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Dried fish in Cambodia: Literature review

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Abstract

The literature reviewed in this report clearly identifies the role of processed fish in Cambodia as an important livelihood option, especially for the poorer segments of the population and women; as an important contributor to food security and nutrition; and as a cultural preference. This body of work is fragmented, however, as it does not focus specifically on the processed fish sector. Research that is directly about fish processing in Cambodia is marked by a focus on technical analysis, including the chemical composition of processed fish and the methods followed in processing fish paste and fermented fish. Some studies that analyze the fisheries sector more generally have included discussions of the processed fish sector, addressing a variety of themes – socio-economic conditions; culture; ecology and environment; nutrition; food security and food safety; and policy and governance.

Introduction

Southeast Asia produces and consumes the greatest quantity and variety of fermented fish in the World. Fermented fish is an important regional specialty, with the centre of production located around the Mekong Delta region [1]. Fermented fish products are indispensable to economically poorer populations throughout Southeast Asia [2]. In Cambodia, consumption of fermented freshwater fish and fish sauce remains an important part of the daily diet [3], and fish processing enables a continuous supply of protein [4], especially for children and the elderly [5].

Historically, fish processing and trade have not only been significant contributors to Cambodia's economy, but also to its culture and heritage, as shown by archeological findings and the depiction of fishing related scenes in the region's ancient temples [6]. In the early 21st Century, with permanent and seasonal wetlands covering 30% of the land mass of the country, Cambodia has one of the world's largest and most diverse freshwater fisheries, following China, India, and Bangladesh [7].

While the contribution of both marine capture fisheries and aquaculture to Cambodia's fishing industry has increased over the years, the freshwater sector continues to dominate fisheries in Cambodia, with most fishing activities taking place along the Mekong basin and in Tonle Sap Lake. Freshwater capture fisheries are the best documented of these sectors [8], followed by aquaculture [9] and marine fisheries [10]. Published research indicates that the Cambodian fishing industry comprises a range of scales, from small-scale or seasonal subsistence fishers to private companies that engage in fish exports. Small-scale family based fishing occurs almost without interruption throughout the year, although in general the peak fishing season for all types of freshwater fishing is from October to February/March [11].

While data and studies exclusively focusing on Cambodia's fish processing sector are limited, a partial and somewhat fragmented picture of this sector can be obtained from literature on fisheries in general, covering socio-economic, ecological, nutritional, and policy and governance angles. The present review of secondary literature is an attempt to synthesize these studies, in conversation with each other where possible, to understand what we know and what we need to know about the Cambodian processed fish sector.

Fisheries provide an important livelihood for the poor, with an estimated 6 million people in Cambodia working as permanent, temporary, or seasonal employees in both harvesting and processing activities [12]. Further, fisheries enhance food security [13], and contribute 75% of the annual protein intake of Cambodian households and 70% of the annual intake of Vietnamese households (living in Cambodia) are from fish [14]. As per the *Strategic Planning Framework for Fisheries 2010-2019* [15], Cambodia's trade and exports of fish have declined steadily from 52,500 tonnes in 2002 to 25,000 tonnes in 2008. Fisheries contribution to GDP is estimated to be 8-10% through landing, harvesting, processing and trade and, according to the *National Strategic Development Plan 2014-2018* [16], the projected real GDP contribution of fisheries for the period 2014-2018 stands at 4.7%. However, given the absence of a systematic assessment of fish prices, the GDP contribution of fish in Cambodia is believed to be undervalued by observers [17], and may be closer to 10% [18].

According to the *Strategic Planning Framework for Fisheries 2010-2019*, the main challenges that face the fisheries sector include declining wild fish stocks due to climate change, pollution, mining sediment, damming, deforestation and land conversion; increasing pressure on stocks due to population growth; increased international trade competition and tighter import regulations; uncontrolled, illegal and destructive fishing; disease in aquaculture; and loss of land for fishing due to weak land management. Both the *Framework for Fisheries* and the *Strategic Development Plan* identify a range of ac-

tivities – including conservation efforts – to strengthen the sector, as discussed below.

A few studies, focusing on the inland water sector, have highlighted the importance of post-harvest or processing activities as an important supplementary livelihood option – especially for poorer households, women, and children. This economic activity is shaped by the open access nature of Cambodia's fisheries [19], and by the fact that subsistence fishing takes place almost throughout the year. Unfortunately, there is a complete lack of research or analysis on marine fish based processed products and their relative contribution to the processed fish sector in Cambodia.

In terms of government policy, post-harvest activities and trade constitute one of the three pillars around which the Strategic Planning for the Fisheries Sector was designed; national policy stresses the need for improving quality and enhancing access to markets for processed products (see below). The *Strategic Development Plan* does not focus on the post-harvest fisheries sector.

However, there are no comprehensive studies that analyse the diverse fish-based products in Cambodia along their respective or interlinked value chains, including trade. Significant knowledge gaps remain on the questions of who engages in fish processing and what socio-economic changes have had an impact on them; the proportion of fish supplied by different types of fishing (wild capture freshwater, aquaculture, and marine fisheries); who supplies processors and from where; what seasonal variations occur in the fish processing industry; how fish workers' labour is shaped by demographic shifts, migration histories, and livelihood security concerns; what local and international marketing routes shape the circulation of fish products; and how prices change at different steps of value chains. Further, there are no comprehensive and contemporary analysis of the cultural and nutritional dimensions of processed fish in Cambodia.

This literature review first presents the types of processed fish in Cambodia, their geographic concentrations, estimated volumes of

production and proportions consumed and sold. Next it presents a brief historical overview of processed fish consumption in Cambodia, followed by an overview of the socio-economic characteristics of processors, including gender dynamics. This is followed by a review of studies focusing on value chain analysis in Cambodia, starting from fish sourcing, to processing, trade, exports, and consumption. A value chain analysis of prahoc (fish paste) is provided as a separate section from the general value chain studies, given the prominence of fish paste in published literature. Next, the review focuses on the nutritional and food security related values of processed fish, followed by an analysis of published literature on relevant policies and challenges to the sector. The review concludes by drawing out highlighting gaps and drawing out specific research questions to be addressed in the next steps of the Dried Fish Matters project.

Types of processed fish in Cambodia

Cambodians produce and consume a wide range of processed fish products. **Trey ngeat** (salted sun-dried fish), **trey cha'eur** (smoked fish), **pa ork** (fermented fish with sticky rice) or **yahe** (fermented shrimp), **prahoc** (fish paste), **mam** (fermented fish with roasted rice powder), **kappik** (fermented shrimp paste), **tak/tuk trey** (aged fish sauce), and **tud try** (non-aged fish sauce) are important condiments in Cambodia [20].

Fish processing has seasonal variations in Cambodia as it is closely follows the fresh fish supply, which in turn is shaped by monsoons. During the floods fish are dispersed, whereas during the dry season - when fish migrate to the main canals and the rivers - capture efficiency is much higher, producing the bulk of fresh fish available for fermentation [21].

Figure 1. Map of Cambodia, showing the location of principal inland fishery areas Tonle Sap Lake (centre) and Mekong (North-East). Source: Wikimedia Commons.

There are no studies that provide a comprehensive analysis of all types of processed fish products, the species used, volume of production by type by region, or the proportion or number of households that engage in processing in Cambodia. Nonetheless, some data are provided by sample surveys. Ahmed et al. [22], drawing on a 5117-household sample covering 83 communes and 51 fishing districts in eight provinces, report that 9% of surveyed households engaged in fish processing. Hap and Johnstone [23] offer an estimated ranking of fish species used for processing and the extent of consumption of five major fish products (Table 1), drawing on meetings with fishers, fish farmers, processors and traders in five provinces, eight districts, 11 communes and 12 villages. According to Hap and Johnstone's estimates, prahoc (fish paste) is the most common type of fish product in Cambodia, closely followed by salted and dried fish. While providing valuable data, this study unfortunately does not provide details on the extent of commercial production.

Table 1. Community involvement in fish product processing and top species used. Consumption rates are given as a percentage of households. Source: Hap and Johnstone [24].

Type of Product	Principal Fish Species	Consumption (%)	Remarks
Fish paste	Riel, Ross, Kompleanh, Chuntul phluk, Chrakeng	95	Produced for sale and household consumption
Salted dried fish	Proma, Pra, Snakehead, Giant snakehead, Phtong	80	
Smoked fish	Riel. Phtong, Chrova mul, Sleuk reusey, Chuntul phluk	20	Mostly for household consumption
Fermented fish	Po, Pra, Kralong, Chrakeng, Chakok	15	
Mam	Bandol ampeuo, Giant snakehead, Chun lounh moan, Chhviet, Snakehead	5	

More recently, Mousset et al. [25] have published results of a survey focusing on household welfare, covering 37 villages and 655 households in the Tonle Sap and Upper and Lower Mekong regions - representing potentially 3.7 million inhabitants - indicating the volume of fish processed, consumed, bartered, and sold, along with net household incomes. According to this study, salted fish is the most commonly produced in terms of volume, followed by prahoc. However, most salted fish is consumed domestically, whereas prahoc ranks highest by volume sold (Table 2).

Table 2. Fish processing- average annual production and net income per household. Source: Mousset et al. [26]

Type of product	Qty. processed (kg)	Qty. consumed (kg)	Qty. bartered (kg)	Qty. sold (kg)	Income (USD)	Cost (USD)	Net income (USD)
Prahoc	18.9	11.9	1.6	5.1	15.8	5.7	10.2
Smoked fish	2.7	1.5	0.2	0.9	4.2	0.8	3.4
Fermented fish	5.6	3.7	0.7	1.1	3.6	2.6	0.9
Fish sauce	3.5	2.6	0.4	0.5	1	0.5	0.5
Dried fish	4.3	3.1	0.4	0.7	3.7	5.3	-1.5
Salted fish	24.1	21.8	0.6	1.6	6.3	29.2	-22.9

In contrast, a study by Rab et al. [27], based on a 410 household sample in Kandal, Siem Reap, and Kampong Chhnang, shows that prahoc ranks only third in terms of volume of production, after semi-processed prahoc and smoked fish (Figure 2-Figure 4). More importantly, when these figures are compared with production volumes reported by Mousset et al. [28], there appears to have been a significant, overall decline in fish processing in the span of 10 years. Two questions arise from this trend. First, what secondary income sources are Cambodian households employing to fill the gaps caused by the reduced production of marketable fish products? Second, what are the implications for food security and nutrition?

Mousset et al. [29] find that the households with very high dependency on fisheries around the Tonle Sap make the highest profits from fish processing (63 USD per year), while households across the entire surveyed area reporting a loss of 9.40 USD per year. However, of the average total annual production, 76% is produced only for domestic consumption. Further analysis of profitability, and costs associated with processing are provided in section on processed fish trade below. In terms of net income by product, prahoc generates the highest returns, at 10.2 USD per annum per household, with salted fish incurring a loss of 22.9 USD per annum (Table 2).

Geographically, processed fish is largely produced in areas where fresh fish is abundant: around Tonle Sap Lake and to a lesser extent in the Upper and Lower Mekong areas, for freshwater fish, and along the coastline for marine fish-based products. Of the three provinces studied by Rab et al. [30], households in Kandal processed almost double the proportion of their fish catch compared to households in Siem Reap. (See “Fish processing” below for further details.)

The study by Mousset at al. [31] provides an analysis of geographical variations in fish processing for three agro-ecological zones. According to this study, households process a certain proportion of their fish catch, across all the agro-ecological zones around the Tonle Sap and the Mekong in Cambodia, as the graph below shows (Figure 6). Ac-

cording to this study 18% of the total catch was processed whereas Rab et al. [32] report only 8% of the total catch as being processed.

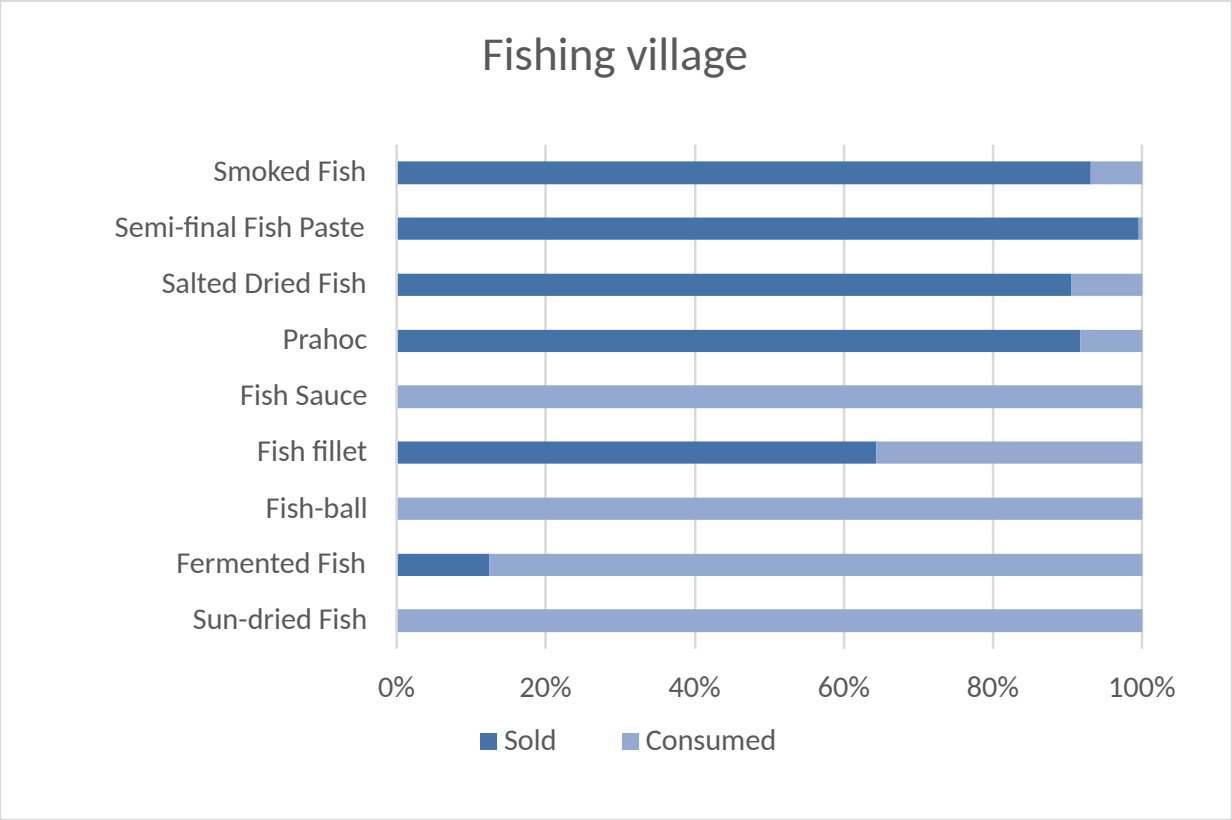

Figure 2. Average proportion of fish product sold and consumed per household by product type, fishing village type, in 2002-2003. Source: data from Rab et al. [33]

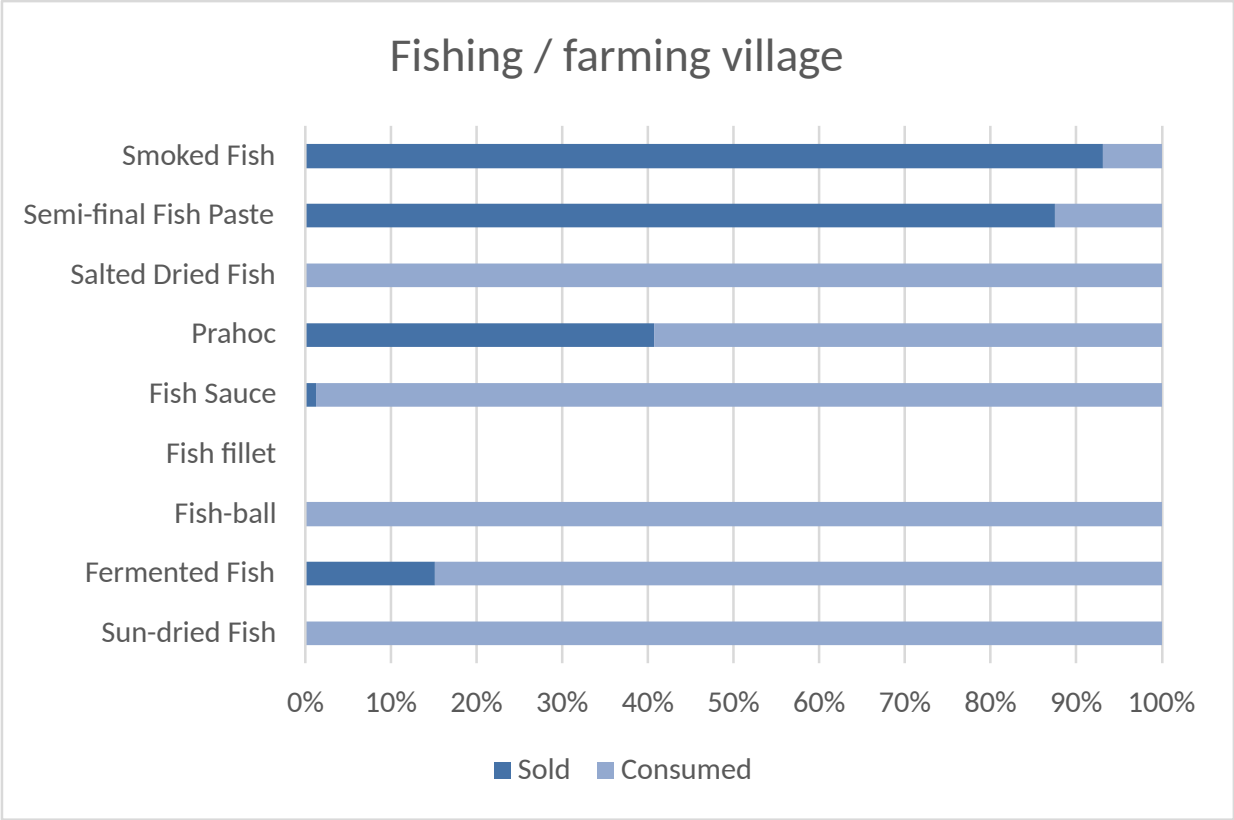

Figure 3. Average proportion of fish product sold and consumed per household by product type, fishing/farming village type, in 2002-2003. Source: data from Rab et al. [34]

