) were applied to the 2020 study. While the yield of these systems is likely to have changed over time, especially due to change 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 were multiplied by the area of the main habitat types to determine the total catch.

**Table 1.2.** Estimated fisheries yield per unit area in the LMB

| 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-estuarine | 300 | | | 300 | | 300 |
| Total | 139 | 86 | 91 | 147.5 | 161 | 112 |

*Source*: Hortle and Bamrungrach (2015) and updated by Hortle (2017)

To complement the literature-based assessment approaches, YPUA was also derived using information from fisher household surveys carried out in 2020. Information on fishing practices, catch and habitat fished acquired from the household surveys (Section 2.2) was used to determine the overall catch by all fishers (disaggregated to full-time, part-time and occasional fishers) for each habitat type and to update the YPUA. The following stepwise procedure was used to determine fish catch and yield from each province in the LMB:

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 2.3.1.
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 (see Section 2.1). Here it is assumed that the population is distributed evenly across the province, although it is recognized that many people may be living in urban centres in some provinces that are partly in or outside the LMB. Once the population size is determined, the number of households in the province is obtained by dividing total population by the average household 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 households in villages surveyed in each province into full-time, part-time, occasional and non-fishing households. The proportion of each category is multiplied by the total number of households in the province to determine the total number of households engaged in each level of fishing activity. It is important to note that the SIMVA data appear to underestimate the number of households engaged in fishing in some districts; hence, these data need to be cross-checked and adjusted against data from the household surveys (Section 2.2.1.2), or national statistics office census data where available. SIMVA also only surveys communities within 15 km of a major water body, and thus some transient fishers in remote households may be omitted. Where no data are available for a province, data from geographical similar and adjacent provinces should be used as surrogate information.
5. The next 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 2.3.1). 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 fishers will move to more productive habitats, especially those associated with seasonal changes in flooding or to target migratory fish patterns. There are also potential issues with large areas of open water such as on Tonle Sap Lake, which 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 surrounding the lake and the mean catch per unit area of open water was derived and added to the total catch for the respective provinces.

6. The total annual catch for each household is determined from the household surveys or FADM surveys. In the household surveys, specific questions are asked of the household to determine the total catch of fish each year and the attribution related to specific major habitat types. (See Section 2.3.1 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 (full-time, part-time, occasional) exploiting each habitat type. It is assumed that the catch rate of occasional fishers is 20% of a part-time fisher, although this needs justifying.
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. This analysis can also be used to derive the yield per unit habitat per year for the different habitat types in each province by dividing the total catch for each habitat type by the area of habitat in the province. Such data can be cross-checked against the YPUA of habitat used in the original method by Hortle (2007) and Hortle and 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 OAAs estimates into crustaceans, amphibians, molluscs, snakes and other OAAs.
11. The percentage contribution of fish and OAAs to the overall catch is determined.

## 1.4 ASSESSMENT OF LOWER MEKONG RIVER BASIN FISHERY AND OAA YIELD BASED ON CONSUMPTION

### 1.4.1 Assessment of consumption of fisheries and OAAs

A complementary method to determine the total fish catch from the LMB for the 2020 assessment is to use fish consumption data collected during the household and SIMVA surveys. To use this approach, it is critical the household surveys collect a random sample of fishing and non-fishing households, commensurate with the proportion of households with full-time, part-time and occasional fishers, as well as those not fishing. This is important because consumption in fishing villages tends to be higher than national averages. However, this was not the case in the 2020 survey, because mostly fishing households were surveyed.

During the surveys, households 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 their diet. It is imperative that all types of fish consumed in each meal are accounted for, including fresh, dried, smoked, pickled, pastes and sauces. Hortle (2007) provides descriptions of the different

fish- and OAA-based foods, as well as conversion factors to upscale consumed food weight to wet weight of fish.

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

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 2.1). 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 households in the province is obtained by dividing the population size by the average household size in the country at the time of the population census.
2. To determine the consumption rate during the household surveys, individuals in the family are asked the amount of fish they consume in a typical day, including all meals, and if possible, during previous meals. It is imperative that all fish types are identified, including, fresh, smoked, dried, pickled, 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 household as a whole, are asked to break down the source of the fish consumed into percentage contribution from their own catch or from their own aquaculture production, or purchased or bartered from the market or from other fishers, or from other sources, for example, marine fish and frozen fish originating from outside the country.
5. The households are then asked to define the frequency of consumption of fish in meals over the previous week and then to estimate the relative consumption patterns in the year. Consumption frequency is divided into: “over 3 times/week”, “2–3 times/week”, “once/week” and “other”, which generally refers to a much lower frequency of consumption.
6. The consumption for each province is determined from:
   *The 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 population size.*
7. The procedure is repeated for the different frequencies of consumption of fish in typical meals each week.

8. 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. Total annual consumption in the country is determined by summing up 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 feeds (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).

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 since children do not necessarily consume fish at a younger age.

For the LMB, imports of inland fish from adjacent basins or from overseas would be minor relative to exports, although it is recognised 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 with the small component of consumption derived from aquaculture.

The use of inland trash fish for aquaculture feed is insignificant in Lao PDR and Thailand (at around a few thousand tonnes per year) because most trash fish is marine-derived (Ingthamjitr, Mattson & Hortle, 2005). By contrast, inland trash fish is important in Cambodia; So et al. (2005) estimated that about 55,000 tonnes per year are used in aquaculture. In Viet Nam, most trash fish are marine-derived, although around 13% of fresh fish that is fed to catfish and snakehead 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 around 55,000 tonnes/year. It is assumed that these proportions of fish remain constant over time.

# 2 FISHERIES AND AQUACULTURE YIELD IN THE LOWER MEKONG BASIN

## 2.1 NATIONAL FISHERIES AND AQUACULTURE DATA

### 2.1.1 FAO data

Fisheries and aquaculture data are collated by FAO from Member States to report to the FAO Committee on Fisheries (COFI). The national fisheries and aquaculture statistics for the four LMB countries were downloaded from the FAO's FishStatJ database (www.fao.org/fishery/en/topic/166235) for the 1950–2020 period (Figure 3.1). These data are updated each year with a two-year lag. However, these data under-report catches from inland capture fisheries, sometimes grossly (Fluet-Chouinard et al., 2018; Ainsworth, Cowx and Funge-Smith, 2023), but they are a reasonable indication of trends. For the LMB and elsewhere, this is because capture fisheries are primarily artisanal or subsistence, with a small percentage (<10%) of full-time fishers in most countries. It should also be recognized that the data are usually reported for the entire country and cannot be disaggregated for the LMB, especially in Thailand and Viet Nam, which have large parts of their countries outside the Basin. Most of Lao PDR and Cambodia are within the LMB so the national figures would be similar to LMB figures. In Thailand and Viet Nam, more accurate data are generated at the provincial level (see Section 3.1.2). However, in Thailand, most of the inland capture fishery data are from reservoirs, while data from large rivers, such as the Mekong, are poorly represented (Ainsworth, Cowx and Funge-Smith, 2023).

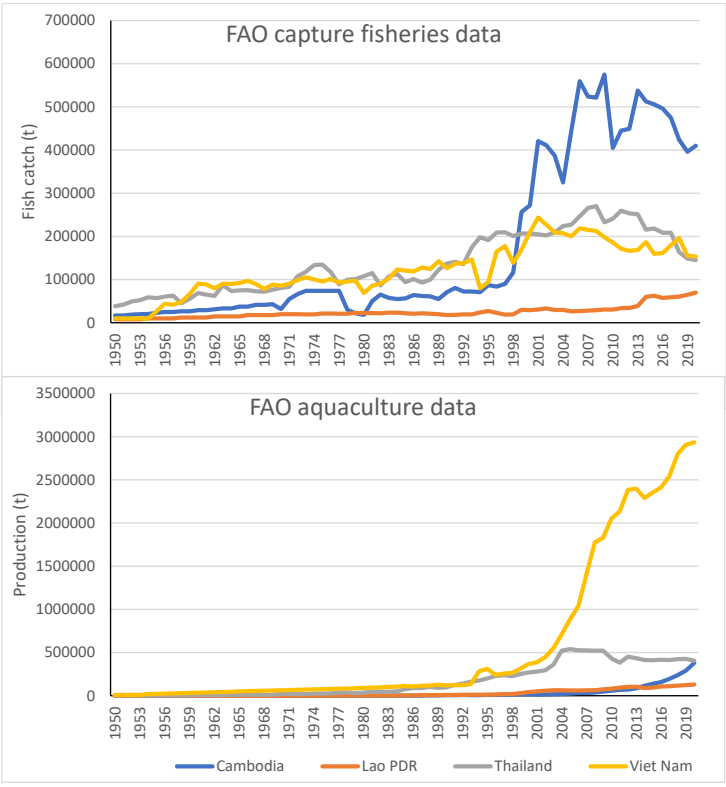


**Figure 2.1.** FAO FishStatJ records of annual fish catch and aquaculture production in Cambodia, Lao PDR, Thailand and Viet Nam

### 2.1.2 Official statistics

#### *2.1.2.1 Cambodia*

In 2020, Cambodia had a population of 16,589,023 comprising 2,038,000 households with an average household size of 4.20.

Fisheries catch and aquaculture statistics are collected by province in Cambodia and reported annually by the National Institute of Statistics (http://camstat.nis.gov.kh). Fisheries data are also collected independently by the Fisheries Administration (FIA). The fisheries sector plays a crucial role in Cambodia's economy. About 1.2 million people work as both full-time and part-time fishers and 2 million in fisheries-related activities (FIA, 2021). Most of the fishing takes place in the Tonle Sap and central floodplain zones, although there is considerable activity in the plateau and mountainous zone (Table 3.1). Aquaculture is predominantly carried out in the floodplain zone.

**Table 2.1.** Number of households engaged in capture fisheries and aquaculture

| | Cambodia | Plain zone | Tonle Sap Lake Zone | Coastal zone | Plateau and mountainous zone |
|---|---|---|---|---|---|
| Number of households engaged in capture fishing | 554,000 | 156,000 | 251,000 | 48,000 | 99,000 |
| Number of households engaged in capture fishing – full-time | 27,000 | 18,000 | 35,000 | 34,000 | 33,000 |
| Number of holdings reporting capture fishing activity in fresh waters | 336,000 | 87,000 | 160,000 | 15,000 | 74,000 |
| Number of holdings reporting capture fishing activity in rice fields | 275,000 | 80,000 | 128,000 | 30,000 | 36,000 |
| Number of households engaged in aquaculture | 125,000 | 82,000 | 29,000 | 7,000 | 7,000 |
| Percentage of households engaged in aquaculture | 6 | 9 | 4 | 5 | 2 |

*Source*: National Institute of Statistics, Ministry of Planning in collaboration with Ministry of Agriculture, Forestry and Fisheries. Cambodia Agriculture Survey 2020 (CAS2020) Final Report.

In 2021, the total fisheries production in Cambodia was 856,400 tonnes, valued at $1,712,800,000, which decreased by > 8.5% from 936,300 tonnes in 2020. The value of fishery products is approximately USD 1.5 billion per year, contributing 6–8% to total GDP. The annual freshwater fish catch increased from 487,000 tonnes in 2015 to 535,000 tonnes in 2018, but decreased to 479,000 tonnes in 2019 and to 380,000 tonnes in 2021 (Figure 3.2; FIA, 2021). The average fish consumption is 52.4–63.0 kg/capita/year, shared between inland fish (44.2 kg), marine fish (17.3 kg) and aquaculture (1.3 kg) (FIA, 2021). Fish provide 76% of the total animal protein intake of the total food intake in the Cambodian daily diet (IFReDI, 2013).

Most of the households (98%) that reported capture fishing activities captured only fish (98%); 24% also captured crab; and 13% also captured snails.

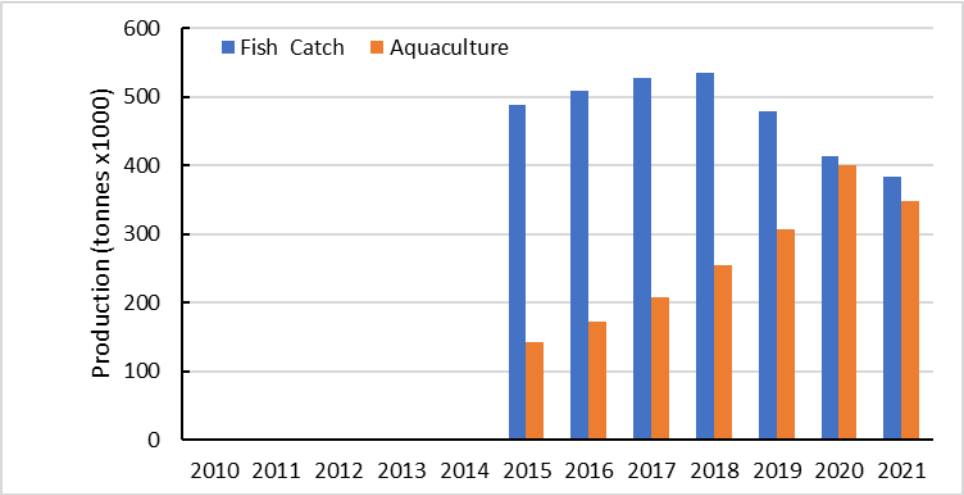


**Figure 2.2.** Annual trends in freshwater fish catch and aquaculture production, Cambodia

### *2.1.2.2 Lao PDR*

In 2020, the population of Lao PDR was 7,231,000, comprising 1,296,980 households, with an average household size of 5.57. This represents a population growth of around 14.7% since 2010. Fisheries catch and aquaculture statistics are collected by province and reported annually by the Lao Statistics Bureau (www.lsb.gov.la).

In 2020, the Lao Statistics Bureau reported a total fish catch of 70,001 tonnes, with an additional 130,021 tonnes produced by aquaculture (Figure 3.3). This represents a 30.5% increase in aquaculture production since 2014, but a relatively stable fish catch, although there was an approximate 7.5% increase in catch between 2019 and 2020. The major share of the fish catch (56%) and aquaculture production (90%) is from the central region (Vientiane to Champasak provinces).

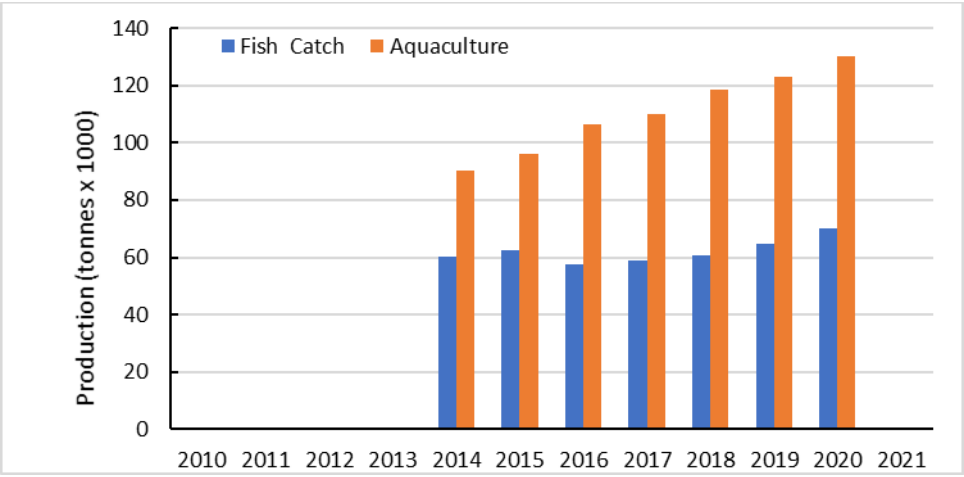


**Figure 2.3.** Annual trends in fish catch and aquaculture production in Lao PDR

The approximate value of fish and fishery products for Lao PDR is LAK 2,761 billion (USD 29.8 million), or 2.1% of GDP, slightly more than the contribution of livestock and livestock products to GDP.

Despite the increase in catch and value, the number of households engaged in capture fisheries has dropped in recent years, from 526,300 households in 2011 to 309,800 households in 2020. The number of households engaged in aquaculture also declined, from 68,200 households in 2011 to 54,000 in 2020 (The 3rd Lao Census of Agriculture 2019/2020).

Fish consumption in Lao PDR increased from 25.6 kg per person per year in 2013 to 26.2 kg per person per year in 2019 (Table 3.2: Lao Expenditure and Consumption Survey VI [LECS 6]). In 2019, fish consumption in the Central region, including Paksan and Pakkading, was 33.9 kg per person per year, but slightly lower in the southern region, which includes Pathoumphone and Khong, at 25.5 kg per person per year, and lower still in the northern region, at 19.2 kg per person per year. It should be noted that fish consumption reported in LECS 6 was based on the expenditure of buying fish and did not include fishers' own catch or farmed fish. As a result, fish consumption is probably an underestimate and needs to be cross-referenced with data from other socioeconomic studies (e.g. SIMVA) and fisheries fish yield assessments.

**Table 2.2.** Meat and fish consumption (kg per person per year) in Lao PDR 2018/2019

| Region | 2012/2013 | | 2018/2019 | |
|---|---|---|---|---|
| | Meat | Fish | Meat | Fish |
| Lao PDR | 20.6 | 25.6 | 18.3 | 26.2 |
| North | 21.5 | 19.7 | 20.2 | 19.2 |
| Central | 19.9 | 27.8 | 19.0 | 33.9 |
| South | 20.3 | 29.3 | 15.5 | 25.5 |

*Source*: Lao Expenditure and Consumption Survey 2018–2019 (LECS 6).

### *2.1.2.3 Thailand*

Thailand has a total land area of around 513,115 km² and a total inland water area of approximately 3,750 km$^2$; 36% of the land area lies within the LMB (188,962 km$^2$). The LMB in Thailand contains a variety of water bodies, including floodplains, tributaries, canals, swamps and reservoirs. In 2021, Thailand's population was 69.95 million, with approximately 37% living in the provinces associated with the LMB. In 2013, there were around 820,000 households that carried out fishing activities across the country, with a high proportion (61%) located in the northeast and a further 7% in the northern region, i.e. around 644,903 fishers living in 561,451 inland fishing households, indicating that some households have more than one fisher.

As previously stated, disaggregating capture fishery data for Thailand is problematic, and allocation to province or region is not feasible. In 2015, inland capture fisheries harvested 184,100 tonnes, although the overall production has declined substantially in recent years (Figure 3.4). Freshwater aquaculture production, by contrast, has increased steadily and stabilized at 450,000 tonnes (Figure 3.4). Aquaculture production from the LMB area of Thailand (Table 3.3) contributes around 29% of this total harvest.

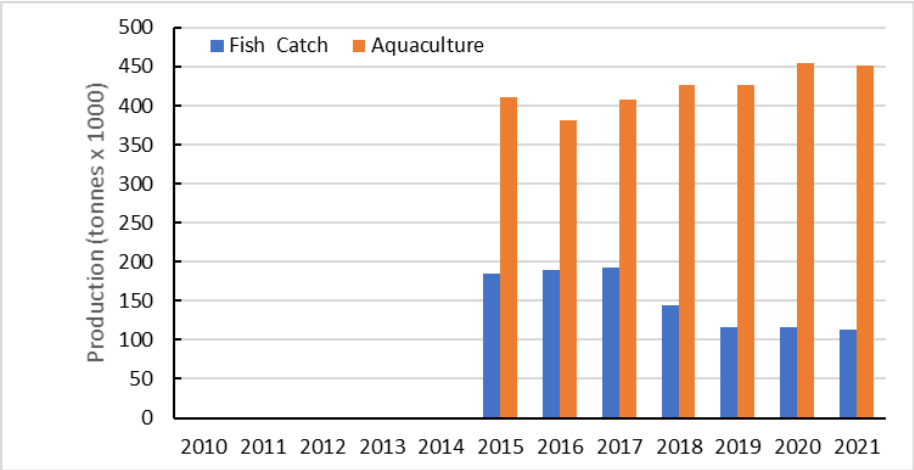


**Figure 2.4.** Annual trends in freshwater fish catch and aquaculture production in Thailand

**Table 2.3** Production from freshwater fish farms, by province, in the LMB in Thailand, 2020

| | 2010 | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| Province | No. of farms | Area (ha) | Production (t) | No. of farms | Area (ha) | Production (t) | No. of farms | Area (ha) | Production (t) |
| Kalasin | 9,677 | 3,183 | 3,870 | 10,298 | 3,437 | 3,949 | 11,606 | 2,848 | 8,554 |
| Khon Kaen | 41,015 | 11,528 | 18,798 | 24,772 | 3,737 | 11,593 | 23,952 | 3,238 | 6,411 |
| Chanthaburi | 613 | 183 | 280 | 627 | 163 | 169 | 273 | 62 | 79 |
| Chaiyaphum | 32,573 | 5,214 | 7,256 | 27,328 | 4,028 | 6,860 | 26,075 | 3,761 | 7,929 |
| Nakhon Phanom | 12,836 | 2,231 | 3,090 | 11,549 | 1,557 | 4,198 | 10,122 | 1,058 | 2,846 |
| Nakhon Ratchasima | 14,449 | 3,535 | 10,307 | 19,641 | 4,318 | 10,803 | 16,293 | 3,200 | 10,730 |
| Bueng Kan | 5,232 | 849 | 1,428 | 7,580 | 1,213 | 2,446 | 9,162 | 1,281 | 1,938 |
| Buri Ram | 11,764 | 1,200 | 1,889 | 11,229 | 1,359 | 2,127 | 17,139 | 1,831 | 2,155 |
| Phayao | 4,859 | 998 | 3,258 | 4,861 | 854 | 3,361 | 9,692 | 1,396 | 4,436 |
| Maha Sarakham | 9,455 | 2,794 | 4,485 | 13,727 | 2,121 | 5,601 | 16,010 | 2,484 | 2,874 |
| Mukdahan | 10,090 | 1,785 | 4,982 | 12,884 | 1,923 | 4,146 | 13,305 | 1,900 | 7,342 |
| Yasothon | 5,849 | 723 | 896 | 8,593 | 954 | 3,028 | 4,969 | 700 | 1,943 |
| Roi Et | 9,703 | 534 | 1,656 | 11,024 | 1,740 | 3,667 | 16,161 | 2,177 | 3,658 |
| Si Sa Ket | 9,857 | 938 | 1,454 | 9,858 | 938 | 1,653 | 6,561 | 564 | 789 |
| Sakon Nakhon | 7,477 | 1,354 | 1,590 | 8,647 | 1,519 | 2,109 | 11,474 | 1,837 | 3,137 |
| Sa Kaeo | 4,589 | 584 | 2,926 | 5,637 | 764 | 3,394 | 7,946 | 982 | 2,779 |
| Surin | 22,738 | 2,309 | 3,897 | 18,110 | 2,257 | 3,820 | 12,044 | 1,333 | 3,678 |
| Nong Khai | 6,945 | 2,123 | 3,996 | 6,945 | 2,123 | 5,818 | 9,070 | 1,966 | 10,666 |
| Nong Bua Lam Phu | 11,686 | 2,386 | 2,238 | 14,091 | 2,738 | 2,269 | 7,811 | 993 | 905 |
| Amnat Charoen | 6,135 | 758 | 1,852 | 9,572 | 1,062 | 1,654 | 9,915 | 947 | 1,358 |
| Udon Thani | 23,320 | 6,518 | 8,381 | 14,750 | 3,524 | 5,857 | 18,801 | 4,023 | 5,741 |
| Ubon Ratchathani | 9,220 | 919 | 7,788 | 14,524 | 1,609 | 7,401 | 18,410 | 2,019 | 20,875 |
| Chiang Rai | 17,844 | 4,599 | 24,557 | 17,643 | 4,461 | 14,468 | 15,503 | 3,043 | 6,552 |
| Chiang Mai | 9,217 | 1,010 | 3,673 | 7,291 | 812 | 3,821 | 7,485 | 931 | 4,202 |
| Petchabun | 6,375 | 1,619 | 3,213 | 9,655 | 2,430 | 4,836 | 9,962 | 2,460 | 7,424 |
| Loei | 15,305 | 2,645 | 6,003 | 15,384 | 2,695 | 2,519 | 16,048 | 1,373 | 3,055 |
| Total | 318,823 | 62,519 | 133,763 | 316,220 | 54,336 | 121,567 | 325,789 | 48,407 | 132,056 |

Inland capture fisheries are an important sector of many local economies in Thailand and are considered important in sustaining the livelihoods of many rural communities. Numerous studies have tried to estimate per capita fish consumption for Thailand, with the most recent estimate of 29.50 kg/capita in 2019, higher than the consumption of the other three main animal protein commodities: pork, beef and chicken. However, this estimate includes all sources of fish, including marine, freshwater and aquaculture sources, and is considerably lower than the 65.5 kg/capita determined from the 183 households (33%, fishing households; and 7%, professional fishers) surveyed in the 2020 assessment, where the mean annual fish catch per household (average 4.8 people in each household) was 276.6 kg/household/year for all habitats.

