

Values of inland fisheries in the Mekong River Basin.

Eric BARAN
Teemu JANTUNEN
Chiew Kieok CHONG

FINAL DRAFT
07/09/2005

Citation: Baran E., Jantunen T., Chong C.K. In press. Values of inland fisheries in the Mekong River Basin. In: Neiland A. E. (ed.) River fisheries valuation: a global synthesis and critical review with particular reference to developing countries. Report for the Comprehensive Assessment of water management in Agriculture. In press.

TABLE OF CONTENTS

1	INTRODUCTION.....	4
2	BASINWIDE ANALYSES.....	5
2.1	Basin overview	5
2.2	Economic valuation analyses.....	6
2.2.1	Direct use values	6
2.2.1.1	Catch values.....	7
2.2.1.2	Market values	8
2.2.1.3	Consumption values.....	8
2.2.2	Indirect use values.....	10
2.2.2.1	Biodiversity values.....	10
2.2.2.2	Cultural values.....	11
2.3	Economic impact analyses.....	12
2.4	Livelihood analyses.....	14
2.5	Impact of changes on fisheries basinwide	15
3	YUNNAN PROVINCE, PEOPLE'S REPUBLIC OF CHINA	18
4	LAO PEOPLE'S DEMOCRATIC REPUBLIC.....	20
4.1	Country overview	20
4.2	Economic valuation analyses.....	21
4.2.1	Direct use values	21
4.2.1.1	Catch values.....	21
4.2.1.2	Market values	22
4.2.1.3	Consumption values.....	22
4.3	Socio-economic analyses	24
4.4	Livelihood analyses.....	25
4.5	Impact of changes on fisheries in Laos.....	25
5	KINGDOM OF THAILAND	27
5.1	Country overview	27
5.2	Economic valuation analyses.....	27
5.2.1	Direct use values	27
5.2.1.1	Catch values.....	27
5.2.1.2	Market values	28
5.2.1.3	Consumption values.....	28
5.3	Socio-economic analyses	29
5.4	Impact of changes on fisheries in Thailand.....	29
5.4.1	Example of Pak Mun dam	29
6	KINGDOM OF CAMBODIA.....	31
6.1	Country overview	31
6.2	Economic valuation analyses.....	32
6.2.1	Direct use values	32
6.2.1.1	Catch values.....	32
6.2.1.2	Market values	33
6.2.1.3	Consumption values.....	35
6.3	Socio-economic analyses	36
6.4	Livelihood analyses.....	37
6.5	Impact of changes on fisheries in Cambodia	38
7	SOCIALIST REPUBLIC OF VIETNAM	40
7.1	Country overview	40
7.2	Economic valuation analyses.....	41
7.2.1	Direct use values	41
7.2.1.1	Catch values.....	41
7.2.1.2	Consumption values.....	41
7.3	Socio-economic analyses	42
7.4	Livelihood analyses.....	42
7.5	Impact of changes on fisheries in Vietnam	43
8	CONCLUSIONS.....	44
9	REFERENCES.....	45

ACRONYMS

ADB	=	Asian Development Bank
AMFC	=	Assessment of Mekong Fisheries project (MRC)
DoF	=	Department of Fisheries (Cambodia)
GDP	=	Gross Domestic Product
IUCN	=	World Conservation Union
LARReC	=	Living Aquatic Resources Research Center
LMB	=	Lower Mekong Basin
MRC	=	Mekong River Commission

ACKNOWLEDGEMENTS

The authors would sincerely like to thank the following persons who reviewed the draft document and contributed, by their comments and contributions, to significantly improving it:

Chris Barlow (Mekong River Commission); Christophe Béné (WorldFish Center); Simon Bush (University of Sidney); Peter Degen; Richard Friend (IUCN); Simon Funge-Smith (FAO); Kent Hortle (Mekong River Commission); Marko Keskinen (Helsinki University of Technology); Kai Lorenzen (Imperial College); Niklas Mattson (Mekong River Commission); Magnus Torell (SEAFDEC); Danilo Israel (WorldFish Center); and Yeo Bee Hong (WorldFish Center).

Thanks also to Rowena Andrea Valmonte-Santos and Hari Balasubramanian who contributed to the initial information gathering, to Greg Cans for assistance in data handling and to Chris Myschowoda for stylistic betterment. Chong Chiew Kieok produced a preliminary draft of this review in 2003.

1 INTRODUCTION

Asia has the most productive inland fisheries in the world and this sector contributes very significantly to the national economies of the region (Revenga *et al.* 2000). Inland fisheries also improve food security by providing a source of protein and a livelihood for millions of people in this part of the world, especially the rural poor. However, increasing competition for water resources, unregulated fishing and high population growth in riparian countries of major river basins have increased pressure on these resources and contributed to increasing threats to fisheries production.

The values of river fisheries are numerous (details in Cowx *et al.* 2004). The purpose of this report is to provide information on the biological, economic, social and cultural values of river fisheries in the Lower Mekong Basin, and to identify the main impacts of environmental changes on these values. A review of fisheries-related literature, including project reports and grey literature, was undertaken. More than 800 documents were reviewed, and original information was extracted from 270 of them. The analysis identified a large number of localised studies leading to generic conclusions.

The review first addresses the basinwide issues and studies, then is organised by nation, namely the Chinese Province of Yunnan then Laos, Thailand, Cambodia and Vietnam. It first gives an overview of each country's economic, fisheries and social situation then details the values documented for river fisheries in each country.

Available information is classified as much as possible according to the following theoretical framework synthesized from Neiland and Béné (this issue) and Emerton and Bos (2004):

a) **resource-centred approaches**, including:

- i) *conventional economic analyses*, the total economic value consisting of:
 - *use values* (direct use value, indirect use value, option values) and
 - *non-use values* (bequest value, existence value)

- ii) *economic efficiency analyses*

- iii) *economic impact analyses*

b) **people-centred approaches**, including

- i) *socio-economic analyses, and*
- ii) *livelihood analyses*

However, the valuation studies at the regional level as well as in each riparian country did not always match or fill in this framework. In practice, the framework used is next:

- Economic valuation analyses

- Direct use values

- Catch values

- Consumption values

- Market values

- Indirect use values

- Economic impact analyses

- Socio-economic analyses (whenever existing)

- Livelihood analyses

This review of the values of fisheries and aquatic products in the Mekong Basin is supplemented by a brief analysis of the impact of changes in river flows and floodplain land use on the fisheries of each country.

2 BASINWIDE ANALYSES

2.1 Basin overview

The Mekong River is the 12th longest river in the world (MRCS 1992) and the lifeline of South-East Asia flowing through the riparian states of China, Myanmar, Laos, Thailand, Cambodia and Vietnam (see figures 1 and 2).

In 2003 the population in the Lower Mekong Basin amounted to 53 million (MRC 2003a). Fifty percent of this population is under 15 years of age, and it is projected to increase to as much as 90 million by the year 2025 (MRC 2003b). The Basin covers nearly 795,000 km², giving a population density of 92 person/km². In comparison with other Asian river basins, the Mekong Basin is not densely populated at present, and land and water resources are still relatively plentiful, as only a part of its potential has so far been developed (Kristensen 2000, ADB/UNEP 2004).

However, industrial development, particularly in upstream countries, is problematic as the rural economies of the downstream countries, Cambodia and Vietnam, are especially vulnerable to upstream changes. For instance, 60% of Vietnam's agricultural production comes from the Mekong Delta (Jones 1997) and 60% of Cambodia's fish catch comes from the Tonle Sap Lake (Ojendal and Torell 1998).

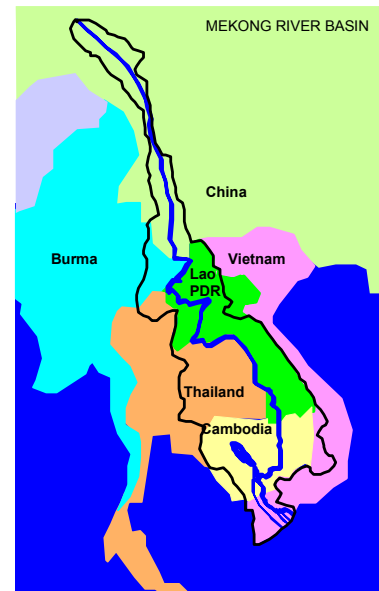


Figure 1: The Mekong River Basin, from Tibet to the South China Sea

The Mekong River has one flood pulse a year followed by a dry season. During the monsoon season (May to November), the river's discharge is the third largest in the world after those of the Amazon and the Brahmaputra, and can reach 54 times the minimum mean discharge (Welcomme 1985). The floods annually inundate some 84,000 km² of floodplains (Scott 1989), which creates huge breeding and spawning grounds for fish. Many Mekong fish species are migratory, crossing national boundaries during their life cycle driven by hydrological pulses, and the fisheries are crucially dependent on the annual flooding pattern. Thus the Mekong floods and the extensive sediment, nutrient and energy transfers they generate between sub-basins and countries play a crucial role in the productivity of the system.

Compared to most international river basins, the Mekong River has a unique cooperation organisation: the Mekong River Commission (MRC). The MRC is a successor of the Mekong Committee and the Interim Mekong Committee, which were in operation during the periods 1957-1975 and 1978-1995 respectively. The UN played an important role in achieving the cooperation in the early 1950s and the United Nations Development Programme (UNDP) provided important negotiation assistance for the drafting of the 1995 Agreement (Ringler 2001).

The mandate of the MRC 1995 Agreement signed by Laos, Thailand, Cambodia and Vietnam is *"to cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin, including, but not limited to irrigation, hydro-power, navigation, flood control, fisheries, timber floating, recreation and tourism, in a manner to optimize the multiple-use and mutual benefits of all riparians and to minimize the harmful effects that might result from natural and man-made activities"*.

Recently, MRC has been involved in the development of several policy, hydrological and management models, which in the near future will provide planning tools for economic valuation and management of water resources in the region. Research in the fisheries sector is also underway by the Mekong River Commission Secretariat (MRCS), including catch and market monitoring, fishery and fish larvae monitoring, consumption studies, and surveys of deep pools in the mainstream (MRC 2004a). Environmental flows, economic valuation and hydrological modelling are also high on the MRC's agenda. However this institution is faced with the conflicting views of the riparian countries about the value and potential of the river. Simply put, China sees it as a source of hydropower and as a trade route, Myanmar is the country with the least share and interest in the Mekong, Thailand is primarily interested in water for irrigation, Cambodia heavily relies on

wild fisheries and Vietnam values the Mekong waters for irrigation of rice fields and as a way to oppose the saline intrusion (Ratner 2003, Campbell 2005).



Figure 2: The Lower Mekong Basin showing major tributaries, large reservoirs and flooded areas (after Van Zalinge *et al.* 1999).

Marine fisheries and the aquaculture sector have been generally regarded in the Mekong Basin as important for revenue generation, export earnings and formal economic benefits whereas traditionally inland fisheries have only been seen as important for rural livelihoods. Consequently official data collection efforts have concentrated on other fisheries than inland fisheries (Coates 2002, 2003). Limited valuation studies have been conducted, and most of the values reported are direct extractive values of fisheries. Underestimation of the inland capture fisheries benefits other sectors, such as hydroelectricity, irrigation and flood control, which in turn adversely affect inland capture fisheries.

2.2 ECONOMIC VALUATION ANALYSES

2.2.1 DIRECT USE VALUES

The Mekong contributes directly to food security in terms of fishery production and irrigation of rice fields. Other direct use values are transportation, domestic and industrial uses as well as tourism activities. The fisheries provide a livelihood not just for fishers and their families but also an income for all those who are employed in repairing boats, selling fishing gears, processing aquatic products, and ultimately selling these things.

2.2.1.1 Catch values

Estimates for total fisheries production in the Lower Mekong Basin have been evolving upwards as new studies, household surveys and improvements in data collection and analysis have been achieved. Interestingly, at the same time, reports of declining fish catches have also been reported. Baran *et al.* (2001a) demonstrated, however, that in Cambodia what has decreased is the catch per fisher, as the population has tripled while the fish harvest has only doubled between the 40's and the 90's.

Another recurrent issue has been the discrepancy between official statistics and those based on scientific surveys, as illustrated in Table I where national capture production figures are lower than those resulting from scientific studies. Coates (2002, 2003) has explained this discrepancy by the partial or total absence of a field-based monitoring system in most riparian countries. This even leads to the conclusion that *"unless detailed investigations indicate otherwise, with few exceptions, policies for river fisheries should not be based upon current national statistics"* (Coates *et al.* 2004). In this review we focus rather on scientific estimates.

Country	Annual catch based on scientific assessments ¹	Annual catch according to official country statistics ²
Cambodia	289,000 – 431,000	245,600
Lao PDR	27,000	29,250
Thailand	303,000	209,404
Vietnam	190,000	161,000
<i>Total</i>	<i>809,000 – 951,000</i>	<i>645,254</i>

Table I: Estimated inland capture fisheries production in the Mekong Basin in 2000, in tons.

¹ Van Zalinge *et al.* 2000; ² FAO data

Starting 1991-1992, reports estimated the catch at 357,000 tons including aquaculture. This figure was increased a few years later to 620,000 tons (Jensen 1996), then close to one million tons (Jensen 2000), then to 1.53 million tons (Sverdrup-Jensen 2002). At that time Jensen (2001a) noticed that the floodplains of the LMB were producing some four times as much fish per square kilometre as the North Sea in Europe. In 2004, the estimates for the Lower Mekong Basin (LMB) have risen to 2.64 million tons from capture fisheries in rivers alone, with an additional 250,000 tons from reservoir fisheries and another 250,000 tons from aquaculture (MRC 2004a, Van Zalinge *et al.* 2004, MRC 2005). These are the main figures published and disseminated; however other intermediate figures, often from the same authors, can be found in project reports and unpublished documents.

This evolution in figures does not reflect any interannual variability (as there has never been a monitoring of basin fish production over years) but rather the increasing acknowledgement of the importance of the Mekong fish resource. However, Dixon *et al.* (2003) also wonder whether a possible upward production trend is sustainable, or masks significant changes in the composition of species in the fisheries, with a strong decline of formerly important and valuable species.