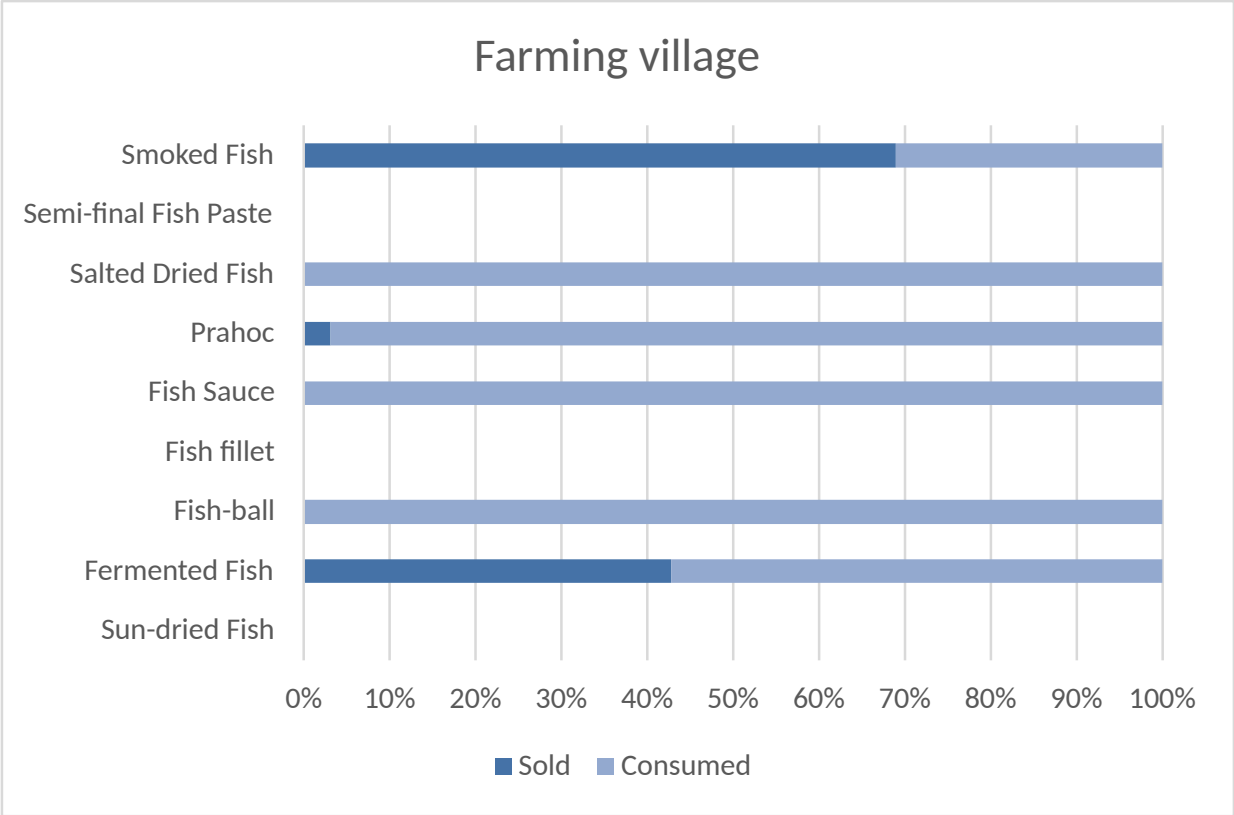

Figure 4. Average proportion of fish product sold and consumed per household by product type, farming village type, in 2002-2003. Source: data from Rab et al. [35]

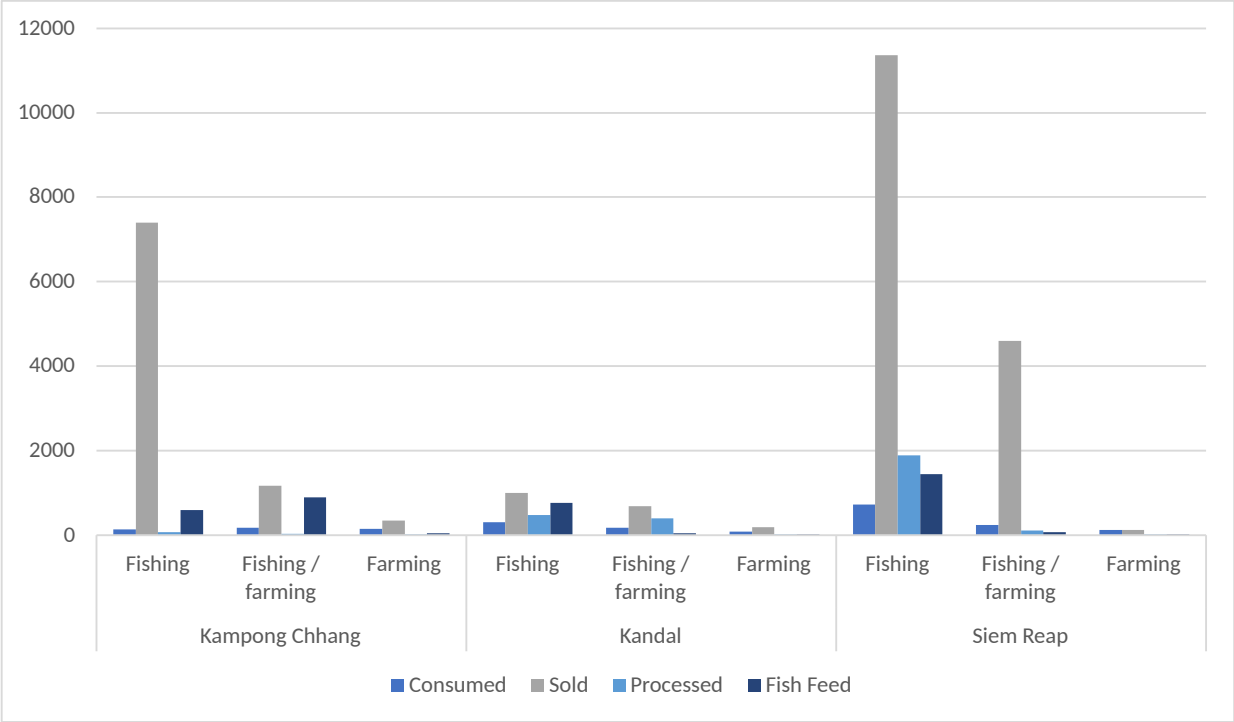

Figure 5. Average catch and utilization (kg) of fish per household by village type in each province during the fishing year (2002-2003) Source: data from Rab et al. [36]

According to the figures presented by Mousset et al., Lowlands households process a higher quantity of fish compared to households from the other two regions, while also processing the highest proportion of their fish catch; households living around the Tonle Sap process the lowest proportion of their catch. The authors do not provide explanatory reasons for this trend, although one could surmise that a combination of factors such as historically established market linkages and better fresh fish preservation techniques, combined with relatively good transport infrastructure and connectivity may have resulted in the households around Tonle Sap selling a larger proportion of the fish that they catch (less than 5% of the respondents of this survey had reported engaging in aquaculture) as fresh fish rather than processing. However, we do not have a comprehensive source of data or analysis on the different volume of processed fish in Cambodia by province, including the coastal regions.

The production cycles for the different types of products vary. Sinh et al. [37], analysing Snakehead fish processing, find that the drying

process happens on a two-day cycle, occurring on average 126.4 times per year, while the fermenting or making of fish paste happens only twice per year, with a production cycle of 90 days. Apart from this study, we found no other research that systematically documents the fish processing cycles in Cambodia.

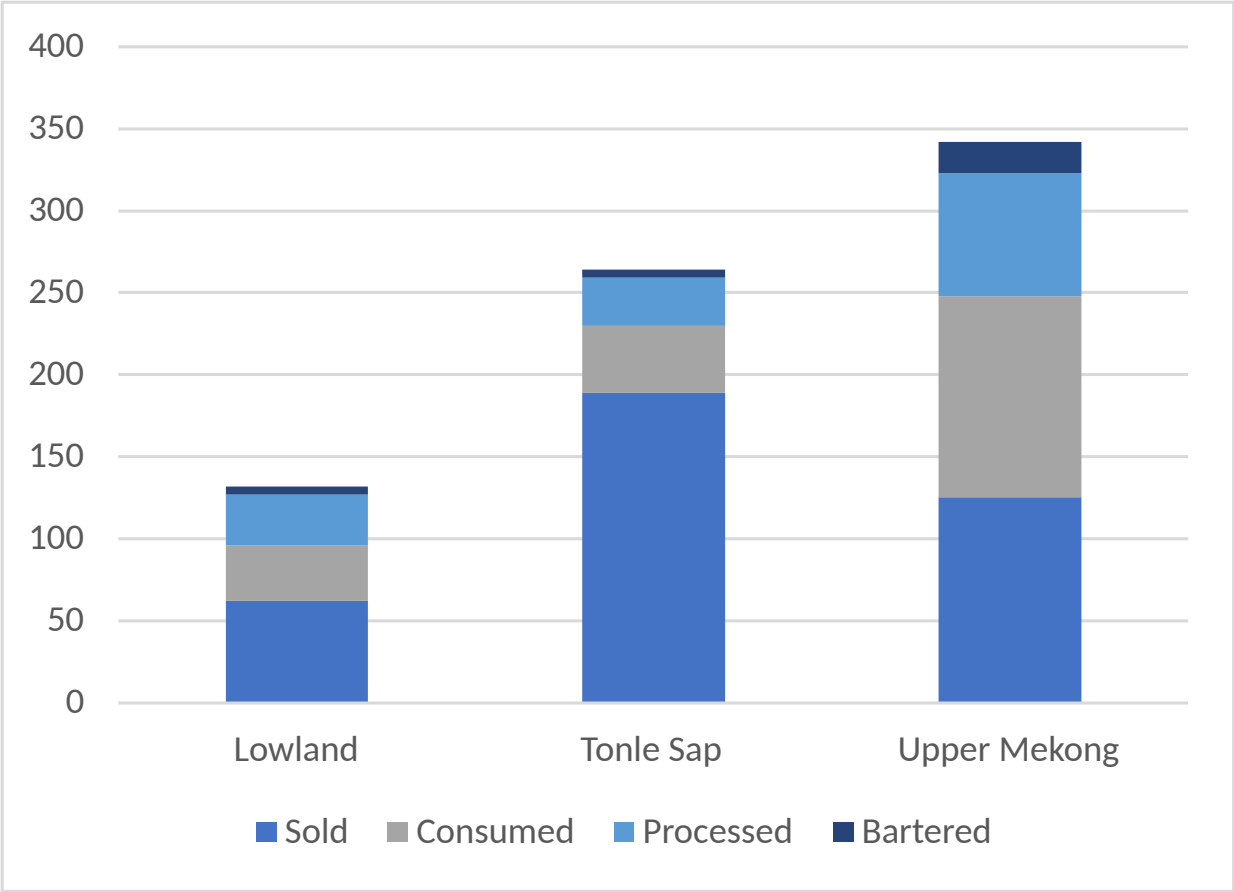

Figure 6. End uses of harvested fish in capture fishery value chains, by agro-ecological zone, by kg/household per year. Source: data from Mousset et al. [38]

Historical overview

Among processed fish products, dried fish and fermented fish have historically received the most scholarly attention. A paper published by the Royal Anthropological Institute of Great Britain and Ireland in 1868, entitled "Notes on Cambodia and its Races", states that "the food of the Cambodians consists chiefly of rice and dried fish" and "they do not appear to be great hunters" [39]. The same paper mentions a temple bas-relief depicting fish and fishing equipment, as well as describing a religious ritual that included offerings of rice and dry fish. The descriptive passage from this text provides brief glimpse into life on water, catching fish, salting, and drying fish, and trade in the mid-19th century:

In fishing they use the net, the spear, and the line and bait. That the use of the line and bait among the Cambodians is as old as their stone temples, is shown in one of the bas-reliefs in Makon Wat, where a river containing fish is represented. There is a boat above, and a figure in the stern dropping a small line, which appears to be attracting the fish below... In these lake villages there are many Cochin Chinese and a few Cambodians, fisher families, who betake themselves to them when the waters of the lake are subsiding, and they remain there taking and curing fish to the end of the dry season... This freshwater lake teems with fish in infinite variety, and of the most excellent quality, and they are caught in such abundance that the fishers in the lake dwellings are careful in selecting only the finest to be salted and dried for exportation. The finest salt fish may be bought on the lake for about six shillings per picul. A great quantity of the fish are conveyed down by Cochin- Chinese to their oil factories, established on the banks of the main outlet of the lake. A large proportion of the Cochin- Chinese in Cambodia are engaged in this fish-oil trade [40].

There is a long history of consumption of fermented fish in the Lower Mekong area [41]. Fermented fish sauce is known to have been used in Southeast Asia as far back as the 15th Century [42]. However, research on fermented fish is fragmented and specialized, focusing primarily on the chemical composition of the different products. Ruddle and Ishige [43] present a historical overview of fermented fish production and consumption in the Southeast Asian region, tracing historical diffusion through human migration, and offer a compilation of vernacular terms used for the different types of fermented fish, fish sauce, and fermented shrimp. They suggest that it is probable that irrigated rice cultivated and associated rice field fishing originated in Yunnan and diffused southwards down the Mekong Valley. Coinciding with this, given the seasonal abundance of fish along the Mekong Valley [44], fish fermentation started with the need to preserve fish to be consumed during the lean fishing periods and is historically associated with areas that experienced seasonal fish-abundance - as opposed to areas where fish was fairly common throughout the year or areas that had a low fish catch such as mountainous areas. Ruddle and Ishige argue that this ecological hypothesis is supported by three factors: “the center of salt production, the ecological zonation of irrigated rice cultivation, and the seasonal behavior of fish stocks” [45].

The exchange of unhusked rice (paddy) from those from the interior areas of the country for processed fish (or fish for processing) from those who live close to the Tonle Sap is a historical tradition [46], however the current prevalence and value of this practice remains to be studied.

Socio-economic characteristics of value chain actors

An extensive body of literature in Cambodia focuses on the socio-economic characteristics of fishers linked to resource conflicts [47], migration of Cambodians for fishing and other livelihoods both within Cambodia and to other countries [48], and adaptive capacities of coastal fishing populations in response to development under climate change [49]. In comparison, only a few studies focus on fish processing as a livelihood or the socio-economic characteristics of those who engage in fish processing [50].

There are a handful of studies that analyse the socio-economic characteristics of fish processors at the household processing level [51]. However, there is a research gap concerning those who own and work at processing plants of different scales, primarily for commercial purposes rather than at a subsistence level.

Based on a survey of 60 households engaging in fish processing in Pursat, Kampong Chhnang, and Siem Reap, Rab et al. [52] conclude that processing is primarily a secondary livelihood activity for processor households, that it provides an important income source especially for women and children, and that those who engage in processing remain poor. These household-level processing units, especially during the peak season, seem to operate as micro enterprises as well. Overall, 58% of the sampled households used hired labor, of which 77% employed 1-4 hired laborers and 6% employed 7-8 hired laborers [53]. Further, **these workers were paid 65,000 to 160,000 riels per month**; wages were allocated based on experience and type of work, with those processing prahoc earning the most and those working on trash fish, dried small shrimp, and dried fish earning the least.

Another study focusing on household production units [54] seems to have captured a significant number of home-based micro-enterprises, insofar as these households employed on average 2.1 workers to complement family labour (the household labour force being on average 3.3 persons out of a total household size of 4.7). As this study analyzed the value chain of only Snakehead as a fish species, it cannot be seen as capturing the socio-economic characteristics of processors in Cambodia in general.

An emerging trend evident from these two studies is the closely interwoven nature of household subsistence level production processes and more commercially oriented production, at least during a certain period of the year.

At the household level, financially vulnerable households process the highest proportion of the fish they catch (Figure 7). As shown in Table 2, prahoc is the most commonly processed product at the household level, accounting for 51% of the total processed products. A majority of processed fish is consumed domestically, with market sales accounting for only 27% of prahoc, 33% of smoked fish, 19% of fermented fish, 16% of dried fish, and 0.06% of salted fish produced by the household [55]. A small portion of the fish not sold through market channels may be bartered.