#### *2.1.2.4 Viet Nam*

Inland fisheries play an important role in Viet Nam, providing sources of protein and livelihoods for millions of people, especially in rural areas (Vu & Phan, 2008). Two main river systems, the Mekong River Delta in the south and the Red River Delta in the north, are exploited for capture fisheries and extensive fish farming. The Viet Nam Mekong River Delta covers an area of 40,000 $km^2$, with a total area of natural inland water bodies (lakes and rivers) of around 4,200 $km^2$, and additional ponds and seasonal flooded areas of 6,000 $km^2$ (Tuan et al., 2013).

In 2020, the Mekong Delta (MKD) had an estimated population of 17.3 million, consisting of around 4,794,200 households, with an average household size of 3.61, slightly lower than the Viet Nam national average of 3.63. Many households living near inland waters (estimated at 459,400 in 2020) are involved in fishing, mostly part-time, but around 5% of these households fish full-time. There are also an estimated 726,900 fishery labourers in the Mekong Delta region. The main fishing gears used in the coastal areas are 12 prison gate traps, simple trap net and trawl nets, while gillnets, fyke nets (or long fence trap nets) and trammel nets are the main fishing used gears in floodplain areas. Fishing gears in the mainstream and tributary areas are relatively diversified, with gillnets, bag nets, fyke nets (or long fence trap nets) and trawl netting the main gears used. In general, fishing is considered a small-scale activity.

Inland capture fisheries production in Viet Nam declined from about 1,297,837 tonnes in 2015, to 1,062,400 tonnes in 2020. A similar trend was observed for inland capture fisheries in the Mekong Delta (Figure 3.5), which declined from 467,637 tonnes in 2015, to 451,009 tonnes in 2020, but particularly in An Giang Province (Table 3.4). There are numerous reasons for the declining catch (Vu *et al.*, 2014). For example, fishers believed that there were “too many people participating in fishing” and “illegal fishing gear was used”. However, the exploitation of fry and juveniles, fragmentation of floodplains, use of pesticides in the agricultural sector to support three crops of rice cultivation, and pollution from other industrial activities are all likely contributors. By contrast, aquaculture production in the Delta has also expanded massively in recent years, from 1,817,146 tonnes in 2015 to 2,318,026 tonnes in 2020.

According to the Nutrition Census 2019–2020 of the National Institute of Nutrition (NIN, 2022), the average per capita consumption of aquatic foods in Viet Nam was 36.99 kg/yr, of which freshwater fish contributed 14.87 kg/yr, accounting for 28.1% of animal protein and

11.5% of total protein per year (FAO, 2021). Per capita consumption of fish and OAAs in various provinces in the Mekong Delta ranged between 29.6 kg/capita/yr and 74.4 kg/capita/yr.

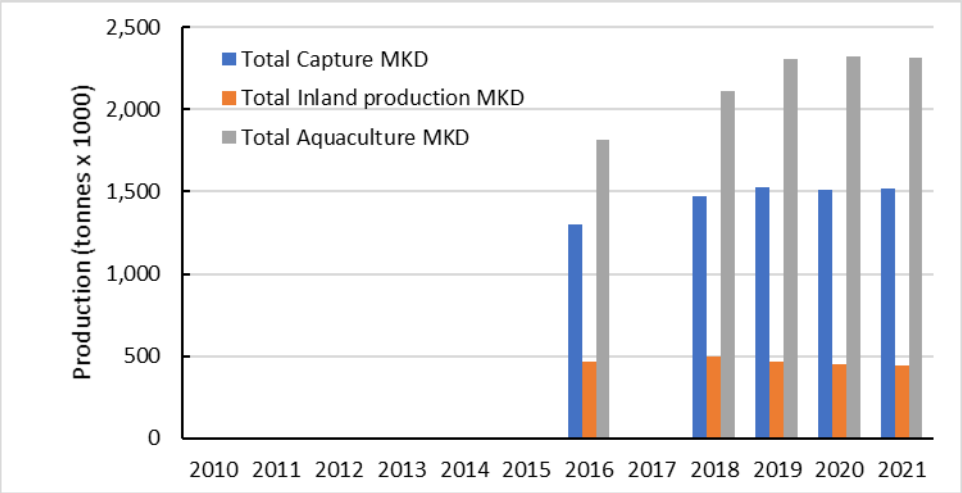


**Figure 2.5.** Trends in inland capture fisheries production (tonnes) in Viet Nam and inland/freshwater provinces in the MKD (An Giang, Dong Thap, Can Tho, Vinh Long, Hau Giang)

*Source*: GSO (2021)

**Table 2.4.** Aquaculture and capture fisheries production (t) in MKD provinces

| | 2015 | | | | | 2020 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Fisheries production** | Capture production | Marine capture | Inland capture | Finfish aqua-culture | **Fisheries production** | Capture production | Marine capture | Inland capture | Finfish aqua-culture |
| Long An | 54,615 | 12,362 | 3,000 | 9,362 | , | 72,123 | 9,984 | 1,900 | 6,484 | 42,490 |
| Tien Giang | 242,769 | 97,777 | 58,900 | 38,877 | 103,466 | 35,7568 | 150,868 | 105,500 | 45,668 | 157,414 |
| Ben Tre | 444,233 | 201,750 | 153,000 | 48,750 | 183,285 | 511,834 | 230,028 | 185,700 | 55,728 | 179,151 |
| Tra Vinh | 167,344 | 75,446 | 23,000 | 52,446 | 48,069 | 228,603 | 75,676 | 32,200 | 36,976 | 72,578 |
| Vinh Long | 112,174 | 6,488 | 0 | 6,488 | 105,593 | 153,302 | 6,527 | 0 | 6,527 | 146,559 |
| Dong Thap | 485,622 | 16,607 | 0 | 16,607 | 465,916 | 565,837 | 18,721 | 0 | 18,721 | 543,403 |
| An Giang | 348,079 | 21,513 | 0 | 21,513 | 324,306 | 511,148 | 15,142 | 0 | 15,142 | 493,676 |
| Kien Giang | 677,300 | 493,820 | 342,300 | 151,520 | 65,454 | 841,416 | 571,687 | 418,100 | 150,687 | 86,400 |
| Can Tho | 172,411 | 6,086 | 0 | 6,086 | 166,290 | 221,091 | 6,351 | 0 | 6,351 | 213,672 |
| Hau Giang | 60,131 | 2,809 | 0 | 2,809 | 56,143 | 75,060 | 2,516 | 0 | 2,516 | 70,848 |
| Soc Trang | 218,742 | 62,700 | 40,600 | 22,100 | 64,861 | 325,295 | 66,987 | 43,200 | 23,187 | 101,091 |
| Bac Lieu | 298,500 | 106,916 | 70,000 | 36,916 | 71,425 | 380,753 | 123,072 | 85,600 | 36,272 | 88,564 |
| Ca Mau | 499,881 | 193,563 | 139,400 | 54,163 | 132,617 | 590,191 | 235,850 | 199,200 | 46,750 | 122,180 |
| **MKD** | 3,781,801 | 1,297,837 | 830,200 | 467,637 | 1,817,146 | **4,834,221** | 1,513,409 | 1,062,400 | 451,009 | 2,318,026 |

*Source*: GSO (2021)

### *2.1.2.5 Summary of national statistics*

Analysis of the area of provinces from each country within, partially within, and outside the LMB confirms that most of the provinces in Lao PDR (87.5%) and Cambodia (87.7%) are within the Basin, but the proportion is considerably lower in Thailand (36.6%) and Viet Nam (21.0%) (Figure 3.6, Table 3.5). The proportion of the area of each country is reflected in the contribution to the total population of each country (Table 3.6). Despite the lower proportion

of the area and populations of Thailand and Viet Nam in the LMB, the contribution of the LMB provinces to fisheries and aquaculture is high (Table 3.7), highlighting the importance of the Basin to fisheries production and food security in the countries as a whole.

**Table 2.5.** Summary of surface area in the Lower Mekong River Basin countries

| Surface area ($km^2$) | | | | |
|---|---|---|---|---|
| Country | Whole country | Area in the LMB | Percentage in the LMB (%) | Percentage of LMB area (%) |
| Cambodia | 178,635 | 155,973 | 87.3 | 25.5 |
| Lao PDR | 229,994 | 207,010 | 90.0 | 33.3 |
| Thailand | 513,115 | 187,968 | 36.6 | 30.2 |
| Viet Nam | 325,490 | 67,028 | 20.6 | 11.0 |
| Total | 1,256,440 | 617,979 | 49.6 | 100.0 |

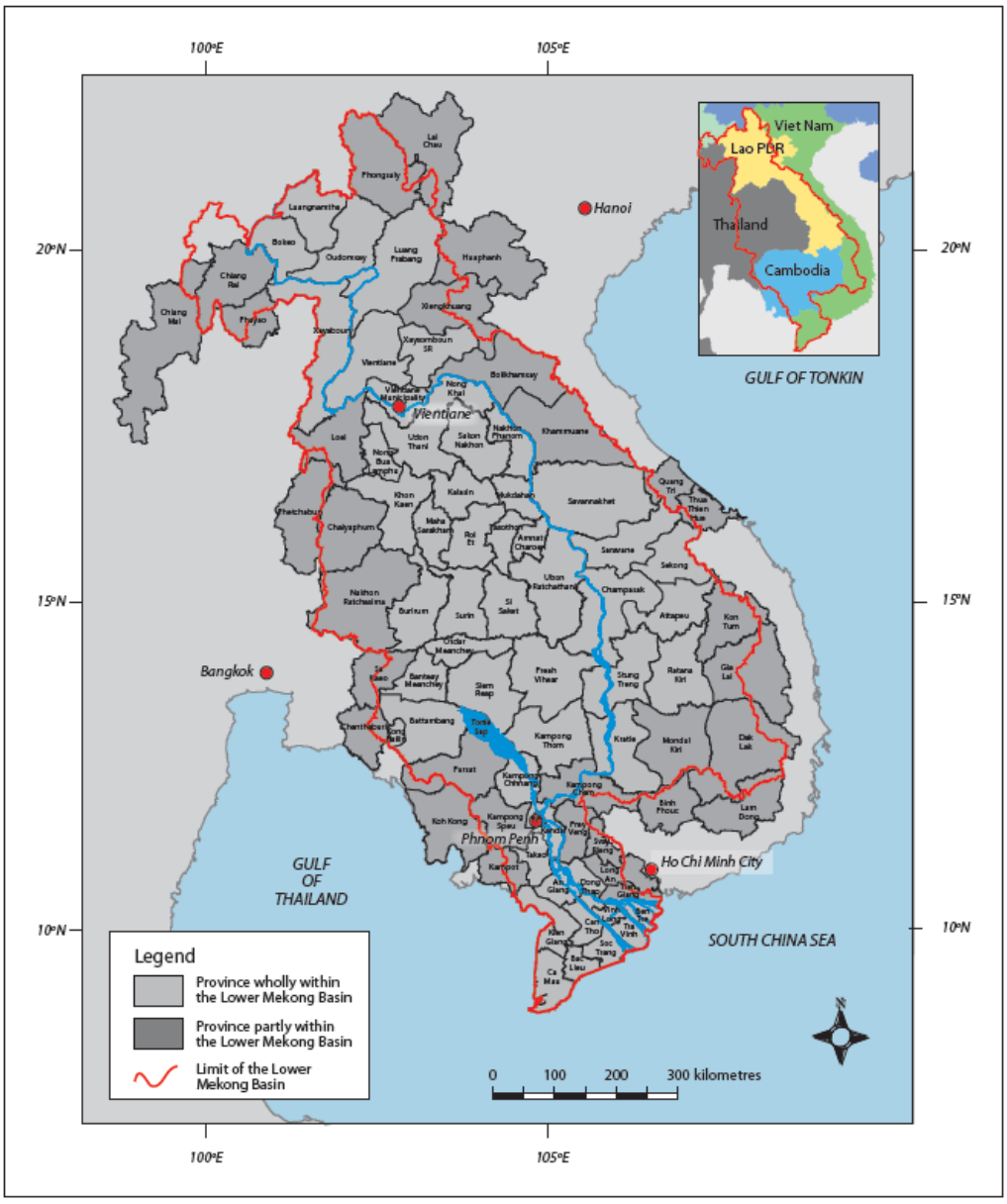


**Figure 2.6.** Provinces wholly or partly in the Lower Mekong River Basin

**Table 2.6.** Population of the Lower Mekong River Basin countries in 2020

| Population (2020) | | | | | |
|---|---|---|---|---|---|
| Country | Whole country | LMB population | Percentage in the 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 MKD and 4.36 in the Central Highlands |

*Source:* Based on National Statistics Offices

**Table 2.7.** Summary of inland fish production in 2020 in the Lower Mekong River Basin countries based on national statistics

| Total fish production (t) in LMB 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 |

## 2.2 VILLAGE AND HOUSEHOLD SURVEY RESULTS

### 2.2.1 Distribution of fishing areas, villages and households

Fishing villages were sampled across the LMB (Figure 3.7; Table 3.8) and approximately 180 persons were interviewed in each country. These data were supplemented by information on fishing activities from the MRC FADM and SIMVA studies. This mostly consisted of the proportion of FT and PT fishers, gears used and fish catches. Little additional information was available about OAAs, which highlights a major gap in the information on status and exploitation of these resources. The selection of the sites for the 2020 surveys was based on the resources available, and where possible, were representative of the major habitat types.

### 2.2.2 Demographic and socioeconomic characteristics of fishing villages

The proportion of full-time and part-time fishers interviewed varied between countries, but most were part-time in Lao PDR, Cambodia and especially Thailand, but most fishers interviewed in Viet Nam were full-time and exclusively so in the brackish-water estuarine zone (Table 3.8). These data contrast markedly with the estimates of full-time and part-time fishers from the SIMVA 2018 study. Particularly, the current study may misrepresent the number of full-time fishers in the overall population, but does estimate the proportion of occasional (perhaps subsistence) fishers in the population. It can be concluded, however, that the number of people engaging in fishing activities in all countries is substantial and highlights the importance of fishing as an alternative livelihood in the LMB.

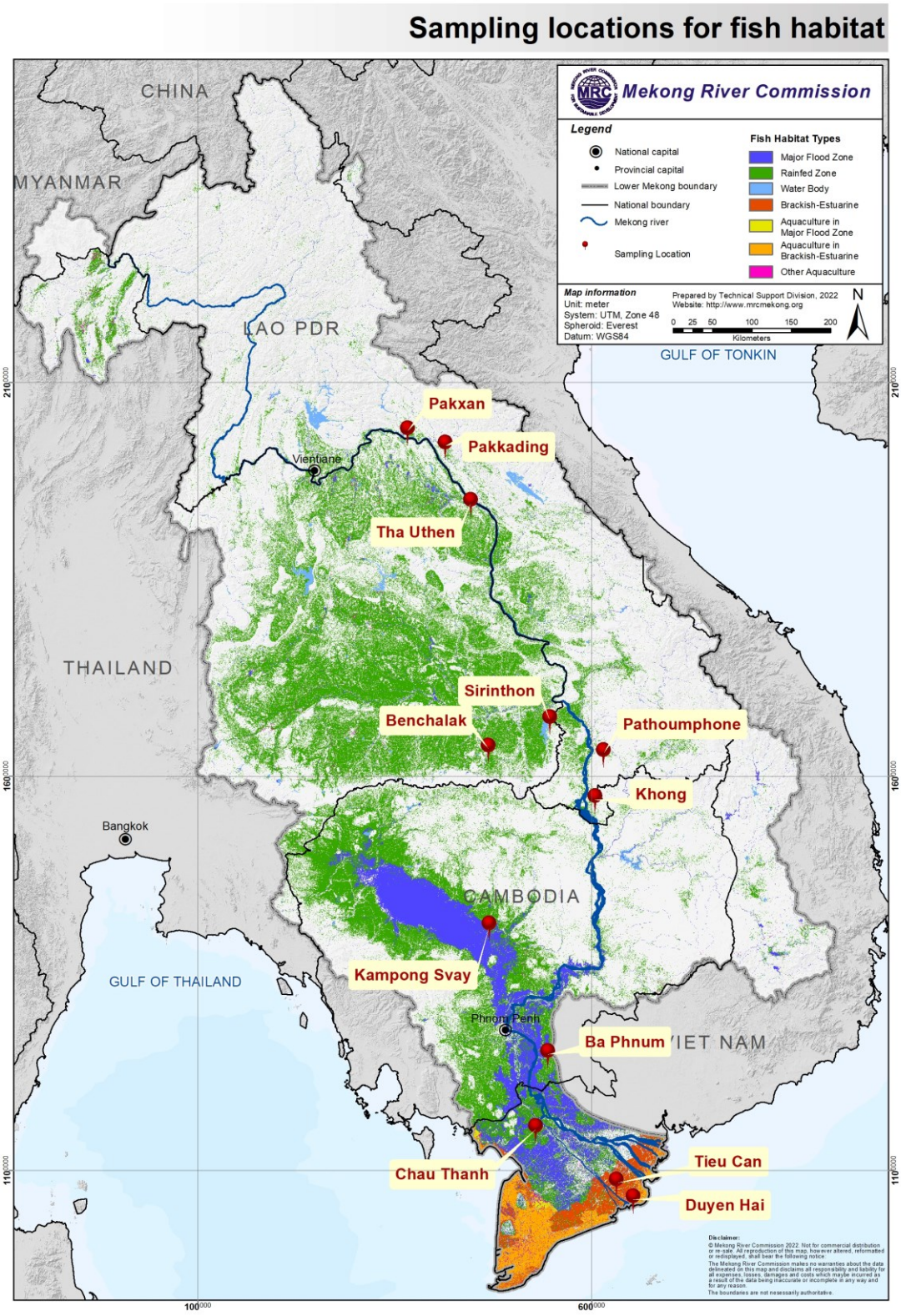


**Figure 2.7.** Distribution of fishing villages surveyed for 2020 assessment in relation to major fish habitats

**Table 2.8.** Fisher characteristics by gender of the 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 |
| Thailand | | | | | |
| | Tha Uthen | Rainfed | 1 | | |
| | | Floodplain | 31 | | |
| | | Reservoir | 29 | | |
| | Sirindhorn | Rainfed | 11 | | |
| | | Floodplain | 19 | | |
| | | Small reservoir | 11 | | |
| | | Large reservoir | 20 | | |
| | Benchalak | Rainfed | 31 | | |
| | | Floodplain | 30 | | |
| | Total | Rainfed | 113 | 8 | 92 |
| | | Floodplain | 50 | 4 | 96 |
| | | Reservoir | 20 | 0 | 100 |
| Viet Nam | | | | | |
| An Giang | Chau Thanh | Rainfed | 36 | | |
| | | Floodplain | 26 | | |
| Tra Vinh | Tieu Can | Rainfed | 38 | | |
| | | Floodplain | 26 | | |
| | Duyen Hai | Brackish-water | 54 | | |
| | Total | Rainfed | 74 | 27 | 73 |
| | | Floodplain | 52 | 25 | 75 |
| | | Brackish-water | 54 | 4 | 96 |

There were also slight differences between where full-time and part-time fishers operate with respect to habitat type (Table 3.9). In Cambodia, more full-time fishers operate in major flood zone areas (H2), while more part-time fishers operate in the rainfed zone (H1). In Lao PDR, the fishing habitats in major flood zone areas (H2) and water bodies (H3) are more important than those in rainfed zones (H1), while in Thailand, the most important fishing habitats are food in rainfed zones (H1). In Viet Nam, full-time fishers are spread evenly between the three zones.