Country	Publishing year	1999 ¹	2002 ²	2004 ³
Cambodia		290,000 - 430,000	508,000	682,150
Lao PDR		27000	133,000	182,700
Thailand		303000	795,000	932,300
Vietnam		190000	597,000	844,850
China			25,000 ⁴	
Total LMB		810,000 - 950,000	2,050,000	2,642,000

Table II Different estimates of LMB fish production from river capture fisheries.

1) Van Zalinge *et al.* 1999; 2) Barlow, 2002; 3) Van Zalinge *et al.* 2004; 4) Yunnan only, estimated from Xie and Li, 2003.

Statistics on Myanmar inland capture fisheries are not available, although these fisheries are very developed (FAO 3003); however only 2% of the Mekong Basin lies in this country, in a mountainous area, and it can be reasonably assumed that the Burmese share of Mekong fish catches is not significant.

FAO statistics record 8 million tons of inland fish caught per year worldwide, including 563,000 tons from the Mekong Basin. As noted in Baran (2005), if one acknowledges the underreporting of catches in official statistics (Jensen 2001b, Coates 2002) and accepts the latest published figure of 2.64 million tons from

Mekong capture fisheries (Van Zalinge *et al.* 2004), then the total catch from inland fisheries worldwide amounts to about 10 million tons. The Mekong Basin would then contribute one fourth of the world freshwater fish catches, even though this relative share might be somewhat of an overestimate due to underreporting of catches in other countries too, in particular in Africa.

2.2.1.2 Market values

A detailed estimate of the value of Mekong inland fisheries, reproduced in Table III, has been proposed by Barlow (2002).

Fish and aquatic product source	Quantity (tons)	Price (\$ per kg)	Value (\$ millions)
Riverine capture fisheries	1,533,000	0.68	1,042
Aquaculture	260,000	1.05	273
Reservoirs	240,000	0.68	163
<i>Total</i>	<i>2,033,000</i>		<i>1,478</i>

Table III: Fish production and value in the LMB (Barlow 2002)

In 2004 Van Zalinge *et al.*, citing Jensen (1996), Sjorslev (2001), Sverdrup-Jensen (2002) and Hortle and Bush (2003) valued the total inland Mekong fish production at more than USD 1,700 million¹, and the MRC (2005) valued it at about 2,000 million. From these assessments it is clear that riverine capture fisheries are by far the most important contributors with more than two thirds of the total value, followed by aquaculture and fish production from man-made reservoirs (around 10%). Yet, despite the remarkable importance and economic value of fish catches in the Mekong riparian countries, the inland capture fisheries sector is poorly represented in the national plans and priorities of Lao PDR and Vietnam.

Aquaculture in the LMB also deserves a section in this review given its close links with capture fisheries. Inland aquaculture production in the Basin shows a steady recorded growth from around 60,000 tons in 1990 to around 260,000 tons in 1999-2000, which equates to 12-13% of the total LMB freshwater aquatic animal production (Sverdrup-Jensen 2002, Phillips 2002). This figure does not include considerable production of fish and shrimp in the brackish waters of the Mekong Delta.

However both shrimp and fish aquaculture industries depend heavily on larvae and fry supplied by capture fisheries. In Cambodia in particular aquaculture consists mainly of captured fish grown in cages (e.g. Ngor Peng Bun 1999), and the food that valuable carnivorous cultured species are given consists of other wild species of lesser value (Phillips 2002). Without the supply of wild fish, Cambodia, for instance, would be left with only 15,000 tons of aquaculture fishes whose cycle is mastered – just 4% of its total fish harvest (Baran 2005).

The aquaculture industry is complemented by a growing trade in ornamental fish and aquatic plants, particularly in Thailand (NACA 2000), but its value has not been documented. Recreational sport fishing is of limited scale in the LMB, even though weekend reservoir fishing is gaining popularity in Thailand and Vietnam (Van Zalinge *et al.* 2004). The value of this aspect of fisheries, however, has never been assessed so far.

2.2.1.3 Consumption values

In 2002 Sverdrup-Jensen estimated the total fish consumption in the LMB at 2.03 million tons per year with a per capita estimate of 36 kg/person/year (ranging from 10 to 89 kg/person/year). Baran and Baird (2003), in a work presented in 2001, gave a range of per capita consumption between 26.2 and 38.4 kg/person/year and show that this is one of the highest rates of fish consumption at the national level in the world². Hortle and Bush (2003) estimated the fish consumption at over 3 million tons per year, or 56 kg/person/year. This jump in the consumption figure is mainly due to the inclusion of processed fish and other aquatic animals (shrimps, crabs, frogs, etc) that remain neglected in classical fish-centered valuation studies. Van Zalinge *et*

¹ However the authors do not detail the estimate of the average price per kg basinwide.

² The record consumption of aquatic products being in Iceland with an average of 90 kg/person/year (FAO statistics). Some local communities also have very high consumption rates, reaching 200 kg/person/year, for instance in the Amazon Basin (Batista *et al.* 1998)

al. (2004), compiling fish consumption figures from different sources, amount it to 2.6 million tons annually for the Lower Mekong Basin (Table IV). However, conservative estimates still amount the consumption of basin dwellers to “over one and half million tons of fish per year” (MRC 2004b).

Country	Population (Million)	Average fish consumption (kg/person/year)	Total fish consumption (tons)	Capture fisheries catch (tons)	Reservoirs fish catch (tons)
Cambodia	11.0	65.5	719,000	682,150	22,750
Lao PDR	4.9	42.2	204,800	182,700	16,700
Thailand	22.5	52.7	1,187,900	932,300 ⁴	187,500
Vietnam	17.0	60.2	1,021,700	844,850	5,250
Total LMB	55.3	56.6	3,133,400	2,642,000	232,200

Table IV: Estimated annual consumption of freshwater fish products, including other aquatic animals in the Lower Mekong Basin by country and by source, in 2000, expressed in whole fresh weight equivalent (Van Zalinge *et al.* 2004)

It is impossible to emphasize too much the importance of fish for food security in the Mekong Basin. According to Jensen (2001b) small fish and fish products provide necessary calcium to the diet of Mekong region people in the same way that milk does in the Western countries, because rice does not contain calcium and milk is not part of the traditional diet in Southeast Asia. Small dried fish eaten whole (as most calcium lies in the bones) contain more than 1,000 mg of calcium per 100 g, i.e. more than 150% of the daily needs of children (MRC 2003b). Calcium from fish can be absorbed by the human body and used in the same way as milk (Mogensen 2001). Guttman and Funge-Smith (2000) also highlighted the qualitative role of fish in the diet: the bulk of the protein (76%) is derived from rice, but rice is nutritionally incomplete and poor in particular in lysine, an essential amino-acid. With 97.6 mg of lysine per gram of protein, fish is three times richer than rice in lysine and provides a nutrient essential to growth, that is lacking in a rice-based diet. Eating fish two or three times a week is encouraged as part of a healthy balanced diet during pregnancy and for all the family (Elvevoll and James 2004). In Cambodia, for instance, more than 60% of all pregnant women and children below five years of age suffer from anaemia. This condition can cause decreased learning capacity and retarded development in children as well as increased risk of maternal death. The economic consequences of these deficiencies are a cycle of malnutrition, low productivity and poverty. Therefore food security is not only a matter of related to quantity, but also to quality.

The role of other living aquatic resources (prawns/shrimps, snails, frogs, shellfish as well as algae and wild water plants and vegetables) in the diet, household budget and livelihoods of local populations is emphasized by several authors (e.g., Shoemaker *et al.* 2001, Torell *et al.* 2001, Thay Somony 2002, Halwart and Bartley 2003, Dixon *et al.* 2003, Meusch *et al.* 2003.). These resources, however, are always absent from national statistics and remain largely unnoticed in scientific surveys.



Figure 3: Lotus plantation in a wetland in Siem Reap province, Cambodia

2.2.2 INDIRECT USE VALUES

According to Petersen (2003), no non-market or indirect use studies on environmental value attributes have been conducted in the LMB so far. Also, to our knowledge no study or document exists on the option values of Mekong inland fisheries, as well as on the non-use values (bequest value and existence values). Similarly no basinwide economic efficiency analysis is known to the authors. However a number of authors, partly reviewed below, have touched upon the biodiversity and cultural value of aquatic resources in the Mekong Basin.

2.2.2.1 Biodiversity values

The biodiversity of the Mekong supports ecosystems and the way they function, which in turn supports the people that depend upon these ecosystems. These services can be regarded as 'free' in that they are not traded in markets³, and Poulsen *et al.* (2002) highlighted the importance of these alternative values.

The Mekong system demonstrates a high level of overall biodiversity, the third worldwide after the Amazon and the Zaire (Dudgeon 2000). Estimates for the inland fish biodiversity (Baran 2005) range from 758 species (FishBase 2004) to 1500 freshwater species (MRC 2004a), with a high rate of endemic species and more fish families than any other river system (64 according to FishBase 2004 and 91 according to the MFD 2003⁴). This aquatic biodiversity includes particular endemic and charismatic species such as the Giant catfish (*Pangasionodon gigas*), the largest freshwater fish which can reach 300 kg (Hogan *et al.* 2004), the giant Mekong carp (*Catlocarpio siamensis*), the seven-line barb (*Probarbus jullieni*), *Mekongina erythrospila*, an icon in Northern Cambodia, and three freshwater dolphin species (*Orcaella brevirostris*, *Sotalia chinensis*, *Neophocaena phocaenoides*), *O. brevirostris* being a significant tourist attraction in Southern Laos and Northern Cambodia, although its number has drastically declined down to about 40 individuals (Baird and Beasley 2005).

The fish biodiversity is illustrated in the table below:

Location	Number of freshwater fish species	Source	Comment
Yunnan province, China	130 species	Yang Junxing 1996	See section 3.
	8 species	MFD 2003	Unrealistically low
Lao PDR	587 species	FishBase 2004	
Thailand	482 species		Calculated from FishBase; no other assessment known for the Thai Mekong Basin
Cambodia	477 species	FishBase 2004	
	440 species	MFD 2003	
Vietnam	273 species	MFD 2003	Vietnamese Mekong only; also 222 brackish and marine species
	145 fish taxa	Vo Tong Anh <i>et al.</i> (2003)	Freshwater areas of the Mekong delta. Also 14 shrimp taxa

Table V: Freshwater fish species richness in the Mekong riparian countries

Dudgeon (2003) showed that the Mekong freshwater biodiversity is scientifically undervalued, with less than 0.1% of freshwater biology papers published in international journals dealing with the conservation of biodiversity in tropical Asian inland waters. More holistically, the WWF has recently undertaken a valuation of the positive aspects of flooding (Hardner *et al.* 2002, Mollet *et al.* 2003) while a joint IUCN/MRC/UNDP project focussing on wetlands management puts the local cultural dimension of aquatic resources at the heart of conservation efforts⁵. In Vietnam, Hashimoto (2001) also detailed in an extensive review the multiple ecosystem values of flooding.

³ As noted by Maris (2005), free ecosystem services such as clean drinking water remain unaccounted for in official statistics, whereas an increased demand for bottled water due to scarcity or pollution in streams appears as an increase in production, trade and GDP figures, in short as a progress.

⁴ See www.fishbase.org

⁵ See www.mekongwetlands.org

2.2.2.2 Cultural values

The cultural value of fish in Southeast Asia was comprehensively analysed in Ivanoff (2003). Southeast Asia in particular is symbolised by the nutritional trilogy of rice, fish and salt (the latter two being united through brine, i.e. fish sauce). The importance and omnipresence of fish is illustrated by a number of proverbs known by all: for instance, in Thai ("In water there is fish, in rice fields there is rice"), in Khmer ("Where there is water there is fish"⁶) and in Vietnamese ("Nothing is better than rice eaten with fish, nothing is better than the love of a mother"). This daily contribution to life and meals paradoxically gives little value to fish and a low status in the hierarchy of values attached to foods (Levy-Ward 1993). Despite this everyday nature, men have not developed a strong emotional or symbolical or mythical relationship with fish (Ivanoff, 2003), which might be reflected in the recurrent claim for a better valuation of fish and aquatic resources.

In terms of religion, fish play a very limited role. Some ceremonies can be mentioned, for instance in Thailand where snakehead fish were sacrificed in the river to call for rain, or in Laos where large catfishes including *Pangasius gigas* and *Pangasius sanitwongsei* were consumed after rituals were performed (Davidson 1975; Ivanoff 2003)⁷. Overall, fish is considered a very common food and as such does not enter much into the symbolic and ritual realms (buffaloes, oxen and chickens being preferred in offerings). In traditional medicine fish is considered a "cold" meal of feminine nature.

Traditionally, freshwater fish have always been preferred to marine fish, whether in Europe or Southeast Asia. On the culinary side, freshwater fish are considered in the peninsula to be soft, sweet and subtle, in contrast to marine fish. In Cambodia for instance, freshwater fish are said to "*mien khlanh tchngang*" (have tasty fat) whereas marine fish are considered "*ch'ap*" (not attractive) (Giteau and Martin 1995).

On the psychological side, traditional rice farmers mastering irrigation have regarded the sea as wild, unmanageable, insecure and somehow devilish, thus marine fishes are not positively connoted. On the contrary freshwater ("sweetwater" as it is often translated from regional languages) is close to man and bears culture (cf. the role of irrigation in the Angkor kingdom; Kumm 2003); freshwater fishes are thus seen much more positively. In fact, fish are part of a scale of values based on geographical proximity, decreasing from the vicinity of the house (rice fields) to further surroundings (streams and lakes) and ultimately far away (the sea and then foreign countries). This decreasing value, from highly valued black floodplain fish (snakehead, climbing perch, etc., generically "*cá song*" in Vietnamese) found in nearby ricefields and ponds to somehow less valuable long-distance migrants from the Mekong ("*cá dong*" in Vietnamese) and then to marine species, can be paralleled to the gradient from domesticated to wild, from the water control essential to a civilization of farmers to nature, unpredictability and danger. This symbolic gradient in values could also help to explain the strong undervaluation of Mekong river fishes, whereas aquaculture is mentioned by all though quantitatively and economically much less significant.