Further, the least fish-dependent households process the highest proportion of their fish catch. Therefore, fish processing plays an especially important role in the food security of households that are financially vulnerable and least dependent on fishing for their livelihoods. This trend can be explained by the tradition of processing fish at the household level primarily for consumption within the family [56].

On the other hand, as indicated above, households with the highest dependency on fisheries around the Tonle Sap also make the highest profits from fish processing (63 USD per year), at a level significantly higher than fish producers from other groups and agro-ecological zones. This trend could be encouraged by the established market linkages in the Tonle Sap area [57]. In this area, the conditions of the

poor and vulnerable are considered more difficult than those in the Lowlands area, as the poorest are often employed as labourers for middle-income families in fishing or are dependent on financiers for their fishing boats and gear, and are bound to sell their catch to the financiers as price takers [58].

Fish processing as a business is also important for households in the medium wealth category, who are able to invest in equipment and raw material for processing [59].Therefore, if future policy and interventions aim to target increases in income and livelihood development of families that engage in fish processing, those with a high dependency on fisheries around the Tonle Sap and those in medium wealth categories could be important groups to target, as they have access to established market linkages and the financial capital to expand and create more jobs.

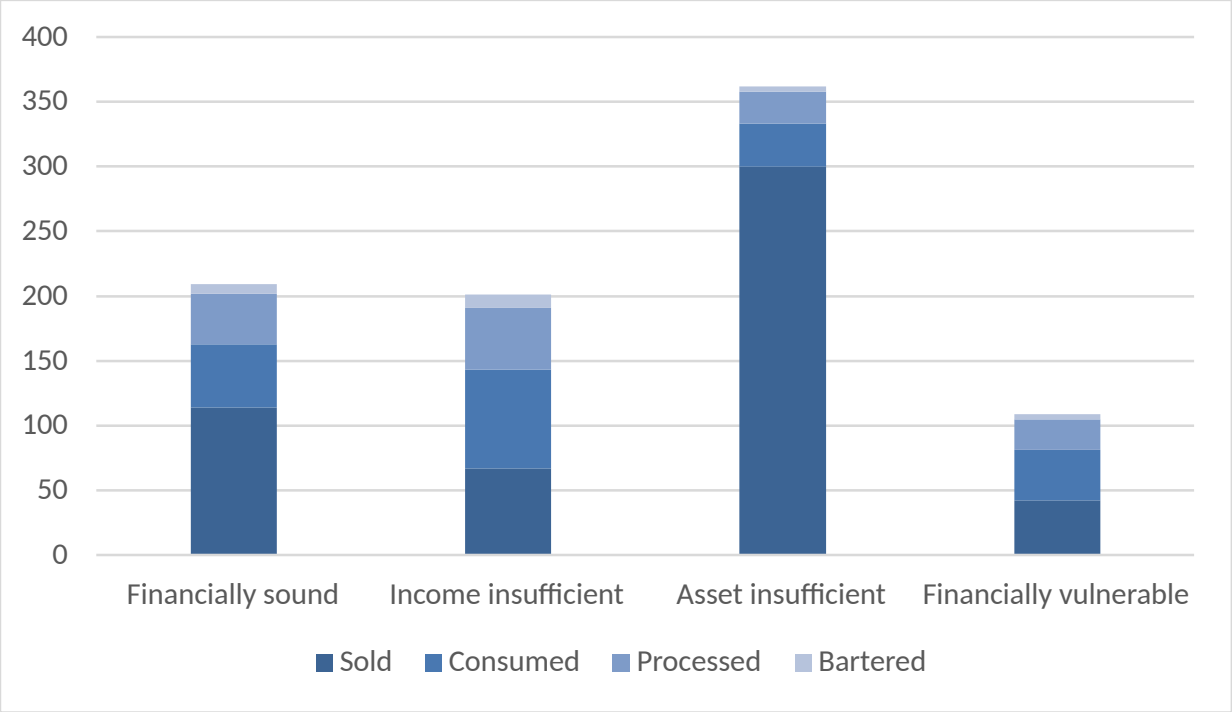

Figure 7. End uses of fish in capture fishery value chain, across wealth quandrants. Source: Mousset et al. [60]

Gender relations in fish processing and processed fish trading

In all three agro-ecological zones around the Tonle Sap and the Mekong in Cambodia, fishing is a man's job while processing and trading are considered primarily women's domains. This division of labour is justified by assertions that men feel tired following fishing trips, whereas “women are better at talking and bargaining with customers” and are familiar with prices [61]. However, when the opportunity and the need arise, women and children do engage in fishing in the rivers using small gill nets [62]. Alternatively, women may participate in fishing where their contribution is limited to activities such as rowing the boat [63], which remain invisible.

Many women acquire processing skills through years of experience in food preparation [64]. Women's involvement in fishing related activities in the Lowlands Zone is shown in Figure 8; these trends are similar for the Tonle Sap Zone and the Upper Mekong Zone as well. Further, women are considered to constitute about 80% of the work force in processing plants [65].

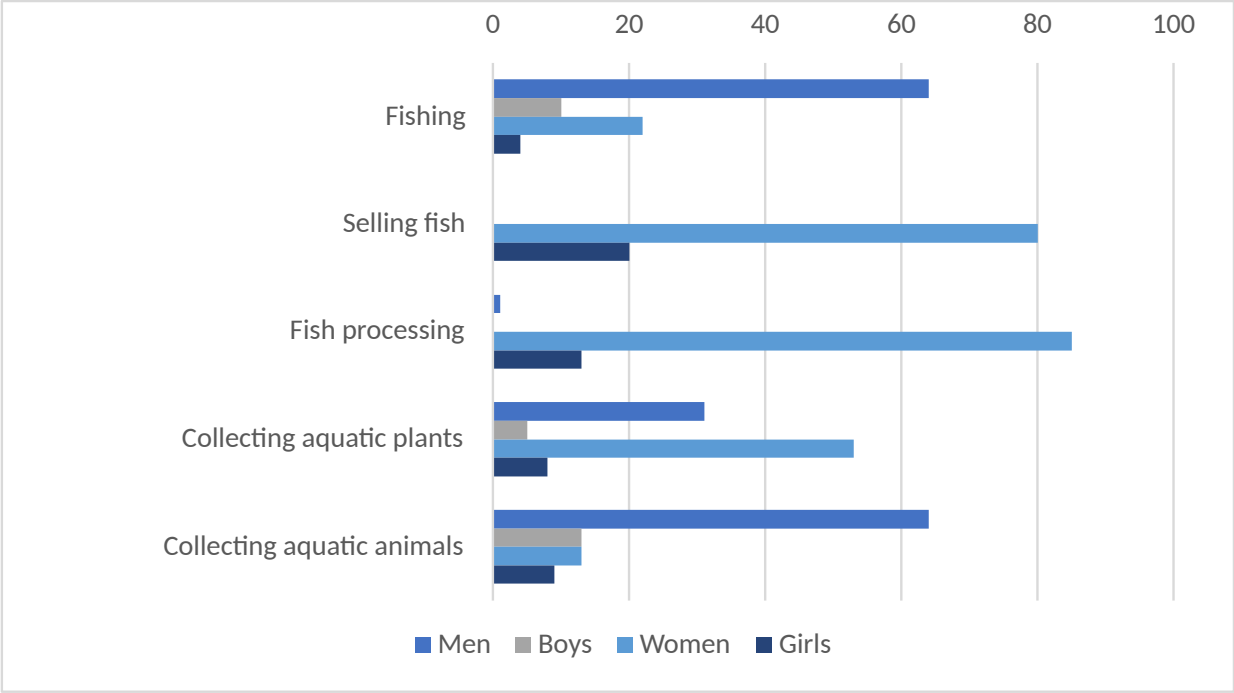

Figure 8. Percentage of adults and children involved in fishing and related activities in Lowlands Zone, by gender. Source: data from Estepa et al. [66]

This gendered division of labour results from the socialization of girls and boys from a young age (Figure 8): boys are ashamed to engage in fish trading because it is considered a woman's job; sons usually help their fathers, although they are not obligated to do so; and mothers teach their daughters how to process fish [67]. Beyond the evidence of such socialization into gendered livelihood options, the published literature on Cambodian fisheries does contain data on inter-generational skills transfer, social capital sharing, or transfer processes.

Hap and Johnstone [68] provide a preliminary estimate of the gendered division of labour in fish processing for prahoc, smoked fish, salted dried fish, mam/mum and pa ork, based on a series of consultations with those engaged in fisheries sector (Table 3). According to this analysis, both men and women play a role in most processing activities at the household level, with women playing a bigger role. The study by Mousset et al. [69] does have a focus on labour in fishing, and analyses level of people's involvement in fishing and related activities; however, this analysis does not reference time spent on liveli-

hood activities, suggesting the need for future research to gain a more representative understanding of labour in fisheries through a time-use analysis. Therefore, the current review finds that an in-depth analysis of the gendered division of labour within households that engage in fishing and fish processing remains a gap.

Table 3. Gendered division of tasks in traditional fish product processing (% involvement by gender). Source: Hap and Johnstone [70]

	Men		Women	
Type of product	**%**	**Tasks**	**%**	**Tasks**
1. Smoked fish	40	Carrying heavy loads, Fire management	60	Frying; Putting fish on a stick to be smoked; Getting firewood
2. Fish paste	40	Carrying heavy loads; Heavy work; Salting fish	60	Cutting fish; Cleaning fish
3. Fermented fish	-		100	
4. Salted dried fish	20	Handling; Heavy work	80	Cutting and cleaning fish; Salting and frying
5. Mam	-		100	

Although women dominate fish processing, at least at the household level, the following analysis presented in Mousset et al. [71] shows the importance of the status of the head of the household and gendered household member composition, for fish processing to be commercially viable. Female-headed households make a loss of more than 20 USD per annum from processing, which strongly points towards processing being more for consumption rather than a commercial activity in those households. On the other hand, male-headed households that are female prevalent [72] make the highest net income from processing per annum (3.2 USD). Once again, this points to towards need for policy and intervention support for the need for careful selection of household processing activities, for income generation. On the other hand, this analysis may also again reinforce the importance of processed products for more socio-economically vulnerable female-headed households.

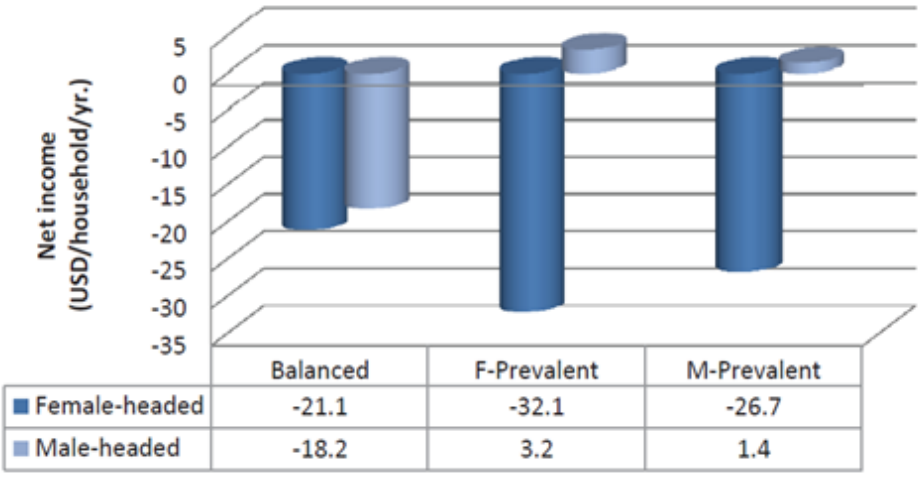

Figure 9. Net income from processing of fish capture-gender based comparison. Source: Mousset et al, 2016: 69

In her study of women fish processors in Battambang, Kusakabe [73] found that gender norms attached to women acting as processed fish traders has created social capital that is passed down to daughters. Gendered power relations - such as female traders' dependence on Thai traders - have made it difficult for women to organize collectively for greater bargaining power. Apart from this study, there are no in-depth analyses of the role of social capital, social networks, and the opportunities and barriers that are created by gendered power dynamics, within the household, with other traders/processors, and with suppliers and buyers within the female-dominated processed fish sector.

In Cambodia, educational status is lower within female-headed households and among women in general, and the education levels of those women from fishing villages are lower than those from farming villages, leading to poorer socio-economic outcomes. The latter difference could be attributed to low levels of access to schools for those who live in floating villages [74]. Despite concerted efforts to improve education levels in Cambodia, the 2019 UNDP Human Development Report indicates the mean years of schooling for women as 4.1, compared to 5.7 for men. The proportion of women above the age of 25

with at least some secondary education is only 15.1%, compared to 28.1% for men.

In the secondary fish trading sector, women are again considered to play a relatively prominent role, especially in border towns such as Poipet. In some cases, with women more actively and intensively engaged in fish trading, husbands have taken over some of the traditional gendered roles such as washing clothes [75].

Therefore, there is a need for identification and in-depth analysis of the socio-economic characteristics of those who engage in fish processing primarily for commercial purposes. This analysis should focus on the role of women and children, ethnic minorities and migrants, their wages, working conditions and benefits, especially linking to decent work standards. For example, a specific research question within this body of work could be the role of the processing sector in providing livelihoods for the vulnerable and very poor groups and how "secure" this livelihood is, within the current and future social, economic, and ecological conditions. This is especially important when the overall education levels of those who live around the Tonle Sap are reported to be low (about 20% with no formal education), and about 40%-60% of families who live around the Tonle Sap are considered poor. Studies that take an intersectional approach to understanding social norms, roles, hierarchies, and hegemonies are completely lacking in the Cambodian context, both in the fishing sector at large and more specifically in the fish processing sector, where levels of inequality could be especially pronounced.

Processed fish in Cambodia

This section presents a synthesis of literature that focuses on value chain and market chain analysis of the processed fish sub-sector in Cambodia, synthesizing findings from available literature on fish sourcing, fish processing and processed fish trading, including exports. This is followed by a section focusing specifically on prahoc, a product that has received the most attention in publications on Cambodian processed fish products and therefore merits separate analysis.

Compared to processed fish through the value chain, the production/harvesting and trading of fresh fish in Cambodia is well documented [76]. Despite the scholarly attention given to prahoc, comprehensive studies on other fish-based products in Cambodia are severely lacking. Hap and Jonhnstone [77], analyzing value chain studies in Cambodia with a focus on fisheries and other aquatic animals, found little evidence of value chain research concerning fisheries products such as smoked fish, dried fish and fish paste. As a first step to address this gap, Hap and Johnstone used a consultative process to identify prahoc and smoked fish as fish-based products that would most strongly benefit from a value chain analysis, using criteria such as the number of actors involved, market demand, and potential for product development/improvement. Their study also identifies opportunities and challenges for the development of these products, including salted dried fish, and potential partners to support product development, as summarized in Table 4.

Table 4. Commodities and products: Opportunities and constraints for market development according to AAS partners

COMMODITY	OPPORTUNITIES	CONSTRAINTS	PARTNERS
Riel and kompleanh	• High demand • Existing skills for processing • Riel in fish paste and smoked fish • Kompleanh - salted fish and fish paste • In many cases not processed, thus lost opportunity	• Limited supply of these species, decline in catch • Production and transportation costs high, while market price low • Fishers in debt to middlemen and bound to sell them • Seasonality of kompleanh, thus limited supply • Legal restrictions	CI
Ross (capture)	None of the identified partners currently specifically working in relation to this species		
Andeng (catfish culture)	• Can be smoked to add value • Link to smoked fish value chain • Increasing number of ponds	• Low fresh product market price • Expensive fingerlings and no local hatcheries • High input costs	HARVEST HURREDO
PRODUCT			
Salted dried fish	• Value addition to fish • High demand	• In less demand than smoked fish • Fragility of product, resulting in value losses due to transport damages	HURREDO COWS
Fish paste (prahoc)	• Improvement of quality • High demand	• Barriers to quality improvement linked to provision of clean water, which is beyond the scope of partner interventions • Chemicals used to keep fish fresh	HARVEST CI

Smoked fish	• Improvement of quality • Value-addition to fish • Improved skills and technology (availability of smoke stoves) • High demand • High market price	• Low quality of product, affecting shelf life • Proper packaging • Environmental issues related to wood use • Negative health implications of smoke inhalation	HARVEST CI HURRE DO

Note: AAS stands for Aquatic Agricultural Systems, a CGIAR Research Program aiming to reduce poverty and strengthen food security for small scale fishers and farmers. Source: Hap and Johnstone [78]

Sourcing of fish for processing

There is currently no published research that systematically assesses the quantity or proportion of fish sourced for processing by sector (wild capture fish, aquaculture, or rice field fisheries). Brooks and Sieu [79], suggest that only 3% of the rice field fisheries catch, which is estimated to contribute to about 20% of the inland fish catch in combination with small scale fishing, is used for processing. According to Mousset et al. [80], a comparatively higher figure of about 19% of the capture fishery catch is used for processing [81]. There are no studies, however, that assess the proportion of aquaculture fish that is processed. With the increasing importance of aquaculture in the fish supply in Cambodia, this gap in data and analysis should be addressed for better policy and strategic direction of the sector.