**Table 2.9.** Number of full-time vs. part-time fishers at the sampling sites

| Country | Occupation | Rainfed zone | Major flood zone | Water bodies | Brackish-water estuarine zone | Total 2019/20 surveys | Proportion of fisher categories 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 |

Most fishers in all countries were male (Figure 3.8) and aged between 40 and 60, with an average age between 45 years in Cambodia and 54 in Thailand. The age distribution suggests an ageing fishing population in all countries, except perhaps in Cambodia, which has a higher proportion of younger fishers. This is worrying if fisheries are to continue to make a major contribution to food security in the region. Urbanization, improved education, and moving to better paid, less onerous jobs may be the reasons for this age demographic of fishers.

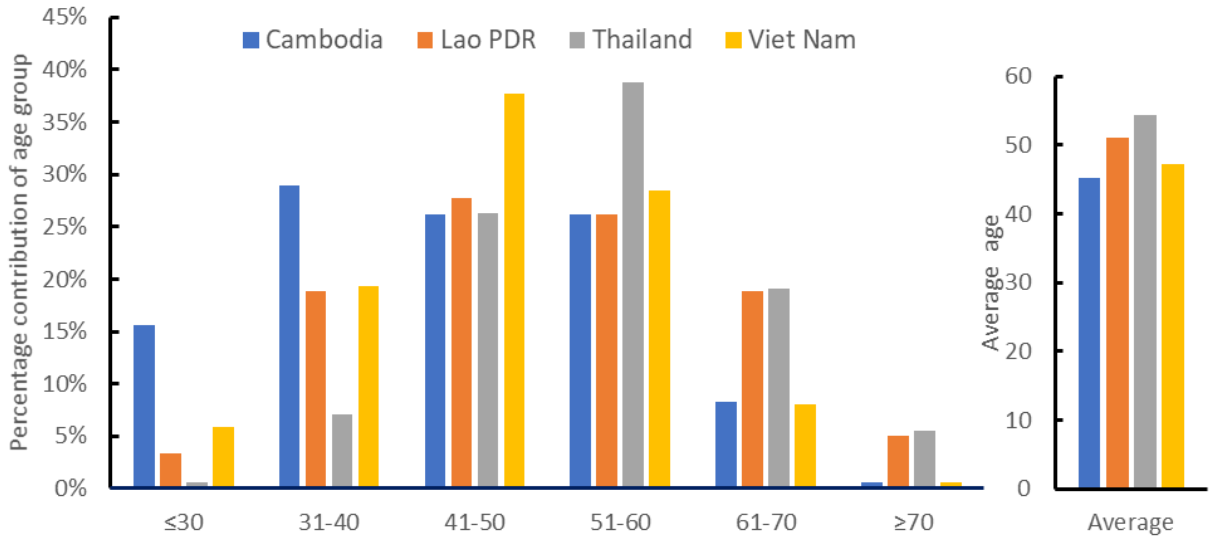


**Figure 2.8.** Age distribution and average age of fishers in villages surveyed in 2019–2020 household surveys

### 2.2.3 Fishing activities

A total of 58 gear types were recorded during the surveys, out of the 160 recognized fishing gear types in the LMB. The most frequently used (by more than 10 fishers) were stationary and drift gillnetting and cast nets (Figure 3.9). Seine nets, traps, and hook and line were also frequently used. The horizontal 12 box-shaped trap is used exclusively in Viet Nam, and stationary gillnets are mostly used in Lao PDR, Thailand and Cambodia.

Fishers in all countries operate in both seasons, although in Cambodia, more fishers work during the flood season (Table 3.10).

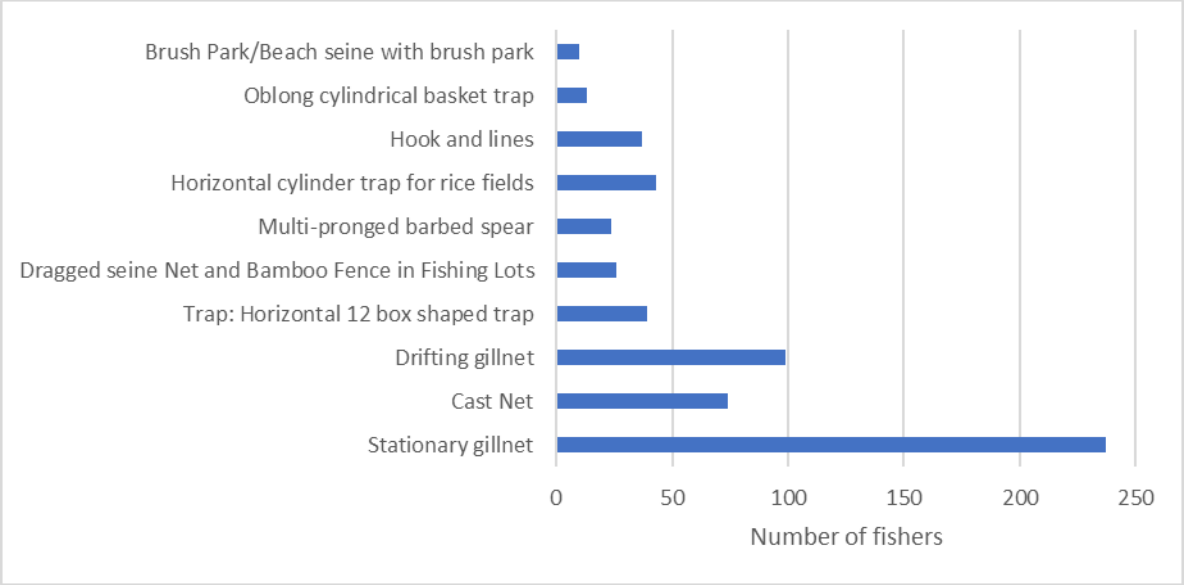


**Figure 2.9.** Main fishing gears used by fishers in the household survey

**Table 2.10.** 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 |

### 2.2.4 Fishing catch and effort

One of the key outputs of the household fisher surveys was an estimate of the mean catch rates (kg/fisher/year) for fish and OAAs, which was derived for fish catches in the different countries and different habitat zones (Table 3.11). With the exception of Viet Nam, where the catch was highest in the brackish-water estuarine zone, the major flood zone (H2) contributed the most to the total catch in each country. Rainfed zones contributed less catches than other habitat types. As expected, the catch rates of fishers in Cambodia and Viet Nam were considerable higher than in Lao PDR and Thailand, possibly reflecting the exploitation of known greater abundance and diversity of fish species in the lower reaches of the Basin below Khone Falls. In most cases, catch rates of part-time fishers were considerably lower than that

of full-time fishers, likely because part-time fishers tend to operate on a seasonal basis to exploit seasonally abundant fish to enhance income from their main livelihood. It is also important to note the high variations (Standard Deviations Table 3.11) in catch rates between fishers, both full and part-time, which in turn may reflect differences in the intensity of fishing effort or gears used by different fishers.

**Table 2.11.** Mean fish catch per fisher in different habitat types in countries of the LMB

| | | Rainfed zone (H1) Mean±SD | Major flood zone (H2) Mean±SD | Water bodies (H3) Mean±SD | Brackish-water 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 | | |

The catch rates found in this study were considerably higher than found elsewhere and in previous studies (Hortle, 2007; Hortle & Bamrungrach, 2015). This is most likely because most of the people interviewed in the 2020 survey were fishers, whereas previously, interviewees included those who did not necessarily fish, especially as a full-time occupation. Care should therefore be taken when applying these results to an overall assessment of the total catch from the LMB because they could inflate the total catch from the system. It should also be noted that there was considerable variance of the catch within each fishing zone, suggesting differences in catch between micro-fishing habitats, fishing gears and fishing effort.

A similar assessment of catch rates was undertaken for OAAs (kg/fisher/year) (Table 3.12). It should be noted that the extremely high catch of three fishers exploiting snails in An Giang Province in Viet Nam were excluded from these data. In Cambodia and Thailand, water bodies (H3) contributed more catch of OAAs than other habitats. By contrast, the major flood zone

**Table 2.12.** Mean harvest of OAAs (kg/fisher/year) 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-water estuarine zone (H4) Mean±SD |
|---|---|---|---|---|---|
| Cambodia | Full-time | 52±42 | 324±532 | 538±1,804 | |
| | Part-time | 78±91 | 193±335 | 121±119 | |
| Lao PDR | Full-time | 86±71 | 287±358 | 173±240 | |
| | Part-time | 55±63 | 483±501 | 249±339 | |
| Thailand | Full-time | 31±70 | 177±224 | | |
| | Part-time | 22±80 | 7±21 | 104±213 | |
| Viet Nam | Full-time | 193±216 | 597±2,100 | | 4,437±5,225 |
| | Part-time | 116±132 | 137±229 | | |

(H2) was the main source of OAAs in Lao PDR. The highest catches in Viet Nam were in the major flood zone (H2) and brackish-water estuarine (H4). These differences are almost certainly related to the species being harvested and the primary gears being used. The huge volumes of OAAs in Viet Nam are likely dredging for molluscs, which are high volume products but of lesser value. Again, the standard deviations of the mean catch data are generally large. In this case, it is probably driven by the types of OAAs (crustacea, molluscs or frogs) being exploited, an aspect that needs further investigation.

### 2.2.5 Consumption of inland fish products

Consumption rates of fish and other aquatic products have been used previously to estimate the total catch for the LMB (Hortle, 2007; Hortle & Bamrungrach, 2015) and globally (Fluet-Chouinard et al., 2018). The median consumption rates of fish and aquaculture products (kg/capita/year) were therefore determined in the 2020 household surveys (Figures 3.10 and 3.11). Fish consumption rates were derived from fishers exploiting different habitat zones to test if there were differences in consumption rates of fishers between the main habitats targeted. Only marginal differences were found between zones with the exception of Cambodia and Thailand, where the highest consumption rates were for fishers targeting major water bodies (H3), despite the major flood zone (H2) being the most productive, and in Viet Nam the brackish-water estuarine zone (H4). There is no obvious reason for these differences, but it is possible that fishers consume the lesser value fish caught in these habitat zones or consume the fish they are unable to sell. It is imperative to carry out further studies of the type of fish consumed to understand these differences in consumption rates between habitats and countries.

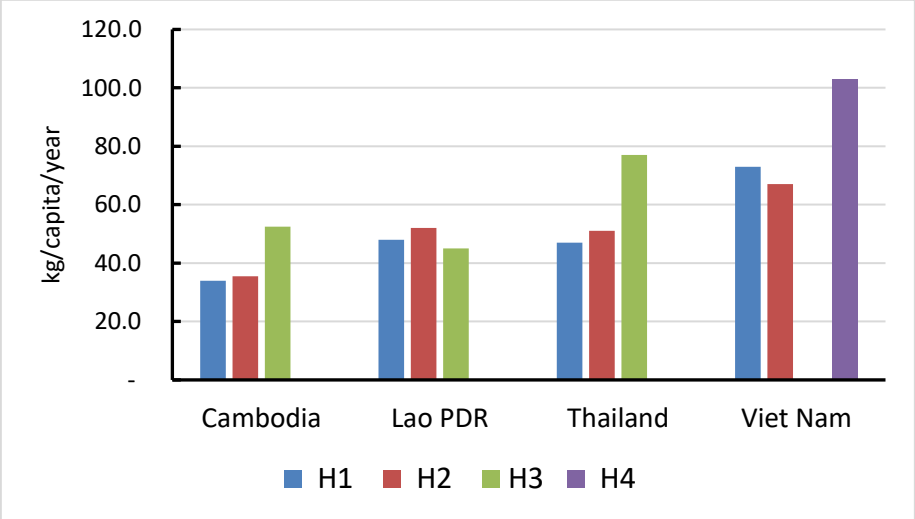


**Figure 2.10.** Average fish consumed by fishers (kg/capita/year) exploiting different habitat types in the four countries of the LMB

A similar analysis was carried out for the consumption of aquaculture products by fishers exploiting different habitat zones. No obvious patterns were found, but fishers exploiting the large water bodies (H3) tended to have a higher consumption rate of aquaculture products, possibly because they had better access to fish farms that often operate in association with large water bodies or along the banks of the major river channels.

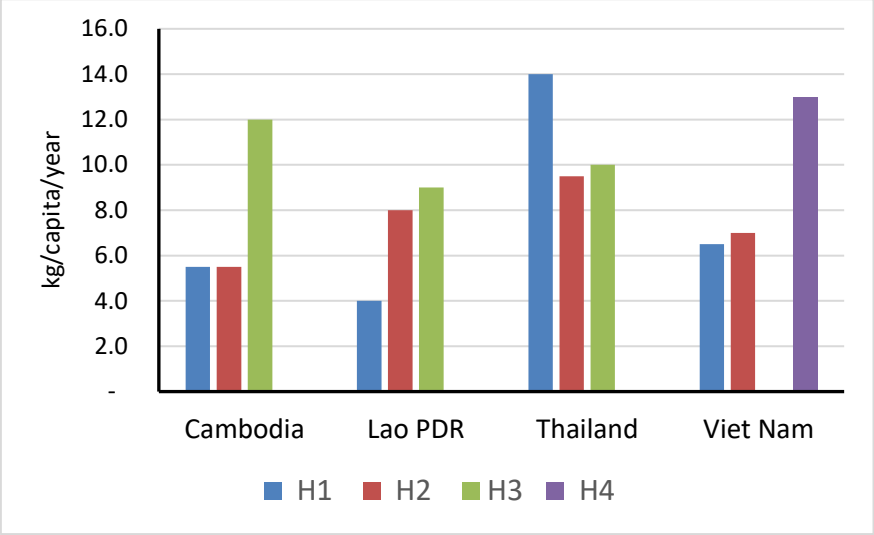


**Figure 2.11.** Average aquaculture-sourced fish consumption of fishers (kg/capita/year) exploiting different habitat types in the four countries of the LMB

### 2.2.6 Fish prices

During the household surveys, fishers were asked the first-sale price of their catch according to three fish length categories (<25 cm, 25–50 cm, >50 cm), as well as the price of similar fish on the market. The median prices of the <25 cm and 25–50 cm fish categories varied between major habitat types fished and between countries (Table 3.13, Figure 3.12). Unsurprisingly, the value of larger fish was higher than smaller fish. There was no obvious trend in first sale value of fish caught between fishing habitats, although fish caught in rainfed habitats were marginally more valuable than those from the flood zone or major water bodies. It is unclear whether this is the result of seasonal exploitation patterns and market demand. Generally, first-sale prices were greatest in Thailand and least in Lao PDR. Again, it is unclear whether this is driven by market demand or local economic drivers. The mean mark-up price of fish to the market price is approximately 63% (based on data from Lao PDR and Thailand).

**Table 2.13.** Average market price ($/kg) of small (<25 cm) and medium- (25–50 cm) sized fish caught in different habitat types in the four countries of the LMB

| | Rainfed zone (H1) | | Major flood zone (H2) | | Water bodies (H3) | | Brackish-water estuarine zone (H4) | |
|---|---|---|---|---|---|---|---|---|
| | <25 cm | 25–50 cm | <25 cm | 25–50 cm | <25 cm | 25–50 cm | <25 cm | 25–50 cm |
| Cambodia | 2.0 | 3.0 | 1.5 | 2.5 | 1.25 | 2.25 | | |
| Lao PDR | 0.89 | 1.96 | 0.89 | 1.87 | 0.8 | 1.92 | | |
| Thailand | 1.30 | 3.10 | 1.30 | 3.90 | 1.25 | 2.81 | | |
| Viet Nam | 1.27 | 2.17 | 1.06 | 2.20 | | | 0.76 | 2.02 |

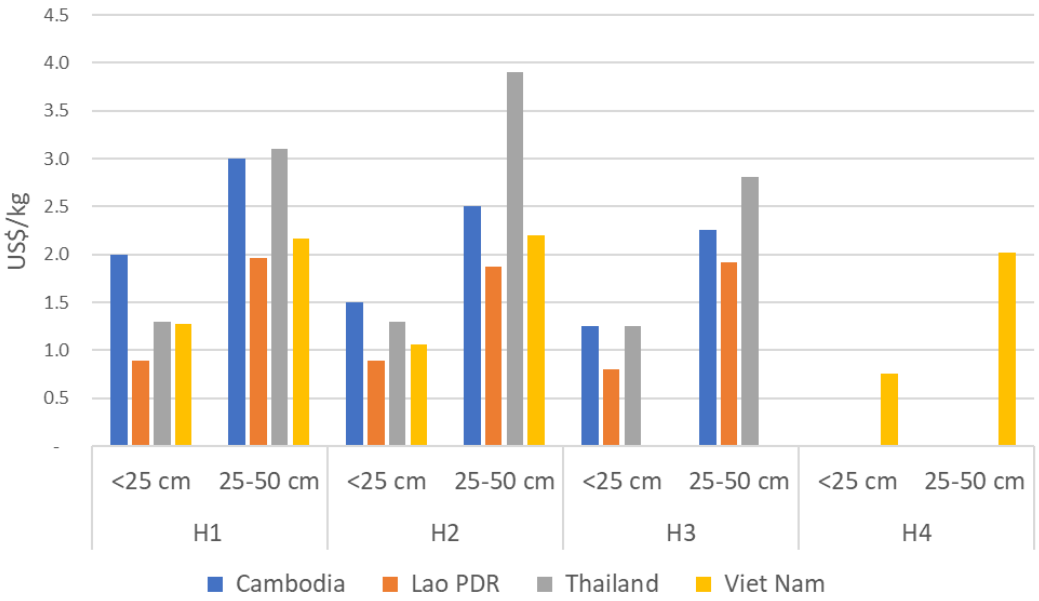


**Figure 2.12.** Average market price of small (<25 cm) and medium- (25–50 cm) sized fish caught in different habitat types in the four countries of the LMB

## 2.3 FISHERIES YIELD BY HABITAT AT THE LANDSCAPE SCALE

The aim of this component is to estimate the yield (catches) and value of fish and OAAs from the main habitat types that support fisheries and aquatic production. A Geographical Information System (GIS) approach was used to determine the relationship between catch per unit area (*CPUA*) derived from interrogation of catch rates by different gears in specific habitat types and *AREA* of habitat for different type of water bodies using *Catch* = *AREA* x *CPUA*. The main conditions here were accurate assessment of the coverage of the different habitat types and estimation of the yield per habitat type to determine the production from the system.

### 2.3.1 Land-cover datasets and maps

GIS mapping tools were used to determine the coverage of the major aquatic habitat types (major flood zone, rainfed zone, large water bodies, brackish-water estuarine zone, and aquaculture zones in each of the major fish habitat types) in the LMB. Coverage of these different habitat types is shown in Table 3.14 and Figure 3.13 for the LMB, and in Figures 3.15, 3.16 and 3.17 for Lao PDR, Thailand, Cambodia and Viet Nam, respectively.