Cambodia is probably the country where the historical and cultural importance of fish is best illustrated. The famous Chinese traveller Chou Ta Kuan noted in the 13th century the exceptional importance of fish in the life of the Angkor people, as depicted in multiple bas-reliefs in particular in Angkor Wat and Bayon temples. Nowadays the notion of indirect use values is underlying in the declaration of the Tonle Sap area as a UNESCO biosphere reserve in 1997. These values were detailed by Bonheur (2001) and Bonheur and Lane (2002) and include Khmer cultural identity and the values of biodiversity conservation. Touch Seang Tana and Todd (2003) and Torell *et al.* (2004) have also highlighted the non-use values of aquatic and wetland resources. Even among Cambodians having emigrated to Brittany (France) and exposed to abundant marine fish, freshwater fish, although in short supply and more expensive, remain much preferred (Simon-Barouh 1993). These immigrants even continue fishing wild fish stranded in drying peri-urban wetlands in summer, just like in Cambodia in the dry season, as detailed by Khin Sok (1993).

Southern Laos provides another example of how aquatic biodiversity and livelihood can intertwine in the Basin, and the activities of fishing communities driven by seasonal and ecological changes have been described in particular by Roberts and Baird (1995), Claridge *et al.* (1997) and Daconto (2001).

A lot can be said about the conversion of fish into fish paste (*pha-ak* in Thailand, *prahok* in Cambodia), and fish sauce (*nam pla* in Thailand, *pa dek* in Laos, *teuk Trey* in Cambodia, *nuoc mam* in Vietnam). However,

⁶ The full popular version being: "*Mien toek mien Trey, mien loi mien Srey*"!

⁷ Currently *P. gigas*, although extremely rare and critically endangered, is still traded from Cambodia to Thailand where it has a high value for its supposed virilizing properties.

this would go beyond the scope of this review. It can be noted however that the stronger these foods, the closer the consumer to his countryside roots (conversely fish sauce is not favoured among those displaying a modern life style). In this sense, these fish-based foods are elements of cultural identity. Another cultural fact is that the taste for *nuoc mam* in Vietnam is a trait anterior to the extension of the Chinese culture in this country, as the Chinese influence is traced by soy sauce, never by fish sauce (Gourou 1984). Thus, fish is an important element in the economy as it allows food self-sufficiency but also exchange, and then becomes a vector of trade and cultural exchange.

Although women are largely involved in fishing, aquaculture, processing and fish trade all over the Basin, the gender issues in Mekong fisheries have surprisingly almost never been addressed. This fact is highlighted by Nandeesha (2001) and Matics (2001), and a little more documented by Suntornratana and Visser (2003) who quantitatively show that experience in fishing for men and women is not much different, but that the knowledge of the latter is sought after in 2 % of questionnaires at most. They also show that, unlike men, women often catch and collect fish and aquatic animals all year round due to their responsibilities for the food security of the family; they could thus provide a more complete and accurate picture of the inland fisheries.

Despite the paradox of high importance and low cultural recognition, the value of river fish for Mekong people is expressed by a number of monuments erected to fish or more specifically emblematic fish species. Thus having large statues of fish in the middle of public squares is not uncommon in Cambodia, with for instance “Trey kolriang”, the giant barb, (*Catlocarpio siamensis*) honoured in Kampong Chhnang or “Trey pase ee” (*Mekongina erythrospila*) iconized in Stung Treng. However the largest monument praising a fish species in the Mekong Basin, and probably one of the biggest in the world, is certainly the fourteen meter high inox and granite monument erected in Chau Doc (Vietnam delta) and displaying eleven catfishes (two large “Ca basa”, *Pangasius bocourti*) and nine “Ca tra”, *Pangasius spp.*) as a symbol of the nine branches of the Mekong Delta and of “the creativity and prosperity of Chau Doc people” who have built up “over a hundred years a unique product famous all over the world”. This refers to the Mekong catfish species grown in the region and exported worldwide⁸.



Figure 4: Mekong catfish monument, Chau Doc, Vietnam.

2.3 ECONOMIC IMPACT ANALYSES

To date, scientifically underpinned comprehensive water allocation mechanisms have not been set for the Lower Mekong Basin (Petersen 2003). Among the preliminary works, the model proposed by Ringler (2000, 2001) to determine the optimal allocation of water resources in the Mekong Basin should be mentioned. Unfortunately, lack of data and data unreliability hampered the predictive power of the model (Johnson *et al.* 2003). In this approach the impacts are assessed through the integration of utility functions for all economic activities related to the river. Ringler finds that artificial diversions of water from the Mekong could readily

⁸ In particular in the USA before 2002, before the Catfish Farmers of America managed to convince the Senate to forbid the use of the label “catfish” for catfishes other than *Ictaluridae*, a native North American family grown by US fish farmers. This decision had a strong negative impact on the exports of the Mekong Delta catfishes, causing great grief in Vietnam (see “The great catfish war”, New York Times, July 22, 2003), and is somehow reflected in the pride expressed by the Chau Doc monument.

cause negative impacts on fisheries and saltwater intrusion into the Mekong delta during the dry season. The author also drew two general conclusions: a) the largest user of water in the basin is irrigated agriculture sector; b) the Mekong Delta is the largest water user and economically benefits most from the river water, making it very vulnerable to water management options taken in upstream countries.

Country/region	Irrigation	Municipal & Industrial	Hydropower	Fisheries	Wetlands	Total
Yunnan, PRC	20	11		0.05		31
Lao PDR	38	6	33	19	5	101
Thailand	320	65	10	151	4	551
- N Thailand	52	5		10		68
- NE Thailand	268	60	10	141	4	483
Cambodia	26	7	7	188	80	301
Vietnam	513	81		188	44	825
- VN, Central Highland	29	6				35
- VN, Mekong Delta	484	75		188	44	790
Total Basin	917	170	43	546	134	1,809

Table VI: Baseline scenario profits from water use in million USD (Ringler 2001)

Table VI shows that total profits from optimal water allocation and use were estimated at USD 1.8 billion in 1990, irrigated agriculture ranking first with USD 917 million and fish catches second with USD 546 million. Vietnam obtains the greatest benefits from basin water uses, contributed chiefly by irrigated agriculture and fish production. Profits from hydropower are largest in Laos, and fish catch and wetlands are the major water-related income sources in Cambodia. One must note that this scenario is based on data available in 1999, when total Mekong fisheries catches amounted to 1 million tons, not 2.6 or 3.2 million tons as per recent estimates.

To our knowledge no socio-economic analysis has been done at the scale of the whole Mekong Basin. At the moment the Mekong River Commission is developing a simple resource allocation and optimization model (RAOM) similar to Ringler's model, but drawing on recent hydrological information to examine how water resources in the LMB can be allocated among various water-consuming activities and functions. The values used to run the model are simply unit estimates, and integration of environmental flow requirements is in principle possible, depending upon the progress that is made with current valuation initiatives by partners (Johnston *et al.* 2003).

The MRC and Halcrow Ltd. have also set up a Decision Support Framework (DSF) that consists of a suite of data analysis software and models intended to assess the magnitude and impact of changes in the water-resource system (Halcrow 2004a). This suite is based on a Knowledge Base which consists of interacting databases and GIS layers and includes environmental and socio-economic impact analysis tools. These tools allow macro-level sustainability analyses and potentially impacted population analyses. However, the nature and contents of these tools are not detailed in the sixteen volumes of documentation about the DSF, and the *"meaningful socio-economic assessment of future development scenarios will require a more detailed set of data"* than the current MRC social Atlas, and *"significant efforts remain to assemble data sets to support socio-economic assessments"* (Halcrow 2004b and c).

In terms of policy Feng Yan *et al.* (2004) analysed the conflicting needs of the riparian countries and the current problems hampering the development of a basin-wide water allocation model that would include China. Fox (2004) highlighted the fact that the terms of the 1995 Mekong Agreement⁹, in line with international laws governing transboundary watercourses, actually refer to a watercourse rather than a watershed despite the frequency of the word "basin" and the catchment management approach promoted by the MRC (Kristensen 2001). Thus, the watercourse definition would rely solely on the aquatic element without addressing the interdependencies between riverine and terrestrial systems, whose conservation is yet essential to sustainable production (cf. flood pulse concept) and thus sustained value.

However, the danger of focussing efforts on controlling and re-directing water, overlooking ecological processes, is that *"local communities will experience common pool resource dilemmas around provision issues long before states experience conflict over appropriation of water"* (Fox 2003). These concerns are echoed by NSF (1998) and Smith *et al.* (in press) who found that the diversity of fisheries-related livelihood strategies is poorly represented in practice by socio-economic analyses and policies and called for a more

⁹ Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin signed by Laos, Thailand, Cambodia and Vietnam

diverse and flexible range of measures securing both the benefits of aquatic resources for poor people and conservation objectives.

Last, Bush and Hirsch (2005) show, from the example of Laos, that diverse actors provide statements of status and change in value of fisheries “that are both socially and politically constructed as well as contingent on the epistemological construction of their knowledge of the fishery itself”.

2.4 LIVELIHOOD ANALYSES

“Livelihood analysis” is understood here as complementary of socio-economic analysis, with a focus on people-centered, dynamic and adaptive approaches, particular attention being paid to a range of capitals including social capital and knowledge, and to non-marketed aspects.

“Understanding livelihoods dependent on inland fisheries” is the objective of a project led by the WorldFish Center in three Mekong countries and in Bangladesh (Dixon *et al.* 2003). The purpose of this project (Sultana *et al.* 2003a) was to characterize the primary stakeholders and their livelihood strategies, identify their dependence upon aquatic resources, describe the nature and status of those resources, and emphasize the vulnerabilities of the poor in relation to loss or mismanagement.

The analyses revealed that fisheries as a common pool resource play a vital role in rural livelihoods, particularly as contributors to expenditure-saving and survival livelihood strategies of the poor. More specifically Smith *et al.* (in press) think that in developing countries, fishing can either be (i) a primary livelihood of last resort, or (ii) part of a diversified semi-subsistence livelihood, (iii) a specialist occupation, or (iv) part of a diversified accumulation strategy.

In the Mekong Basin, the bulk of the catch originates from part-time and subsistence fishers rather than from those classified as full-time fishers (Dixon *et al.* 2003). According to the WorldFish study, in the three Lower Mekong countries studied, the majority of full-time fishers categorise themselves as very poor, and also highly dependent on others for finance. However, they are considered relatively less vulnerable than agriculturally-based poor who are more subject to seasonal scarcity periods. The majority of part-time fishers also categorise themselves as poor or very poor. The third group of subsistence fishers includes landless labourers, women, children and small farmers. They range from very poor to rich and in most cases are not fully dependent upon the fisheries for income-generation or subsistence. As such, they are less likely to be deeply impacted by a degradation of the wild resource. The fact that inland fisheries are often regarded as an activity for the poor but can also be an activity for the more wealthy was noted by Béné and Neiland (2003), which led Coates *et al.* (2004) to call for a better understanding of how fisheries and their management contribute to, or are affected by, wealth differentiation.

Consultations with local communities allowed the identification of two main threats to fisheries common to the three Mekong countries: unsustainably high fishing pressure, and degradation or loss of wetlands and floodplain habitat. The latter was specified as resulting from i) increased agricultural activities (inducing deforestation and agro-chemical pollution), and ii) modification of river-flows by flood control, drainage and irrigation structures or hydropower schemes. Among on-going conflicts were mentioned competition for fish and privatization of common property resources for aquaculture development.

The threats to fisheries take place in a context of limited knowledge, if not ignorance, about the extent and importance of natural resources in terms of overall household livelihood strategies. The lack of detailed information about the role of fisheries in livelihoods is an immense disadvantage to poor people as what is recorded is what is produced, consumed and sold by the rich or less poor people while the unrecorded products and uses are those on which poor people depend. Consequently, the resources of the poor are not included in impact assessments (be they environmental, economic or social) or taken into account when making development decisions (M. Torell, pers comm.). The usual census approach, which consists of thinking in terms of primary and secondary occupations, further conceals the importance of diversified activities and particularly of inland capture fisheries to the livelihoods of the Mekong rural poor (Dixon *et al.* 2003; Keskinen 2003)

In this regard, the most important initiatives in the basin are those that will: 1) integrate aquatic resources values with livelihood values and aquatic resources management in the policy development process; 2)

assess the role of markets and market forces, including the impact of international trade on fisheries livelihoods; and 3) provide further in-depth analysis of livelihood outcomes and impacts related to planned and ongoing natural resource management projects.

Participatory rural appraisal results also showed that all of the above challenges and threats to inland fisheries have already reduced the livelihood base of poor people and made them more vulnerable to hazards from drought and flooding, natural declines of the fish population, inadequate market access and high population growth. However, the study also concluded that in terms of pressing issues, access to fisheries and threats to aquatic resources come after personal and communal poverty issues such as lack of rural infrastructure (roads, clean water sources, sanitation facilities, schools), lack of land for farming rice and crop pests. Normal flooding was not a problem, only exceptional floods are.

2.5 IMPACT OF CHANGES ON FISHERIES BASINWIDE

Preliminary calculations suggesting a 20% increase in demand for fish in the LMB over the next 10 years (Svendrup-Jensen 2002), combined with a major threat that fisheries habitats will be reduced due to barriers to migration, conversion of floodplains into agricultural and urban areas, and changes in natural flow regimes due to dams and irrigation, make the future of Mekong fisheries uncertain. We detail below some of the major changes whose impacts have been at least partly documented.

2.5.1 CHANGES IN FLOW REGIME

The degree of inundation in the Mekong depends on the strength of the annual monsoon, as 85-90% of the discharge is generated during the wet season. However, the average wet season discharge in the last twenty years (1979-98) appears to be at least 10% lower than in 1924-1956, while the inter-annual variations have become more extreme (Nam Sokleang 2000). The downward trend seems to be independent of fluctuations in rainfall and therefore has been linked to dam building activities that started in the late fifties in the basin (Van Zalinge *et al.* 2003). White (2000) also identified dams as the projects that pose the highest degree of systematic risk to the region, under criteria that include displacement of vulnerable people, impact irreversibility, environmental impacts on the mainstream river flow and quality, and economic impact. In addition, although no literature was researched on this topic, climate change and possible changes in rainfall patterns could adversely affect the flow regime of the Mekong.