Mousset et al. [82] find that households from all the agro-ecological zones around the Tonle Sap and the Mekong engage in fish processing to varying degrees. Among these households, those who are less dependent on fishing process a higher proportion of their relatively smaller fish catch, with the three categories with increasing dependency on fishing, processing a smaller portion of their fish catch [83]. Rab et al. [84] also find that while 78.7% of the surveyed fishing households process fish for sale, only 37.7% of farming households do so. These trends may indicate that those households who are engaged in subsistence fishing process a higher proportion of their fish for their own consumption. This trend may have potential implications for any interventions that target the development of the fish processing sector at the household level.

In contrast to the studies that focus on processed fish products and their value chains, more studies have focused on socio-economic values of capture fisheries and aquaculture in Cambodia [85]. Among these, some studies focusing on capture fisheries have selected certain

commercial fish species for focused analysis, some of which are used in processing fish-based products that are of interest to the Dried Fish Matters project. Specifically, Hap et al. [86] focus on Giant Snakehead, Pangasius, Croaker, Reddish and Riel; Sinh et al. [87] focus on the Giant Snakehead; and Nam et al. [88] discuss small-sized fish species that are primarily used for making fish paste (prahoc).

According to Sinh et al. [89], Snakehead account for 66% of the total fresh fish/raw material used for fish processing in the Lower Mekong region of Cambodia. According to their research, Snakehead for processing are sourced from both farms and from wild catch, but it is unclear what proportion is sourced from each. Processing of Snakeheads was found to be seasonal; processing happens four to nine months per year and nearly all Snakehead fish (95%) was salted and dried, with the remainder made into fermented fish and boneless fish paste.

Although focusing exclusively on Snakehead fish in the Lower Mekong region, and therefore primarily addressing salted/dried fish and fish paste, the study by Sinh et al [90] offers insights into the processed fish value chain structure/channels, actors, [91] and the value added at each step (Figure 10). The lack of a direct linkage between Snakehead fishers in the Lower Mekong and the processors, the direct linkages between the processors and the restaurants, and the direct linkages between processers and the traders in the Phnom Penh city are noteworthy. The latter could be explained by the relative proximity of the Lower Mekong region to Phnom Penh. While the prices of all the inputs may have increased since 2014, this study provides some broad trends useful for analysis. The value chain mapping below could be used as the basis for developing the chain further, including other products and geographic locations as well.

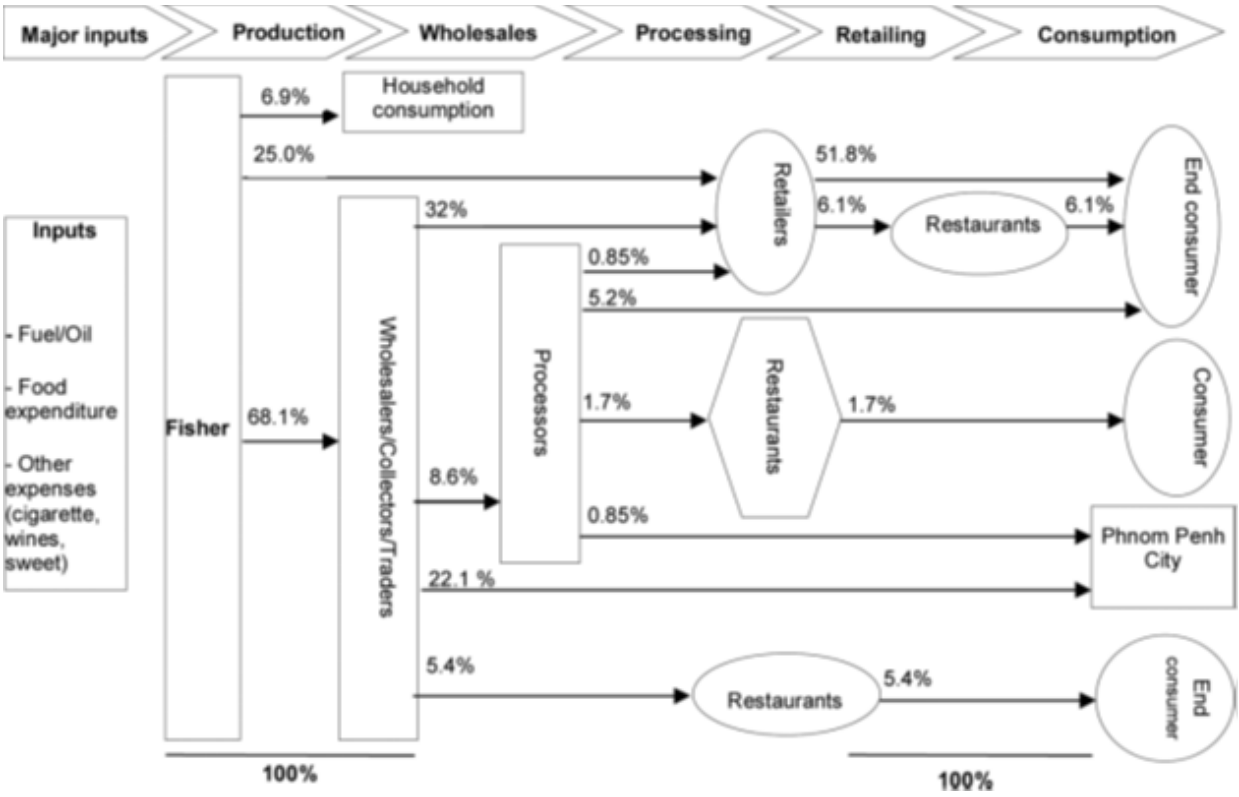

Figure 10. Mapping of the value chain of the Snakehead fish in Lower Mekong Basin. Source: Sinh et al. [92].

A study by Nam et al. [93] that focuses on small-sized fish in Battambang, Siem Reap, Kandal, Kampong Chhnang, and Phnom Penh city provides additional insights into fish processing in Cambodia. According to this research, small fish is processed into brolak (salted dried fish), smoked fish, fish sauce, fermented fish, and fish paste. According to a grading system used by the Fisheries Administration prior to 1975, the 3rd grade of small fish, when in abundance considered trash fish and the cheapest, was used for making fish paste, low quality smoked fish, and fermented fish paste. It is not clear whether the practice of using the lowest quality small fish for processing continues.

Fish processing

Fish processing is organised at different scales - small/family scale, medium scale, and large scale [94]. Family scale processing is oriented primarily toward consumption, or alternatively for sale within the village or local market. This level of processing usually employs only family members as labour, occurs during the short peak fishing season, when the requirement is to process fish very quickly, historically, usually by hand within the household [95]. This processing happens along the river banks or shorelines of the Tonle Sap [96]. Middle scale processing is primarily family run, using family members and relatives as labour, supplemented in the peak season by up to 5-10 hired workers. These small enterprises produce sun-dried fish, smoked fish, fish paste, and fermented fish at locations in fishing villages or close to fishing lots/dai. Such processors also dry fish for fish feed, which is primarily exported to Vietnam [97]. Large scale processing plants are operated by fisheries enterprises and fish sauce factories, primarily in Phnom Penh and Sihanoukville. They typically employ 40-60 workers, with a labour force that is 80% female, and process fish paste, fish sauce and salted sun-dried products [98]. Prior to the abolition of fishing lots, large scale fish processing took place on floating platforms near the fishing lots, usually with fish cages attached, into which the fish waste from processing was fed [99].

These categorizations may need to be reconsidered in the current context, especially given the closely interwoven nature of subsistence and commercial production purposes of processing, linked to seasonality and fish availability, and the changing patterns of latter may have impacts on the production processes, profits, labour arrangements and marketing structures of processing.

According to an FAO study, modern or industrial processing was concentrated as of 2011 within four processing plants - one in Phnom Penh and three in Sihanouk Ville [100]. Lian Heng trading company operated one wholly Cambodian-owned plant in Phnom Penh and a second plant with Hong Kong investment in Sihanouk Ville, while Sun Wah Fisheries, also based in Sihanouk Ville, was 100 percent foreign-invested. The plants based in Sihanouk Ville engaged mainly in the export of processed and frozen seafood, whereas the plant based in Phnom Penh exported smoked fish and other products to the USA. As there have not been any major follow-up studies on these modern industrial-scale processing companies in Cambodia, the current status of their activities is not clear.

Table 5 provides a snapshot of costs associated with fish processing in 2005/6, the most recent published cost data that could be located. Cost data specifically for prahoc is discussed separately below.

Table 5. Percentage of fish processing households using different raw materials by village type. Source: Rab et al. [101].

Raw Materials	Fishing	Fishing/ Farming	Farming	All
Fish	100.00	100.00	100.00	100.00
Salt	100.00	87.96	98.15	95.26
Sugar	53.57	37.96	64.81	49.64
Firewood	50.89	65.74	68.52	60.22
Charcoal	0.00	0.00	1.85	0.36
Sun-dried materials	4.46	0.93	0.00	2.19
Total	**(n=112)**	**(n=108)**	**(n=54)**	**(n=274)**

Retail and Wholesale Trade of processed fish

This literature review suggests that the local and cross border trade segments of the processed fish value chain appear to be the least studied segments to date.

The study by Mousset et al. [102] provides an indication of household-level sales to a certain extent, by providing cost and net income figures by processed product. Similarly, Rab et al. [103] provide useful data concerning processed fish retailers including their number of years in business, average number of workers, average trade volume, and average prices from 2001-2002. Future studies on processed fish trade could build on this analysis and broaden it to include other components related to retail trade. We were unable to locate any studies that focus on the wholesale processed fish trade.

At the household processing level, the most important marketing channel was via wholesalers operating both within and outside the province [104], highlighting the important role played by wholesalers in the processed fish value chain.

Table 6. Marketing of processed fish produced in 2003. Source: Rab et al. [105].

Type of Marketing	Number of Processors (n=61)	% of Processors
Sell directly to customers in local markets	3	4.92
Sell to middlepersons/traders who collect from processors	3	4.92
Sell to wholesalers within the province	42	68.85
Sell to wholesalers in different cities outside the province	30	49.18
Sell to exporters	2	3.28
Export directly to Thailand	6	9.84

Table 7 [106] presents the selling price of processed fish products produced at the household level. According to this data, fishing

households sold comparable products at lower prices than fishing/farming and farming households - for example, farming households are reported as obtaining more than twice as much for fermented fish than fishing households. Although there are no current published data on processed product prices, certain inferences can be made from the study data by looking at the volume of processed products sold and gross income per household. We can see that prahoc was sold, in US-dollar equivalents, for around $3.00/kg, smoked fish for $4.20/kg, dried fish for $5.20/kg, fish sauce for $2.00/kg, and fermented fish for $3.00/kg. These calculations can be used to understand the rising prices of processed products in the period from 2002-2003 to 2014-2015.

Table 7. Average price (USD) of processed fish by product type and village type during 2002-2003. Source: Data from Rab et al. [107]

Type of Product	Fishing (n=72)	Fishing/ Farming (n=13)	Farming (n=50)	All villages (n=135)
Fermented fish	0.56 (0.27)	0.43 (-)	1.25 (-)	0.70 (0.40)
Fish fillet	0.25 (-)	0.00	0.00	0.25 (-)
Fish sauce	0.28 (0.08)	0.20 (0.06)	0.00	0.25 (-)
Fish paste (prahoc)	0.31 (0.22)	0.50 (0.28)	0.19 (0.24)	0.36 (0.25)
Salted dried fish	0.43 (0.18)	0.00	0.00	0.43 (0.18)
Semi-final fish paste (prahoc)	0.37 (0.16)	0.15 (-)	0.00	0.35 (0.16)
Smoked fish	0.41 (0.13)	0.66 (0.24)	0.75 (-)	0.62 (0.24)
Total	**0.34 (0.19)**	**0.55 (0.28)**	**0.46 (0.49)**	**0.46 (0.27)**

According to the 2016 data presented in Table 2, households incurred an annual loss of $9.40 from fish processing. However, net profits or losses vary by type of processed fish. The overall reported loss was primarily attributable to salted fish, which incurred a $22.90 loss per year according to this survey, with dried fish also incurring a loss of $1.50. Prahoc provided greatest income, at $15.80 for the year. Given the close dependency of prahoc production on surplus fish availability during the peak season, it could be assumed that this income is not spread over the year; however, if roughly averaged out, it comes to

just over $1.00 per month. This trend should be considered when evaluating future supports to household level processing intended to enhance income generation. Such decisions should also not completely exclude the subsistence value of production for household consumption, which carries strong nutritional and food security indications. An interesting continued historical cultural and socio-economic practice associated with production/processing is the barter system, which still appears to be practiced, albeit at a lower scale. A study of the way the barter system is organised may provide interesting insights into the production processes and subjective values attached to socio-economic processes in Cambodia.

Table 8 and Figure 11 provide an indication of the average years in business of processed fish sellers, number of workers in retail trade, and sales volumes and prices in city markets, provincial markets, and rural markets in Kampong Chhnang, Siem Reap, and Kandal provinces.

Table 8. Average number of years in business and number of workers in each processed retail fish shop. Source: Rab et al. [108]

Market Location	Years in Business	Number of Workers
Provincial/ Rural		
City markets	11.89	1.79
Rural markets	10.26	1.26
Provincial markets	14.75	1.50
Provinces		
Kampong Chhnang	10.93	1.13
Siem Reap	11.67	1.58
Kandal	12.50	1.25
All	**11.6**	**1.50**

The retail prices in the city markets are clearly higher than the other two markets as Figure 11 shows.

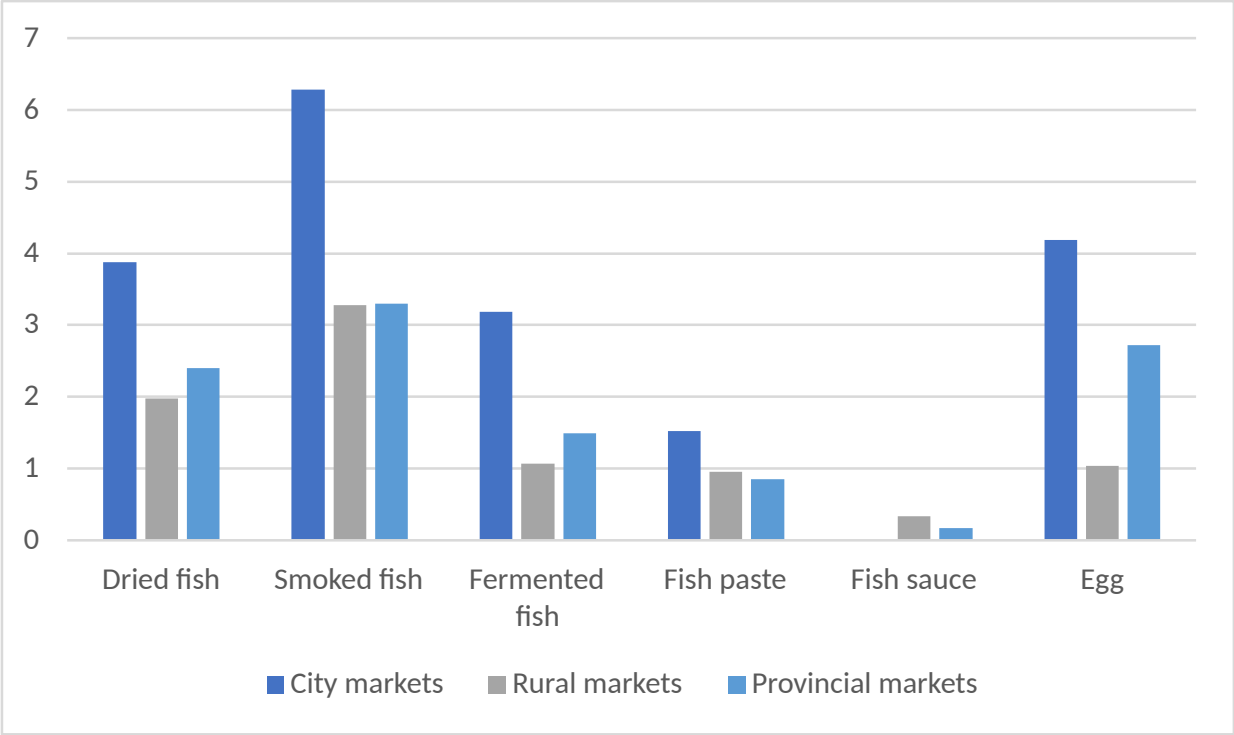

Figure 11. Average price ($/kg) by product type and market location of processed fish products. Source: Data from Rab et al. [109]

Fish paste (prahoc) was the most commonly traded product among all the processed fish products (39.5 kg per day) made from small-sized fish, as prahoc was seen to be most preferred to be consumed by Cambodians [110]. As Table 9 highlights, sales of processed products of small fish by processors [111] were organized in different ways, with fish paste showing the most diverse range of buyers, and fish sauce and smoked fish showing more centralized trade patterns.