**Table 2.14.** Area ($km^2$) of broad classes of aquatic or wetland habitats

| 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; includes 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.
*Source*: Simons (2022)

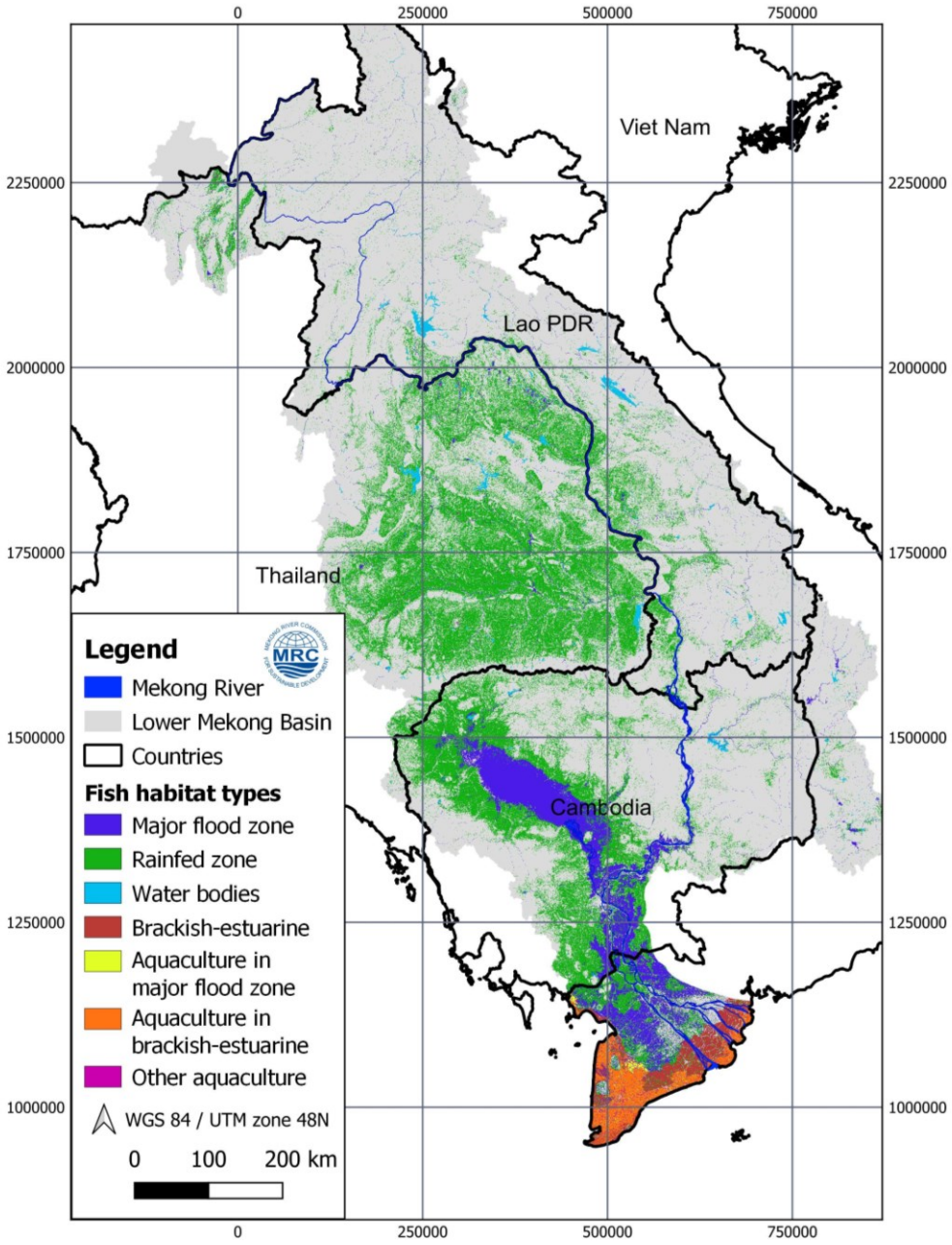


**Figure 2.13.** Coverage of different fish habitat types in the LMB

*Source*: Simons (2022)

The GIS modelling outputs highlight the proportion of the major habitat types in each country and the LMB in general. The wetland habitat area is dominated by rainfed wetlands and water bodies (133,109 km$^2$), of which the greatest proportions were found in Thailand (56.3%) and Cambodia (27.7%), and by major flood zones (33,597 km$^2$), of which the greatest proportions were found in Cambodia (56.8%) and Viet Nam (28.3%). The high proportion of rainfed habitat in Thailand is likely the result of much of the region being converted to rice fields, and underlines the construction of major water control infrastructures through the region. As would be expected, the major flood habitat is in the Cambodian floodplain and Vietnamese Delta regions. However, the small contribution of flooded habitat in Lao PDR is surprising, and

either reflects the disconnection of the Champasak and Savannakhet floodplain areas for agriculture production or the limited flooding represented in the 2020 modelling.

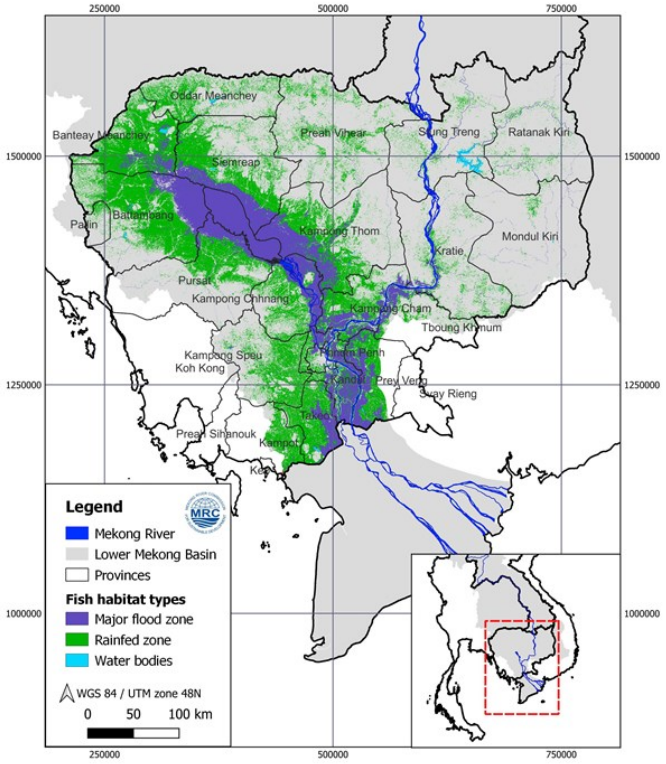


**Figure 2.14.** Map of major fish habitat types in Cambodia

*Source*: Simons (2022)

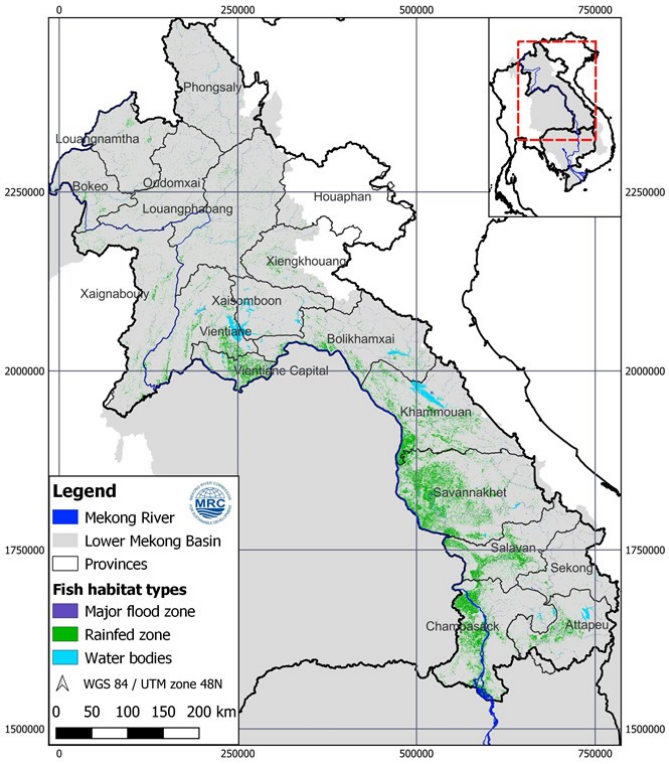


**Figure 2.15.** Map of major fish habitat types in Lao PDR

*Source*: Simons (2022)

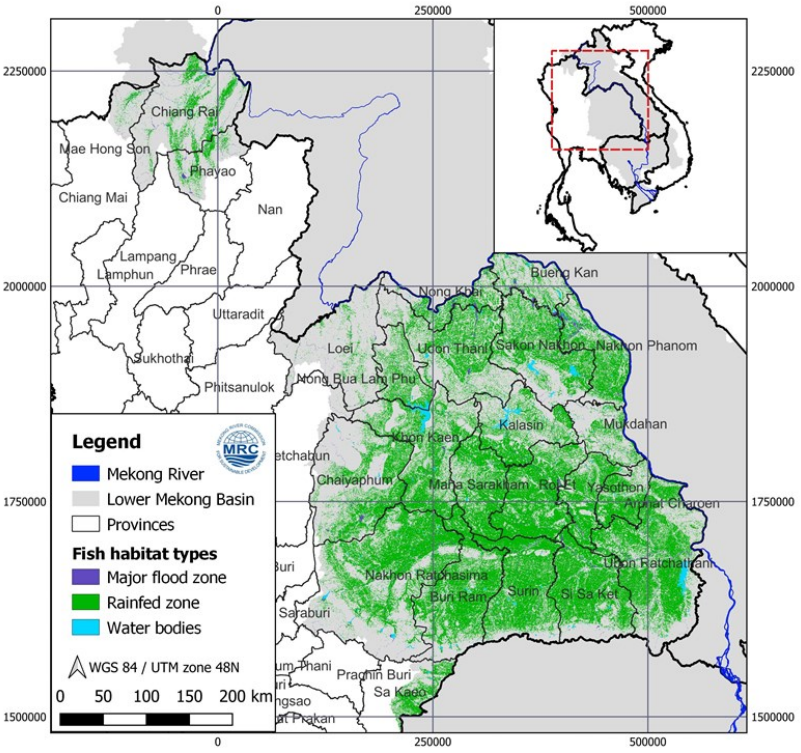


**Figure 2.16.** Map of major fish habitat types in Thailand

*Source*: Simons (2022)

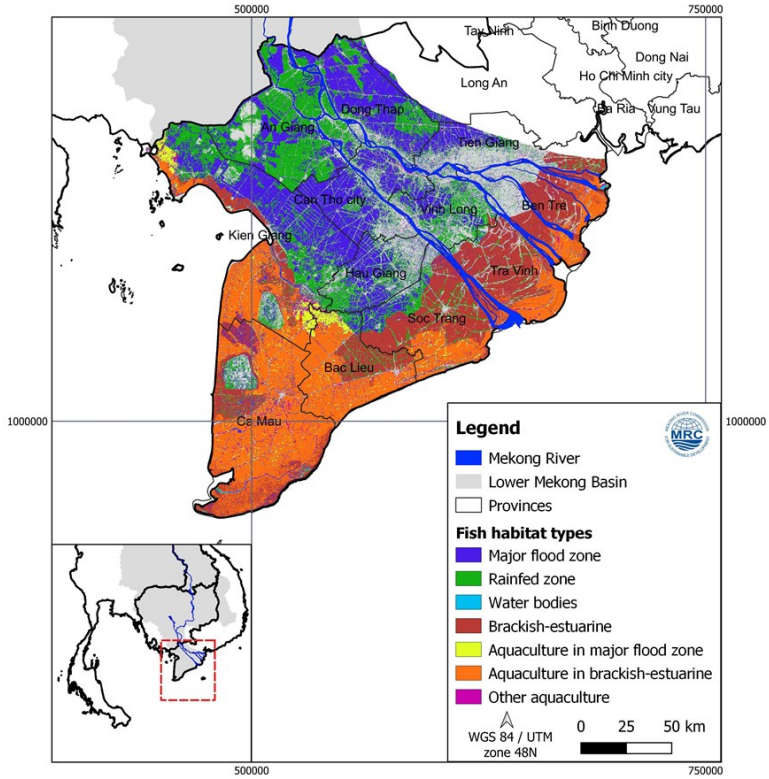


**Figure 2.17.** Map of major fish habitat types in the Viet Nam Mekong Delta, with aquaculture classes added

*Source*: Simons (2022)

Significant changes in the habitat areas were found between the 2000, 2010 and 2020 assessments (Figure 3.18; Table 3.15). Data for 2003 are also shown in Table 3.15 to provide an example of change in wetted area, which were the result of a strong flood year. The 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, as 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, 2019). 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. This is also combined with the extensive drought conditions found in the Mekong region in 2019–2021 as a result of El Niño climate events. Both will have a considerable impact of fisheries productivity since there is an intrinsic link between flooded area and fisheries production.

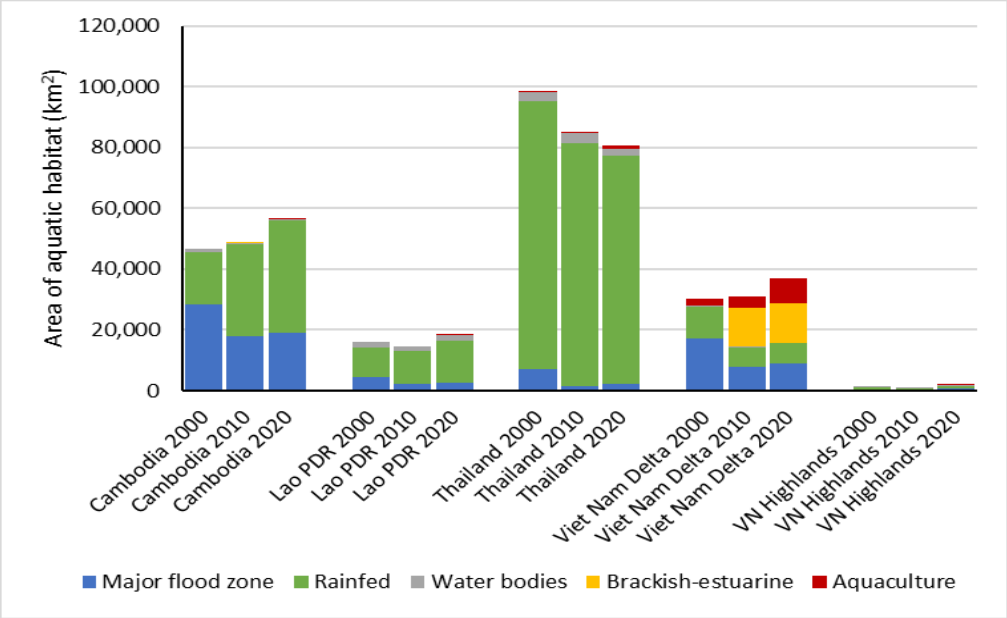


**Figure 2.18.** Comparison of areas of fisheries habitat zones in each LMB country between 2000, 2010 and 2020

**Note:** Overall country data for 2020 are shown in Table 6. Flooded area does not vary significantly during a major flood.

**Table 2.15.** Changes in major habitat areas (km$^2$) in the LMB derived by GIS

| Habitat type | 2000 | 2003 | 2010 | 2020* |
|---|---|---|---|---|
| **Major flood zone** | 57,197 | 58,017 | 30,183 | 33,597 |
| **Rainfed** | 126,547 | 129,835 | 127,741 | 133,109 |
| **Water bodies** | 6,533 | 7,512 | 5,483 | 5,251 |
| **Brackish-water estuarine** | | | 12,940 | 13,013 |
| **Total** | 192,277 | 197,367 | 178,357 | 184,970 |
| **Aquaculture** | 2,095 | 2,373 | 6,792 | 9,910 |

**Note:** *The results of this study are largely based on data collected for 2020, combined with 2010–2019 flood conditions. It is thus assumed that the results are valid for 2020 conditions.

### 2.3.2 Fisheries yield per habitat type

Having estimated the area of aquatic habitat in each province/country of the LMB using GIS (Section 3.3.1), the second step is to determine the YPUA (kg/ha/yr) of fish and OAA harvest for each major habitat type. In the first approach to estimating yield per habitat area for the Mekong, Hortle (2007) reviewed the available literature on catch for large river systems. Based on this review, three levels of yield were assumed, 'low', 'medium' and 'high': 50, 100 and 200 kg/ha/yr, respectively.

The 2020 study tested the alternative methodology (Section 2.3) of deriving fish YPUA from household surveys (Table 3.16). These estimates were supported by data from the SIMVA and FADM surveys to tune what are considered unrealistically high yield per unit habitat estimates for the habitat types (Table 3.17). Perhaps the most marked difference between YPUA from this methodology and that of Hortle and Bamrungrach (2015) is found in Cambodia in general and for major water bodies, which were both much lower than predicted by Hortle and Bamrungrach (2015). The cause for these lower yield estimates requires further investigation.

**Table 2.16.** 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 | Percenaget 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-water | 60 | 40 | 100 | 60.1 | 39.9 |

**Table 2.17.** Estimated fisheries yield per unit area (kg/ha/yr) in the LMB based on SIMVA and FADM tuning of household 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 |

### 2.3.3 Fisheries yield in the Lower Mekong River Basin

The total fish yield for each country and the LMB as a whole were determined as the product of YPUA of different habitat types in each country and the area of the habitat types in each country. This was compared with the same method but using the LMB average yield per unit habitat against the totals of each habitat type in the LMB. These data were also compared with outputs derived from using the literature-based yield per unit habitat type from Hortle and Bamrungrach (2015), reported in Hortle (2017).

The total annual fish yield from the LMB in 2020 was estimated to range between 1,510,687 tonnes based on summing the yield for each specific habitat type in each country, and 1,712,320 tonnes if the average catch per unit area per habitat type for the whole LMB was used (Table 3.18), and 2,109,688 tonnes using the literature-based habitat yields of Hortle and Bamrungrach (2015) (Table 3.19). The differences arise because of variability in catch per unit habitat area between the different methodologies. In particular, the catches per unit habitat area of Hortle (2007) and Hortle and Bamrungrach (2015) were higher than the more recent calculations based on fisher household surveys. Caution is therefore recommended when using the values of Hortle and Bamrungrach (2015) because they were based on studies in southern and South-east Asia, and catches in the river basin outside the LMB may not necessarily reflect those of the Mekong, which also vary considerably between riparian countries (Table 3.17). Overall, catches from the LMB in 2020 are estimated at 1.51–1.71 million tonnes.

**Table 2.18.** Estimated total inland capture fishery yields in each LMB country (t) based on SIMVA and household study

| 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 2.19.** Estimated total inland capture fishery yields in each LMB country (t) based on literature-based yields per unit area

| 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 |

A comparison of the total catches from each country between the 2000 (Hortle 2007), 2010 (Hortle & Bamrungrach 2015) and 2020 surveys is provided in Figure 3.19 for estimated total catch by habitat based on SIMVA and household data, and in Figure 3.20 based on the catch per unit habitat provided by Hortle (2017). The latter figure (Figure 3.20) is provided to allow a direct comparison with previous studies using the same catch per unit habitat data. There is a clear decline in total catch from the LMB in all countries except Viet Nam. In Thailand and Cambodia, the decline is substantial and reflected in the country reports. There was a marked increase in Viet Nam, largely because of the reallocation of wetland habitat to brackish-water estuarine habitat, which had a substantially higher YPUA than other wetland habitat types. The declines in catches were not very prominent in the analysis using the methodology of Hortle and Bamrungrach (2015). This is largely because of the higher catch rates per unit area generated by Hortle (2017) rather than the decline in wetland habitat area associated with the 2020 study. It is recommended that the catch per unit area of the different habitat types be revisited to understand any biases in using literature-based values, and whether historical catch data for the LMB are overestimated.

In addition to exploring the contribution of different countries to the total catch from the LMB, the data have been broken down into provinces of each country to understand the contribution from different regions (Figures 3.21–3.24). 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 that contributed the most were also driven by human population density as well as the proportion of the households that fished full-time and part-time.

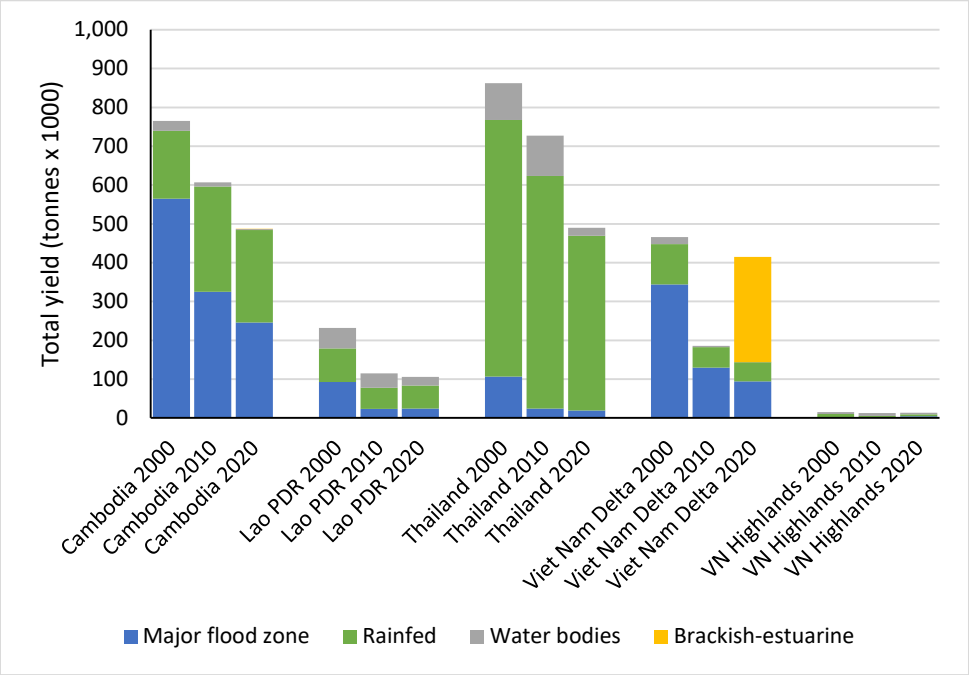


**Figure 2.19.** Comparison of total catch (t x 1,000) from habitat zones in each of the LMB countries between 2000, 2010 and 2020 based on SIMVA and household surveys

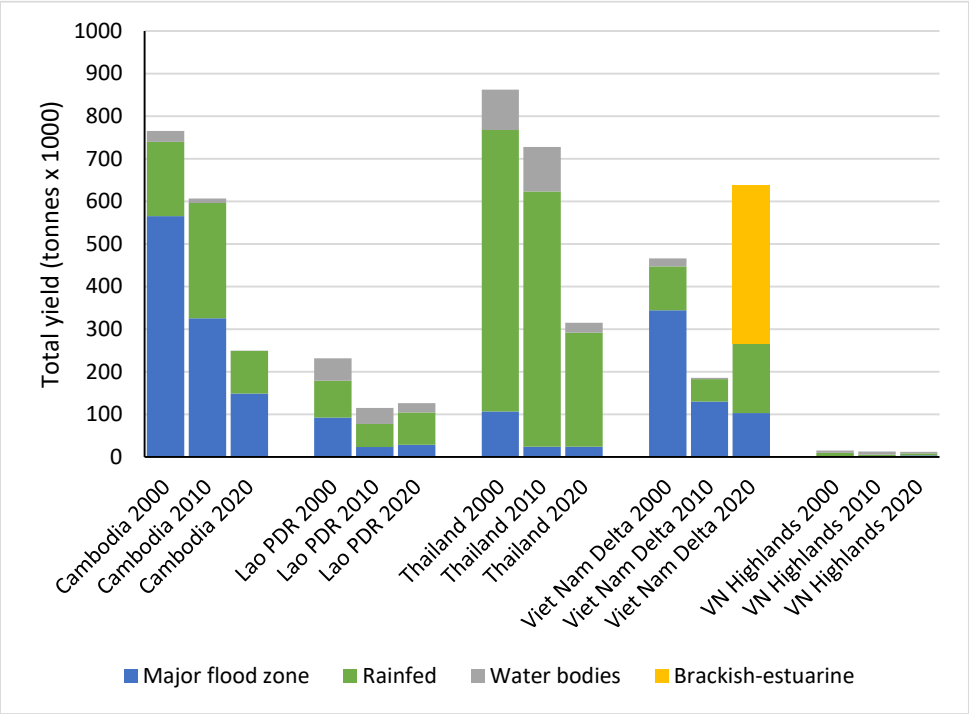


**Figure 2.20.** Comparison of total catch (t x 1,000) from habitat zones in each of the LMB countries between 2000, 2010 and 2020 based on literature-based habitat yield