In the Mekong Basin according to the MRC (2003b), thirteen hydropower dams of a capacity higher than 10 megawatts existed in 2003: two in China on the mainstream, 5 in Laos, 4 in Thailand and 2 in Vietnam, the latter nine being on tributaries, for a total production of 4,400 megawatts (15% of the Basin hydropower potential estimated at 30,000 megawatts). Many more are under construction or being planned, including at least six in China and “a number” in Laos, and there is “a positive attitude towards hydropower development” in Vietnam (MRC 2001), as attested by the recent plans of Electricity of Vietnam to build 173 new hydroelectric power stations with a total capacity of 2,296 MW to supplement the existing 500 small and medium sized hydroelectric power stations¹⁰. No new major dams are planned at the moment in Thailand and Cambodia.

This assessment only refers to hydropower dams of medium or large size which do not consume water but only alter the flow regime and fragment aquatic habitats. However, these dams are supplemented by thousands of small irrigation reservoirs and weirs that aim at extracting water from the river and thus reduce flow, among other impacts. These small schemes are not individually identified, although they are quite visible on remote-sensing maps, particularly in North-East Thailand (see for instance MRC 2003b). In addition to existing ones, multiple smaller schemes are being considered (including 15 dams for irrigation purposes, mainly in Thailand and Vietnam). Overall, more than 130 potential sites for dams have been identified.

The impacts of dams on Mekong aquatic resources have been highly debated (e.g. Roberts 1995, Siebert 2001, TERRA 2003, FEER 2004). Hill and Hill (1994) first attempted a thorough assessment of the

¹⁰ Vietnam Economic Times, 04 August 2005

consequences of dams on Mekong fish and fisheries. They highlighted the exceptional ecological importance of the Khone Falls area, the devastating consequences that a dam across the Tonle Sap River would have, the need to consider true “run-of-the river” dams rather than blocking dams, and overall the absence of appropriate information. In fact their review itself is hampered by a systematic lack of data.

Ten years later, specific information on the impacts of dams on fisheries is still lacking and/or of poor quality. In his review of the Economic Impact Assessment of the Nam Theun 2 dam in Laos, Wegner (1997) takes note of the high value of indigenous fish species and expresses concern that these have not been considered adequately in the impact assessment. Similarly the World Bank (in Amornsakchai *et al.* 2000) acknowledges the fact that for the Pak Mun Dam in Thailand the lack of detailed baseline studies on fisheries has made it difficult to estimate fishery losses in the cost-benefit analysis of the dam (see section 5.4). Bernacsek (1997a) notes that aquatic impact assessments were carried out before impoundment in only seven cases out of 40 dams or reservoirs surveyed in the Basin.

In a scenario analysis prepared for the MRC, Halcrow (2004d) estimated that the impact of five additional large dams in the Lower Mekong Basin would reduce the maximum longitudinal fish migration network by only 1.6%. However, among other flaws and biases, the distances computed include *twice* the length of large streams, with the argument that “*fishes migrate most commonly along either river bank*”! (op. cit., appendix A). Of course, this bias minimizes the calculated impact of upstream dams on the whole river network open to migrations.

A recent study (Podger *et al.* 2004) assessed the impact of different water management scenarios on flows and on a number of indices, including a fish habitat availability index (HAI). The study concluded that the expected losses to the HAI ranges between 1% and 13% for the area downstream from Kratie in northern Cambodia. However, going beyond benign relative values, Barlow (pers. comm.) highlighted the fact that this is a fraction of a huge resource amounting to 2.6 million tons (cf. Table II) and showed by a pro-rata calculation that this limited relative reduction would correspond, in Cambodia and Vietnam alone, to a loss of 15,000-199,000 tons with a monetary value of USD 10-135 million a year. The livelihood value of this fraction is not detailed.

The negative effects of dams on inland fisheries have been extensively described (WCD 2000) and alternatives or mitigation measures such as fish ladders have been proposed. Warren and Mattson (2000) expressed reservations about the efficiency of such mitigation measures in the Mekong context; Roberts (2001a) confirmed the inefficiency of the Pak Mun dam fish ladder and Baran *et al.* (2001b) showed that the intensity of migrations (e.g. 30 tons of fish caught per hour in the Tonle Sap River during the migration peak) makes fishways unrealistic in most main channels (Jensen 2001c).

One of the issues that recently surfaced is the trapping of sediments and the reduced flow speed that result from dams, particularly those across the mainstream (Sarkkula *et al.* 2003, Kummu *et al.* 2005). Analyses detailed in Plinston and He Daming (2000) showed that about half the sediment reaching the Mekong Delta derives from the Upper Mekong in China. A scenario analysis showed, particularly through mapping of sediment concentrations and sedimentation rates, that flow reduction and sediment trapping by the Chinese dams on the Mekong would have a dramatic impact on the net sedimentation and productivity of the Tonle Sap Lake (Sarkkula *et al.* 2003). Following additional studies, the impact of Mekong dams on sedimentation and productivity basinwide will be better quantified by 2006 (Sarkkula *et al.* 2005).

On the positive side of dam building, additional water reservoirs increase fish production locally (Lagler 1976, Bernacsek 1997b). The latter author gives an equation predicting the catch of a new reservoir:

$$\text{Catch in tons.year}^{-1} = 1.877 \times (\text{Reservoir area in km}^2) - 12 \times (\text{mean depth in m}) + 0.03835 \times (\text{Affluent inflow volume in mcm.y}^{-1})$$

It should be noted, however, that i) this equation does not integrate the loss in wild fish production down the reservoir (as demonstrated in southern Laos by Lorenzen *et al.*, 2000), and ii) the biological productivity generated by this environmental modification is often concomitant with significant social changes in fisheries, particularly in terms of access rights, wealth distribution and equity (WCD 2000, Hirji and Panella 2003).

Among the beneficial impacts of damming are the increased dry season flows that would oppose the annual saline intrusion hampering rice culture in the delta (Feng Yan *et al.* 2004). However, the saline intrusion is also highly beneficial to fish production (abundant coastal fishes entering the delta) and shrimp aquaculture

(one kilogram of shrimp being worth about 50 kg of rice), and the trade-offs between these different commodities and their underlying social-economic implications remain to be assessed (Baran *et al. in press*).

The impact of Chinese dams is also feared in the Mekong Delta, though according to Nguyen Minh Tang (2003), the hydrologic impacts of the Manwan dam observed in Northern Laos are not perceptible in the Mekong Delta. However, the impact of reduced flows and sediment input on the productivity of Vietnamese coastal fisheries is surprisingly never mentioned, although it was already highlighted by Chevey (1933) seventy years ago. The impacts of dams on coastal fisheries have proven very significant in a number of countries, and assessing them in the case of new damming plans is a recurrent recommendation (Vidy *et al.* 2000; Blaber 2002, Dugan *et al.* 2002; Arthington *et al.* 2004).

2.5.2 CHANGES IN FISHING PATTERNS

Disruptive fishing methods, such as explosives, mosquito nets, electric fishing and poisoning, as well as over fishing are commonly reported in the region, and their actual impact is heavily debated. Bao *et al.* (2001) claimed that most Mekong fish species reach sexual maturity early, lay a great amount of rapidly developing eggs, and are thus more sensitive to environmental change than to over fishing. In Cambodia, however, the dominance of these low-value opportunists is thought to be increasing as a result of over-exploitation (Srun Lim Song pers. comm.).

It should also be noted that the evolution of the size of fish caught is a parameter that should be integrated to valuation studies (Van Zalinge and Nao Thouk 1999). Year after year, total catches seem to contain a higher proportion of less valuable small fish and a lower proportion of medium and big sized fish of high economic value. This evolution is similar to that of other freshwater fisheries (Welcomme 1995), but the economic impact of this evolution, invisible in global statistics, has never been assessed. The positive consequences for food security of a larger share of small fish of high nutritional value (as detailed in section 2.2.1.3) have likewise never been assessed.

Fishing patterns are also driven by the demand for fish, that is itself partly driven by aquaculture, whose activities are net consumers of fish (fry and feed of carnivores coming from the wild; Phillips 2002). Small-scale aquaculture can contribute to environmental improvement; for example, aquaculture ponds contribute to dry season water storage and recycling of agricultural wastes. However, under dual environmental and exploitation constraints, the basin capture fisheries are likely to decline much faster than aquaculture can expand. This would obliterate gains made by expanding fish farming (Coates *et al.* 2003). It should also be noted that small scale aquaculture is generally not an activity taken up by the poorest because of fundamental limits of capital (Bush 2003a, Keskinen 2003, Vo Tong Anh *et al.* 2003)

2.5.3 CHANGES IN POLITICAL AGENDAS

Inland capture fisheries are characterized by diversity in the range of gears and target species, but also in social and cultural environments. This complexity is reflected in the nature of the data collected and then analysed in view of management.

According to Coates (2002, 2003), most published figures for inland capture fisheries in Southeast Asia do not actually qualify as 'statistics' because they are not based upon data. Inland capture fisheries are clearly seriously under-reported in all countries in the Mekong Basin, by 250 to 360%. Major sources of bias in official statistics include underestimates of the importance of small-scale fishing activities and misreporting by government officials. Other biases include inadequacies in recording the level of participation in capture fisheries and lack of attention to biodiversity considerations and livelihood aspects. In addition, there is a general disinterest in accuracy. More generally, Hirsch (2004) highlighted the different and often conflicting values inherent to the environmental, biological, economic, social or political approach to fisheries, and similarly the opposing values conveyed by governments, institutions, private sector or NGOs.

Bush (2004a) studied three fisheries production meta-statistics from the Association of Southeast Asian Nations, the MRC and the Lao government. He concluded that the three examples of fishery production meta-statistics highlighted the differences in the political agendas of the different organisations with a stake in the management of the resource. The estimates were not sensitive to the causes of deficit or surplus and therefore promoted policy responses that were inappropriate and potentially damaging.

3 YUNNAN PROVINCE, PEOPLE'S REPUBLIC OF CHINA

Yunnan Province has a surface area of 397,000 km² and a population of about 42 million, 81.7% of it being rural (population density: 107 persons/km²). The province remains poorly developed, with a per capita GDP of USD 565 in 2000 (but only USD 180/year for rural dwellers). The population growth reaches 1.2% per year (2000 data in ADB/UNEP 2004¹¹). With 10% of the total Lancang River Basin population living below or just above the poverty line, this region is one of the poorest areas in Yunnan and in China (ADB, 2000). In fact, the productivity and standard of living in the 7 prefectures of Yunnan bordering the Mekong are below the provincial average, itself below the national average (Makkonen 2005)

This mountainous province (from 6740 meters down to 76 meters in altitude (MRC 1997) is considered the biodiversity-rich garden of China, with 18,000 plant species (more than half China's total), a large forest cover (32.4% of the land area) and a large proportion of protected areas as well (6.9% of the province surface). One can note, however, that these protected areas are terrestrial and that the Mekong mainstream and its banks are systematically excluded from these areas¹².

Statistics and figures for Yunnan and the Upper Mekong are difficult to find (NSF 1998; Chapman and He Daming 2000; Buncha Apai 2003), as confirmed by the brief description above. There is not enough information available in English about the Chinese section of the Mekong River (named Lancang or Lancang Jiang in Mandarin) to develop a full chapter similar to those on the other riparian countries. Most of the information about the hydrological characteristics of the river, its biodiversity, fisheries and development plans are supposedly in Chinese language, and apart from a number of articles originating from conservation NGOs, very few scientific documents could be found¹³.

With 165,000 km² the Mekong Basin covers 38% of the province and this section of the river contributes 16% of the average annual flow of the whole Mekong (MRC 2003b). Twenty-one percent of the Mekong Basin area lies in China (Feng Yan *et al.* 2004), and the Chinese section of the Mekong contributes 45% of the dry season flow in Cambodia (Goh 2004).

He Daming and Hsiang Te Kung (1997) gave a geographical and hydrological description of the Lancang River. In its most upper part, the river is small and often flows through deep valleys. Development targets are mainly animal husbandry, forestry and to a certain extent tourism, whereas the development targets for the middle and upper reaches of the river are hydropower generation and mining, supplemented by irrigation and tourism. Fishing is not a dominant activity in this region (personal obs.; Heinonen and Vainio-Mattila 1999). The overall fish production in Yunnan has been estimated at approximately to 25,000 tons (Xie and Li 2003) and capture fishery labour in this province represents about 15,000 persons (ibid.).

Four hundred and thirty-two fish species are recorded in Yunnan, and 130 species are found the Chinese section of the Mekong River (Yang Junxing 1996). These species are characteristic of headwaters, rapids and high streams. Most of them are short-distance migrants. A strong decline in fish biodiversity is noted, with 280 species that have become rare or have not been found in the past five years (ibid.). This region is also characterised by massive introductions programs, of 34 species overall, that had a strong negative impact on native species, particularly in lakes.

The Mekong River Commission (2003b) detailed the hydropower development plans in the Lancang River Basin, which consist of a cascade of eight dams totalling 15,550 megawatts (dam characteristics in Plinston and He Daming 2000). The possible consequences of these dams on fishery production have been mentioned in the above section. Other environmental impacts were reviewed in Roberts (1995), NSF (1998), Roberts (2001b), He Daming and Chen Lihui (2002) and Osborne (2004). However, it is also argued that the development of a the Lancang mainstream cascade dams would have a much higher economic benefit and lower impact on ecosystems than a (hypothetical) series of dams on the lower Mekong (He Daming and Hsiang Te Kung 1997; He Daming and Chen Lihui 2002).

¹¹ Other socioeconomic indicators provided by the ADB and UNEP are not Yunnan-specific but refer to the entire country

¹² Map of existing and proposed nature reserves in Yunnan, by the Nature Conservancy and the Yunnan Provincial Government. Brochure of the project "Yunnan great rivers action plan". Yunnan econetwork, Kunming, China. 2001.