Table 9. Percentage distribution of demanding sources of processed freshwater small fish (% of volume) by type of product. Source: Hap et al. [112]

Description	Salted-dried	Smoked	Fermented	Paste	Fish sauce	All
Household consumption	4.7	1	0.5	1.1	-	**1.4**
End consumers (direct selling)	9.3	-	-	23.8	-	**15.3**
Collectors/ Middlemen	-	-	49.9	27.5	-	**30.6**
Wholesalers/ Retailers	86.0	99	49.6	36.6	100	**40.5**
Other processors	-	-	-	11.0	-	**12.2**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Processed fish exports

There are no studies that specifically analyze exports of different processed fish products. As part of a broader study, Hap Navy [113] found that processed fisheries products totalled 33,772 tonnes in 2001, of which 18,140 tonnes or 54 per cent were sold through export channels. Nam et al. [114] provide some further insights into exports of processed small fish, reporting that two types of products are exported - salted fish (trey brolak) being more commonly exported in terms of volume, followed by fish paste (prahoc). Average daily exports at that time were 14,792 kg for freshwater small fish, 19,584 kg for salted fish, and 10,000 kg for fish paste [115]. However, the export potential of Cambodian fisheries remains unfulfilled, with fresh fish and semi-processed fish from Cambodia believed to be re-imported following export to countries such as Thailand [116].

Rab et al. [117] provide export data on fresh fish by province from 1992 to 2002, but do not provide data concerning exports of processed products. The body of research on fresh fish value/marketing chains has expanded more recently, with studies such as [118] that focus on estimating the value of the fresh fish in inland fisheries in Cambodia along the different steps of the value/market chain. This study finds that the average value of a tonne of fresh fish sold at the fishers' level was $1096 (USD equivalent), [119] $1,776 at the traders' level, and $1,813 at the exporters' level [120]. The same study notes that fish prices are highest in the Mekong region, with the Tonle Sap recording lower prices and the lower Mekong prices being close to the average. However, unlike the two studies discussed above, this study does not include fish processors/fish processing as a step in the value/market analysis.

Consumption

The most recent analysis of fish and fish based consumption for Cambodia is provided by Mousset et al. [121]. According to this study, while 3.55 kg of fresh fish is consumed per week by a household, 0.53 kg of prahoc is also consumed. Prahoc is overall the fourth most consumed food product according to this household survey, which excludes vegetables, and is consumed about 2 days per week (Figure 12).

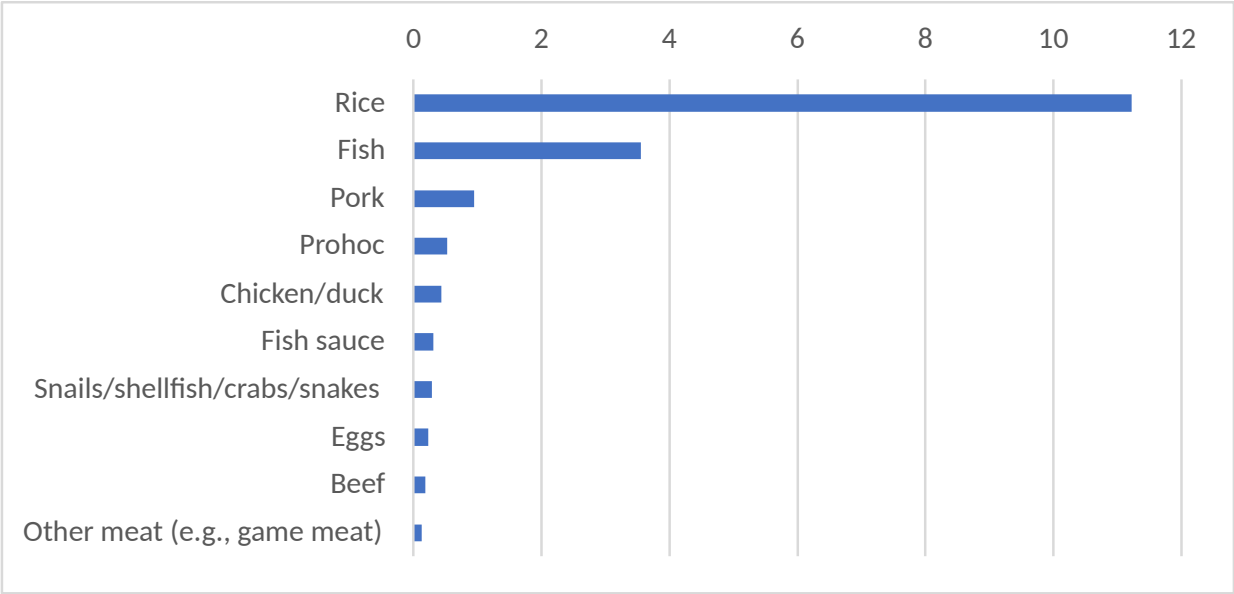

Figure 12. Average household weekly food consumption (kg). Source: data from Mousset et al. [122]

Fish paste and fermented small fish

Of the diverse fish-based products in Cambodia, prahoc is the only one to have received dedicated research attention. At least four studies have focused on the different steps in prahoc production [123] and the production volumes and marketing channels of prahoc [124]. The main findings and conclusions of these studies, and the gaps that remain, will be discussed in the sections below.

A traditional and popular form of fish processing in Cambodia, prahoc is a form of crushed, salted, and fermented fish paste made from mud fish or small fish [125]. Prahoc continues to be an important condiment used in soup and in poorer, rural regions this is consumed with rice.

Fish catch and supply for fish paste and fermented fish

Either large-scale industrial or small-scale household techniques are employed to secure the fish catch that is required for prahoc preparation. Historically, large-scale fishing gear such as the stow net (dai) and barrages (rao-lop) were usually operated as fishery lots (samra); these were very popular and well-developed techniques that operated as limited-access fisheries [126]. With the contemporary ban on fishing lots, dai nets continue to be used as large-scale fishing gear in supplying much of the fresh fish for processing, especially for fish paste and fermentation.

The bulk of subsistence fishing takes place in villages around the Tonle Sap. According to Rab et al. [127], in fishing villages around the Tonle Sap, 98% of the fish catch in Siem Reap, and 89% in Kampong Chhnang is used for processing. [128] However, according to the more recent study by Mousset et al. [129], households around the Tonle Sap process only 11% of their fish catch, with the bulk being sold as fresh fish. In contrast, households in the Upper Mekong and Lowlands process a higher proportion of their fish catch (22-23%). Households in farming villages [130] keep about 95% of processed fish for their own consumption, whereas in the fishing villages, about 91% is sold [131]. Across the three ecological zones of Tonle Sap, Upper Mekong, and Lowlands, 63% of the total household production of prahoc is consumed domestically, 26% is sold, and 8.6% is bartered [132].

Historically, at a larger scale, the stow net/stationary trawl nets (dai) are reported to produce 75% of the daily fish catch for fermentation [133], and around 14% of annual fish catch from the Tonle Sap and up to 7% of the estimated total annual fresh fish production in Cambodia [134]. These nets have been used for over 140 years, operated be-

tween the 5th and 15th on the lunar calendar three or occasionally four times a year, starting from December to February [135]. As Halls et al. note, dai fishing "targets the refuge migrations of a multi-species assemblage of fish as they migrate from the Great Lake to the Mekong main channel via the Tonle Sap with the receding floodwaters each year" [136]. Dai nets are arranged in 15 rows, comprising one to seven nets per row. During the peak fishing season, the baskets attached to the nets are raised at intervals of five minutes to obtain a fish catch of about 100kg [137].The dai fishery employs about 2000 rural people and is considered a major supplier of fish for prahoc [138].

Through a survey of 55 farmers who came to dai fisheries to purchase fish for prahoc in January-March 2003, McKenney and Tola [139] found that fish availability concerns were the most frequently cited reasons for farmers seeking fish from dai sites (Figure 13). With changes in availability of fish, harvest levels in dai fisheries, improved transport, and infrastructure development since this study was carried out, a follow-up study would help understand the ongoing link between dai fisheries and prahoc production.

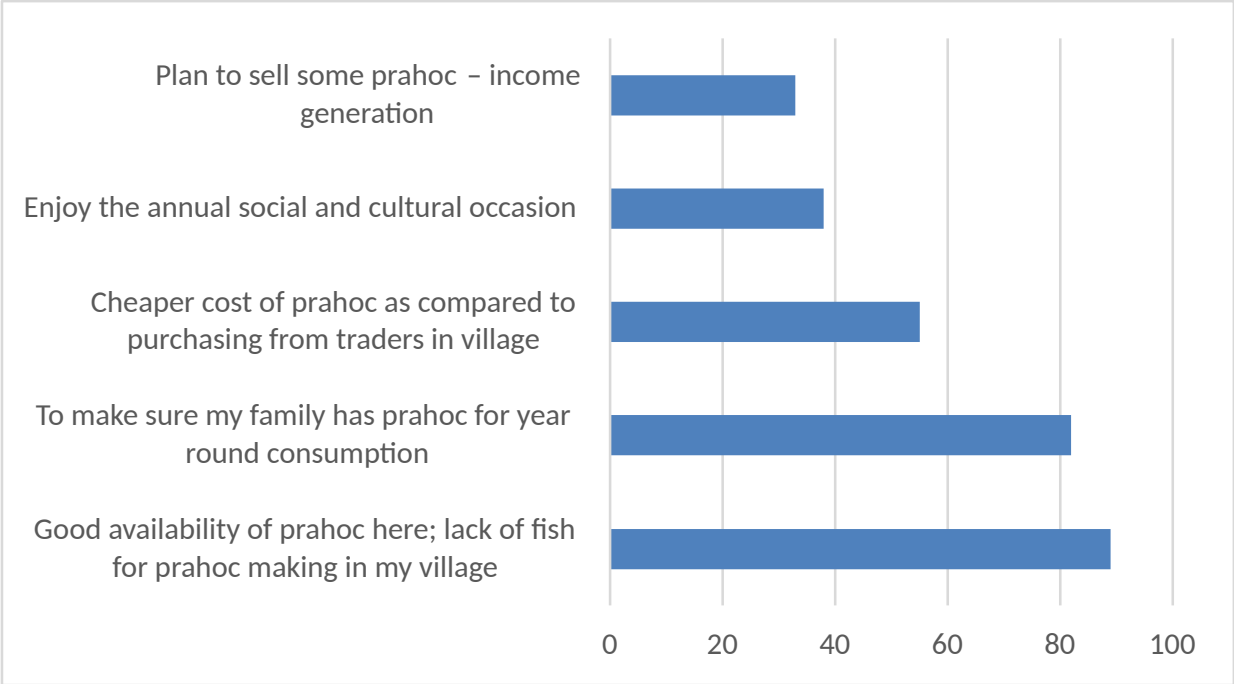

Figure 13. Why farmers come to dai fisheries. Percentage of survey participants selecting each factor, with multiple responses allowed. Source: data from McKenney and Tola [140].

A Mekong River Commission Report [141] provides an analysis of the periodic catch monitoring for the important dai fishery in Cambodia. This report states that the small fish from dai fishing is used for processing prahoc, other types of processed fish such as pa ork and mum, and feed for fish, ducks, pigs, and chickens. Notably, individual feed producers may purchase up to 150 tonnes of fresh fish [142]. More recently, Ngor et al. [143] analyzed dai fish catch time series data for a 15 year period (2000-2015), discovering that while catch levels for medium to large-bodied species had declined over that period, small fish catch levels had remained either relatively stable or increased. As a result, the total biomass of the catch had remained relatively stable as smaller sized fish catch compensated for the decline of stocks in the medium/large sized fish. This study does not provide any estimates or analysis on the proportion or quantity of fresh fish supplied for processing; however, given the use of small fish for processing both prahoc and smoked fish, these findings suggest that processed fish products may not be impacted negatively, at least in the immedi-

ate future. The impact of changing fish stocks and composition on fish processing remains an area for ongoing analysis.

The proportion of fresh fish used for processing may have changed at both the subsistence level as well the larger-scale commercial level in the 10-15 years since most of the studies discussed above were published. Changes may be attributed to several factors: the declining stocks of medium to large-sized species; increasing fish culture practices at the household level; the exploitation of small species as feed, despite the ban on fish farming for some species such as Snakehead [144]; and improved road transportation. On the other hand, the lifting of the ban on Snakehead farming in 2016 may have facilitated a better supply of that fish for use in the preparation of boneless fish paste (prahoc sachs), fermented fish (mum), and smoked fish. Given the lack of systematic data on total fish catch used for processing for the country, including those sources/methods outside of the dai fishing, however, it is difficult to provide reliable estimates of the amount of fish that is actually used for processing [145].

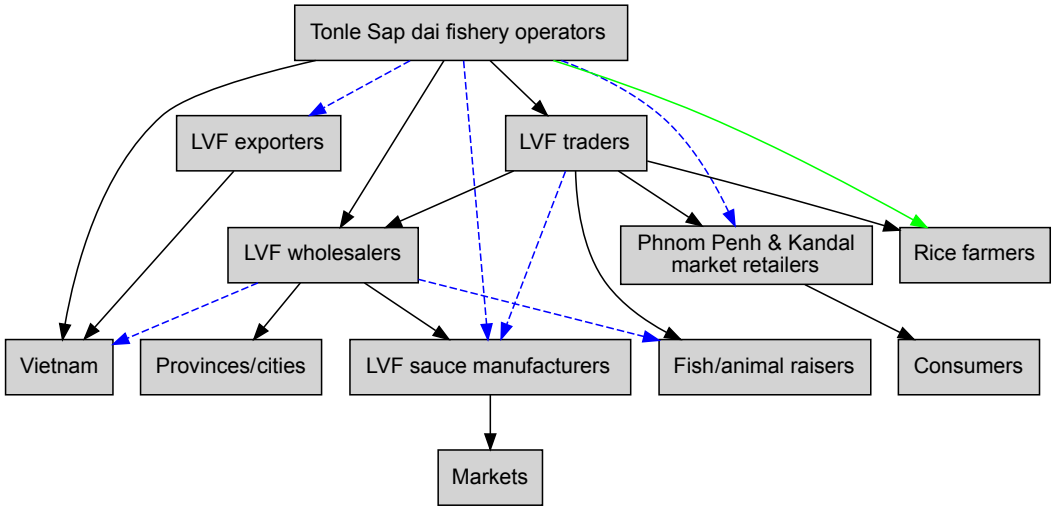

Figure 14. Fish catch disposal chains for low value fish (LVF) or small fish. Black arrows: Common pathways. Blue dashed arrows: Occasional (less common) pathways. Green arrow: Common pathway, also recommended by the MoFL for researchdais(rice farmers given priority to landings over traders). Source: Adapted from So et al. [146].

There are competing demands for small or low-value fish in the Cambodian context, which may have an impact on the future of the pro-

cessed fish sub-sector in Cambodia - potentially having effects on food security, employment, and incomes of poor people. According to So et al. [147], for example, pond and cage culture and crocodile farming in Cambodia source 60%-100% of their feed from low value small fish, depending on feeding practices. Snakehead farming was also seen as a main driver of the overexploitation of small species such as Trey Riel, which is considered an important food security species [148]. (Trey Riel is commonly used for making a fish paste that can be kept for over a year, therefore providing a secure food supply during the lean fishing season.) Joffre et al. [149] have reported that the proportion of inland capture fish used as feed in aquaculture is as high as 96%, with only 3% of aquaculture feed derived from marine low-value fish and 1% taking the form of manufactured pellets. Further studying these changes will provide important insights into how competing use of low-value fish affects food security.

The following section on challenges to the processing sub-sector presents the issues related to depleting fish stocks and their potential impacts on the processing sub-sector.

Fermented fish/ fish paste processing

During the peak fishing season, prahoc, mum, and pa'ork are processed at both subsistence and commercial scales close to the Tonle Sap. Rural rice farmers and their families establish temporary camps and process fish for subsistence purposes, with each camp using about 80-100 kg of fresh fish for making prahoc.

Norng et al. [150] document two types of prahoc micro-scale processing. The processing chains of prahoc with bones (Figure 15) and without bones (Figure 16) are mapped out below.