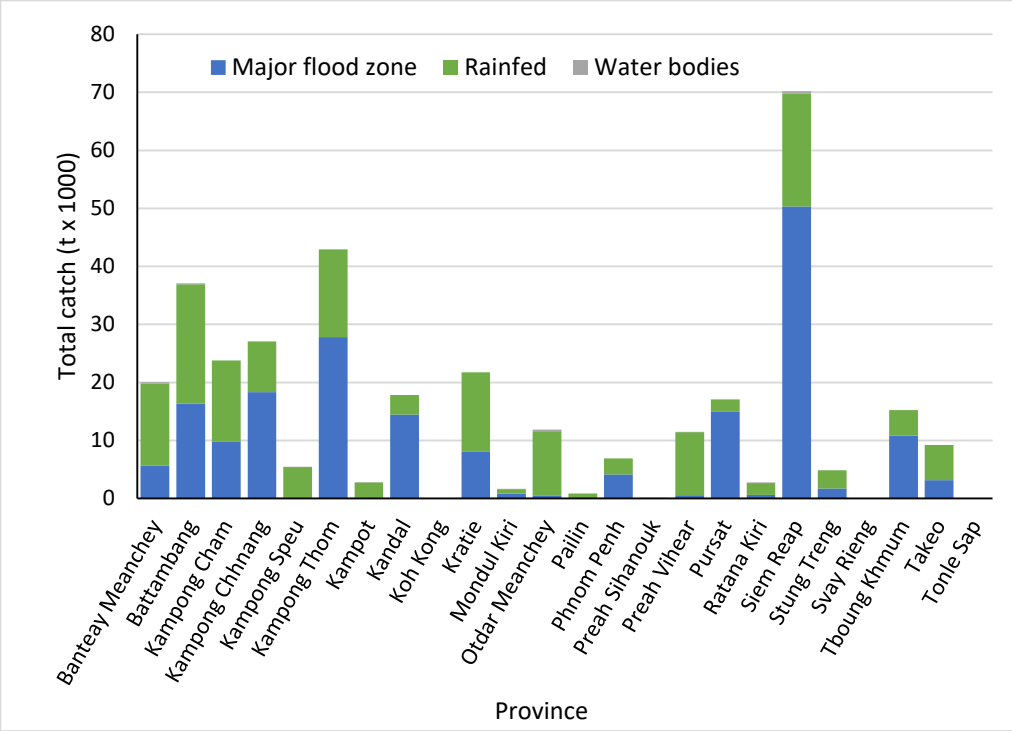


**Figure 2.21.** Comparison of total catch from different habitat zones by province in Cambodia in 2020 based on SIMVA and household surveys

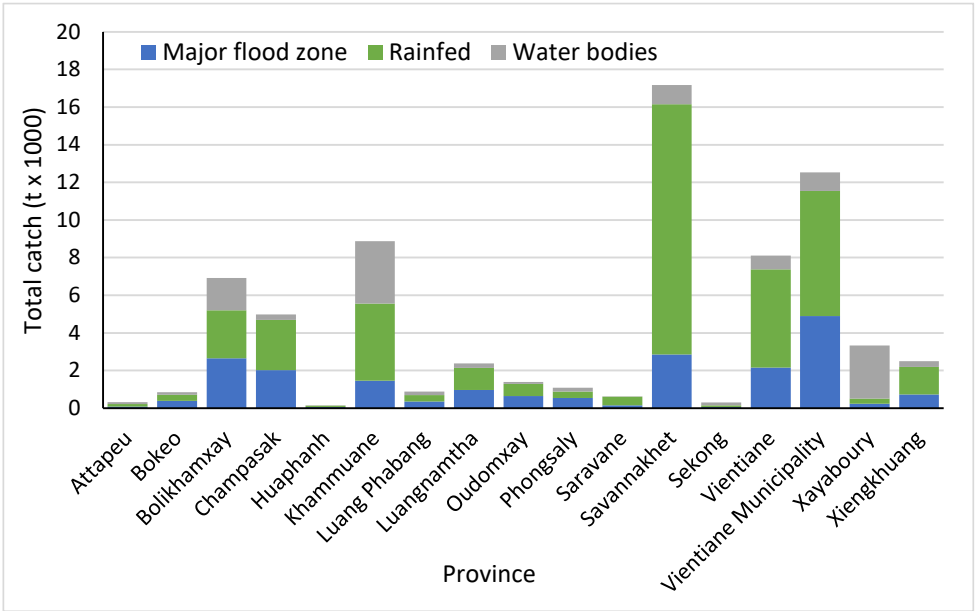


**Figure 2.22.** Comparison of total catch from different habitat zones by province in Lao PDR in 2020 based on SIMVA and household surveys

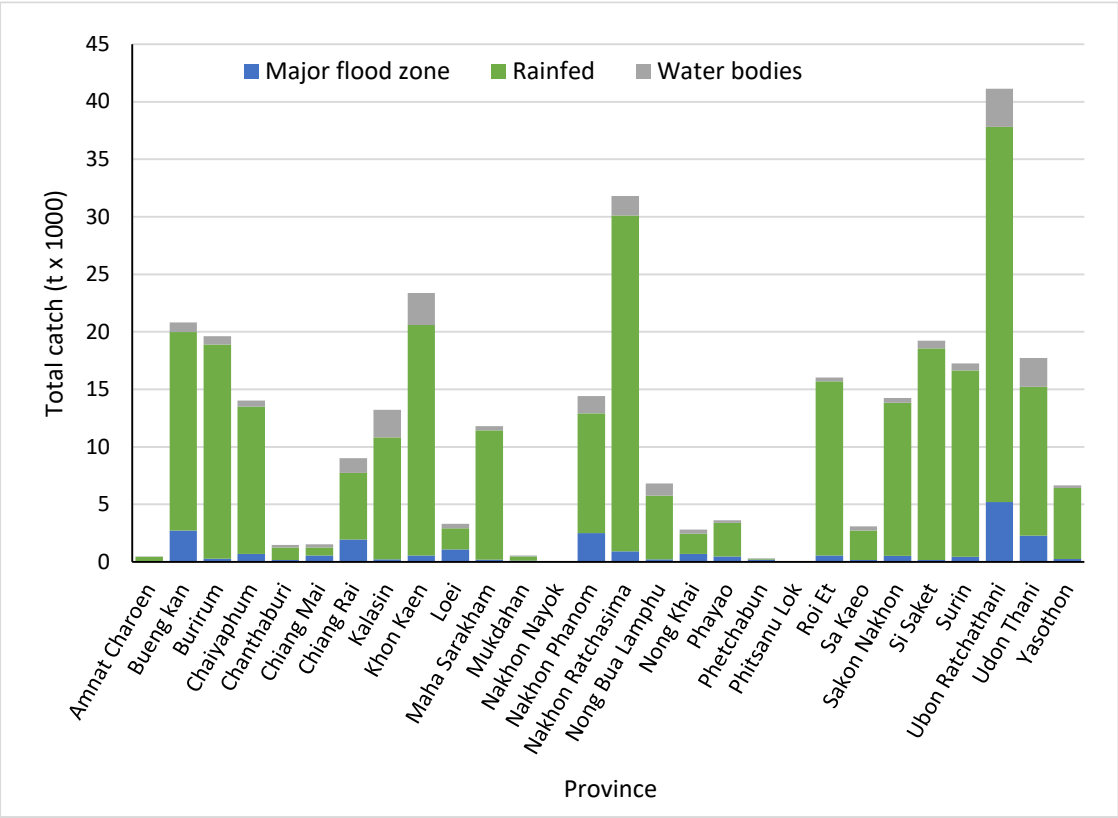


**Figure 2.23.** Comparison of total catch from different habitat zones by province in Thailand in 2020 based on SIMVA and household surveys

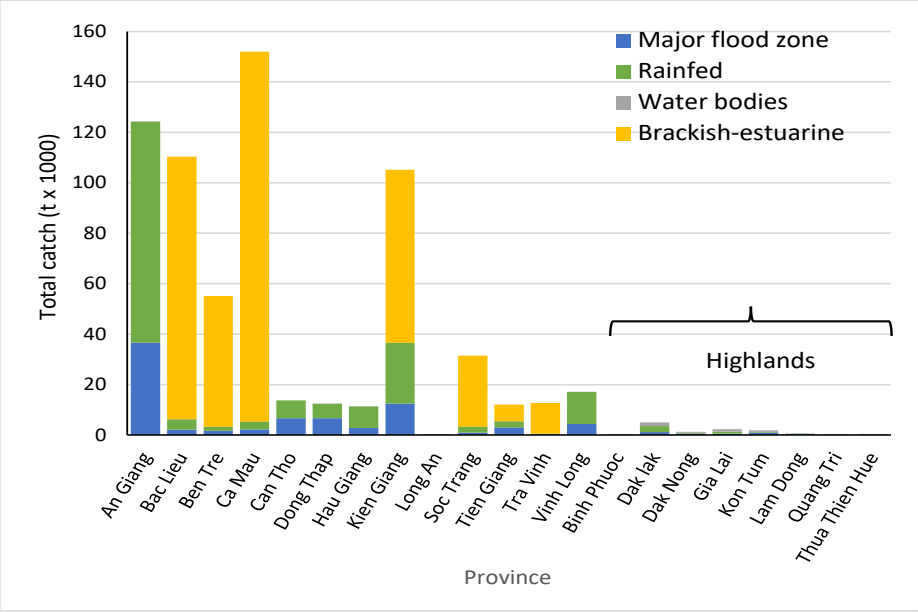


**Figure 2.21.** Comparison of total catch from different habitat zones by province in Viet Nam in 2020

*Source*: Based on SIMVA and household surveys

One element that was not included in the 2020 surveys was an estimate of the catch of OAAs. Although the individual countries determined the harvest of OAAs from the household surveys, this has not yet been directly used to estimate total catch. Instead, the average

harvest of OAAs from the different habitat types were used to estimate the total catch of OAAs (Table 3.20). An estimated 442,810 tonnes of OAAs were harvested from the LMB in 2020.

**Table 2.20.** Estimated total inland OAAs yields in each LMB country

| Annual yield of OAAs | 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 |

*Source*: Based on literature-based yields per unit area after Hortle and Bamrungrach (2015)

## 2.4 CONSUMPTION OF FISH AND OAAS IN THE LOWER MEKONG RIVER BASIN

### 2.4.1 Updated fish consumption data

The most up-to-date information on fish consumption in the region is based on the 2018 SIMVA survey supplemented by the 2020 household surveys. To date, no information is available for OAA consumption. Consumption rates vary between countries and provinces within countries, and were particularly high in Thailand (Table 3.21). Consumption rates reported for the 2020 household 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 household surveys were based on fishing villages only, where access to fish is high, while the SIMVA-based results were based on households 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 2.21.** 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 |

Consumption rates reported from the 2020 survey and SIMVA-based results were considerably different from previous studies in 2000 (Hortle, 2007) and 2010 (Hortle & Bamrungrach, 2015) (Figure 3.25). These are generally a higher consumption rate reported in Thailand and lower rates in Lao PDR and Cambodia. The consumption rates reported for the Viet Nam Mekong Delta is similar to the 2000 rates. These differences may arise because of the impact of biases of the SIMVA methodology when deriving fish consumption rates, which are based on only people living within 15 km of the nearest water body.

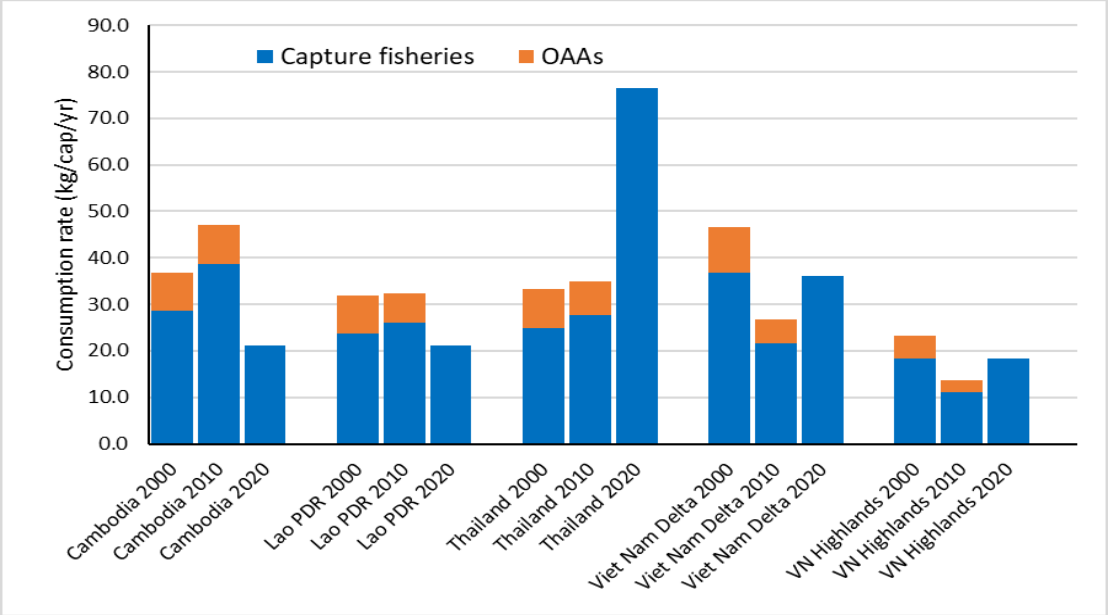


**Figure 2.22.** Comparison of average weight of fish and OAAs consumed per person between 2000, 2010 and 20120 surveys

**Note:** 2020 survey outputs are based on SIMVA data.

### 2.4.2 Total LMB consumption

Total consumption of inland fish, OAAs and aquaculture-derived products were estimated from the mean consumption rates and the populations in each country of the LMB (Table 3.22). Considerable differences were found between countries and these reflect the differences in population size of provinces of the different countries in the LMB. The greatest volume of fish consumed was in Thailand, followed by the Viet Nam Mekong Delta region. The lower total consumption in Cambodia is of concern and may also reflect the methodology used not accounting for the consumption of fish derived from the major Dai fishery on the Tonle Sap. Aquaculture-derived products also make a major contribution to food intake of people in the region, especially in Thailand and Viet Nam, and probably reflect the intensity of production, both in the household and also the general scale of aquaculture production in the provinces in the LMB.

**Table 2.22.** Total annual consumption of fish, OAAs and aquaculture products derived from the SIMVA

| | 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 | | 6,302 |
| Total | 1,651,857 | 0 | 128,369 |

A comparison of 2000, 2010 and 2020 consumption studies in the LMB countries shows a systematic decline in the volume of inland fish and OAAs products consumed over the

reporting period (Table 3.23; Figure 3.26) from 1,974,231 tonnes of inland fish products in 2000 to 1,710,376 tonnes in 2010 and 1,651,857 tonnes in 2020. A similar decline is noted in OAAs consumption, from 506,877 tonnes in 2000 to 412,553 tonnes in 2010, but a slight increased to 442,811 tonnes in 2020. The declines are, however, consistent across countries. In addition, increases in consumption volume were found in Thailand and Viet Nam Delta in 2020 compared with 2010, but this contrasted with a sharp decline in consumption volume in Cambodia in 2020. Declines in consumption of OAAs were also observed in all countries, except Cambodia, which showed a slight increase.

In addition to exploring the total volumes of fish consumed in different countries, the data have been broken down to understand the differences in consumption between provinces of each country (Figures 3.27–3.30). The provinces with the highest consumption were largely driven by human population density.

**Table 2.23.** Comparison of total consumption of fish and OAAs products (t) based on household consumption surveyed in the LMB, 2000, 2010 and 2020

| | Capture fisheries yield (t) | | | OAAs harvest (t) | | |
|---|---|---|---|---|---|---|
| | 2000 (Hortle, 2007) | 2010 (Hortle, 2017) | 2020 SIMVA | 2000 (Hortle, 2007) | 2010 (Hortle, 2017) | 2020 SIMVA |
| Cambodia | 481,537 | 524,524 | 292,614 | 105,467 | 114,625 | 80,116 |
| Lao PDR | 167,922 | 144557 | 141,007 | 40,581 | 35,203 | 27,048 |
| Thailand | 720,501 | 645,170 | 732,801 | 190,984 | 170,602 | 143,355 |
| Viet Nam Delta | 559,700 | 371,497 | 422,416 | 160,705 | 86,359 | 192,292 |
| Viet Nam Highlands | 44,571 | 24,628 | 63,019 | 9140 | 5764 | |
| **Total** | **1,974,231** | **1,710,376** | **1,651,857** | **506,877** | **412,553** | 442,811 |

Interestingly, there was a marked increase in the volumes of aquaculture products consumed in 2010 compared with 2000, but this was not carried through to 2020 (Figure 3.26). This could be attributed to the source of the data for the different surveys, with the SIMVA methodology being constrained to some extent in the coverage of villages used.

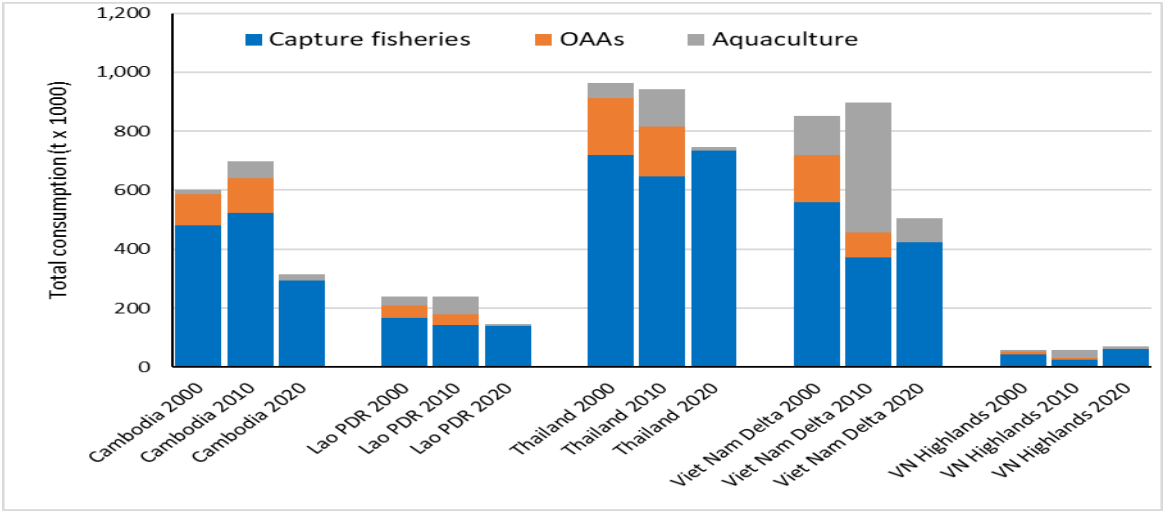


**Figure 2.23.** Comparison of total consumption of inland fish, OAAs and aquaculture products based on household consumption studies in the LMB between 2000, 2010 and 2020

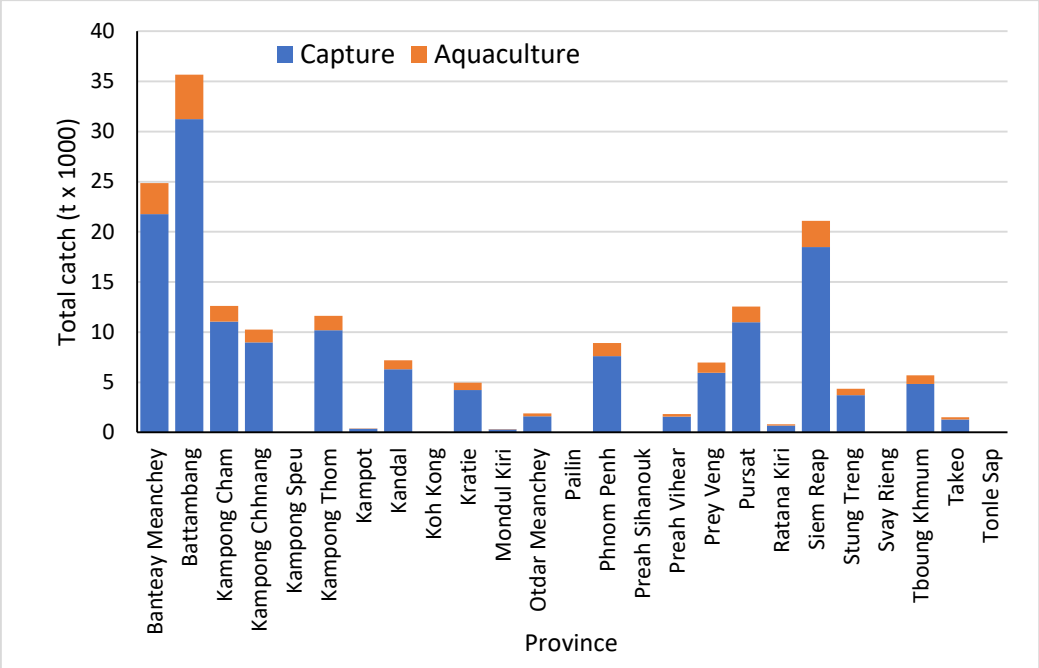


**Figure 2.24.** Comparison of total consumption of fish and aquaculture production based on household consumption studies by province, Cambodia