¹³ See however the Asian International Rivers Center: <http://www.lancang-mekong.org>

In addition to the dams, China has initiated a navigation improvement project in the Upper Mekong River that includes dredging and blasting rapids of the Upper Mekong River (21 reefs and rapids to be blasted in phase 1 along a 360 km stretch to provide access to 100 ton ships, and 90 to 100 additional reefs and rapids to be blasted in phase 2 for 300 ton ships). The project has been heavily criticized in particular for incomplete and biased assessment of the potential impacts on the river's fisheries (McDowall 2002) and on its biodiversity (Campbell 2003). Regarding fisheries, the first concrete evidence of changes consists of a drastic increase in water fluctuation in Northern Thailand. These large daily fluctuations prevent fishers from operating their gears normally, alter migration patterns, has reportedly reduced the fish catch by 50% in the area (Chainarong Sretthachau and Pianporn Deetes 2004).

4 LAO PEOPLE'S DEMOCRATIC REPUBLIC

4.1 COUNTRY OVERVIEW

Lao PDR has a population of about 5.1 million, approximately 77% of which lives in rural areas and 40% of which lives below the World Bank poverty line. Annual per capita GDP was estimated at USD 280 in 1999. The main economic sector in Lao PDR is agriculture, accounting for 52.6% of the national GDP. However, the overall importance of agriculture is declining as industry and services increase. Selected economic indicators for Lao PDR are summarized in Table VII.

Economic indicator	2000	2001	2002	2003
Agriculture (% of GDP)	52.81	50.89		
Industry (% of GDP)	23.01	23.44		
Services (% of GDP)	24.17	25.67		
GDP (billion US\$)	1.71	1.75	1.83	2.04
GDP growth (%)	5.81	5.68	5	5
Aid per capita (US\$)	53.38	45.38	50.32	
Population growth (%)	2.32	2.32	2.32	2.32
Population total (millions)	5.28	5.4	5.53	5.66

Table VII: Selected economic indicators for Lao PDR from 2000 to 2003 (World Bank web site).

Wood products contributed 34% and manufactures 23% to total exports of USD 337 million in 1998. The agricultural sector by contrast contributed only 2.4% or USD 8 million. The export of hydropower to Thailand and China is expected to be a major source of foreign exchange earnings. However, according to Rigg and Jerndal (1996) serious environmental and social issues are linked to hydropower development (population displacement, downstream impacts on flow regimes and fisheries) and to the exploitation of timber resources (deforestation, loss of soil and biodiversity, siltation).

The Mekong Basin covers 97% of the country (202,000 km²) and Laos contributes 35% of the average annual flow of the Mekong. Therefore, it has major role to play in basin-wide water resource management, especially as the country is now keenly developing hydropower.

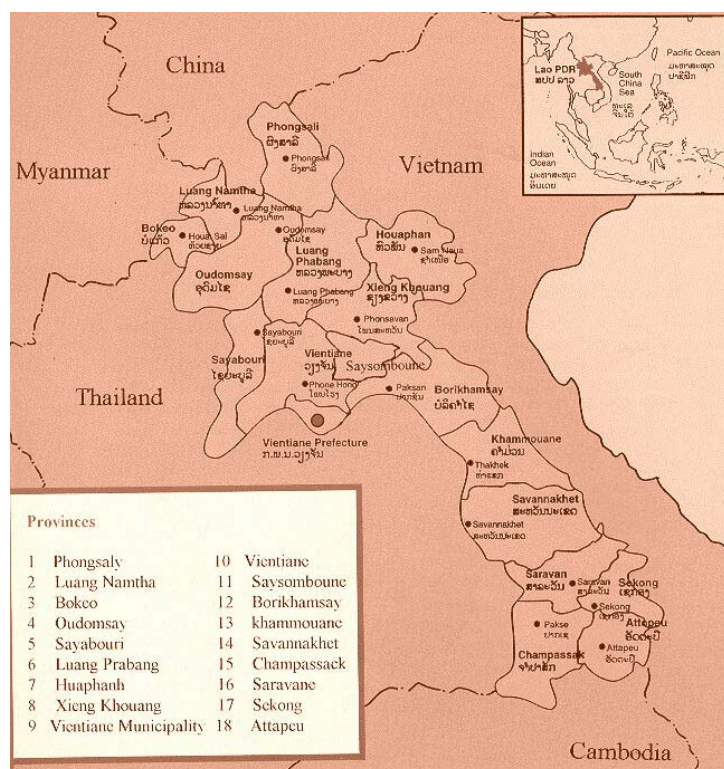


Figure 5: Map of Lao PDR

4.2 ECONOMIC VALUATION ANALYSES

4.2.1 DIRECT USE VALUES

Laos, like most Mekong Basin countries, has seen its river capture fisheries reassessed and their value revised upward several times in the recent years. Interestingly, fish production is not even mentioned in the 2001 statistical yearbook (NSC 2002), nor the importance of the fish resource to the population in the 2001 Lao PDR state of the environment report (UNEP 2001).

4.2.1.1 Catch values

Inland fisheries catch statistics are much disputed in Lao PDR. In 1997, national fisheries catches amounted to 37,825 tons (DLF 1997 in Guttman and Funge-Smith 2000). However, Jensen (2000) suggested that catch figures were underestimated. Guttman and Funge-Smith (2000) upgraded the annual fish catch figure to 59,774 tons. In 2002, capture fisheries production alone was estimated at 29,250 tons (Table VIII).

Type of water resources	Area in (ha)	Productivity (kg/ha/year)	Total production (tons/year)	% of total fisheries production
Mekong and tributaries	254,150	70	17,790	40.4
Reservoirs (stocked)	57,025	60	3,421	
Irrigation and small reservoir (natural and stocked)	34,460	150	5,169	
Swamps and wetlands	95,686	30	2,870	
Total for capture fisheries	441,321		29,250	
Total for aquaculture	503,460		42,066	59.6
Grand total (capture + aquaculture)	944,781		71,316	100

Table VIII: Lao PDR inland fisheries production and productivity in 2000 (Souvannaphanh *et al.* 2003). The sums have been recalculated.

The latest estimates, integrating rice paddies, amount to 82,500 tons, including 64,600 tons from capture fisheries (Lorenzen *et al.* 2003b), which accounts for 78% of the country's fish production (Table IX). The authors believe the share of aquaculture remains grossly overestimated¹⁴.

Type of water resources	Area in (ha)	Productivity (kg/ha/year)	Total production (tons/year)	% of total fisheries production
Mekong and tributaries	254,150	70	17,790	78
Reservoirs (stocked)	57,025	60	3,421	
Irrigation and small reservoir (natural and stocked)	34,460	150	5,169	
Swamps and wetlands	95,686	150	14 352	
Rice paddies and floodplain	477 176	50	23 858	
Total for capture fisheries	441,321		64 593	
Total for aquaculture	503,460		17 911	22
Grand total (Capture + aquaculture)	944,781		82 504	100

Table IX: Estimates of capture fisheries and aquaculture production in Lao PDR (Lorenzen *et al.* 2003b).

The highest estimate of fish production is that of Sjorslev (2001), detailed in Hurtle and Bush (2003), who concluded that fish consumption alone (excluding trade with neighbouring countries) amounts to 204,800 tons annually. This figure, based on raw consumption studies, is much higher than that of other authors.

¹⁴ The 1998/1999 Lao Agricultural census estimated that 8.3% of agricultural holdings were engaged in aquaculture (ACO 2000). However according to Lorenzen *et al.* (2003b), "Household surveys in different rural areas of Lao PDR have yielded a consistent estimate of about 2% of households engaging in private aquaculture, with an average pond size of 0.12 ha. Scaled up to about 1 million households, this gives a pond area estimate of just 2400 ha which, with a realistic average production estimate of 650 kg/ha/year, gives a total production of no more than 1560 tons."

4.2.1.2 Market values

The gross value of fisheries output is estimated at around USD 48 million, commercial capture fisheries contributing approximately 4% of GDP and subsistence fisheries another 2% (Lorenzen *et al.* 2003a and 2003b). Souvannaphanh *et al.* (2003) consider that fisheries account for about 8% of national GDP. According to Emerton and Bos (2004) quoting STEA (2003), fish and other aquatic animals are worth USD 100 million a year. The LARReC Medium Term Plan 2000-2005 estimates the value of total annual aquatic production to be in the range of USD 66 million, excluding aquatic plants. This estimate is based on the average market value of fish/frog/turtle (wet weight) at USD 0.66 per kg. According to Lorenzen *et al.* (2000), fish in local markets costs between 0.5 USD/kg for small “trash” fish and 1.5-2.5 USD/kg for larger fish. As household catches consist of about one third “small” and two thirds “large” fish, the average value reaches 1.5 USD/kg. More recently, Bush (2003b) gave a value for the overall average price of capture species in three lowland districts (USD 1.14 per kilo) that is superior to the average value of aquaculture species (USD 0.98/kg)

An alternative value of the fish consumed in Laos is detailed in Table X.

	Consumption value, in million kip	Consumption value, in USD (2005 change rate)
Fresh fish	30,750	3,075,000
Canned fish	1,237	124,000
Frozen fish	1,351	135,000
Dried fish	2,183	218,000
Prawns, crabs etc.	1,853	185,000
Fermented fish	2,934	293,000
Preserved fish	755	76,000
Others	4,995	500,000
Total (rounded up)	46,000	4,600,000

Table X: Value of the fish consumed in Laos (1997-1998). Cited in Souvannaphanh *et al.* 2003). Sum has been recalculated. Currently one US dollar is worth approximately 10,000 kips, but early 1998 one US dollar was worth approximately 1300 kips.

The fish trade analysis was pioneered in Laos by Baird (1994) who monitored the local and seasonal trade of *Probarbus julleni* and *Probarbus labeamajor* (two highly migratory protected species) between southern Laos (Champassak), northern Cambodia and Thailand. Baird estimated the value of fish traded in the district at US \$1 million/year. However Phonvisay and Bush (2001) deepened the study and concluded that 435 tons of fish are traded annually from Siphandone district to the main markets in Pakse and Thailand. At an average value of 9500 kip/kg, they valued this trade at around US\$ 440,000. The study also led to the conclusion that about 87 tons of fish is imported every year from Northern Cambodia to Southern Laos. In a study of five Vientiane markets, Phonvisay (2001) found that nearly 6 tons of fresh fish are traded daily. Out of this, nearly 1.8 tons come from Thailand, for a value of up to 5.188 billion kip per year or USD 576,700 per year. At least 405 kg of fermented or processed fish is also traded daily and supplemented by about 146 kg of dry fish. Still in Vientiane, Gerrard (2004) showed in her analysis of the values of an urban wetland that the capture fisheries component of this wetland alone is worth USD 1.1 million a year (more than half its use value). The value of these resources in more urban villages also tends to be greater in both relative and absolute terms.

4.2.1.3 Consumption values

The fish catch is important for consumption, particularly in the southern Lao provinces, and fermented fish (*pa dek*) is a significant staple diet in all villages, particularly during periods of low fish abundance or peak agricultural labour requirements.

Consumption of aquatic products in Laos has been addressed in a number of studies. Available figures are summarized in the following table.

Figure	Source	Comment
7 kg of fish/person/year	Phonvisay 1994, cited in Bush 2002	Early government estimate originating from a figure provided by USAID in 1972
4.7 kg of fish /person/year in urban areas	Household surveys (1992-1993 and 1997-National Statistics Center 1998; cited in Souvannaphanh <i>et al.</i> 2003	Figures based on a sampling of 2,940 households from 147 villages. Three facts make these figures very unlikely: i) in countries with rich natural resources and limited communication networks, consumption of aquatic resources is usually higher in rural areas than in urban areas; ii) these figures are extremely low compared to all other estimates; iii) fish is usually much more abundant than other aquatic animals such as shrimps, frog, etc.
4.4 kg of aquatic animals /person/year in urban areas		
2.5 kg of fish /person/year in rural areas		
2.8 kg of aquatic animals /person/year in rural areas		
17.1 kg of aquatic products/person/year	FAO PADP 1998 cited in Guttman and Funge-Smith 2000	Oudomxay province (northern hilly province bordering the Mekong)
24.2 kg of aquatic products/person/year		Savannakhet province (southern province bordering the Mekong)
15.1 kg of aquatic products/person/year		Sayaboury province (central province bordering the Mekong)
21.2 kg of aquatic products/person/year		Sekong province (southern province away from the Mekong mainstream)
25.6 kg of aquatic products/person/year		Xieng Khouang province (central hilly province away from the Mekong mainstream)
42 kg of fish /person/year	Baird <i>et al.</i> 1998	Khong district, Champassak province (in the Khone Falls area)
8.5 kg of fish /person/year	FAO 1999	Based on national statistics
17.5 kg of fish/person/year	Garaway 1999	Savannakhet province (southern province bordering the Mekong)
29 kg of fish and other aquatic animals /person/year	Sjorslev 2000	Luangprabang province (northern hilly area)
61.1 kg of fresh fish /person/year	Mattson <i>et al.</i> 2001	Around the Nam Ngum dam reservoir
50 kg/person/year of living aquatic resources	Singhanouvong and Phoutavong 2002.	Champassak province (southern area including extensive wetlands)
19.9 kg of aquatic resources /person/year	Bush 2003b	Figure based on a brief survey in Savannakhet province. Annual figure inferred from the average daily consumption of 54.7g/day/person during the survey. Fresh fish makes 75% of these aquatic resources, other aquatic organisms 23% and processed fish 2%.
11.8 kg of fish/person/year	Calculated from Garaway 2005	Based on a one-year survey (103 households) in Savannakhet province in 1997-1998.

Table XI: Per capita consumption of fish and other aquatic resources

A quick analysis of the above table shows that i) figures about consumption of living aquatic resources in Laos have increased considerably over the years, reflecting an increasing knowledge illustrated by a growing number of studies; ii) official figures are much lower than those based on scientific studies¹⁵; and iii) that fish consumption seems to be the highest in the Champassak province, characterized by extensive wetlands, but that other Central and Northern provinces also exhibit relatively high consumption figures.