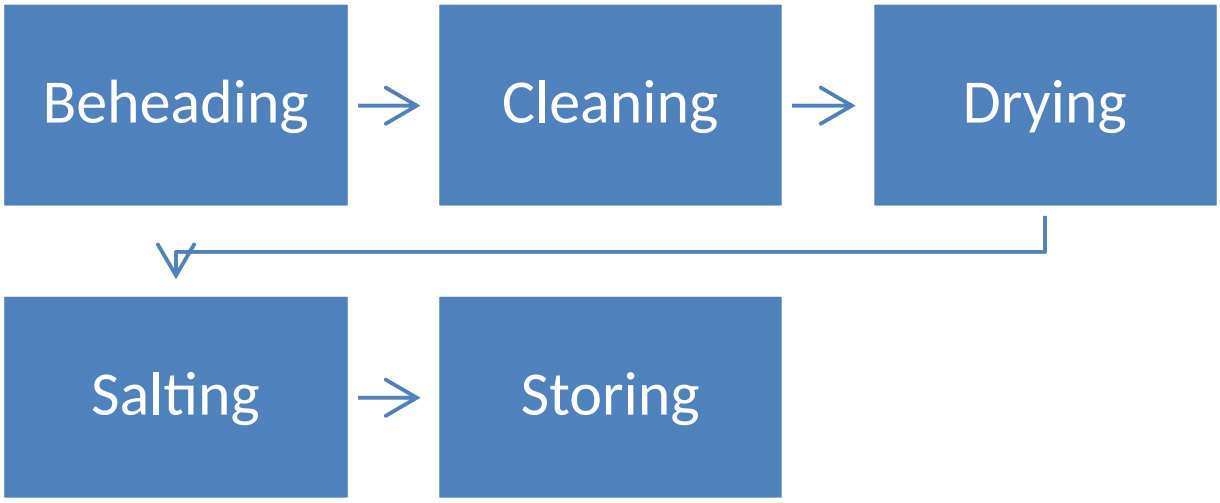

Figure 15. Processing chain for prahoc cha-eang (with bones). Source: Adapted from Norng et al. [151]

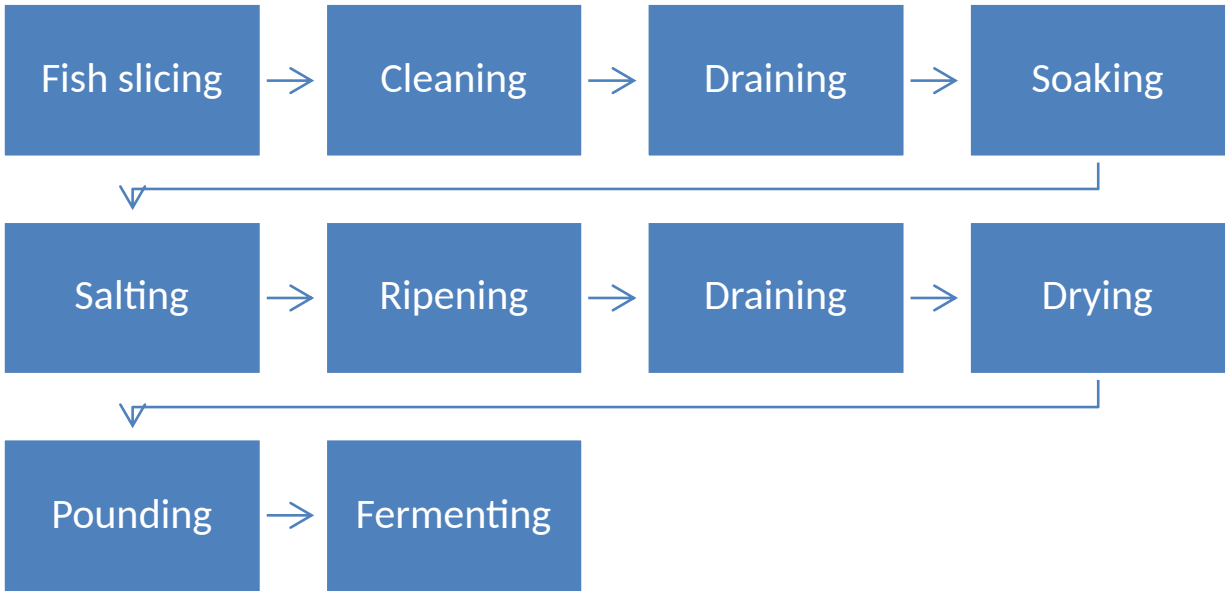

Figure 16. Processing chain for prahoc sach (boneless). Source: Adapted from Norng et al. [152]

Aldin-Lundgren [153] found that there are regional differences in the amount of fresh fish that is used for prahoc production, attributable to variations in the availability, accessibility, and price of fresh fish across the different provinces.

Table 10 lists average processing costs associated with prahoc production at dai fisheries for the three years 2001-2003. More up-to-date estimates of production costs for prahoc or other products would help build our understanding of the changes that have taken place in fish input supplies and related costs for fish processsing.

Table 10. Cost of farmers to make prahoc at Dai Fisheries. Costs are presented in US dollar equivalents. Source: Adapted from McKenney and Tola [154]

Item	2003	2002	2001
Fish price (per kg)	$0.05	$0.04	$0.03
Fish costs per 65 kg prahoc	$5.09	$3.92	$3.19
Salt Price (kg)	$0.06	$0.13	$0.13
Salt costs per 65 kg prahoc	$0.83	$1.93	$1.98
Total prahoccosts	$5.92	$5.85	$5.17
Prahoc cost per kg	$0.09	$0.09	$0.08
Fish as % of prahoc costs	**86%**	**67%**	**62%**

Value chain actors

According to Un et al. [155] there are broadly three main players in the fermented fish paste value chain: processors, export companies and wholesalers, and retailers. The types of actors, scale of operations, and sourcing and marketing channels differ among the different provinces included in their research. Un and colleagues additionally identify fishers and middlepersons as actors in the value chain for salted small fish, which can include two levels of processors and two levels of middlemen (shown as "first" and "second" processors and middlemen in Figure 17). Value chains and associated market channels further vary by product condition (finished or unfinished) and by the type of transport used (car, cart, or boat). For example, processed fish can be sold domestically to consumers as a finished product, but might be exported as a semi-finished product, to be processed further according to export market demand.

Volume of Production, marketing, and value chain actors of fish paste

Among the provinces studied by Un et al. [156], the fish paste value chain activity in Battambang province - which borders Thailand - is largest by volume (56% of Cambodia's annual trade) and most diverse and complex in terms of the nature of actors and scale of operations. [157] Actors in the Battambang value chain include first processors and middlemen, vendors at provincial markets, middlemen in Phnom Penh, and Thai market vendors. Kampong Chhnang and Siem Reap markets are both smaller than Battambang by volume of processed fish traded (14.43% and 16.53% of Cambodia's annual trade respectively), yet both also include a diverse range of actors. These wholesale markets supply end markets in Vietnam and Thailand, in addition to supplying processed products to companies in Battambang. In contrast, Phnom Penh (Figure 18) and Kandal provinces report smaller volumes of processed fish sales (6.34% and 6.70% of Cambodia's annual trade respectively). Most trade at these markets involves destinations within the province or with neighbouring provinces.

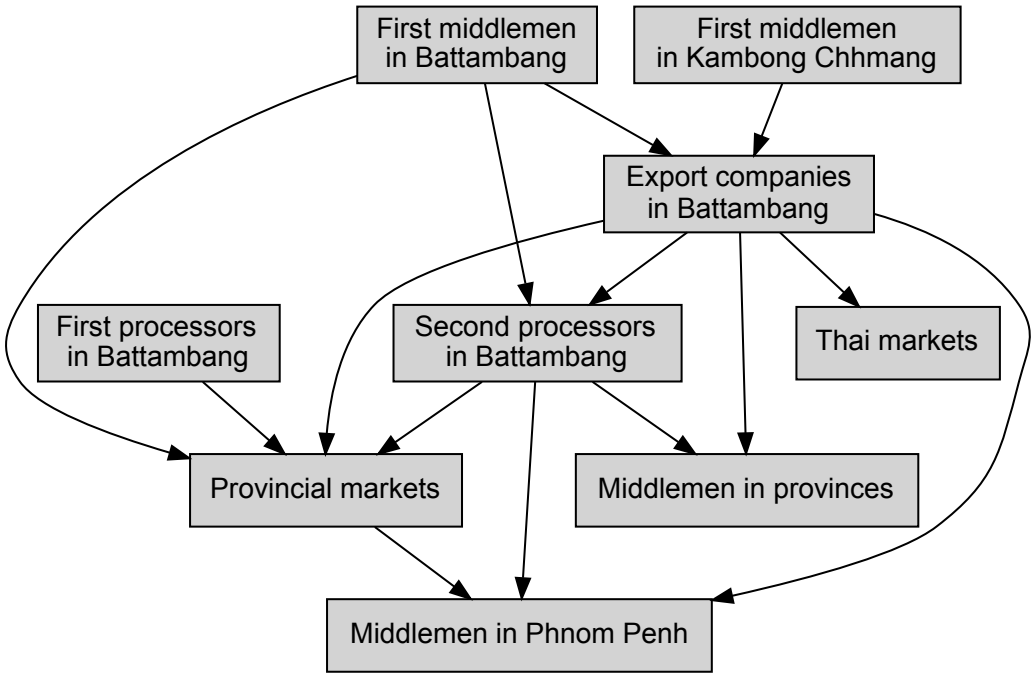

Figure 17. Marketing channels of small-sized fish paste in Battambang Province. Source: Adapted from Un et al. [158].

Prahoc consumption

Aldin-Lundgen [159] recorded annual *household* prahoc consumption levels of 31.33 kg in Kampong Cham, 31.67 kg in Prey Veng, and 21.88 kg in Kandal province, contrasting to the much higher average annual *per capita* consumption level of 10.1 kg reported by Baran [160]. Mousset et al. [161] report average *household* consumption of 0.53 kg of per week, which amounts to an annual *per capita* consumption of approximately 5.2 kg given a mean household size of 5.3 in their study. These figures suggest a decline in prahoc consumption. Given the important nutritional value of prahoc, as discussed below, further analysis will be required to understand whether prahoc consumption is in fact declining and if so, among which demographic groups/households this is the case - and what types of food are replacing prahoc.

Aldin-Lundgen [162] additionally found that fisher-farmer household members and rice farmer household members eat comparatively higher proportions of prahoc than fisher families in Kampong Cham and Prey Veng provinces, indicating the dietary importance of prahoc for households that engage in farming. Mousset and colleagues' study does not present consumption data disaggregated by household fishing involvement, therefore, a more recent trend is absent. As suggested by McKenny and Tola [163], prahoc is considered an economical “fast food” with higher consumption patterns during the harvesting and transplanting seasons among farming communities.

Prahoc production faces a series of challenges, including lack of quality control, which impacts market prices; access to export markets that yield higher profits; increasing prices of raw materials; lack of access to modern technology [164]; and lack of access to clean water to ensure better quality and hygiene in processing [165].

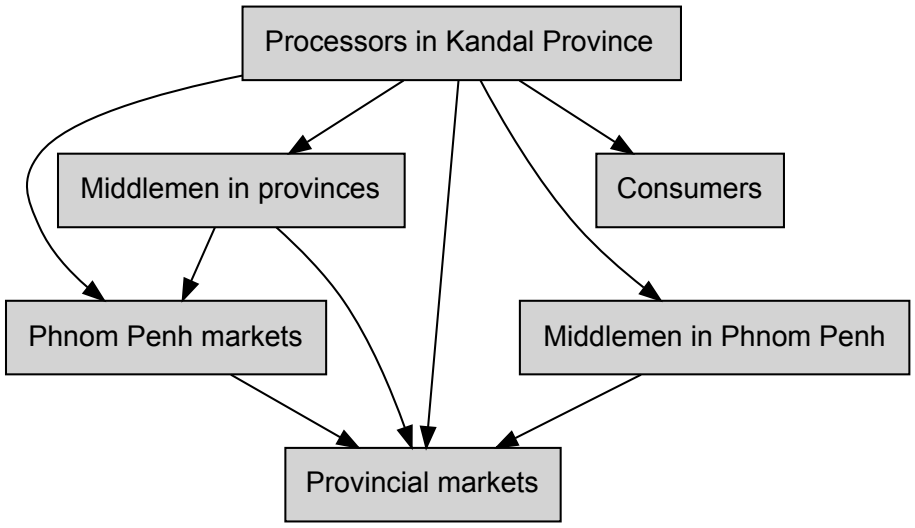

Figure 18. Marketing channels of fish paste produced from small fish in Phnom Penh Province. Source: Adapted from Un et al. [166]

Although prahoc had received more attention in published literature, with the rapid ecological, climate related and socio-cultural changes taking place in Cambodia, further research is required if we are to understand the continued role of prahoc as an important food preference; the production process at different scales of production, including any changes to the traditional production process along river banks close to Phnom Penh during the peak fishing season; and practical options for improved hygienic practices in production, which could lead to improved food quality and marketability to high-end segments.

Smoked fish

Although neither as popular for consumption or production/processing nor as well studied as the fermented fish, smoked fish also plays an important role in the Cambodian dried fish economy. One of the few studies that focus on smoked fish in Cambodia, published by Slamova et al. [167], reports that smoking remains a preferred method of fish preservation due to the low level of rural electrification in Cambodia (electricity access limited to only 66% of the population in Cambodia according to 2014 World Bank figures). The authors of this study note:

Traditional smoking involves treating of pre-salted, whole, eviscerated, or filleted fish with wood smoke. The smoke is produced by smoldering wood and shavings or sawdust in the oven, directly below the hanging fish or fillets, laid out on mesh trays [168].

As the primary focus of this study is the possible health problems that may be caused by the carcinogenic components of wood smoke processing techniques, it does not discuss the socio-economic importance of the processed product nor does it map the value chains.

Food and nutrition security in Cambodia

The importance of fish and fish-based products for the nutrition of Cambodian people is widely acknowledged. Research by the Inland Fisheries Research and Development Institute (IFReDI) indicates that aquatic resources are the largest non-rice food source for Cambodians, representing 76% of their annual protein intake [169]. Further, traditional fish-based meals - such as sour soup - play an important role in enhancing nutrition, meeting 45% of the total dietary iron requirement of Cambodian women; this is particularly important given that iron deficiency is the most widespread nutritional deficiency in Cambodia [170].

Studies regarding the nutritional value of processed fish products are rare. Since the 1980s several studies have examined the chemical composition of fermented products [171]; more recently Chuon et al. [172] provide a detailed analysis of the microbial and chemical properties of fish paste, fish sauce and shrimp paste. There is no link with the nutritional values of these products, however. Giri et al. [173] studied the aroma active compounds in fermented fish, while Slamova et al. [174] focus on the health implications of processed fish consumption, with specific attention to the prevalence of polycyclic aromatic hydrocarbons in Cambodian smoked fish.

Different fish processing techniques have known general impacts on nutritional value and overall food safety. Sun-drying maintains the nutritional value for protein, fat, and minerals (iron, zinc and calcium), but destroys nearly all Vitamin A [175]. Salting presents food safety issues, where contamination with pathogenic bacteria is a risk. Steaming and oven-drying result in the destruction of 50% of vitamin A, while nearly all vitamin A is lost through fermentation [176]. A laboratory analysis of fermented fish from Thailand, Lao PDR, and Cambodia found that fermented fish had a lower protein content than

fresh fish, but substantially higher concentrations of calcium and phosphorus [177]. This nutritional evidence suggests that fermented fish can be an important calcium source for people in the region and a substitute for milk, particularly since the former is more culturally familiar [178]. Indeed, prahoc is considered an important source of protein, calcium, and vitamin A, especially for the poor, towards the end of the dry season when fresh fish is scarce [179].

An emerging body of research focuses on the effectiveness of locally produced, ready-to-use supplementary food on children's nutrition. One such study by Borg et al. [180] finds that the locally developed specialized products, using fish as a base, have a limited effect on reducing growth faltering of children. Another study by Skau et al. [181] finds that while complementary food products can improve the nutritional quality of the diet, they do not ensure adequate intake of micronutrients, especially iron, thiamin and folate, among 6 to 11-month-old infants. However, these studies do not have a focus on traditional fish-based products, and therefore an assessment of the nutritional value of processed fish products remain a gap in Cambodia.

Policy frameworks

Historically, the management of commercial fisheries, which had been codified by the French protectorate in 1908 and reinstated following the civil war, involved the auctioning of demarcated areas to leaseholders, who then employed fishers using a wide range of gear types - from purse seines to small basket eels [182]. This practice guaranteed elite stakeholders the exclusive right to continued extraction of aquatic resource rents, little tax payment and little accountability to fisheries authorities [183].

As a response to this "institutional crisis" in fisheries management, Cambodia has undertaken an ongoing set of fisheries reforms since 2000, beginning with the partial cancellation of approximately 56% of fishing lots, followed by the establishment of the Community Fisheries institution (CFi) and the full cancellation of fishing lots in 2012 [184]. The reforms also included passage of the 2006 *Law on Fisheries* and 2007 *Sub-decree on Community Fisheries Management*, with the Fisheries Administration - located within the Ministry of Agriculture, Fisheries, and Forestry - assuming oversight of fisheries in Cambodia [185]. Along with these reforms, the number of conservation areas in which fishing is prohibited increased, providing a total of 25 such areas in the Tonle Sap alone by 2014 [186].

A relatively strong body of literature analyses and documents the impacts of these changes. Research has addressed the institutional uncertainties introduced by the reforms, including the increase in unregulated fishing activity among small and medium-sized operators [187]; risks and conflicts; the role of patronage networks and other broader socio-cultural and political dynamics in the implementation of fisheries governance; gendered dimension of fisheries management; inconsistencies between the legal framework definitions of Community Fisheries and the actual implementation; and, more re-

cently, an assessment of the status of Community Fisheries in Cambodia and their experiences in the context of the FAO Small Scale Fisheries Guidelines [188]. However, none of these studies focus on linkages between Community Fisheries and processing of fish, or the potential role that community-based collectives such as Community Fisheries can play in developing the processing sector.