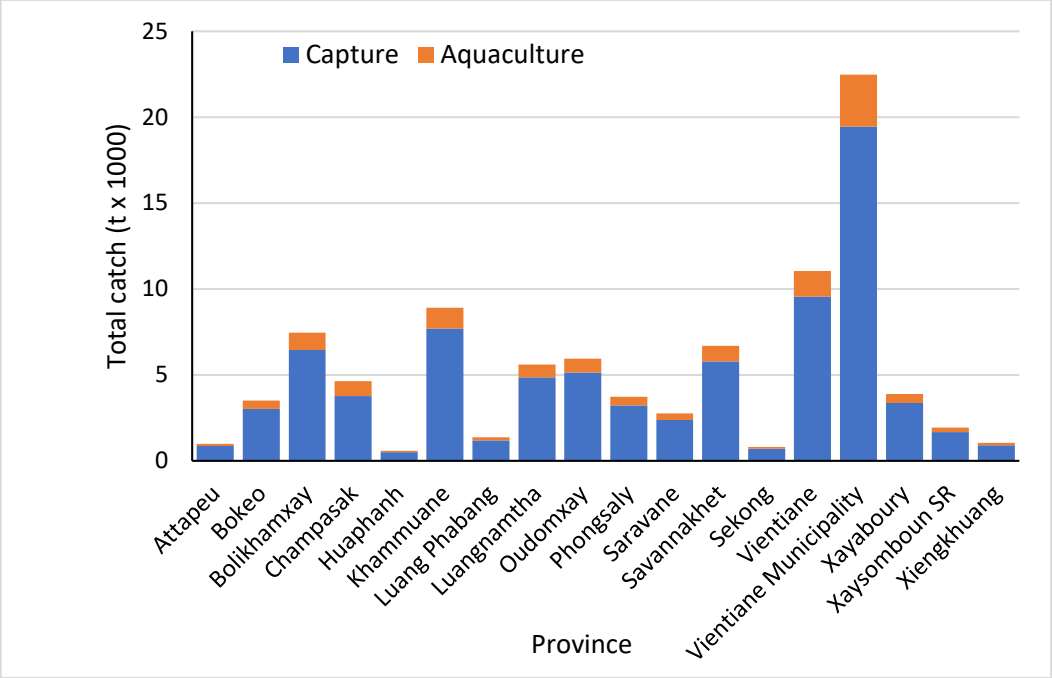


**Figure 2.25.** Comparison of total consumption of fish and aquaculture production based on household consumption studies by province, Lao PDR

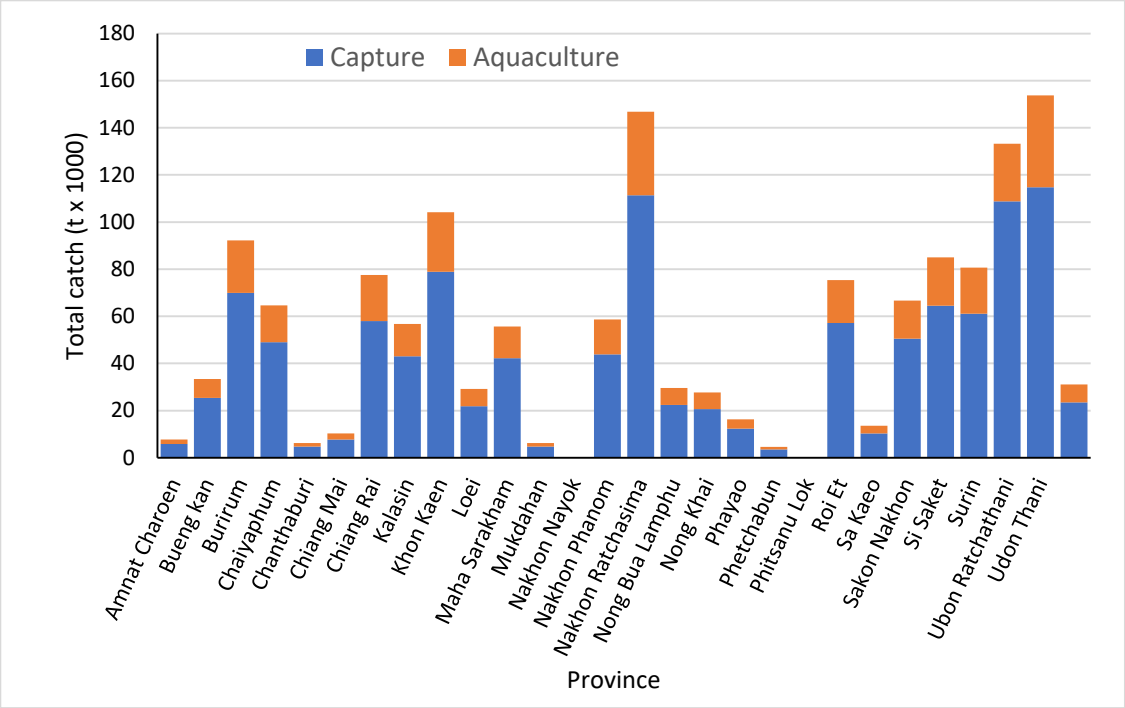


**Figure 2.26.** Comparison of total consumption of fish and aquaculture production based on household consumption studies by province, Thailand

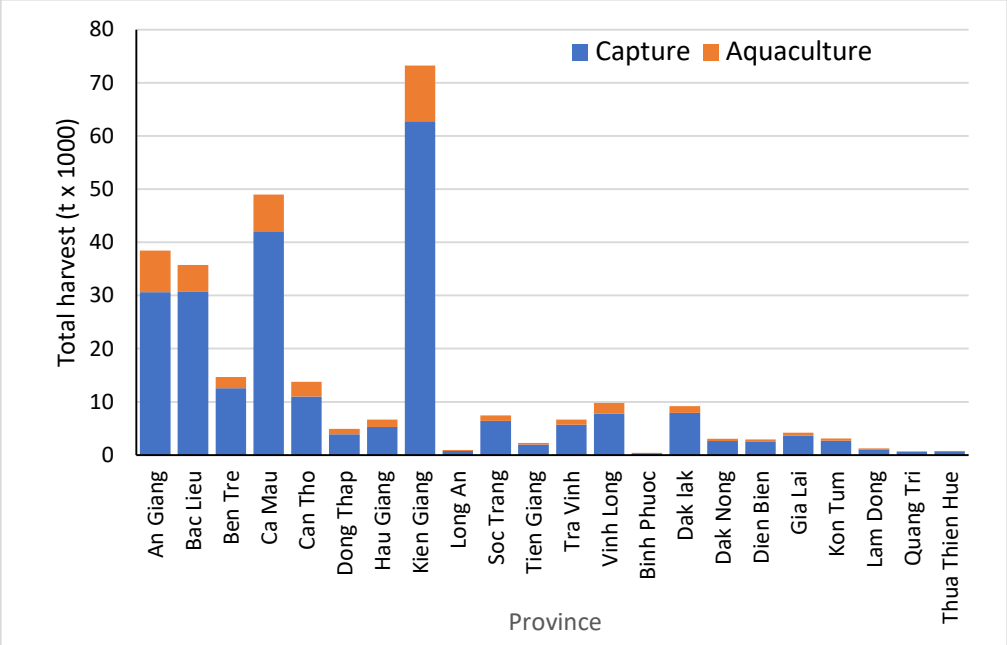


**Figure 2.27.** Comparison of total consumption of fish and aquaculture production based on household consumption studies by province, Viet Nam

## 2.5 VALUE OF FISHERIES IN THE LMB

One of the key outputs of the capture and OAAs fisheries surveys is the economic value of the products and their role in food security. During the household surveys, fishers were asked the first-sale price of the fish they caught according to three size groups: > 25 cm, between 25 and 50 cm, and fish larger than 50 cm. The mean first-sale price of the different size categories was derived from these estimates for each district and each country (Table 3.24). A weighted mean first-sale value based on the product of the proportional representation of the catch by different size groups was also derived for comparison.

In addition to the first-sale price of fish, the final market value of fish (total consumptive use value - TCUV) from the LMB was also collected. This can be achieved using the mark up of first sale value of the products, but to aid comparison against previous studies (see So et al., 2015), the final retail price of fish products ($/kg) from So et al. (2015) were adjusted for annual inflation from 2015 to 2020 (World Bank inflation data) to derive the TCUV (Table 3.24). It is notable that the final retail sale price in 2015 was considerably higher than the final sale price obtained from fishers for the present study because the price in 2015 was based on only few of the most valuable fish species in the catch, rather than the full diversity of species caught.

**Table 2.24.** Mean first-sale price ($/kg) of different sized fish in different provinces in 2020

| | Mean first-sale price ($/kg) | | | Weighted mean first-sale price ($/kg) | Average sale price* |
|---|---|---|---|---|---|
| | fish <25 cm | fish 25–50 cm | >50 cm | | |
| Cambodia | 1.88 | 2.96 | 7.50 | 1.88 | 4.15 |
| 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 | 6.09 |
| 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 | 6.96 |
| 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 | 2.47 |
| 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:** *Final retail sale prices from So et al. (2015) are provided for comparison.

The total values (first-sale price and TCUV) of fish caught was 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 3.25). Values for fish yield derived from both the household survey ($7.131 billion) and consumption survey ($8.372 billion) outputs were derived. The differences are due to the different estimates of fish catch; nevertheless, both are considerably higher than the $2.737 billion and $2.948 billion, respectively, based on first sale values from the 2020 study. This clearly shows the mark-up value of the fishery products through the value chain. It further highlights the value of the fishery, in terms of livelihoods for fishing communities and those communities further up the value chain, as well as in terms of food security, which cannot be trivialized.

**Table 2.25.** Total value ($ million) of capture fisheries in the LMB, based on 2020 household and consumption surveys

| | Fish production based on household surveys (t) | Fish production based on consumption surveys (t) | Average retail sale price using 2015 values ($/kg) | Value household surveys based on final retail price $ million | Value consumption surveys based on final retail price $ million | Weighted mean first-sale price 2020 ($/kg) | Value first-sale price household surveys 2020 $ million | Value first-sale price consumption surveys $ million |
|---|---|---|---|---|---|---|---|---|
| Cambodia | 486,916 | 292,614 | 4.15 | 2,022 | 1,215 | 1.88 | 915 | 550 |
| Lao PDR | 105,998 | 141,007 | 6.09 | 645 | 859 | 1.55 | 164 | 218 |
| Thailand | 489,674 | 732,802 | 6.96 | 3,407 | 5,100 | 1.69 | 827 | 1,238 |
| Viet Nam | 427,751 | 485,436 | 2.47 | 1,055 | 1,197 | 1.94 | 829 | 941 |
| LMB | 1,510,339 | 1,651,858 | | 7,131 | 8,372 | 1.9 | 2,737 | 2,948, |

**Note:** Final retail sale value based on values from So et al. (2015) adjusted for inflation are provided for comparison.

Although less data were available, the same valuation procedure was applied for OAAs (Table 3.27). Here, the OAAs were divided into Crustacea, Mollusca, Amphibia and Reptilia, although Amphibia exclusively of frogs. With the exception of Thailand, where Crustacea (mainly *Metapenaeus*) commanded the highest unit value, frogs were the most valuable OAA commodity sold. Molluscs had the lowest market value, presumably because of the small meat content of the product. The weighted mean value of OAAs was also calculated based on the proportional contribution of the different OAAs groups to the catch. These values can then be used to estimate the total value of OAAs in the LMB.

The total value of the OAAs harvested was derived from the product of the total catch in each country (Table 3.22) and the weighted mean first-sale price of the OAAs (Table 3.26). Overall, the first sale value is estimated at around $1.338 billion (Table 3.27), highlighting the considerable economic value of these aquatic food products and their importance to food security in the region. It should be noted that Crustacea harvested in Thailand and Mollusca in Viet Nam accounted for the largest proportion of this value.

**Table 2.26.** Mean first-sale price ($/kg) of OAAs in different provinces in 2020

| | 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 |
| Grand Total | 2.74 | 0.91 | 2.78 | 2.27 |

**Table 2.27.** 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 in household surveys (t) | Value of OAA in 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 |

# 3 DISCUSSION

This report provides an assessment of the harvest of fish and OAAs in the LMB for 2020. The assessment uses targeted household survey data combined with extensive data from complimentary surveys, especially the MRC FADM and SIMVA data, to estimate the fish and OAA harvests from inland waters in the LMB. The study specifically triangulated data from national reporting with consumption data from household surveys and aerial GIS-based habitat yield estimates. (Table 4.1). The report also provides comparison with previous studies carried out to assess the fish and OAA yield from the Basin (Hortle, 2007; Hortle & Bamrungrach 2015; Hortle, 2017) (see Table 3.23 and Figure 3.26).

The 2020 data suggest that annual fish yield from the LMB falls within a range of 1.51–1.71 million tonnes based on GIS habitat yield modelling and the estimate based on consumption studies falls within this range at 1.65 million tonnes (Table 4.1), with OAAs around 442,811 tonnes. These data represent a considerable decline in catches of around 25–30% since the 2000 and 2010 surveys. Most of this yield is harvested from rainfed and flooded habitat (Table 3.18), accounting for 53% and 25% of the catch, respectively. In addition, the brackish-water estuarine zone, especially in Viet Nam, contributes around 18% of catch. This distribution of catch among wetland types highlights the importance of protecting and preserving these key habitats to sustain the fish stocks.

**Table 3.1.** Comparison of total catch from the LMB countries in 2019–2020 using different assessment approaches

| | Inland fish yield – official statistics (t) | Inland fish yield – GIS household surveys (t) | Inland fish yield - consumption surveys (t) | Value household surveys based on final retail price<br><br>USD million | Value consumption surveys based on final retail price<br>USD million |
|---|---|---|---|---|---|
| Cambodia | 413,200 | 486,916 | 292,614 | 2,022,484 | 1,215,420 |
| Lao PDR | 70,001 | 105,998 | 141,007 | 645,860 | 859,174 |
| Thailand | 67,873 | 489,673 | 732,802 | 3,407,994 | 5,100,097 |
| Viet Nam | 451,009 | 427,751 | 485,436 | 1,055,530 | 1,197,876 |
| LMB | 1,002,083 | 1,510,340 | 1,651,858 | 7,131,869 | 8,372,566 |

The value of the fish catch varied between USD 7.13 billion and USD 9.11 billion annually based on habitat yield modelling and USD 8.37 billion based on consumption. This represents a significant contribution to GDP and food security in countries of the LMB. In addition, the harvest of OAAs is estimated at around USD 1.13 billion. This represents a considerable decline in value from the 2015 assessment (So et al., 2015), which was due to a lower fish catch. This also reflects the impact of environmental change in the LMB on aquatic productivity, brought about by a plethora of water resource development projects, ranging from large-scale hydropower schemes to intensification of agriculture and sediment extraction.

Differences were found between national reported statistics and estimated catch from household consumption and aerial GIS habitat-based assessments. With the exception of Cambodia, the nationally reported catches were lower than the estimated catches, although in Viet Nam the differences were small. Possible reasons for the differences from the national

surveys are possibly associated with the effort and resources used to estimate the national statistics and the procedures used are often linked to other activities, such as general statistical surveys; however, in Thailand it may be because only catches from reservoir fisheries are reported (Ainsworth, Cowx and Funge-Smith, 2023). The considerably lower estimates of catch from habitat-based and consumption surveys in Cambodia are possibly because catch from key fisheries, such as the Dai fishery and wider fishery from the Tonle Sap, are not fully captured by the methodologies used. To partially accommodate this, the annual catch from the Dai Fisheries (e.g. 8,152 tonnes in 2020–2021 compared with 11,167 tonnes in 2019 tonnes) should be added to the household estimates for Cambodia.

The other problem for Cambodia is that there are no SIMVA data for the proportion of fishers operating in several provinces, especially in the south-west provinces. To overcome this, values from topographically similar nearby provinces were used. The other issue is that the model does not directly estimate catches from the Tonle Sap Lake because national statistical surveys do not provide estimates of people living on the open water of the lake. Instead catches from the surrounding provinces were included the lake itself. It is unclear whether this adequately accounts for the catches from the lake where there are many floating fishing villages and considerable illegal fishing, but also whether the modelling accounts for the considerable variability in annual production brought about for the annual variation in flooded area of the Tonle Sap.

There are several possible reasons for the decline in fish catches observed in the 2020 period, not least of which the impact of the El Niño events that were occurring during the survey period, and caused an extended period of low flows and reduced flooding, especially in the Cambodian floodplain and the Viet Nam Mekong Delta. Given that fish productivity in the LMB is intrinsically linked to flooding (Halls et al., 2013; Sabo et al., 2017; Ngor et al., 2018a,b), this decline would be expected. In addition, there has been a systematic conversion of floodplains to agricultural production, especially in Cambodia and Viet Nam, which has disconnected the floodplains, thus impacting fish recruitment processes. Combined with this isolation of the floodplain is the potential reduction in floodplain productivity caused by the systematic disruption of sediment dynamics and the nutrients they carry and deposit as a result of dam construction and aggregate mining in the LMB. This will have a considerable impact on productivity as highlighted by the MRC Council Study BioRA (MRC, 2017), which predicted a 25% decline in the capture fishery by 2020 as a result of dam development.

In addition, the 2020 surveys were carried out during the COVID–19 pandemic. This could have seriously constrained the efficacy of the household surveys, but possibly reflect shifts in fishing activities and adaptation to market opportunities during this period. Restrictions on movement of people and depressed markets because the fish could not be sold easily may have contributed to the lower catch rates and overall catches. Whether this is the case is unclear since fishers would still need to make a living, and the local people would still need to eat. Indeed, it is also possible that people whose ability to work was heavily impacted by the COVID-19 restrictions may have supplemented their diet by fishing, as is common in other parts of the world when disasters strike communities. Thus, fishing pressure may actually have increased.

Nonetheless, in recent years, fishers have stated that fish catches have declined considerably since the completion of large dams on the mainstream, arguing that they cannot catch sufficient fish to stay engaged in the fisheries sector.[2] The current study precedes the period over which the considerable decline in catches has been observed, but overlaps with the closure of Don Sahong and Lower Sesan 2 hydropower plants (HPPs) and potential disruption of fish migratory pathways and recruitment processes. It is critical that the study be repeated to confirm this decline in catches, but with specific surveys on fishing households in the heavily impacted reaches, especially in the Stung Treng and Kratie reaches of the LMB.

To this effect, a study was carried out by IFReDI in 2019 in the Kratie and Takeo provinces using the same household survey methodology as adopted in this study. Although this survey again precedes the closure of the large HPPs in the area, it may reflect the indirect effect of closure of the migratory pathways at Don Sahong and in the 3S system. Catch rates in these provinces were indeed found to be declining over time (Table 4.2), but it is difficult to determine whether this is due to the HPP developments, or a general decline in catches due to increased fishing pressure, or other factors including climate change effects.

**Table 3.2.** Production of catch per fisher in different major habitat types in the Kratie and Takeo provinces of Cambodia

| Province | Habitat | Fisher type | Catch rate (kg/fisher/yr) | | |
|---|---|---|---|---|---|
| | | | 2010 | 2015 | 2019 |
| Kratie | H1 | FT | 972.5 | 837.5 | 783.0 |
| | H1 | PT | 411.7 | 310.4 | 209.7 |
| | H2 | FT | 1,706.8 | 1,275.0 | 806.6 |
| | H2 | PT | 600.3 | 445.4 | 323.4 |
| | H3 | FT | 2,536.1 | 1,843.3 | 1,554.6 |
| | H3 | PT | 733.3 | 538.0 | 361.5 |
| Takeo | H1 | FT | 1,350.0 | 1,250.0 | 1,387.8 |
| | H1 | PT | 724.7 | 456.3 | 250.5 |
| | H2 | FT | 1,462.5 | 1,195.0 | 825.8 |
| | H2 | PT | 431.9 | 286.1 | 201.5 |
| | H3 | FT | - | - | - |
| | H3 | PT | 560.0 | 360.5 | 217.1 |

Another issue that arises from the analysis it that the estimates of catch based on the Hortle & Bamrungrach (2015) and Hortle (2017) data on mean catch per unit area are considerably higher than those derived from modelling from the household catch data applied in this study (Table 3.19; Figure 3.20). The Hortle methodology, while setting the platform for GIS-based, aerial assessment of fish yield from the LMB, appears to overestimate the total catch. This is largely because the average catch per unit area of habitat type is based on the literature from a number of countries in South-East Asia, and these data do not necessarily account for the actual productivity in the LMB environment, both provincial and local scale, or fishing effort. They also do not account for interannual variability of fisheries production of water bodies, which can be high, and are known to be associated with the extent of flooding (Halls et al., 2013; Sabo et al., 2017; Ngor et al., 2018a,b). The lower estimates derived for the LMB in the present study are possibility linked to the impact of COVID-19, as discussed above, but more

[2] www.mekongeye.com/2023/02/27/cambodia-catches-shrink

likely the prolonged period of severe droughts associated with the El Niño/La Niña events during the 2018–2021 period.

Finally, the consumption estimates derived in this study were based exclusively on all households living in the LMB and may represent an overestimate since all members of the household are considered to consume the same amount of fish. However, infants and younger children will likely not consume the average daily intake across each country. In addition, consumption of aquatic products in large urban centres is likely to be lower than in rural areas in close proximity to a major water body with easy access to catch. The consumption rates of people living in close proximity to large water bodies is known to be higher than in urban areas, thus partly compensating for the potential biases.