In Khong district (Champasack province), Baird *et al.* (1998) estimated the average annual catch for a family at about 355 kg, of which 249 kg was consumed. Mollot *et al.* (2003) found an average household collection of fish amounting to 704 kg/year in Attapeu and Savannakhet provinces.

The role of fish and other aquatic resources in the diet of Lao rural population was detailed in Guttman and Funge-Smith (2000) and in the Attapeu province, Meusch *et al.* (2003) also highlighted the deplorable nutritional status of the population and the importance of aquatic resources in supplementing a nutrient-poor diet. A table summarizing available studies is provided below:

¹⁵ Bush and Hirsch (2005) pointed out a certain confusion in statistics or assessments by the Department of Livestock and Fisheries, which are not based on field surveys and hard data.

Percentage in the diet	Source	Note
Fish consists of approximately 78% of the animal protein consumed	Baird <i>et al.</i> 1998	Khong district, Champassak province.
Fish contributes 42.5% of animal proteins consumed	FAO 1999	I.e. 8.5 kg of fish out of 20 kg of proteins. Average figure based on national statistics; however, this proportion can vary between 10% among hill tribes and 90% among the Lower Lao population.
Fish contributes 17% of the agricultural production intended for home use.	LECS 2 (1999) cited in Guttman and Funge-Smith (2000)	
Aquatic products contribute from 26.6% to 57.1% of total protein	Guttman and Funge Smith (2000)	Range over 6 rural provinces; average: 40.6%
Fish and other aquatic animals account for 43% of the total animal product consumption	Sjorslev 2000	The study specifies that aquatic resources actually account for 55- 59% of the total animal intake if differences in the protein contents of various foods are integrated.
Fish contribute 52-95% of all meals	(Baird 2000; Baird and Flaherty 2000)	Khong district, Champassak province. Fish is also the largest source of cash income
Fresh and processed fish contribute 56.3% of total animal protein intake	(Mattson <i>et al.</i> 2001)	Around the Nam Ngum reservoir
Fish and other aquatic animals resent in 85% of all meals	Bush (2003b)	Savannakhet province; figure based on a brief survey.
Fish and other aquatic animals comprise between one third and one half of total protein consumption at the national level	Emerton and Bos (2004), quoting STEA (2003)	
Fish contribute 18% to food supply	Mollot <i>et al.</i> (2003)	Attapeu and Savannakhet provinces.

Table XII: Contribution of fish and aquatic resources to diet in Lao PDR

4.3 SOCIO-ECONOMIC ANALYSES

In Laos, 2.7 million people live along a river (MRC 2003b). The Agricultural Census indicated that more than half the population of Lao PDR was engaged in capture fisheries in one way or another¹⁶. In a detailed study Lorenzen *et al.* (2000) reported that wild fish were more highly priced for their taste than cultured species and that participation in fishing is predominant in rural households, with more than 80% of households in Southern Lao PDR being involved (Lorenzen *et al.* 2003). Lorenzen *et al.* (2000) showed that in an average household, the use of aquatic resources (with an estimated value of USD 90) accounted for about 20% of gross income (Lorenzen *et al.* 2003). On average 70% of household fish supply is caught by households themselves; less than 20% is purchased; and 10% is received as gifts, reciprocal exchange, or payment in kind for labour (Lorenzen *et al.* 2003b, Garaway 2005).

Nguyen Khoa *et al.* (2003) showed that the average household fishing effort was consistent at about 5 hour/week, but household catches were lower in weirs (0.77 kg/week) than in dams (2.07 kg/week). The authors indicated that the difference in catches was likely to reflect differences in the hydrology of weirs and dams depending upon their location within watersheds.

On the trade side, the FAO (1999) reported that almost the entire aquatic resource production in Lao PDR is consumed within the country, with little or no fish exports. However Baird and Flaherty (2000) and Bush (2002, 2004b) highlighted the fact that the fisheries regarded until recently as remote, isolated and subsistence-oriented are in fact becoming embedded in a regional trade network that increasingly drives local fishing pressure. In fact, a considerable amount of catch from the Mekong River may be landed in Thailand where market prices are higher (Lorenzen *et al.* 2003).

¹⁶ This figure is probably an underestimate as most rural people in Lao PDR primarily consider themselves to be rice farmers, and this leaves fishing unnoticed, although widely practiced by all. The fact that the importance of fisheries remains unnoticed by rural people themselves, although it is objectively their major source of protein, deserves greater attention (Bush, pers. comm.).

4.4 LIVELIHOOD ANALYSES

The livelihood dimension of fisheries in Central and Southern Laos has been highlighted by several authors, particularly Roberts and Baird (1995), Shoemaker *et al.* (2001), Friend (2001) and Bush (2003a and web site¹⁷). Shoemaker *et al.* (2001) showed how important the contribution of the river to livelihoods was, thanks to fishing but also riverbank gardening, edible and medicinal plants from river wetlands and flooded areas, transportation in the wet season and drinking water in the dry season. Emerton and Bos (2004) highlighted the fact that ecosystem goods have high levels of substitution or complementarity with other goods, and can be used when other products are unavailable or unaffordable. Fish can also provide a small amount of cash at a crucial time, for instance to buy rice seeds at the end a long dry season (Béné, pers. comm.), thus securing both the food and the livelihood of the following year. In view of this diversity and seasonality, Friend (2001) highlighted the flaws and “*limited value of socio-economic surveys*”, as they assume a level of uniformity or regularity and cannot reveal the dynamic aspect of relative values of natural resources in rural livelihoods. Bush and Hirsch (2005) showed that, following environmental changes, local fishing communities might experience higher fluctuations in catches without economists noticing a variation in the value of the fish, while fishers might experience fishing constraints and changes in the species composition without biologists noticing a change in the value of the fish biomass.

Laos is extremely poor, as illustrated by the fact that agriculture accounts for more than half of the GDP when only around 3% of the country's land area is cultivated, partly because much of the country is mountainous. In this context natural resources are of considerable importance to a major proportion of the population; hunting, fishing, and gathering play an important role in the household economy. In fact aquatic resources also constitute the main coping strategy for periods of rice deficit, but there are no coping strategies for periods of aquatic resource deficit (Meusch *et al.* 2003).

Fishing ranks as the second or third most important activity after rice farming and animal husbandry and contributes on average about 20% to rural household income (Lorenzen *et al.* 2003b). Full time fishers account for only a few percent of the Lao population, but fishing is central to livelihoods in the Southern provinces of the country (e.g. Roberts and Baird 1995, Baird 1996, MRAG 2002) and reliance on fishing is similar for all wealth groups within villages (Garaway 2005)

Guttman and Funge-Smith (2000) detailed the time spent by Lao people in rural occupations. Fishing takes up around 10% of the time spent on income generating activities in rural areas, which is dominated by rice cultivation followed by fishing and tending animals. They also showed, like Garaway (2005), that the poor spend more time fishing than the other categories of the population. Fishing as an activity is not gender specific (Lorenzen *et al.* 2003b).

In an urban context (a wetland in Vientiane), Gerrard (2004) showed that incidence of fishing and its total value increases as household income status declines, underlining the importance of incorporating capture fisheries into local poverty reduction strategies.

4.5 IMPACT OF CHANGES ON FISHERIES IN LAOS

The main issue regarding river changes and fisheries in Laos is hydropower development. The impact of Lao hydropower dams on the environment and poor communities has been addressed for a number of years by multiple NGOs but few scientists have undertaken detailed impact studies. An overview of the issues inherent to each major dam is provided, with a pro-poor pro-conservation perspective, in IRN (1999). We review below some fisheries-related issues in the case of Nam Ngum and Nam Theun 2 dams.

¹⁷ See www.mekong.es.usyd.edu.au/case_studies/fisheries/index.html

4.5.1 EXAMPLE OF NAM NGUM DAM

Nam Ngum Reservoir is a 477 km² hydropower dam located 90 km from the capital Vientiane. Several studies have been conducted to estimate the fisheries production in the reservoir, but none has been done on the environmental impacts of the dam. A study done in 1982 by the MRC estimated the total fish production at 1,470 tons, while another study found it to be 6,833 tons (Mattson *et al.* 2001). According to Mattson *et al.* (2001) the increase could be due to reduced predation pressure, the initial high-value predator species having been fished out. Other studies on reservoir fisheries in the dam indicated that the initial catch was low due to problems in water quality, but since the flooded trees in the reservoir were cut the water quality has improved. The fisheries landings are said to have increased by a factor four between 1982 and 1998 (cited in Mattson *et al.* 2002), in correlation with an increase in fishing effort, particularly gillnets. The total estimated landings (6,833 tons) correspond to a 143 kg/ha/year yield. Annual registered yield amounted to USD 800,000 in 1997 (Ringler 2000). However, Roberts (2004) pointed out that in 1971-1979 the reservoir was largely anoxic with very little fish, and after a peak in fisheries production in 1985-1990 the fish catch declined. Careful management of the reservoir fishery is obviously essential. Lorenzen *et al.* (2000) found in their study that dam schemes in Laos are associated with declines of about 60% in fishing effort and catch for rural households. However, we did not locate any literature on the impact of the dam on migratory species or the effect on downstream fisheries except that of Schouten (1998) who showed that the water released from the Nam Ngum reservoir has a much lower dissolved oxygen level than that in natural rivers and is unfavourable for aquatic life most of the year, especially during the wet season.

4.5.2 EXAMPLE OF NAM THEUN 2 DAM

Nam Theun 2 is the largest and most controversial hydropower project being planned in Lao PDR (IRN 1999). The project is planned for central Laos and consists of a 50m high dam on the Theun River, the fourth largest tributary of the Mekong. The river provides habitat for 85 species of fish of which 16 are endemic (Roberts 2004); of these species 33-55% are strongly migratory. Out of the 85 species only 27 are likely to become established in the reservoir and of these 14 are small species with little or no commercial value (Roberts 2004). Several Environmental Impact Assessments have highlighted the fact that the dam would have a serious negative impact on fisheries by disturbing migration, creating a large body of still water to which most of the species could not adapt and degrading water quality downstream (IRN 1999). Cumulative impacts have also been envisioned, and a significant negative impact on fisheries and aquatic biodiversity has been foreseen, although not detailed (NORPLAN 2004). The reservoir fishery can be expected to increase during the first 5-10 years, but then it will decline (Roberts 2004).

5 KINGDOM OF THAILAND

5.1 COUNTRY OVERVIEW

Thailand is the richest country in the region, with a GDP of USD 7,400 per inhabitant for a population of 64.8 million. Ten percent of these inhabitants live below the poverty line. However, there is a great disparity between regions, and the North-East provinces bordering the Mekong River are among the driest and poorest in the country.

Agriculture contributes less than 10% to the economy, while industry and services contribute 40% and 50% respectively (Table XIII). Out of all LMB countries, Thailand is least dependent on the Mekong economically. However, fisheries have huge importance for rural food security and employment in the North-East provinces. The population growth of the country is slow compared to its neighbours and very similar to that of developed countries.

Economic indicator	2000	2001	2002	2003
Agriculture (% of GDP)	9.02	9.12	9.37	8.77
Industry (% of GDP)	41.97	42.12	42.67	41.44
Services (% of GDP)	49.01	48.76	47.96	49.79
GDP (billion US\$)	123	116	127	143
GDP growth (%)	4.76	2.14	5.41	6.74
Aid per capita (US\$)	11.5	4.59	4.8	
Population growth (%)	0.8	0.75	0.7	0.65
Population total (millions)	60.7	61.2	61.6	62

Table XIII Selected economic indicators for Thailand from 2000 to 2003 (World Bank web site).

Water resources are managed heavily in Thailand for hydropower, irrigation, industrial and domestic uses. However, inefficient use of water by various sectors, deteriorating water quality due to urban sewage and industrial waste, and excessive use of fertilizers and pesticides creates problems of availability and adequacy of water resources. In addition, the present water demand for irrigable areas and other uses is estimated to be 68,000 mcm (million cubic meters) per year for the whole country. This figure is expected to increase to 86,000 mcm/year in 2006, 43% of the total annual runoff. Within Thailand there are 1,872 reservoirs located in the Mekong River Basin with a total surface area of 2,120 km² and an estimated total fish catch of 25,428 tons (Cherdsak Virapat and Mattson 2001).

Inland capture fisheries in Thailand usually operate in major rivers and their floodplains, canals, swamps, wetlands, paddy fields, lakes and reservoirs. Pawaputanon (2003) reported a total area for inland fish habitat of 4.9 million hectares. This area consists of 4.5 million hectares of wetlands and 47 rivers and 400,000 hectares in the form of 21 large reservoirs. The fisheries are mainly subsistence based, but commercial fishing, especially aquaculture, is increasing rapidly. Inland fresh- and brackish-water ponds and tanks have 320,000 ha of production area in Thailand. However, most of the ponds are freshwater and are operated for various purposes (e.g. school and village ponds are operated for food and income for poor families).

5.2 ECONOMIC VALUATION ANALYSES

The review indicates that Thailand is the LMB country for which published literature in English on fisheries is least available. Possible explanations for this situation are i) the high priority given by the Thai Department of Fisheries to aquaculture, with some studies on reservoirs following up fish stockings; ii) the fact that most reports and publications are written in Thai, and ii) the relatively low level of research done in Thailand by the MRC. Therefore, some gaps in the economic valuation remain in this section about Thailand.

5.2.1 DIRECT USE VALUES

5.2.1.1 Catch values

Inland fisheries contribute approximately 6% (about 200,000 tons) of the total fisheries production in Thailand (Pawaputanon 2003). Indeed in 1996 the Department of Fisheries amount this contribution to 5.8%, the northeast region that lies in the Mekong Basin contributing 122,000 tons (cited in Preeda Prapertchob

1999). contribution Marine and aquaculture production seem to outweigh inland fisheries production considerably (Table XIV) with marine production dominating the fisheries sector (over 3 million tons).

Year	Capture fisheries production (t)			
	Freshwater	Marine	Others	Total
1997	205,000	2,679,500	499,900	3,384,400
1998	202,300	2,709,000	594,600	3,505,900
1999	206,900	3,166,400	252,600	3,625,900

Table XIV: Capture fisheries production in 1997-1999 in Thailand (tons; adjusted from Pawaputanon 2003).