Following the introduction of reformed fisheries policies designed to promote community management, 440 community fisheries organizations were established by 2006, growing to 517 in 2018 - including 477 in the inland fishing communities and 40 in the marine communities, with 228 community fisheries organizations are located in the Tonle Sap flood plains [189]. However, the sector is challenged by ecological, socio-economic, and institutional problems. The official rounds of assessments conducted in 2003-2004 in three provinces show a decrease in poverty levels and an increase food security. However, more recently, Chap et al. [190] argue that "the rights-based regulations and incentive structures that are in place for community fisheries are inadequate to improve the management of either coastal or inland fisheries in all dimensions (productivity, control of illegal activities, benefit sharing, etc.)". Unclear Community Fisheries boundaries and the non-exclusionary nature of Community Fisheries has resulted in a surge of illegal fishing, both by small-scale fishers and by medium-scale commercial operations. Other issues faced in the co-management process include the lack of rights granted to Community Fisheries to operate commercial fishing activities; the lack of legal restrictions on household fishing gear, other than net length and mesh size requirements; and the limited rights of fishers to participate in fisheries management, given the stronghold of the state [191].

CamCode, the *Cambodian Code of Conduct for Responsible Fisheries*, stresses the importance of fisheries to vulnerable groups, particularly women and marginalized groups. As Chap et al. note, this principle recognizes "the key role of women in harvesting, aquaculture, processing, trade, purchasing, preparation and provision of fish for household consumption, and mainstreaming gender in all aspects of

fisheries management, development, conservation, and use" [192]. However, women often legitimize their presence in community fisheries, if any, through ties to powerful men; those women who are single heads of households or are less well off, are compelled to access resources at the margins of water bodies like the Tonle Sap, that fall outside the control of "influential networks" of powerful local elites [193].

According to the *Strategic Planning Framework for Fisheries 2010-2019*, the fisheries planning process in Cambodia comprises the three-year *Fisheries Development Action Plan,* the *Annual Fisheries Plan* and the Fisheries Cantonment *Annual Action Plans*. Together with CamCode - the *Cambodian Code of Conduct for Responsible Fisheries* - these plans provide overall guidance and structure for all fisheries stakeholders in Cambodia. There is no legal requirement to follow CamCode, nor are there any penalties for failing to do so [194].

According to the *Strategic Planning Framework for Fisheries*, strategic plans for the processed fish sector include the following:

1. At least 80% of fish processors and 80% of fish produced comply with quality and safety assurance regulations and standards by the end of 2019.

2. Co-operative associations provide established and functioning channels to access finance and markets by the end of 2019.

3. Interventions at the community level, leading to product and quality improvements and better market access, are implemented on a nationwide basis by the end of 2019.

According to the strategic plan, FiA is tasked with developing a full range of product standards to improve processing, quality, and packaging. There is no published literature that discusses the establishment and operation of the Technical Working Group on fisheries.

Challenges

Although the total fish biomass from dai fishing and from inland fisheries has remained relatively stable over the years [195], declining catch levels per household or fisher will present challenges in sourcing raw material for fish processing. Further, the declining catches for medium-large bodied fish species and the decreasing individual fish weights and sizes for some common species [196] may also mean changes for the processing sector. As a rough estimate, Ahmed et al. [197] found that the average annual catch per household from small-scale and family fishing was 647 kg in the 1990s, whereas data from approximately 15 years later suggest that the average annual household fish catch had declined to 245 kg [198]. However, a majority of fishers do not perceive a decline in their overall fish catch over the years [199].

Four major factors affecting the fish supply are summarized below.

Hydropower initiatives have contributed to a loss of fresh fish supply for processing.

The annual flooding and the reversal of flow is considered the heart-beat of the Mekong system [200], and is linked to fish migration as well. There are five hydropower dams currently in operation in the Upper Mekong, both of which are operated by China, while a further two dams for construction in the Lower Mekong by Cambodia are in the development stage. Dams and other structures reduce the flow of water, causing less water, fish, and nutrients to make their way into the Tonle Sap. A recent Stimson Center policy report sounds the alarm:

> In Cambodia alone, the connectivity of the country's 11,000 kilometers of the Mekong/Tonle Sap river system has already been reduced by 31% by the construction of two hydropower dams and six irrigation reservoirs. The improper siting of dams on Cambodia's tributaries would reduce connectivity by more than 60%, and mainstream dams at Sambor and Stung Treng would cut the Tonle Sap's connection to most of the Mekong River system. [201]

As a result of this damming, altered river flows, fragmented habitats, and blocked fish migrant routes will hinder the completion of fish life cycles and cause loss of nutrients and sedimentation [202]. These changes will have a negative impact on the fisheries, and in turn on fish processing. With migratory species forming 63% of the catch by weight from the Tonle Sap flood plains and up to 82% in the Tonle Sap River, disruptions to these fish migration patterns may result in drastic reductions in fish catches threatening food security and livelihoods. A recent study by Golden et al. [203] concerning the impacts of hydropower development in the Lower Mekong notes estimates that damming may decrease Lower Mekong Basin fishery production by as much as 42%, then projects increased risk of nutrition deficiencies in Cambodia (and the entire Lower Mekong Basin region) by 2030. According to this study:

> the median best- and worst-case scenarios indicated that, by 2030, there would be up to an additional 190,000-350,000 people newly at risk for deficiency for zinc in Cambodia... For protein, as many as 340,000-660,000 more individuals would be at risk for deficiency... Projections for the maximum increase in the population at risk for niacin deficiency spanned 160,000-310,000... the population newly at risk for thiamin deficiency to increase by up to 70,000-130,000 people... Riboflavin projections indicated that there would be as many as 260,000-470,000 additional people at risk for deficiency, for calcium, median projections indicated no additional risk of deficiency for Cambodia, largely because 99% of the Cambodian population is currently at risk for calcium deficiencies, not leaving much space to increase risk, and by 2030, 58% of the Cambodian population will have an average iron intake that is already lower than 150% of their estimated requirement [204].

Weak resource management and governance structures have failed to protect fish stocks due to poor policy implementation.

According to Cambodia's *Strategic Planning Framework for Fisheries 2010-2019*, weak enforcement and management capacities of fisheries related institutions, combined with continued illegal fishing practices, have contributed to increased pressure on the fishery resources and have sometimes led to tensions and conflicts among different user groups. Monofilament gill nets are considered a “wall-of-death” to many migrating fish species and are blamed for the decline of several fish species. The rising population in Cambodia and a lack of other livelihood options has caused an increased number of fishers, in turn putting pressure on fish stocks where individual fishers/fishing units may report lower fish catches per unit. While the restrictions are in place for type of gear, fishing season and fishing locations, there should be resources allocated for the implementation of these regulatory mechanisms [205].

However, given that Cambodia is regarded as an "example where formal rules can be replaced by informal rules", with a culture that adheres to "deference, obedience and patronage networks" [206], adopting a technocratic approach to enforcement capacity problems may not bring about the desired changes. Further, as key state policies on water, energy and agriculture tend to marginalize or ignore the social values of fisheries [207], the fisheries sector in Cambodia suffers from policy incoherence, despite its crucial role in livelihoods, food security, and biodiversity. Policy and governance challenges will have an impact on the future directions of the processed fish sector as well.

Aquaculture industry demand for small fish as feed reduces the availability of fish for human consumption.

Competing stakeholders have different interests in small fish processing in Cambodia, dependent on socio-economic class. Prior to the ban on Snakehead fish farming, around 92% of small fish were used as fish feed in the aquaculture industry [208]. Following the implementation of the ban, the small fish stock depletion rates declined and more fish have become available to small-scale processors, resulting in around 50% of the captured small fish coming to be used for making fish paste or fish sauce [209]. Snakehead farming did not entirely disappear during the 12-year ban period, due to poor enforcement [210]; and fish farming has increased in the Tonle Sap since the lifting of the ban in 2016, as a complementary livelihood activity to wild fish capture [211].

This trend highlights the importance of local and global debates over competing uses of small fish - either as fish feed, supporting the livelihoods of poor and vulnerable producers, or for human consumption, meeting the food security and nutrition needs. The case of Cambodian fish culture, especially small-scale pen and cage culture in the area of the floating villages, may provide some further new insights into this debate.

Climate change presents adverse effects on fish supply.

Cambodia has been identified as one of the countries most sensitive to climate change in the Southeast Asian region [212]. Cambodia's vulnerability is further exacerbated by low adaptive capacity [213]. Disasters and ecological change will continue to prove adverse for these populations who rely on vulnerable natural resources and ecosystems such as the water bodies of Cambodia.

Future climate and environmental changes in Cambodia are expected to take the form of more frequent or earlier floods, more frequent or earlier droughts, increasingly unpredictable rainfall patterns, changes to the hydrology of the Mekong water system [214].

The unique hydrological system of the Mekong, which floods during the rainy season and subsequently drains out Southwards from the Tonle Sap, is essential to the fish that support livelihoods and food security [215]. Disruptions to this pattern resulting from climate change impacts such as shorter and lower rainy seasons or modified flooding levels, combined with other factors such as damming and agriculture, will create impacts on fish-dependent livelihoods and food security. Focusing on the coastal communities and their adaptive capacities, using an “adaptive development” frame, Horlings and Marschke [216] find that fishers are diversifying their livelihoods at the household level by seeking work in the Special Economic Zones; yet concerns remain over the lack of capacity in urban systems. Governor [217] states that climate change and its impacts should not be treated in isolation from other socio-economic issues that have proven to be challenging to fisher communities, and that historical factors such as the impact of the genocide and other cultural factors that shape adaptive capacity should be also taken into consideration.

Conclusions

The literature reviewed in this report clearly identifies the role of processed fish in Cambodia as an important livelihood option, especially for the poorer segments of the population and women; as an important contributor to food security and nutrition; and as a cultural preference. This body of work is fragmented, however, as it does not focus specifically on the processed fish sector. Research that is directly about fish processing in Cambodia is marked by a focus on technical analysis, including the chemical composition of processed fish and the methods followed in processing fish paste and fermented fish. Some studies that analyze the fisheries sector more generally have included discussions of the processed fish sector, addressing a variety of themes - socio-economic conditions; culture; ecology and environment; nutrition; food security and food safety; and policy and governance.

A multidisciplinary lens is needed if we are to arrive at a comprehensive understanding of the processed fish sector in Cambodia, with the aim of addressing knowledge gaps or proposing practical interventions for development of the sector. Cambodia's fisheries sector - and particularly the processed fish sector within it - is closely connected with nutrition, food security, livelihoods, and socio-cultural identity, but is deeply affected by rapid ecosystem changes caused by climate change and human actions such as damming. Any analysis, policy, or intervention that does not pay sufficient attention to these interconnected dimensions will run the risk of producing skewed results, exacerbating ongoing vulnerabilities that may even jeopardise the entire fragile ecosystem.

As one specific example of an integrated approach, site selection for future practical interventions could address the socio-economic characteristics of those who engage in processing. Interventions that aim

to improve incomes, livelihoods, and employment levels should focus on the region around the Tonle Sap and on those households that are highly dependent on fishing, while incorporating analysis of fresh fish supply and their ability to deal with climate-related risks such as fish stock depletion. If the aim of an intervention is to strengthen food security and food safety, target groups should include those who are less dependent on fishing but still process fish for consumption purposes, or those who traditionally consume processed products as an important part of their diet and are financially insecure.

Socio-economic analysis and value chains of processed fish

Who does what?

Some of the studies reviewed here focus on value chains for specific fish species, and therefore include information about the processing of those fish species (e.g., low-value small fish, Snakehead). Another set of studies focuses on the socio-economic characteristics of those who engage in fishing, including sub-sections with detail on fish processors and traders of processed fish. These studies may analyze processors' and traders' socio-economic characteristics, the role played by women, costs involved in processing, value added through processing of specific fish species, household income, household consumption patterns (from fishing dependent households to those who are least dependent on fishing), labour arrangements within the household, and hired labour. As most of these studies were published at least five years ago, they do not necessarily reflect current conditions. Additionally, given that these studies do not take a comprehensive approach to analyzing the processed sector, they are unable to provide a deeper understanding of the socio-economic characteristics of large scale processing plants; impacts on specific groups, such as women and children; and changes in socio-economic characteristics of those who are part of the processed fish value chains.

Questions for follow-up research include:

- What is the role of the fish processing sector in providing livelihoods for the vulnerable and extremely poor groups? How "secure" is this livelihood, within the current and future social, economic and ecological conditions?
- What are the socio-economic characteristics of those who own processing plants and who work in them? What is their

role/contribution in the overall processed fish value chain?

- How important is fish processing for women and children as a source of income, and how does engaging in processing shape their broader socio-cultural positioning within Cambodian society?
- How do gendered socialization processes continue to shape young girls' and boys' engagement with fisheries and fish processing?
- What changes have occurred in home-based production processes, including prahoc production, along the water bodies during the peak fishing season?

What fish goes where for processing?

There is a gap in our understanding on the origins of fresh fish supplied for processing, both in terms of geographical location and in terms of the source fishery type (freshwater capture, aquaculture, or marine capture). We also lack knowledge of the proportion of fish supplied domproestically or through imports, particularly with the aquaculture sector. Within this supply chain, it remains unclear what grading systems are being applied or what decision-making processes are followed as fish are selected for processing or other purposes. The following research questions may help us fill these gaps:

- What proportions of freshwater capture fish, aquaculture fish, and marine fish are used for processing? How have these proportions changed?
- What proportions of locally harvested/produced fish and what proportions of imported fish are used for processing?
- What is the role of aquaculture in ensuring a steady supply of fish for processing in Cambodia?

- What is the impact on the processing sector of the increasing demand for low value small fish as animal feed?

Another clear knowledge gap concerns the market structure for the diverse range of processed fish that are sold within Cambodia and across borders. A few studies from the early 2000s provide information about prices and quantities sold at retail markets, as well as some socio-economic characteristics of retail traders, such as the number of years they had been in business. There are no studies that focus on wholesale trade or on exports. The following research questions are proposed:

- How is the marketing of processed fish organised in Cambodia? What are the main markets? How do the different processed products flow through the markets?
- How much processed fish is exported from Cambodia? What is the export demand for processed fish from Cambodia?
- What are the defining socio-economic characteristics of wholesale traders of processed fish in Cambodia, and what are their linkages with the other actors along the value/market chain?
- What is the continued role of bartering practices in fish processing? Who engages in them? How does bartering shape socio-economic dynamics of those parties who are involved in the practice?
- What role can domestic, diaspora, and international tourism play in processed fish marketing?

The available literature has an overwhelming focus on fermented, freshwater fish, especially prahoc. Several authors have documented the steps in prahocprocessing and outlined value chains for the product, showing regional variations. There is a clear lack of analysis marine fish-based processed products such as fermented shrimp paste (kapi), which is seen to play a relatively important role in the pro-

cessed fish industry in Cambodia. Similarly, other processed fresh fish-based products, such as smoked fish and salted and dried fish, also receive less attention compared to prahoc.

- What are the processing techniques used for the processed fish products other than prahoc? Who is engaged in this processing and what are the sourcing and marketing channels?
- How is the marine product-based processing organized? Where are the main processing sites located? Who engages in the processing? How does the sourcing and marketing occur?

Who consumes what? Why?

While published studies have identified the consumption of processed food as a traditional practice and cultural preference, there are no studies that have analysed food preferences and how these may be evolving along with the broader changes that are taking place within Cambodian society. Some specific questions to fill these gaps:

- How has preference for prahocchanged over generations? What are the foods seen as alternatives toprahoc?
- What are the preferences of Cambodian people for processed fish?
- Does the younger generation have a preference for processed fish? Why?

Nutrition, food safety, and food security of processed fish

How can the use of small fish as a nutrition source be augmented, especially for economically poorer households that live away from water bodies?

- What are the nutritional values of the traditionally processed fish products such as prahoc, pa ork, or salted and dried fish in

Cambodia?

- How will the decrease in certain types of fish, and catch per unit, impact the nutrition and food security provided by processed fish?
- What are the food safety issues involved in fish processing?

Linked to use of technology and sustainable technology transfer:

- How can improved quality standards be introduced and maintained to ensure better food safety? What are the incentives for processors to follow such standards?
- What are the steps necessary to make processors more receptive to technology transfer?

Ecology, environment and climate change and linkages with processed fish

A strong body of literature on the impacts of climate change on Cambodia's fish ecology and water bodies, and those who are dependent on these resources, is emerging. A few gaps remain and the following questions are proposed:

- How will the declining catch per unit for wild freshwater fisheries impact the processed fish sector, including incomes/livelihoods and trade?
- In what ways can the declining wild fish stocks be supplemented? What is the role of aquaculture?
- Can improvements in processing systems provide higher incomes from fish processing, to offset the impacts of climate change?

Fisheries policy, governance and related practical interventions, and their impacts on processed fish sector

Cambodia's *Strategic Planning Framework for Fisheries 2010-2019* and the *National Strategic Development Plan 2010-2019* recognize the importance of the fisheries sector and propose a range of interventions and policy decisions, including strengthened implementation of the fisheries policy reforms and better implementation of policies to deter illegal fishing.

Some proposed research questions for the policy domain are:

- What is (or could be) the involvement of community fisheries in strengthening the processing sector?
- How can women's voices within community fisheries be augmented meaningfully, in connection with their involvement in fish processing?
- What is the role of interventions coming from the private sector and from state institutions in the processed fish sector?
- What development projects have targeted the fish processing sector in Cambodia? What are the lessons learnt?