## 3.1 RECOMMENDATIONS REGARDING THE 2020 FIELD SURVEY

The 2020 study was based on triangulating the nationally reported statistics against consumption data from the household surveys and GIS-based aerial habitat yield estimates. (Table 4.1). The GIS-based, aerial habitat yield estimates were derived from a new approach calibrating the average catch per unit area of fish and OAAs by individual fishers in different habitat types in different provinces derived from household surveys against the area of those major habitat types in the province. This is different from the previous studies by Hortle and Bamrungrach (2015) and Hortle (2017), which used literature-based catch per unit area data that were greater than the figures derived here. Given the considerable differences between the catch per unit area data used from different sources, there is a clear need to calibrate the data by follow-up surveys of fishers in different provinces, especially those zones with different proportions of the major habitat types and different levels of fishing effort.

Consideration should also be given to maximizing the utilization of existing and periodic monitoring such as FADM and SIMVA, plus the national GSO surveys to validate the catch data from fishers. The FADM surveys consist of the daily monitoring of fish catches, which could easily be enhanced to include OAAs, but more importantly, report on the main gears used and the main habitat type fished, together with the weight and species of fish caught. This additional information could be used in conjunction with dedicated fish habitat surveys used in this study.

Linked to above utilization of the FADM data, there is a clear need to improve the reporting of fishing activities in the SIMVA studies. While the surveys are basin-wide, there is a clear disconnect in the results with the proportion of fishers that are operating full-time. For example, no full-time fishers were reported in the Thailand SIMVA results, yet they were definitely recorded in the household surveys carried out as part of this study. It is likely this bias arises because of the types of questions asked under the SIMVA survey that may confuse main employment as the major source of income, rather that the most time spent on particular livelihoods.

There is also a need to increase understanding of the relationship between full-time, part-time and occasional fishers. Some indication of the relative fish catches between full-time and part-time fishers was found in the present study, with part-time fishers catching between 10% and 100% of the catch of full-time fishers (Table 3.11), depending on province and major

habitat type fished. This problem is further exacerbated with problems of accounting for the catch of occasional fishers. In this study, their catch was given a fixed catch rate of 20% of the catch rate of part-time fishers. This assumption needs confirming, but more importantly, the definition of 'occasional' fishers needs to be standardized. Occasional fishers are assumed to earn some income, either by selling or bartering fish they catch, but there are also numerous people who carry out fishing for subsistence, particularly those who live in close proximity to the river or wetland, and catch fish or collect OAAs to supplement the household diet. This type of activity was found to be a common practice when families were interviewed as part of the prior consultations of the proposed hydropower schemes in the LMB. These 'subsistence' fishers could potentially be numerous, and even if they only catch or collect around 0.5–1 kg of fish or OAAs each day, their contribution to the overall harvest from the LMB could be considerable.

This potential missing catch also raises another issue of how many people fish in each household. It is assumed that only one person fishes in each household, yet there is clear evidence that more than one person in the household fishes at least part-time or occasionally. Future household surveys need to clarify this situation to improve the estimates from the GIS-based aerial assessments.

To address these problems, future large-scale surveys could be part of the routine work of national statistics agencies, since they could be readily incorporated in rural and agricultural censuses (e.g. GSO) or national household censuses. More intensive surveys can be successfully carried out by fisheries agencies, but should involve statistics agencies to ensure that methods and results are broadly accepted.

Finally, during the 2020 study, the area of different habitat types was provided by GIS interpretation of the land use area in the LMB. However, misinterpretation of the contribution of certain habitat types was found, especially of the flooded area, because an average of the previous ten years flooding pattern was used. This caused problems, not just because the catches should be related to the extent of habitat in the specific year, but because the algorithms had to be adjusted to account for the different habitat types**.** It is therefore recommended that the approach to assess the extent of each habitat type and GIS algorithms used to carry this out be standardised for future studies.

The studies reviewed for this report generally lack quality assurance, a problem compounded for this review by their poor compatibility in terms of approach, coverage and units between the 2020 surveys and those undertaken in the past (Hortle, 2007; Hortle & Bamrungrach 2015; Hortle, 2017). The previous surveys were based on literature reviews rather than empirical data for household surveys. A common methodology is required to improve these estimates of catch per unit habitat, potentially utilizing the methodology adopted in the study.

Similarly, most of the consumption surveys were based on interviews often using recall data, which may have introduced considerable biases, not least from recall of the contribution of processed products such as pastes and sauces. Although numerous fishing households were interviewed, biases may have been introduced, and no information on the precision or certainty of the estimates is provided. Given the uncertainty, it is important to consider other approaches for collecting better data to produce more precise estimates of consumption.

Again, these could be linked to rural and agricultural censuses surveys or upgraded SIMVA surveys should they continue.

## 3.2 CONCLUSIONS AND RECOMMENDATIONS FOR POLICY AND PLANNING

Although the exact size of the LMB fisheries will continue to be debated, the importance of wild capture fisheries is undeniable yet clearly poorly understood and undervalued. More attention should be focused on accurately assessing the size and value of capture fisheries and on measures to maintain and where possible increase their yield. This assessment suggests that the status of the fisheries across the LMB are in decline, both in terms of total catch and CPUE of fishers. There is a clear need to fully understand the reasons underlying the decline and whether it can be attributed to fishing pressure, as has been suggested by some stakeholders, or external factors acting on the fish stocks. For example, the MRC Council Study (MRC, 2017) and Viet Nam Mekong Delta Study (DHI, 2015) predicted that the fish populations of the LMB would be compromised by between 25% and 40% as a result of run-of-river hydropower schemes in the mainstem Mekong, and this does not account for hydropower schemes constructed on major tributaries, such as Lower Sesan 2, which are likely to further impact fish stocks. In addition, flow regulation and loss of sediment as a result of the cascade of hydropower dams in the Lancang reach of the Upper Mekong will likely cause loss of productivity in the LMB (Koehnken et al., 2020; Kondolf et al., 2022). Beyond hydropower development, the conversion of floodplain habitat into agricultural production, especially rice fields, and associated fragmentation of the floodplain and river network by irrigation infrastructure and levee systems (Freed et al., 2020; Vu et al., 2021), had disconnected the previously flooded areas and disrupted ecosystem functioning, potentially resulting in the observed decline.

The prospect of substituting the lost fisheries catch in the LMB with fish products from aquaculture sources is considered fraught with problems. Aquaculture offers a different economic outcome and distribution of equity to local communities, since it generally requires capital investment, land tenure and access to considerable financial resources because of the high cost of feed and seed. This mostly excludes rural people and fishers, who are dependent on the wild fish and fisheries for their livelihoods and food. Consequently, social inequalities may be exacerbated by policies that seek to replace capture fisheries by aquaculture. As well as considering the various socio-economic aspects, the negative environmental aspects of aquaculture should also be recognized, including the potential for pollution, the spread of diseases, parasites and non-native invasive species, and competition with the capture fisheries to provide broodstock, fry and feed.

Further, the substitution of wild caught fish and harvested OAAs with aquaculture products has considerable knock-on nutritional problems. Aquaculture products are typically larger specimens of fish and prawns that are filleted or peeled for the meat products and not eaten whole. Therefore, the consumer does not ingest many of the micro-nutrients and calcium consumed when eating small fish or shrimps whole. This can potentially lead to nutritional diseases or stunted infant growth (Funge-Smith & Bennett, 2019; Simmance Armstrong et al., 2022). Aquaculture products also tend to be more expensive than wild caught products, and the utilization of wild caught, low-value, fish products for fish feed removes it from the human

food chain. These issues need to be resolved if fisheries continue to be given low priority in the face of economic development.

In the Mekong context, fisheries management should consider the relative importance of different types of productive wetland habitat types and protect their integrity and functioning. The MRC (2023) has already identified key habitats for fish recruitment and growth, and habitats that need protecting or restoring to ensure sustainable fish populations and fisheries. It is critical that the relationship between these habitats and their potential for restoration is better understood to manage the resources sustainably in view of economic development.

Fisheries production can be enhanced by a range of measures including stocking, management of fishing pressure and regulation of gears, especially through co-management arrangements. Stocking is also a common response to supplement stocks (Cowx, Funge-Smith and Lymer, 2015), but these and other fishery management tools are not likely to be sustainable unless the bottlenecks to natural production are addressed. Further, management of environmental issues and ecological integrity of the river form and function is likely to be more cost-effective in the long term. Opportunities to increase yield from floodplains and rainfed habitats should therefore be explored (see MRC, 2023), and include: improving habitat management and restoring critical habitats for fish; improving controls of fishing in deep pools to protect broodstock; reinstating fish passage across the many existing barriers in the LMB; improving the design of water-management structures; and creating refuges on floodplains. Rice-fish production systems, in particular, should receive a higher priority for habitat management to ensure sustainable fisheries production.

Overall, the 2020 assessment of the yield for the LMB is considered a reasonable reflection of the production from the system and exhibits a trend towards declining catches and catch rates. However, there is still a need to explore mechanisms to improve the robustness and accuracy of the assessment methodologies to ensure standardization of approaches and provide inputs into the management of fisheries resources in the LMB. These include the following:

- Novel methods to improve the accuracy of the habitat yield estimation, for example:
  - improving coverage of different habitat types to reflect major fishing zones;
  - improving accuracy of yield per habitat area using catch assessment and frame survey techniques, especially more detailed information about fishing gear efficiency and fishing effort.
- Other complementary sources of information within the MRC Core River Monitoring Network should be considered to improve the estimation, for example:
  - expand the scope of FADM in monitoring/analysing the trends in fish catch in relation to the hydrology and condition of the river;
  - integrate SIMVA surveys into the methodologies to provide more up-to-date information about fish consumption, market data and fishing communities.

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# ANNEXES

## ANNEX 1: QUESTIONNAIRE FOR HOUSEHOLDS/FISHERS AT MAJOR KEY HABITATS IN THE LOWER MEKONG RIVER BASIN

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

*Instructions for the interviewer.*

*A blank version of the questionnaire for the survey is provided separately.*

**HOUSEHOLD AND INTERVIEW DETAILS**

**Table 1.** Information of respondents (should interview person who oversees fishing activities). Example of filling information below:

| Name | Age | Gender[1] | No. of family members[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 in this table is 'occupation', which later helps to understand the family fishing activities and catches. The change of occupation from the last five years also elucidates some social aspects related to the catches and values. For example, in Mekong Delta, there are not many full-time fishers now since the catches have declined and the economic incentives from the fishing are much lower than other opportunities such as aquaculture or services.*

**Instructions** for the interviewer on how to fill in the questionnaire:

- [1] Gender: **M**: Male; **F**: Female
- [2] No. of family members: Number of family members who have physically lived in the house for last 12 months.
- [3] Occupation: **Full-time**: If total income in a year is >70% from capture fishing, including fish and OAAs, otherwise **Part-time or Occasional**.
- [4] Last 12 months: The interviewer could ask the HH's occupation in 2019 since the information in 2020 and 2021 could be biased due to the COVID-19 pandemic.

**1. FISHING GEARS**

**Table 2.** Fishing gears, habitats, relative effort and catches per year. (Example of how the information should be completed is provided)

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

***Purpose**: To provide information on gear efficiency, the habitat boundary where HHs fish, and on the likely most productive habitats. Fishers aim to utilize the most efficient gear and go to where they can get the most fish. Therefore, the information in this table will help to identify the likely habitat boundary where HHs fish and to understand and justify which habitat is likely the most productive.*

**Instructions**:

- [1]Most frequently used gear: order of the most frequently used gear, from the most frequent (First) to least frequent (Second, Third, Fourth).
- [2]Gear name: Refer to common gear types in the LMB in **Annex 2**. If a gear type is special, describe it or take photos of it, and take photos of some gears used in the field if possible.
- [3]Habitat: where the gear is used. Either use codes or habitat names below for input into the 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 type of gear divided by the total number of fishing days in a year. The interviewer should double-check to make sure that the total percentage of fishing days by gear type adds up to **100%.**
- [7]Percentage of catches: weight of catches using each type of gear divided by the total catches in a year. The interviewer should double-check to make sure that the total percentage of catches by gear type is **100%**.

## 2. FISH CATCH ESTIMATED BY THE HOUSEHOLDS

**Table 3.** Estimated fishing effort and **fish catches** from each habitat by the households 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. Multiplying this figure by the total number of fishers and then dividing it by area (hectare) of habitat will provide likely catch/yield per ha per year. Please double-check with habitat information in Table 2 to make sure that the habitat information is consistent.*

**Instruction:**

- [1]Most frequent habitat visited: order of the most frequent habitat visited, from the most frequent (First) to the least frequent (Second, Third, Fourth).
- [2]Habitat: where to go fishing. Either use codes or habitat names below for input into the questionnaires
  H1: Rainfed rice fields and associated habitats
  H2: Floodplain-large river
  H3: Reservoir
  H4: Brackish-water estuarine
- [3]Fishing days/month: The interviewer could ask the HHs for their 2019 fishing information because the information in 2020 and 2021 could be biased due to COVID-19. Encourage the HH/fisher to remember the number of fishing days each month. All MCs should use the sun calendar.
- [4]Catches (kg/day): Estimate the average kg of fish caught per day each month. The interviewer should take note and convert the local measuring unit into the standard unit of **kg**.
- [5]Catches (kg/month): Multiply the number of fishing days by the average daily catch to obtain the monthly catch. If the HH/fisher cannot remember the amount of catch per day, fill in the 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 | | | | | | | | | | | | T (kg/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 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) | | | | | | | | | | | | | |

**Instruction**: Same as fish catches in Table 3.

**Table 5.** Trend in catches, 2010, 2015 and 2019
Example of how to fill in the form is shown below

| Parameter | 2010 | 2015 | 2019 | Note |
|---|---|---|---|---|
| Catch of fish per year (kg) | 1000 | 900 | 1500 | |
| Catch of OAAs per year (kg) | 500 | 700 | 800 | |

***Purpose**: To understand the trend in fish catches in the area by comparing the catches in this survey with those of the previous survey. Discuss with the HHs their views on why the trend has increased or decreased. For example, the trend may decrease due to water quality or fewer fish, or it may increase due to fewer fishers in the area, etc.*

**Instruction**: The interviewer should ask the HHs/fishers to recall the amount of total catches of the household in each year. The year could be flexible, i.e. between 1 year before or after 2010, 2015, 2019. Please note down the information.

**3. MAIN SPECIES CAUGHT AND PRICES**

**Table 6.** Species caught, 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/individuals (<25 cm) | | | | | |
| 2. Medium-sized fish (25–50 cm) | | | | | |
| 3. Large-sized fish (> 50 cm) | | | | | |
| **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 share of catches sold and consumed, and the value of the different fish species and OAAs. This information could help obtain a rough estimate of the economic value of the fisheries in the LMB. The consumption data (Consumption = Total caught – Total sold) are obtained from the HHs catches; other consumption data are further discussed in Table 7.*

**Instruction**: [1]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) consumed[1]** | **Percentage from different sources[2]** | | | | |
|---|---|---|---|---|---|
| | Captured fish/OAAs | | Aquaculture | Meat | Others |
| | Caught by the HH | Bought by the HH | | | |
| | | | | | |
| | | | | | |

***Purpose**: This table aims to provide information on HH consumption from different kinds of animal protein sources. The table should help to roughly estimate the consumption of fish/OAAs (kg/HH/week). Multiply the quantity of animal protein consumed per week by 52 to obtain kg of fish/OAAs/HH per year. The interviewer should discuss the resulting data with HHs to verify whether he consumption of fish/OAAs (kg/HH/year) seems reasonable to them. This figure could be double-checked later with national consumption survey data, which the survey team should collect from the country's national statistical office. The entire study is based on the assumption that total catch from inland capture fisheries was consumed in the LMB, so that the information from this table could be used to justify the yield of fish in the LMB.*

**Instruction**:

- [1]Estimate roughly how many kg of fish and OAAs the family consumes in a week.
- [2]Estimate the percentage of the animal protein from different sources consumed in a week.

**Toolbox 2: Questionnaire for fisheries management officers at selected provinces for the HH interviews in the LMB**

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

## 1. OFFICER INFORMATION

**Table 1**: Information of respondents
Example of how to fill in the information below.

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

## 2. USAGE, IMPORT, EXPORT AND AQUACULTURE

**Table 2:** Information on the **usage of captured inland fish and OAAs in each MC in the LMB**
Example of how to fill in information below:

| Fishery products[1] | Usage of captured inland fish and OAAs from within country [2] | | | | | | Import quantity and country of origin | |
|---|---|---|---|---|---|---|---|---|
| | Quantity (tonnes) [3] | Human consumption % | Aquaculture feed % | Animal feed% | Others % | Export % | Import (tonnes) [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** | | | | | | | | |

**Instruction**: 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 feeds (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 fishery products.
[2] Usage: Percentage (%) of usage of the fishery products; these data can be obtained from country sources.
[3] Quantity (tonne): These data can be obtained from the economic statistical office and indicated in % of usage for each purpose, including human consumption, aquaculture feeds, animal feed, export, etc.
[4] Import: The quantity of tonnes of each product that is 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 field are converted into aquaculture ponds. The information from this table will help exclude these areas and production from the capture fisheries estimate, i.e. actual area of habitats used by wild fish and actual captured fisheries production.*

**3. OTHER INFORMATION RELATED TO THE IMPORT AND EXPORT OF INLAND FISHERIES AND OAAS**

**4. LIST OF INFORMATION THAT MUST BE COLLECTED AT THE PROVINCES SELECTED FOR THE HH INTERVIEWS**

- Geographical data and information on the survey sites (province and district surveyed).
- Detailed information on demographics and HH members' occupations at the survey sites (province and district surveyed)
- Other economic activities related to aquaculture and capture fisheries
- The importance of capture fisheries and fish products to food security, livelihoods and the local economy
- Information from the national expenditure and consumption survey.

**Toolbox 3: Open-ended questions to be used in group discussion with households/fishers**

*Instructions for the interviewer.*

*A black version of questionnaire for the survey is provided separately.*

Instructions: The purpose of the group discussions is to validate the results from the household survey and reflect on different perspectives that would not be recorded during household/fisher interviews. Basically, the groups will be asked the same questions as in Toolbox 1 and 2. The questions below are just general guidelines. The interviewers are encouraged to come up with any questions to deepen understanding about fish and fisheries in the area.

1. **Fishing gear**
   - What is the most popular fishing gear used in your areas in dry or wet seasons and in different habitat types?
   - 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 (2019 can be used if the fishing in 2020 and 2021 was interrupted by COVID-19)**.
   - What is the range of HH fish catches (**kg/month and kg/year**)? What are the months with the most and with the least catches? In which habitats are they caught (H1, H2, H3 or H4)?
   - What is the likely fish yield (**kg/month/ha and kg/year/ha**) in each habitat (H1, H2, H3 or H4)?
   - What is the range of HH OAA catch (kg/month and kg/year) ? What are the months with the most and with the least catch? In which habitats are they caught (H1, H2, H3 or H4)?
   - What is likely PAA yield (**kg/month/ha and kg/year/ha**) 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 last 12 months**

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

**Instructions:** [1]Key species name: 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 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 a week.

[2]Estimate percentage of the consumption of fish and OAAs a week from different sources.

6. Do villages export fresh fish and OAAs to other countries? Discuss further with villagers.
7. Are there any fishing regulations applied in your fishing grounds? Describe the fishing regulations.
8. How often do you encounter law enforcement regarding fishing regulations? How do they operate?