This assessment of freshwater fish catches for the 1997-1999 period is 2.6 times higher than that available for the year 1996 (Table XV):

Category	Area (ha)	Production (kg/ha)	Total (t)
Reservoirs	432,176	83	35,818
Public waters	185,527	199	36,843
Fish ponds	22,163	273	6,050
<i>Total</i>	<i>639,866</i>		<i>78,711</i>

Table XV: Inland fish production per water body type in Thailand in 1996 (cited in Cherdsak Virapat and Mattson, 2001).

5.2.1.2 Market values

Surprisingly, it was possible to find only one study in English detailing the value of inland capture fish production in Thailand:

Category	Total (t)	Value (USD)
Reservoirs	35,818	27,469,000
Public waters	36,843	28,255,000
Fish ponds	6,050	4,640,000
<i>Total</i>	<i>78,711</i>	<i>60,364,000</i>

Table XVI: Inland fish value per water body type in Thailand in 1996 (cited in Cherdsak Virapat and Mattson, 2001).

Should the 1996 price per kilogram figure (USD 0.77/kg) be applied to the 1997-1999 assessment detailed in Table XIV, a total value of USD 157.5 million for Thailand's inland fish production would result. As a comparison, the value of all fish and fish products in Thailand is estimated as US \$3.6 billion in 1995 (NACA 2000).

Given the problems in small-scale fisheries data collection in Thailand (Coates 2002) it can be assumed that the open waters figure is seriously underestimated. According to Coates (2002) *"It is widely held that dams have significantly reduced fisheries in major rivers in Thailand. This is probably true and has certainly been used as a major reason to devote most attention to reservoir fisheries and aquaculture"*. An analysis by Pawaputanon (2003) revealed that inland capture fisheries production reported by the Department of Statistics reflected only the production in reservoirs and large wetland water bodies, covering up to 2.7 million hectares. Cherdsak Virapat *et al.* (1999) supported the view that statistics reported by the DOF referred almost exclusively to reservoirs As noted, *"... this confirms that the perception of inland capture fisheries in Thailand is one of reservoirs. Whilst reservoirs are obviously important ... Thailand in fact does still have considerable river and swamp fisheries, plus some production from rice-fields"* (cited in Coates, 2002).

5.2.1.3 Consumption values

The main source of information about fish consumption in Thailand is the review of Preeda Prapertchob (1999). According to this review, Preeda Prapertchob *et al.* (1989), based on a 500 households survey, amounted the freshwater fish consumption in northeast Thailand to 21.3 kg/person/year in average, with a variability ranging between 13.3 kg/person/year in dry areas and 36.4 kg/person/year in areas rich in water resources. The annual consumption of freshwater fish in Northeast Thailand was subsequently amounted to 395,000 tons (i.e. almost twice the 207,000 tons estimated in Table XIV). Fish was by far the dominant food item in the diet of the people surveyed, followed by chicken and pork meat (respectively half and one third the consumption of fish). Seventy one per cent of the fish consumed was captured from the wild. Little *et al.*

(1996) also showed that poor people and those living far from water resources tended to be more dependant on other aquatic animals such as crabs and frogs than on fish. In 1995 the fish consumption was estimated at 27 kg/person/year by the Department of Fisheries, the central and northern region importing fish from other provinces due to insufficient local supply.

5.3 SOCIO-ECONOMIC ANALYSES

Inland fisheries play a significant role in Thailand in terms of providing food security and employment to fishing communities and rural populations. According to Cherdsak Virapat and Mattson (2001), about 825,000 labour households earned their living from both agriculture and inland fisheries, and an additional 47,000 households earned their living from inland fisheries alone. More than 80% of the total households that rely on agriculture and/or inland fisheries live in the Mekong River Basin.

5.4 IMPACT OF CHANGES ON FISHERIES IN THAILAND

A large body of journalistic literature addresses the impact of dams on the aquatic resources and on the people who depend on them; however there are few scientific studies to back journal articles. We detail below the example of the famous and controversial Pak Mun dam, that has generated more scientific studies than any other case of river modification in Thailand.

5.4.1 EXAMPLE OF PAK MUN DAM

This analysis of the impacts of Pak Mun Dam is mainly based on a report of the World Commission on Dams by Amornsakchai *et al.* (2000).

The Pak Mun Dam is a run-of-the-river dam built on the Mun River, 5.5 km upstream from its confluence with the Mekong, in North-East Thailand. The dam has a maximum height of 17 m, a total length of 300 m. The budget for the project was 3.88 billion Baht, but the unanticipated cost of compensation for the loss of fisheries increased the total cost.

The environmental impact assessment done in 1981 predicted that fish production from the reservoir would increase considerably, although some fish species would be affected by the blockage of river flows by the dam. The fish yield expected was 100 kg/ha/year without fish stocking and 220 kg/ha/year with a fish-stocking programme. However, in Thailand even storage reservoirs, which do perform better, have a fish yield of about 19 to 38 kg/ha/year under fish stocking programmes. There has been no evidence that the fish productivity of Pak Mun reservoir has reached anywhere near the anticipated 100 kg/ha/year, and the value of the total annual headpond fishing yield has been estimated at 0.9 million Baht, instead of the expected 19.7 million Baht (USD 69,000).

Regarding biodiversity, Roberts (1993) reported that the number of fish species in the Mun river declined from 121 fish species in 1967 to 66 species in 1981 and 31 in 1990.

After the completion of Pak Mun dam, the lower Mun River experienced a decline in fishing yields with an estimated value of USD 1.4 million per annum at 20 Baht/kg. In addition, the decline in fish species upstream led to the closure of 70 Tum Pla Yon traps. At the end of the 1980s, the value of the annual catch from this single fishery amounted to USD 212,000 per annum (at a rate of 38 Baht for 1 dollar), and the reservoir fisheries created did not match the losses generated by the dam building.

In the post Pak Mun dam period, fishing communities located upstream and downstream of the dam reported a 50 to 100% decline in fish catch and the disappearance of many fish species. The number of households who were dependent on fisheries in the upstream region declined from 95.6% to 66.7% and the villagers who were dependent on fisheries for income found no viable means of livelihood. These conclusions have been largely confirmed by the Thai Baan research initiative (SEARIN 2004), which provides additional insights on the consequences of the dam on the livelihoods of the local population. By March 2000, 488.5 million Baht (USD 19.5 million) had been paid to 6,202 households as compensation by the Thai government for the loss of fisheries and livelihood.

Because of its location this dam is a greater barrier to fish migrations than reservoirs and dams built on low order tributaries further up in the catchment areas. Out of the 265 fish species recorded in the Mun-Chi watershed before 1994, 77 species were migratory and 35 species were dependent on habitat associated with rapids. Out of 169 species found in the present catch, 51 species were significantly less abundant since the completion of the project, while at least another 50 species of fish that were dependent on upstream rapids had disappeared. Nowadays, only 50 migratory species are left. The decline has been higher in the region upstream from the dam where the catch has declined by 60-80% since the completion of the run-of-the-river hydropower project. Amornsakchai *et al.* (2000) conclude that the difference in the number of species in fish surveys before and after dam construction may well be exacerbated by the cumulative impact of many different developments in the watershed. Therefore, the Pak Mun Dam cannot be solely blamed for the apparent decline of some of the fish species.

As the fish ladder build on Pak Mun to mitigate the impact of the dams on migrating fish has proven inefficient (too steep, dry six months a year, not used by fish; Roberts 2004), changes following a lengthy conflict were ultimately made to the operation of the dam in order to reduce its impact on fisheries and livelihoods. In January 2003, it was agreed that the sluice gates would remain open four months each year.

6 KINGDOM OF CAMBODIA

6.1 COUNTRY OVERVIEW

Cambodia is the poorest country in Southeast Asia with a GDP per capita level of USD 297 (UNDP 2004). The population of Cambodia has tripled over the past couple decades from approximately 4 million people in 1979 to about 13.8 million in 2003. It is estimated that the population will further increase to 16.6 million by 2010 and to over 20 million by 2020. With an annual population growth rate of 1.6%, about 300,000 jobs will need to be created each year (Degen *et al.* 2000) in the future, considerably straining the country's already weak economy (see Table XVII for details).

Economic indicator	2000	2001	2002	2003
Agriculture (% of GDP)	39.65	37.56	35.58	
Industry (% of GDP)	23.27	25.62	27.98	
Services (% of GDP)	37.08	36.82	36.44	
GDP (billion US\$)	3.60	3.71	4.00	4.30
GDP growth (%)	7.03	5.67	5.48	7.64
Aid per capita (US\$)	31.38	32.46	36.96	
Population growth (%)	2.22	2.01	1.79	1.58
Population total (millions)	12,7	12,9	13,2	13,4

Table XVII: Selected economic indicators for Cambodia from 2000 to 2003 (World Bank web site)

The rural population comprises about 90% of the nation's poor, 43% of whom live below the poverty line (cited in Zurbrügg 2004). According to Keskinen (2003), the economic importance of the whole agricultural sector is decreasing, being only 34% in 2000 compared to more than 50% in 1990. The role of agriculture has much greater significance to employment, because it provides jobs for almost 80% of the population. On the other hand, the proportion of GDP for both agriculture and fishing might be considerably underestimated, partly because of the subsistence nature of both sectors (Keskinen 2003).

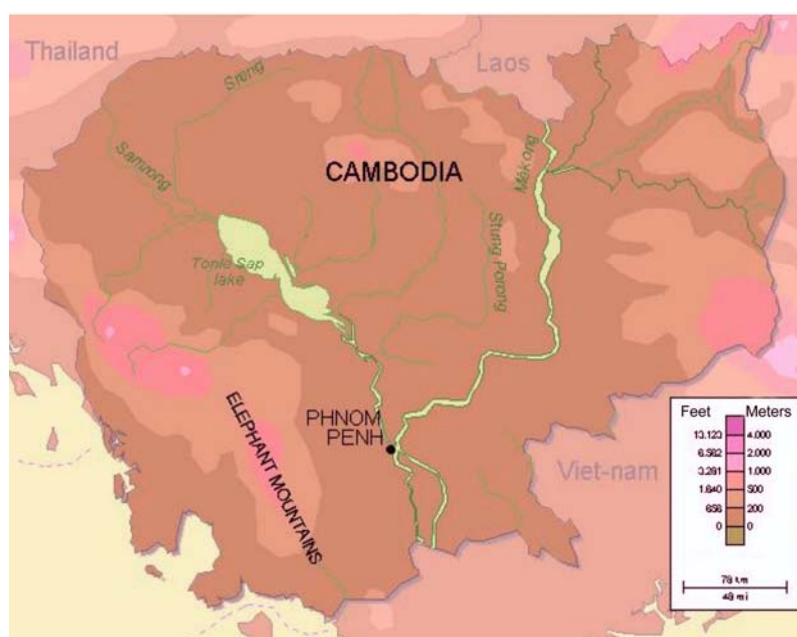


Figure 6: Map of Cambodia

6.2 ECONOMIC VALUATION ANALYSES

6.2.1 DIRECT USE VALUES

On his way to Angkor Wat in 1858, Henri Mouhot noted that “*the Great Lake is in itself a source of wealth for a whole nation; it is so full of fish that at the time of low waters they are crushed under boats; and rowing is often hampered by their number*” (Mouhot 1868). Today, inland fisheries contribute 90% of Cambodia’s total fish catch (Sam Nouv *et al.* 2003) of which the Tonle Sap Lake provides about 60% with 179,500–246,000 tons annual harvest over the 1995-2000 period (Ahmed *et al.* 1998, Lieng and Van Zalinge 2001). In 1998, according to the DoF (2001a), 35% of the Cambodian population was living in a fishing dependent commune.

6.2.1.1 Catch values

Like fish consumption figures in Lao PDR, fish catch figures in Cambodia have been evolving a lot over the past 10 years, with a strong initial mismatch between official statistics and scientific assessments. Although multiple project reports mention various figures, estimates all rely on only three basic sources: i) official national statistics; ii) catch statistics of the MRC project “Management of the Freshwater Capture Fisheries of Cambodia,” partly based on field sampling, and iii) estimates based on consumption studies led by the MRC in particular in 1995-1996. Official as well as MRC statistics have themselves been reconsidered over time, with several confusing recalculations tentatively reviewed in Baran *et al.* (2001b) and Baran (2005). The resulting production figures originating from these three main sources are reviewed in the table below.

Figure (tons of inland fish per year)	Source	Note
130,000 tons	Chevey & Le Poulain 1939	Earliest scientific assessment, preceded by a rough estimate of 200,000 tons by Chevey (1938)
Catch varying between 50,500 and 75,700 tons between 1981 and 1998	Department of Fisheries data and DoF 2001b	Statistics not based on any scientific monitoring (Coates 2002, 2003)
255,000 - 380,000 tons	Van Zalinge <i>et al.</i> (1998a)	First post-war assessment partly based on a scientific monitoring
289,000 - 431,000 tons	Van Zalinge and Nao Tuok 1999, Van Zalinge <i>et al.</i> 2000, Hortle <i>et al.</i> 2004a	Most commonly agreed figure, including results from scientific studies about catches of the dai fishery and rice field fisheries, and “guesstimates” about middle-scale and lot fisheries
Catch varying between 231,000 and 385,000 tons between 1999 and 2002	Department of Fisheries data	Upgraded national statistics (still not based on extensive monitoring) integrating catches of subsistence fisheries
500,000 tons	Van Zalinge 2002	
600,000 tons	Hortle <i>et al.</i> (2004a)	Upgrading by 20% of the previous figure to integrate the population growth in order to reflect today’s situation
682,000 tons	Van Zalinge <i>et al.</i> 2004	Most recent estimates, integrating the results of fish consumption studies

Table XVIII: Cambodia inland fisheries catches, according to various authors

In fact these figures result from an aggregation of various localised studies (e.g. bagnet fishery, rice-field fisheries, consumption studies, etc.) but not from a comprehensive assessment. The major fisheries remain too profitable for scientific monitoring to be allowed by operators (case of the lot fishery; CNMC/Nedeco 1998, Degen and Nao Thuok 2000) or too dispersed to be efficiently monitored (case of the mobile gears fisheries). Similarly, the evolution of the production figure over time reflects the progressive integration of previously neglected catches (e.g. from rice fields, subsistence fisheries, etc.), but does not result from long-term scientific monitoring, which still does not exist in Cambodia despite the efforts of the MRC over the past ten years (Coates 2002, Baran 2005)¹⁸.