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19. ↑ Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.
20. ↑ Yamamoto, “Ethnic Fermented Foods and Beverages of Cambodia” Yoshida, “Umami Taste and Traditional Seasonings”.
21. ↑ Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”.
22. ↑ Ahmed et al., “Fish Consumption Pattern in Major Freshwater Fisheries Provinces of Cambodia”.
23. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”.
24. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”, 13.
25. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
26. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 12.
27. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”.
28. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
29. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
30. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”.

31. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
32. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area".
33. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area", 43.
34. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area", 43.
35. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area", 43.
36. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area", 34.
37. ↑ Sinh, Hap, and Pomeroy, "Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam".
38. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 8.
39. ↑ Thomson, "Notes on Cambodia and Its Races", p. 250.
40. ↑ Thomson, "Notes on Cambodia and Its Races", 249-251.
41. ↑ Yankowski, Kerdsap, and Chang, "'Please Pass the Salt' – an Ethnoarchaeological Study of Salt and Salt Fermented Fish Production, Use and Trade in Northeast Thailand".
42. ↑ Yoshida, "Umami Taste and Traditional Seasonings".
43. ↑ Ruddle and Ishige, "On the Origins, Diffusion and Cultural Context of Fermented Fish Products in Southeast Asia".
44. ↑ See Khumsri, Ruddle, and Shivakoti, "Rights and Conflicts in the Management of Fisheries in the Lower Songkhram River Basin, Northeast Thailand"; Ruddle, "The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea".

45. ↑ Ruddle and Ishige, “On the Origins, Diffusion and Cultural Context of Fermented Fish Products in Southeast Asia”, 10.
46. ↑ Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”.
47. ↑ Chansothea et al., *Asserting Rights, Defining Responsibilities*.
48. ↑ Asif, “From Sea to City: Migration and Social Well-Being in Coastal Cambodia”; Derks, “Migrant Labour and the Politics of Immobilisation”.
49. ↑ Horlings and Marschke, “Fishing, Farming and Factories: Adaptive Development in Coastal Cambodia”.
50. ↑ see Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.
51. ↑ Estepa et al., “Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia”; Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*; So et al., “Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia”; Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”; Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
52. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
53. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”, 30.
54. ↑ Sinh, Hap, and Pomeroy, “Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam”.
55. ↑ author calculation based on Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

56. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 12.
57. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
58. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia", 11.
59. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia", 6. The referenced study includes focus group discussions with men and women separately from the wealth groups of medium, poor and very poor, but does not explicitly specify the definition criteria for these wealth categories.
60. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 9.
61. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia", 12.
62. ↑ Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.
63. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia".
64. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia".
65. ↑ Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.
66. ↑ Estepa et al., "Trends, Opportunities and Constraints in the Contribution of Fish to the Welfare of Rural Communities in Cambodia", 8.

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68. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”.
69. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
70. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”, 14.
71. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
72. ↑ In the referenced study, designates households where 60% or more household members are female.
73. ↑ Kusakabe, “Women Fish Processors in Cambodia: Challenges for Collective Business”.
74. ↑ Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.
75. ↑ Kusakabe, “Women and Men’s Perceptions of Borders and States”.
76. ↑ See Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study” for a detailed analysis of the landing sites, and fish supply and trade chains.
77. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”, 8.
78. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”, 26.
79. ↑ Brooks and Sieu, *The Potential of Community Fish Refuges (CFRs) in Rice Field Agro-Ecosystems for Improving Food and Nutrition Security in the Tonle Sap Region*.

80. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

81. ↑ author calculation based on Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)* fig. 5. It is unspecified in the study whether or not this figure includes rice field fisheries.

82. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

83. ↑ author calculation based on Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)* fig. 5.

84. ↑ Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area", 42.

85. ↑ Ahmed et al., "Fish Consumption Pattern in Major Freshwater Fisheries Provinces of Cambodia"; Baran, *Cambodian Inland Fisheries*; So et al., "Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia"; Rab et al., "Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area".

86. ↑ Hap et al., "Value Chain Analysis of Five Key Fish Species".

87. ↑ Sinh, Hap, and Pomeroy, "Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam".

88. ↑ So et al., "Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia".

89. ↑ Sinh, Hap, and Pomeroy, "Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam".

90. ↑ Sinh, Hap, and Pomeroy, "Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam".

91. ↑ This study focuses on households that engage in processing, with half of the households engaging labour (2.1 workers on average).

92. ↑ Sinh, Hap, and Pomeroy, “Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam”, 80.
93. ↑ So et al., “Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia”.
94. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”.
95. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
96. ↑ Doulman, “Reconstruction and Rehabilitation of the Cambodian Fisheries Sector”.
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99. ↑ Doulman, “Reconstruction and Rehabilitation of the Cambodian Fisheries Sector”.
100. ↑ FAO, “Fishery Value Chain Analysis in Cambodia”.
101. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”, 43.
102. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.
103. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
104. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
105. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”, 50.

106. ↑ taken from Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”, 44.
107. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”, 44.
108. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”, 22.
109. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”, 23.
110. ↑ So et al., “Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia”.
111. ↑ Processors in this study refer to household level processors and not processing plants.
112. ↑ Hap et al., “Value Chain Analysis of Freshwater Small Sized Fish in Cambodia”, 290.
113. ↑ Hap, “Trade, Marketing and Processing of Fisheries and Fishery Products”; cited in Chansothea et al., *Asserting Rights, Defining Responsibilities*.
114. ↑ So et al., “Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia”.
115. ↑ So et al., “Value Chain Analysis of Freshwater Small-Sized Fish in Cambodia”, 237.
116. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”.
117. ↑ Rab et al., “Marketing Infrastructure, Distribution Channels and Trade Pattern of Inland Fisheries Resources Cambodia: An Exploratory Study”, 32.
118. ↑ Mille, Hap, and Loeng, “Economic Value of Fish in Cambodia and Value Added along the Trade Chain”.

119. ↑ Weighted average integrating value and proportion in sales of each species over a year.

120. ↑ Mille, Hap, and Loeng, “Economic Value of Fish in Cambodia and Value Added along the Trade Chain”, v.

121. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

122. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 25.

123. ↑ Norng et al., “Small-Sized Fish Paste (Prahoc) Processing in Cambodia”; So et al., “Development of Alternatives to the Use of Freshwater Low Value Fish for Aquaculture in the Lower Mekong Basin of Cambodia and Vietnam”.

124. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”; Kusakabe, “Women Fish Processors in Cambodia: Challenges for Collective Business”.

125. ↑ Hortle et al., “An Introduction to Cambodia’s Inland Fisheries”.

126. ↑ See Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”, 7 for a detailed technical and ecological analysis of the large scale fishing methods.

127. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”; see also Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.

128. ↑ Villages where 80-90% of the households consider their primary occupation as fishing.

129. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

130. ↑ Villages where more than 80% of the households consider farming as their primary livelihood.

131. ↑ Rab et al., “Socioeconomics and Values of Resources in Great Lake-Tonle Sap and Mekong-Bassac Area”; see also Hap, Leang, and Chuenpagdee, *Socioeconomics and Livelihood Values of Tonle Sap Lake Fisheries*.

132. ↑ author calculation based on Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)* table 6.

133. ↑ Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”.

134. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

135. ↑ Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”.

136. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”, viii.

137. ↑ Ruddle, “The Ecological Basis for Fish Fermentation in Freshwater Environments of Continental Southeast Asia: With Special Reference to Burma and Kampuchea”.

138. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

139. ↑ McKenney and Tola, “Prahoc and Food Security”.

140. ↑ McKenney and Tola, “Prahoc and Food Security”, 6.

141. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

142. ↑ So, Vann, and Kura, “Study of the Catch and Market Chain of Low Value Fish along Tonle Sap River, Cambodia: Implications for Management of Their Fisheries”; see also Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

143. ↑ Ngor et al., “Evidence of Indiscriminate Fishing Effects in One of the World’s Largest Inland Fisheries”.

144. ↑ Sinh, Hap, and Pomeroy, “Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam”.

145. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

146. ↑ So, Vann, and Kura, “Study of the Catch and Market Chain of Low Value Fish along Tonle Sap River, Cambodia: Implications for Management of Their Fisheries”, 7; see also Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”, 30.

147. ↑ So et al., “Use of Freshwater Low Value Fish for Aquaculture Development in the Cambodia’s Mekong Basin”.

148. ↑ So et al., “Use of Freshwater Low Value Fish for Aquaculture Development in the Cambodia’s Mekong Basin”; see also Joffre, So, and Chheng, “Aquaculture Production in Cambodia”.

149. ↑ Joffre, So, and Chheng, “Aquaculture Production in Cambodia”.

150. ↑ Norng et al., “Small-Sized Fish Paste (Prahoc) Processing in Cambodia”.

151. ↑ Norng et al., “Small-Sized Fish Paste (Prahoc) Processing in Cambodia”, 38.

152. ↑ Norng et al., “Small-Sized Fish Paste (Prahoc) Processing in Cambodia”, 38.

153. ↑ Aldin-Lundgren, “Role of Low Value Fish for Consumption and Possible Interactions/Conflicts with the Aquaculture in Cambodia”.

154. ↑ McKenney and Tola, “Prahoc and Food Security”, 7.

155. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”.

156. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”.

157. ↑ The five provinces included in this study are Phnom Penh, Battambang, Kandal, Kampong Chhnang, and Siem Reap. Three of the export companies for fermented small fish paste studied by Un et al. are located in Battambang Province.

158. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”.

159. ↑ Aldin-Lundgren, “Role of Low Value Fish for Consumption and Possible Interactions/Conflicts with the Aquaculture in Cambodia”.

160. ↑ Baran, Jantunen, and Chong, *Values of Inland Fisheries in the Mekong River Basin*.

161. ↑ Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*.

162. ↑ Aldin-Lundgren, “Role of Low Value Fish for Consumption and Possible Interactions/Conflicts with the Aquaculture in Cambodia”.

163. ↑ McKenney and Tola, “Prahoc and Food Security”.

164. ↑ Norng et al., “Small-Sized Fish Paste (Prahoc) Processing in Cambodia”.

165. ↑ Hap and Johnstone, “Commodity and Product Identification for Value Chain Analysis”.

166. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”.

167. ↑ Slámová et al., “Polycyclic Aromatic Hydrocarbons in Cambodian Smoked Fish”.

168. ↑ Slámová et al., “Polycyclic Aromatic Hydrocarbons in Cambodian Smoked Fish”, 249.

169. ↑ Chap, Touch, and Diepart, “Fisheries Reforms and Right-Based Fisheries”.

170. ↑ Roos et al., “Iron Content in Common Cambodian Fish Species”.

171. ↑ For example: Yoshida, “Umami Taste and Traditional Seasonings”; Mizutani et al., “Chemical Components of Fermented Fish Products”; Kimizuka et al., “A chemical analysis of fermented fish products and discussion of fermented flavors in Asian Cuisines”; Ruddle and Ishige, “On the Origins, Diffusion and Cultural Context of Fermented Fish Products in Southeast Asia”.

172. ↑ Chuon et al., “Microbial and Chemical Properties of Cambodian Traditional Fermented Fish Products”.

173. ↑ Giri et al., “Olfactometric Characterization of Aroma Active Compounds in Fermented Fish Paste in Comparison with Fish Sauce, Fermented Soy Paste and Sauce Products”.

174. ↑ Slámová et al., “Polycyclic Aromatic Hydrocarbons in Cambodian Smoked Fish”.

175. ↑ Michaelsen et al., “Choice of Foods and Ingredients for Moderately Malnourished Children 6 Months to 5 Years of Age”.

176. ↑ Mogensen, “The Importance of Fish and Other Aquatic Animals for Food and Nutrition Security in the Lower Mekong Basin”; Michaelsen et al., “Choice of Foods and Ingredients for Moderately Malnourished Children 6 Months to 5 Years of Age”; cited in Vilain and Baran, “Nutritional and Health Value of Fish”, 12.

177. ↑ Udomthawee et al., “Protein, Calcium and Phosphorus Composition of Fermented Fish in the Lower Mekong Basin”.

178. ↑ Udomthawee et al., “Protein, Calcium and Phosphorus Composition of Fermented Fish in the Lower Mekong Basin”, 327.

179. ↑ Halls et al., “The Stationary Trawl (Dai) Fishery of the Tonle Sap-Great Lake, Cambodia”.

180. ↑ Borg et al., “Development and Testing of Locally-Produced Ready-to-Use Therapeutic and Supplementary Foods (RUTFs

and RUSFs) in Cambodia".

181. ↑ Skau et al., "The Use of Linear Programming to Determine Whether a Formulated Complementary Food Product Can Ensure Adequate Nutrients for 6-to 11-Month-Old Cambodian Infants".

182. ↑ KC et al., "Exploring Tropical Fisheries through Fishers' Perceptions"; see Ratner, "Community Management by Decree?" for an historical overview of fisheries law in Cambodia.

183. ↑ Chap, Touch, and Diepart, "Fisheries Reforms and Right-Based Fisheries".

184. ↑ Chap, Touch, and Diepart, "Fisheries Reforms and Right-Based Fisheries".

185. ↑ see Chap, Touch, and Diepart, "Fisheries Reforms and Right-Based Fisheries" for a detailed description of the legal mechanisms that govern Cambodian fisheries.

186. ↑ Dina and Sato, "Is Greater Fishery Access Better for the Poor?"; see also KC et al., "Exploring Tropical Fisheries through Fishers' Perceptions".

187. ↑ KC et al., "Exploring Tropical Fisheries through Fishers' Perceptions", 453.

188. ↑ KC et al., "Exploring Tropical Fisheries through Fishers' Perceptions"; KC et al., "Evaluating Community Fishery Management Using Fishers' Perceptions in the Tonle Sap Lake of Cambodia"; Kurien, "Community Fisheries Organizations of Cambodia"; Chap, Touch, and Diepart, "Fisheries Reforms and Right-Based Fisheries"; Marschke, *Life, Fish and Mangroves*; Elmhirst and Resurreccion, "Gender, Environment and Natural Resource Management".

189. ↑ Ngor et al., "Evidence of Indiscriminate Fishing Effects in One of the World's Largest Inland Fisheries".

190. ↑ Chap, Touch, and Diepart, "Fisheries Reforms and Right-Based Fisheries", 22.

191. ↑ Chap, Touch, and Diepart, “Fisheries Reforms and Right-Based Fisheries”, ii-iii.

192. ↑ Chap, Touch, and Diepart, “Fisheries Reforms and Right-Based Fisheries”, 21.

193. ↑ Elmhirst and Resurreccion, “Gender, Environment and Natural Resource Management”.

194. ↑ Chap, Touch, and Diepart, “Fisheries Reforms and Right-Based Fisheries”.

195. ↑ Ngor et al., “Evidence of Indiscriminate Fishing Effects in One of the World’s Largest Inland Fisheries” Sinh, Hap, and Pomeroy, “Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam”.

196. ↑ Ngor et al., “Evidence of Indiscriminate Fishing Effects in One of the World’s Largest Inland Fisheries” KC et al., “Exploring Tropical Fisheries through Fishers’ Perceptions”.

197. ↑ Ahmed et al., “Fish Consumption Pattern in Major Freshwater Fisheries Provinces of Cambodia”.

198. ↑ Author calculation based on Mousset et al., *Roles and Values of Fish in Rural Welfare in Cambodia (Welfare Data Analysis)*, 8.

199. ↑ KC et al., “Exploring Tropical Fisheries through Fishers’ Perceptions”.

200. ↑ Eyler and Weatherby, “Letters from the Mekong: Toward a Sustainable Water-Energy-Food Future in Cambodia”.

201. ↑ Eyler and Weatherby, “Letters from the Mekong: Toward a Sustainable Water-Energy-Food Future in Cambodia”, 3.

202. ↑ Ngor et al., “Evidence of Indiscriminate Fishing Effects in One of the World’s Largest Inland Fisheries”, 7.

203. ↑ Golden et al., “Impacts of Mainstream Hydropower Development on Fisheries and Human Nutrition in the Lower Mekong”.

204. ↑ Golden et al., “Impacts of Mainstream Hydropower Development on Fisheries and Human Nutrition in the Lower Mekong”, 6.

205. ↑ Ngor et al., “Evidence of Indiscriminate Fishing Effects in One of the World’s Largest Inland Fisheries”, 7.

206. ↑ Marschke, *Life, Fish and Mangroves*, 8.

207. ↑ Chap, Touch, and Diepart, “Fisheries Reforms and Right-Based Fisheries”.

208. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia” see also So et al., “Use of Freshwater Low Value Fish for Aquaculture Development in the Cambodia’s Mekong Basin”.

209. ↑ Un et al., “Market Chain of Fermented Small Size Fish Past in Cambodia”.

210. ↑ Joffre, So, and Chheng, “Aquaculture Production in Cambodia”.

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213. ↑ Horlings and Marschke, “Fishing, Farming and Factories: Adaptive Development in Coastal Cambodia”.

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215. ↑ KC et al., “Exploring Tropical Fisheries through Fishers’ Perceptions”.

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217. ↑ Governor, “Private Sector Partnership as an Adaptive Capacity Change Mechanism”.

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