## ANNEX 2: COMMON GEAR TYPES IN LMB

| Code | International Name | in Cambodia | in Lao PDR | in Thailand | in Viet Nam |
|---|---|---|---|---|---|
| 2 | Bag net liked gillnet | | | มองอู่/ข่ายถุง | |
| 3 | Barrage | ផ្នះ | | | |
| 10 | Brush bundle filled in a basket trap (Brush Bundle Basket) | ឈ្នាងត្រាំ | ຂາ | ขา/กร่ำ/เย๊าะ/ส้อมกร่ำ | Chà mùng |
| 13 | Cast Net | សំណាញ់ | ແຫ | แห | Chài quăng |
| 20 | Deep Drag Net (Trawl) | នាម | | | |
| 22 | Eel clamp | កង្ហារត្រីឆ្លួញ | | | |
| 37 | Giant Lift Net | ឈ្មក់ | ກະດຸ້ງໃຫຍ່ | | Vó cất |
| 38 | Giant wedge cone trap | លាយយក្ស | | | Lợp đứng |
| 39 | Gillnet: Drifting gillnet | មងបណ្តែត | ມອງໄຫຼ | | Lưới rê trôi |
| 40 | Gillnet: Drifting gillnet-2 layers net | មងបណ្តែត ២ ស្រទាប់ | | ตาข่าย/มองไหล 2 ชั้น/ข่ายไหล 2 ชั้น | Lưới rê trôi 2 lớp |
| 41 | Gillnet: Drifting gillnet-3 layers net | មងបណ្តែត ៣ ស្រទាប់ | | ตาข่าย/มองไหล 3 ชั้น/ข่ายไหล 3 ชั้น | Lưới rê trôi 3 lớp |
| 42 | Gillnet: Drifting gillnet-at bottom | មងបណ្តែតនៅបាត | | ตาข่าย/มองปลิว(พื้นน้ำ)/ข่ายไหล(พื้นน้ำน้ำ)/ไหลโขง(พื้นน้ำ) | Lưới rê trôi tầng đáy |
| 43 | Gillnet: Drifting gillnet-at surface | មងបណ្តែតនៅផ្ទៃលើ | | ตาข่าย/มองปลิว(ผิวน้ำ)/ข่ายไหล(ผิวน้ำ)/ไหลโขง(ผิวน้ำ) | Lưới rê trôi tầng mặt |
| 44 | Gillnet: Encircling gillnet | មងក្រឡុក | | | |
| 45 | Gillnet: Stationary gillnet | | ມອງແຊ່ | | Lưới rê cố định |
| 49 | Hand-dragged seine net | អួនអូសដៃ | | | |
| 52 | Handle scoop net | រើកត្រីកាំផ្លៀរ | ສະຫວິງ | | Đẩy xiệp |
| 53 | Hit gillnet | | ມອງຕີ, ມອງໄວ | ข่ายไล่/มองกวด | |
| 55 | Hook and line | សន្ទូចបង្គៃ | ເບັດປັກ | | Câu cấm |
| 72 | Lift net | ផ្នង | ກະດຸ້ງ | | Vó |
| 76 | Long handle scoop basket | ឈ្នាងចាក់បណ្តោយ/ឈ្នាងកងត្រីផ្នោង | | | |
| 79 | Long line, bottom set | | | เบ็ดราว(พื้นน้ำ)/เบ็ดหยั่ง | |
| 101 | Scoop net | | ສະຫວິງ | | Te |
| 105 | Seine net | | ດາງກວາດ | อวนทับตลิ่ง | Lưới rùng bãi |
| 111 | Spear | ស្នរ | ແຫຼມ | แหลน/ส้อม/ฉมวก | Chĩa |
| 115 | Trammel net | | | | Cào |
| 150 | Trap | | | | |
| 159 | Water pumping | បូមជាចបូមទឹកជាចទឹក | ມຸດນ້ຳ | | Tát đìa |
| 160 | Other | | | | |

## ANNEX 3: LIST OF COMMON SPECIES IN LMB

| FAO English Name | Scientific Name | Species Code | Photo page no. |
|---|---|---|---|
| African sharptooth catfish | *Clarias gariepinus* | 180 | 27 |
| Beardless barb | *Cyclocheilichthys apogon* | 1139 | 29 |
| Black sharkminnow | *Labeo chrysophekadion* | 58 | 49 |
| Black spotted catfish | *Hemibagus spilopterus* | 84 | 41 |
| Butter catfish | *Ompok bimaculus* | 98 | 62 |
| Climbing perch | *Anabus testudineus* | 123 | 12 |
| Common carp | *Cyprinus carpio* | 19 | 30 |
| Giant featherback | *Chitala topis* | 142 | 23 |
| Giant gourami | *Osphronemus goramy* | 127 | 63 |
| Glass catfish | *Kyrptopterus* spp. | 95 | 48 |
| Goonch | *Bagarius bagarius* | 91 | 15 |
| Hampala barp | *Hampala barp* | 51 | 39 |
| Indonesia snakedhead | *Channa micropeltes* | 129 | 22 |
| Java Barb | *Barhonymus gonionotus* | 39 | 17 |
| Long pectoral -fin minnow | *Macrochirichthys macro chirus* | 13 | 55 |
| Malayan leaffsh | *Pristolepis facista* | 122 | 78 |
| Mozambique tilapia | *Orechromis mossambicus* | 1560 | 64 |
| Nile tilapia | *Orechromis niloticus* | 137 | 65 |
| Nilem carp | *Osteochilus* spp. | 66 | 65 |
| Red fin bargus | *Hemibagus wyckioides* | 87 | 23 |
| Red-tail tinfoil barb | *Barhonymus altus* | 40 | 17 |
| Royal knifefish | *Chitala blanci* | 4 | 69 |
| Silver barb | *Barbonymus gonionotus* | 39 | 17 |
| Striped catfish | *Pangasianodon hypophthalmus* | 104 | 69 |
| Striped snakehead | *Chana striata* | 128 | 23 |
| Tinfoil barb | *Barbonymus schwanenfeldii* | 38 | 17 |
| Torpedo-shaped catfish nei | *Clarias* spp. | 116 | 26 |
| Walking catfich | *Clarias sp. (batrachus)* | 116 | 27 |
| | *Osteochilus* spp. | 70 | 65 |
| | *Osteochilus* spp. | 66 | 66 |
| | *Osteochilus* spp. | 68 | 66 |
| | *Osteochilus* spp. | 1824 | 67 |
| | *Hemibagus filamentus* | 1330 | 39 |
| | *Hemibagus capitulum* | 4016 | 39 |

*Note: To support identification please refer to "Photos of common fishes in the Lower Mekong River Basin, Fisheries Programme, MRC, June 2016.*

## ANNEX 4. ESTMATES OF AERIAL YIELD AND BLACKFISH YIELD PROPORTION FROM RICE FIELDS AND FLOODPLAINS (FROM HALLS 2010; HORTLE 2015)

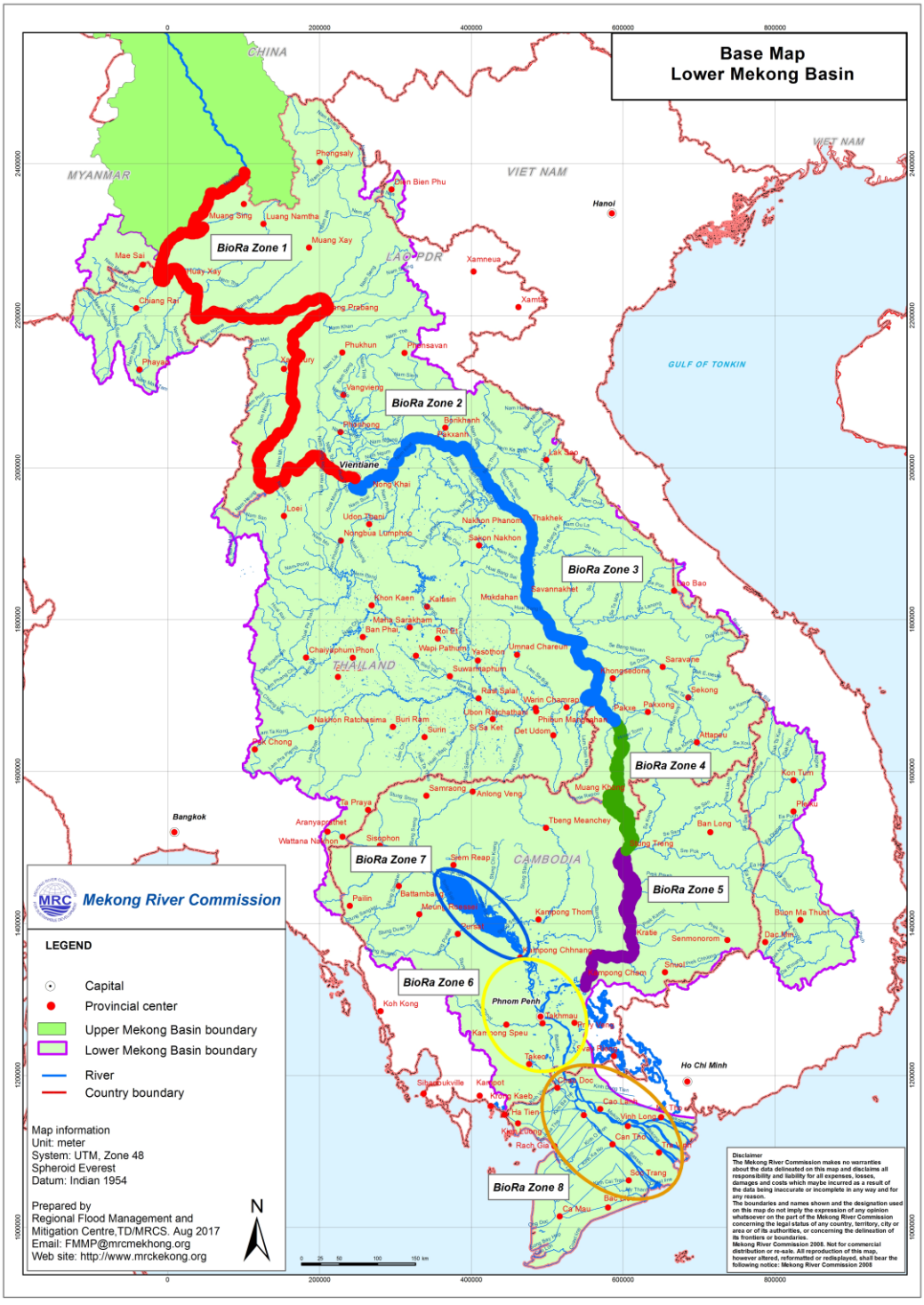
| Country | Location | Habitats | Flooded, Irrigated or Rainfed? | Stocked? | Yield all (kg/ha/yr) | Yield fish (kg/ha/yr) | Mid-range fish yield (kg/ha/yr) | Fish | OAA | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Cambodia | Battambang | Rice fields, single crop | Rainfed (and flooded) | 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 Laos | 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) |
| Vietnam | Hanoi (L) | Rice fields | Irrigated | Y | 52 | 44 | 44 | 0.84 | | Amilhat et al. (2009) |
| Vietnam | Phu Xuyen (U) | Rice fields | Irrigated | Y | 151 | 127 | 127 | 0.84 | | Amilhat et al. 2009) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cambodia | Tonle Sap | Floodplain, ricefield and perm. w/bs | Flooded | N | 243–532 | 310 | 310 | 0.8 | | Dubeau |
| Cambodia | Tonle Sap | Entire floodplain | Flooded | N | | 230 | 230 | | | Baran et al. (2001) cited by Hortle & Penroong (2009) |
| Cambodia | Tonle Sap | Entire floodplain (1995–1999) | 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) |
| Vietnam | Mekong Delta | Floodplain rice fields | Flooded | ? | 42–63 | 25 | 30 | 0.47 | 0.53 | de Graaf & Chinh (2000) cited by Hortle & Suntornratana (2008) |
| Vietnam | 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) | Floodplain | Flooded | N | | 104–130 | 117 | | | Halls et al. (1999) |
| Bangladesh | Tangail | Floodplain and perm. w/bs | Flooded | N | | 165 | 165 | | | De Graaf et al. (2001) |
| Bangladesh | Tangail | Floodplain | 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 FISH ABUNDANCE AND DIVERSITY MONITORING 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 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)* |

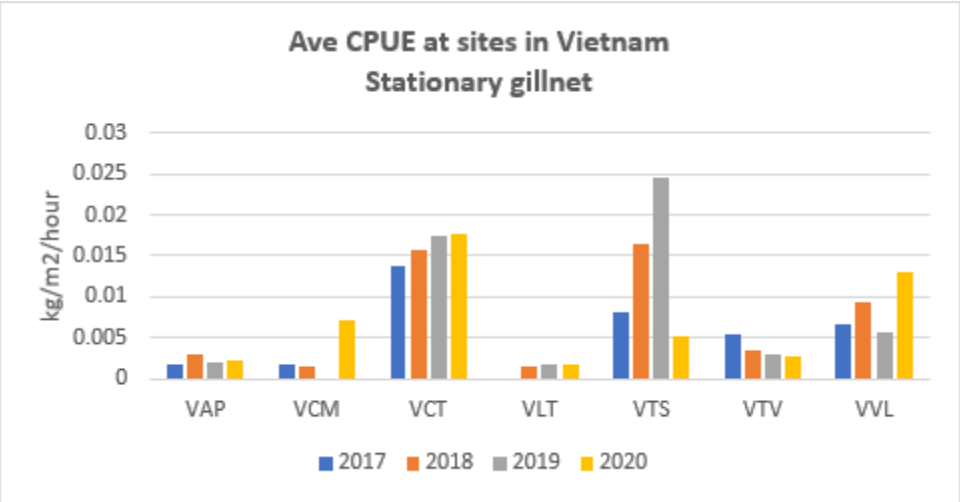
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | Lao PDR | Champasak | Khong | | Hangsadam | Mekong mainstream | 13°56'8.04" | 105°57'31.84" | 3 | LARReC | New (2017-21)** |
| 27 | Thailand | Loei | Chiang Khan | | Ban Noy | Mekong mainstream | 17°54'38.64" | 101°41'45.81" | 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 |

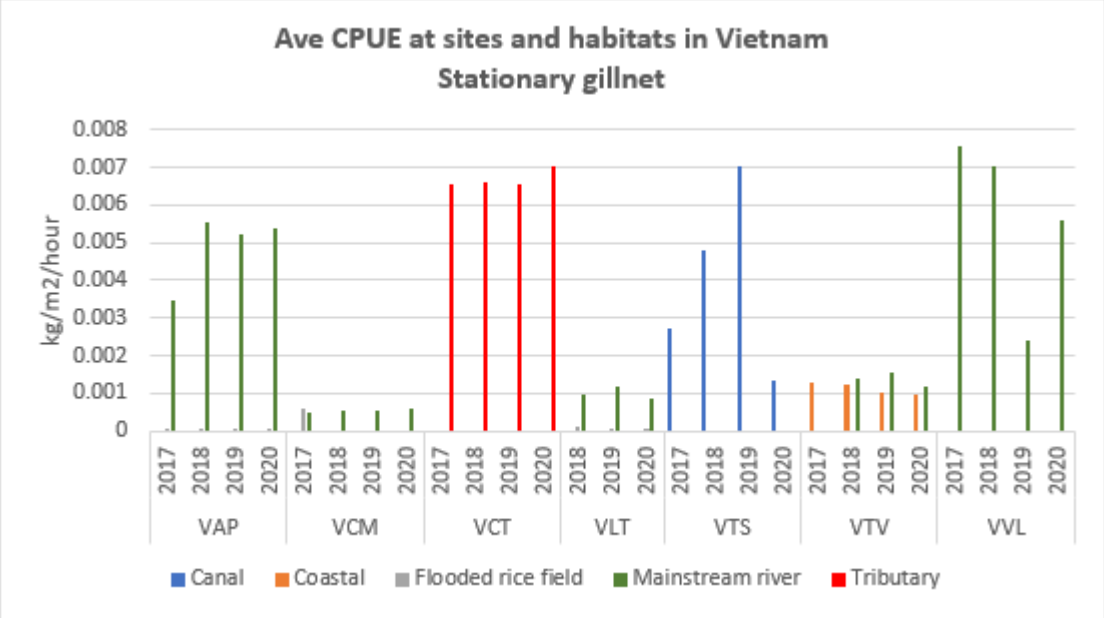



**Note:** * represented non-operated sites and ** represented newly selected sites in 2017

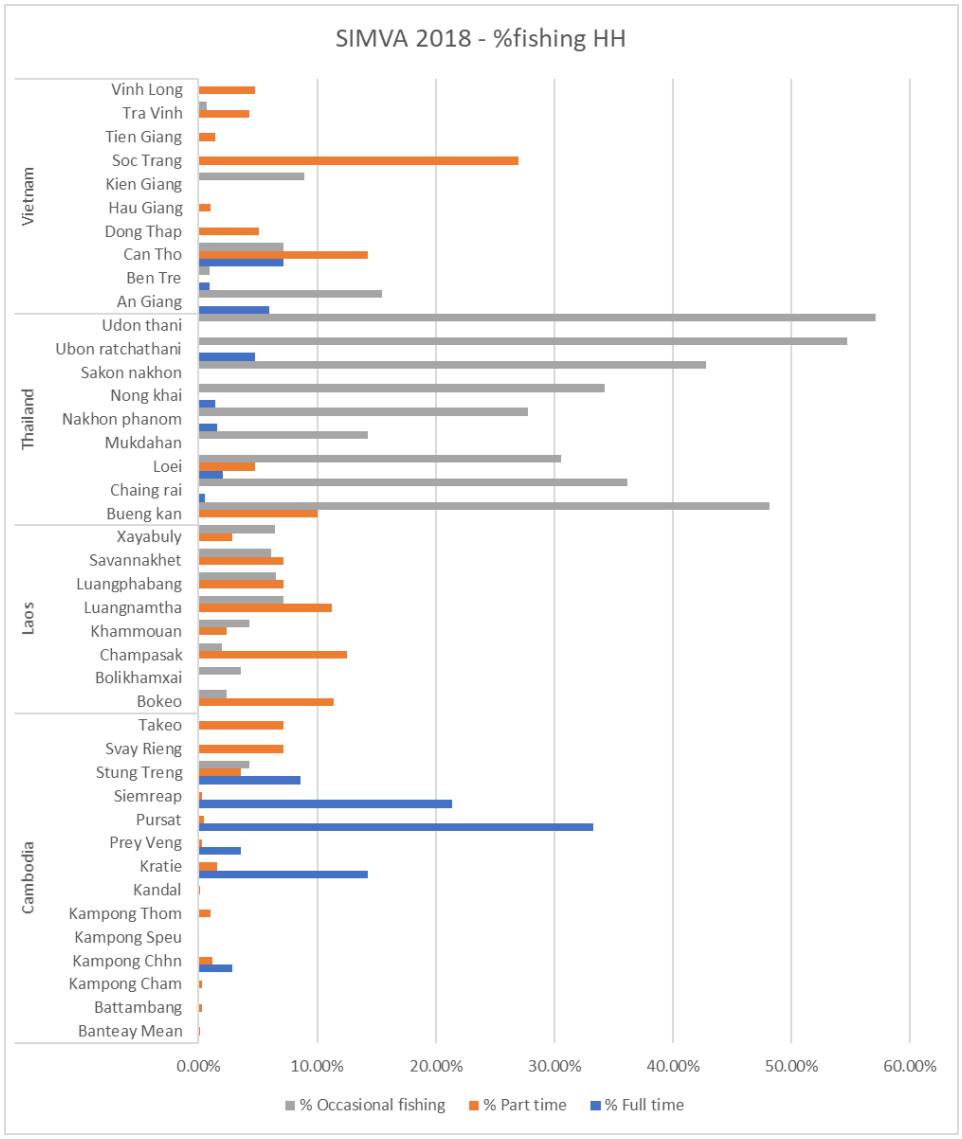
## ANNEX 6. SUPPLEMENTARY SUPPORT DATA

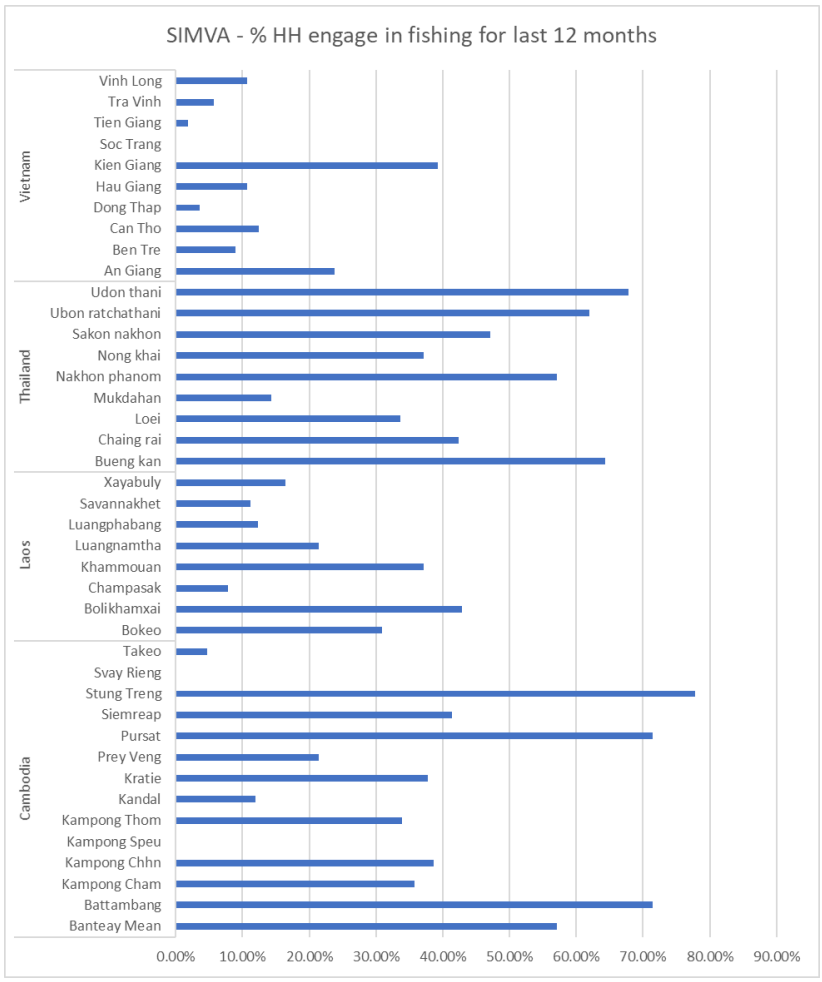
FADM



SIMVA


SIMVA 2018 - %fishing HH
Vietnam
Vinh Long
Tra Vinh
Tien Giang
Soc Trang
Kien Giang
Hau Giang
Dong Thap
Can Tho
Ben Tre
An Giang
Thailand
Udon thani
Ubon ratchathani
Sakon nakhon
Nong khai
Nakhon phanom
Mukdahan
Loei
Chaing rai
Bueng kan
Laos
Xayabuly
Savannakhet
Luangphabang
Luangnamtha
Khammouan
Champasak
Bolikhamxai
Bokeo
Cambodia
Takeo
Svay Rieng
Stung Treng
Siemreap
Pursat
Prey Veng
Kratie
Kandal
Kampong Thom
Kampong Speu
Kampong Chhn
Kampong Cham
Battambang
Banteay Mean
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
% Occasional fishing
% Part time
% Full time


SIMVA - % HH engage in fishing for last 12 months
Vietnam
Vinh Long
Tra Vinh
Tien Giang
Soc Trang
Kien Giang
Hau Giang
Dong Thap
Can Tho
Ben Tre
An Giang
Thailand
Udon thani
Ubon ratchathani
Sakon nakhon
Nong khai
Nakhon phanom
Mukdahan
Loei
Chaing rai
Bueng kan
Laos
Xayabuly
Savannakhet
Luangphabang
Luangnamtha
Khammouan
Champasak
Bolikhamxai
Bokeo
Cambodia
Takeo
Svay Rieng
Stung Treng
Siemreap
Pursat
Prey Veng
Kratie
Kandal
Kampong Thom
Kampong Speu
Kampong Chhn
Kampong Cham
Battambang
Banteay Mean
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%

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