Assuming an annual production of 300,000 to 400,000 tons, Cambodia’s freshwater capture fisheries rank fourth worldwide after China, India and Bangladesh. Furthermore, as shown by Baran (2005), when the catch is

¹⁸ The only fishery scientifically monitored in the basin is the bagnet (“dai”) fishery, that represents, with 15,000 tons/year, approximately 4% of the total catch in Cambodia and 0.6% of the catch basinwide.

divided by the population (i.e. the number of people who can realize the harvest) Cambodia is the most intense inland fishery in the world with 20 kg of fish caught per inhabitant per year (Figure 7).

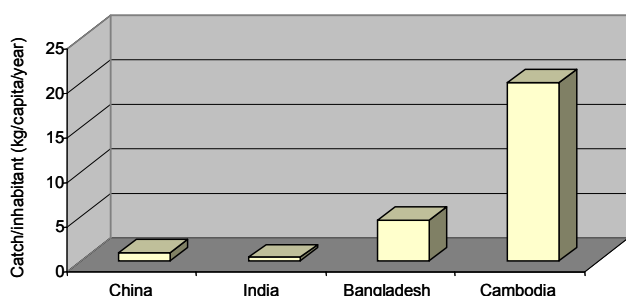


Figure 7: Fish catch per inhabitant in the four countries having the biggest inland fish catch (Baran 2005)

Baran *et al.* (2001b) and Lieng and Van Zalinge (2001) estimated the fish yield of the Cambodian floodplains, which amount to between 139 and 230 kg/ha/year. This is the highest value among the other tropical floodplains compared (Thailand, Laos, Indonesia, Bangladesh, Amazon) which range between 24 and 173 kg/ha/year (the latter figure being in Laos, within the Mekong Basin). At a specific site of the Tonle Sap Basin, the fish yield amounted to 243–532 kg/ha/year (Dubeau *et al.* 2001) and the average catch to 2.4 kg per fisher per day (Ouch Poeu and Dubeau 2004). The exceptional productivity of the Cambodian floodplains is explained by three interconnected factors: high biodiversity, accessibility of the floodplains and a very high exploitation rate over decades (Baran 2005).

6.2.1.2 Market values

In a recent large-scale study led on 540 households in three provinces (Stung Treng, Siem Reap and Takeo), Israel *et al.* (2005) calculated that the annual net economic value (NEV) of aquatic resource based activities is USD190,000 for an average village community, deducting for the cost of labor that is generally not accounted for. This NEV however varies between USD 440,895/village/year and USD 6,106/village/year depending upon the degree of dependence on aquatic resources and market access. The annual returns to labor (i.e. the amount the communities earn from aquatic activities) reaches USD 108,614/village/year in average.

On the macroeconomic side, the perception of this resource's importance has evolved dramatically. Before 2000, the total revenue generated from the fisheries sector was estimated at USD 2.4 million a year (Gum 2000). However, the evolution in the catch assessment led to radical revisions. Van Zalinge *et al.* (2000) estimated the monetary value of the catch at the landing site to range from USD 100 to 200 million, and to increase in the marketing chain up to USD 250 to 500 million. Nowadays, official statements estimate the fishery at 300,000 - 450,000 tons/year with a value of USD 150 to 225 million¹⁹. Hurtle *et al.* (2004a) value the total catch at USD 300 million. Thuok and Sina (1997) estimate that the value of fisheries in 1995 contributed 3.2 to 7.4% of GDP. However, the contribution of fisheries to the GDP has recently been estimated at 11.7% (Starr 2003) and 16% (Van Zalinge *et al.* 2004). This represents more than half the share of the whole country's industry (21.9% in 2001).

Inferring value from catch is highly dependent upon the average price per kilo factor used, and very few studies detail this factor. Rab *et al.* (2004a) detailed the evolution of the price along the trade chain (Table XIX) and showed that the price at the landing site can be five times that received by the fisher.

	US\$/kg
Price received by fishers	0.39
Price paid by the households	0.6
Retail market price	1.84
Landing site price	2.16
Export house price	4.26
Border price	5.28

¹⁹ Minister of Agriculture, Forestry and Fisheries, National Fish Day 2004

Table XIX: Average price of a kilo of fish at each level of the trade chain (Rab *et al.* 2004a)

In a similar study, Yim Chea and McKenny (2003a) found that the marketing margin (profit share in the retail price) varies between 65% and 75% (i.e. a price multiplied by 2.8 to 4.2 between the fisher and the local consumer), depending on species. The geographic variability of prices in retail markets as well as the variability by meat quality were also highlighted by Rab *et al.* (2004b, 2005b; Table XX), while Ker *et al.* (2001) outline their temporal variability (fish prices being generally highest from June to August and lowest from December to February).

Average price (USD/kg)	Phnom Penh	Kampong Chhnang	Siem Reap
Grade 1	3.48	5.83	0.74
Grade 2	2.50	3.20	0.51
Grade 3	1.92	1.81	0.48

Table XX: Average price per kilogram of fish (USD) per quality ("grade") at various retail markets during the closed season (Rab 2005b)

Ker Naret *et al.* (2001) also showed that the mean price of all meats is generally higher than that of cultured and wild fish, making the latter a more affordable staple for the poor. Touch Seng Tana and Todd (2003) estimated the value of processed and export inland fish commodities, such as fish sauce, dried fish, smoked fish, etc, at USD 23.7 to 29.4 million.

The export market is particularly informal, difficult to monitor and undervalued. As noted by the DoF (2001c) *"the trade statistics published by the Ministry of Commerce reported only 517 tons of exports in 1998 at a value of USD 4.34 million. On the other hand, statistics prepared by the Department of Fisheries (DoF) under the Ministry of Agriculture, Forestry and Fisheries indicated 40 240 tons of exports of fishery products in that year, which seems more realistic"*. Officially, Cambodia exported 23,700 tons of inland fish in 2001 (Nao Thuok *et al.* 2001 cited in Hortle *et al.* 2004a)²⁰. By comparison, in the 40's, under a strong colonial administration backed by extensive studies of the fisheries sector, the fish export was estimated at 28,000 tons a year (Le Poulain 1942), for a total population three times smaller than nowadays (Baran *et al.* 2001a).

Yim Chea and McKenney (2003a, 2003b and 2003c) found that fish exports registered by the Department of Fisheries were often one third or even one tenth of their real weight. Yim Chea and McKenney (2003b) also showed that official and above all informal fees add more than 50% to the cost of exporting a ton of fish to Thailand. For example, a shipment of fish sent by road from the Tonle Sap Lake to Thailand is subject to 27 different fees by 15 institutions, 19% of which are unofficial fees. Overall, the value of fees represents more than twice the profit margin of the trader, and thus fish resources benefit a number of institutions that have in theory nothing to do with fisheries. The authors do not view investment and business growth as possible in the current situation.

Taxes and fines from the fisheries system are primarily supposed to benefit the Department of Fisheries in charge of monitoring and management of the resource. However, the corresponding government revenue in the year 2000 was less than USD 3 million (FACT 2001). Thus, the official revenue collection from an estimated USD 300 million worth resources amounts to only 1% taxation. This can be compared to the taxation rate under the French Protectorate, which ranged between 1% and 10% depending upon the gear (average: 5.6% among 6 gears, calculated from Chevey & Le Poulain 1939). In fact, the supposedly very low current taxation rate rather highlights a governance and reallocation issue (Ratner *et al.* 2004) and does not necessarily leave the Department of Fisheries with sufficient resources to efficiently face the challenge of properly monitoring and managing the fish resource.

In the informal sector, bribery in relation to the fishing lot licences has been estimated at USD 3-4 million (Touch Seang Tana and Todd 2003).

²⁰ out of a total of 38,100 tons of fish exported, for a total value of USD 31,14 million according to DoF statistics

6.2.1.3 Consumption values

The consumption of fisheries products is extremely high in Cambodia, as illustrated by the following table:

Figure	Source	Comment
13.5-40 kg of fish are consumed per person and per year	Kim Sour and Hav Viseth 2004	Consumption estimated before the study by Ahmed <i>et al.</i> (1998)
75.6 kg of fish are consumed per person and per year	Ahmed <i>et al.</i> 1998	Large-scale study of in the provinces bordering the Tonle Sap Lake. Detailed consumption figures are: - 43.5 kg of fresh fish/person/year, - 14 kg of processed fish paste (= 27.5 kg of fresh fish), - fish sauce, fish oil and transformed products (= 4.6 kg of fresh fish/person/year). - 8 kg/person/year of other animal proteins (chicken, pork, beef, duck, etc)
Small scale fisheries provide 65% to 75% of the animal protein requirements of households	Ahmed <i>et al.</i> 1998	
79% of the animal protein consumed originate from fish	Israel <i>et al.</i> 2005	Large scale study (540 households in a northern, a western and a southern province)
In average 53% of the vegetable consumed are sourced from aquatic plants, (the figure reaches 61% among the lower wealth groups)	Israel <i>et al.</i> 2005	
5.2 kg of other aquatic organisms (non fish) are consumed per person and per year	Hortle <i>et al.</i> (2004a)	Other aquatic animals = shrimps, crabs, mollusks, frogs, etc.
4.5 kg of other aquatic organisms (non fish) are consumed per person and per year	Mogensen (2001)	

Table XXI: Fish consumption and contribution of aquatic resources to diet in Cambodia.

Fresh fish consumption is important among people living close to fish production areas and markets, but in rural areas far from natural water bodies or markets, processed fish is more important (Deap Loeung 1999). At peak periods, when catches are very large, most fish is processed into fish paste (*prahoc*), fermented fish (*phaok*), sweet fish (*mum*), smoked fish and fish sauce. Surplus fish is dried for pig feed or fertilizer. McKenney and Tola (2004) estimated the average consumption of processed fish paste (*prahoc*) at 62 kg/household in 2002, or 10.1 kg/person. For 2003, surveyed farmers were making on average 95 kg/household (15.7 kg/person). The cost of *prahoc* was USD 0.09 per kg, whereas low quality pork was worth USD 1-2 per kilogram. The cost of *prahoc* rose by 60% from 2001 to 2003 due to low fish catch. If similar rises follow, food security for many Cambodian could be severely threatened as no substitute for *prahoc* exists.

Rab *et al.* (2004a, 2005a), in an extensive study of 410 households in 3 provinces bordering the Tonle Sap Lake and River, detailed the use of fishery resources; they showed that in the area surveyed, three quarters of the fish is sold, providing cash, while a quarter is used locally for consumption or aquaculture (Table XXII). This is to be related to the per capita consumption in the above table: can 75 kg/person/year really represent only one fourth of the overall catch?

	Average among all village	
	Open season 2002	Closed season 2003
Total catch (kg)	3501	488
Consumption (%)	5.0	12.5
Sold (%)	74.9	73.9
Processed (%)	9.3	1.2
Fish feed (%)	10.8	12.3

Table XXII: Average catch and utilization of fish in Tonle Sap villages (Rab 2005a).

6.3 SOCIO-ECONOMIC ANALYSES

The first recent socio-economic study of Cambodian fisheries after those of Le Poulain in the forties (Chevey & Le Poulain 1939, 1940; Le Poulain 1942) was that of Ahmed *et al.* (1998) which surveyed 83 fishing dependent communes in eight provinces of Cambodia and provided a detailed assessment of the socio-economic status of these communes, particularly fish consumption and the role of fisheries in the local economy. This study showed that fishing was the primary occupation of 10.5% of the households while another 34.1% were engaged part-time in fishing. Several other results originating in this study have been detailed above. The most recent and comprehensive analysis is that of Keskinen (2003) also focusing on the Tonle Sap Lake. The originality of the latter study is that it is based on altitudinal zoning, which actually defines the access of people to open water and the role of aquatic resources versus agriculture in their livelihoods. Both studies focus on an area that produces 60% of the Cambodian inland fish production and includes 1.18 million inhabitants.

In terms of the involvement of households in income-generating activities, Ahmed *et al.* (1998) found that 90% of households had access to common property resources and nearly 80% used big rivers and lakes for fishing and irrigation. Households primarily involved in fishing amounted to 39% compared to 77% in farming.

In official statistics, however, the 1998 Population Census pretends that only 5.7% of persons living in the Tonle Sap floodplain are involved in fishing. This gross underestimation of the importance of fishing is due, according to Keskinen (2003), to the fact that *"the subsistence nature of fishing and wide part-time involvement in it remains unnoticed because statistics simply do not offer tools to include these into their classifications. For example, the Census records only major occupations, secondary or tertiary occupations are not included in it. This kind of simplified approach misrepresents the essence of Cambodian's subsistence production, where agriculture and fisheries are two tightly intertwined main components"*. The figures proposed by Keskinen are detailed in Table XXIII: :

	Primary occupation	Secondary occupation
Fishing	15.5%	20.0%
Fishing-related activities (fish selling, fish processing, fish culture, fishing gear making)	1.6%	8.5%

Table XXIII: Proportions of primary and secondary occupations around the Tonle Sap Great Lake (Keskinen 2003, after Ahmed *et al.* 1998)

The income of fishing households in the Tonle Sap area was also found to be significantly lower than the income of non-fishing households (Keskinen, 2003), which might help explain a negative migration rate in 4 of the 5 provinces surrounding the Lake (Haapala 2003).

Rab *et al.* (2004a, 2005a) showed that fish-related activities make up to two thirds of income in the villages of the Tonle Sap system (Table XXIV). They also highlight the fact that households collect in average 2,355 kg of common pool resources per year (mainly aquatic plants and firewood) that have a value of USD 132.

	Fishing	Fish culture	Fish processing	Fish trade	Farming	Wage income	Govt/NGO jobs	Small trading	Other	Total
Value (USD)	495.57	207.09	19.74	24.61	230.55	25.11	32.86	51.34	141.87	1158.5
Percentage	40.3	16.9	1.6	2.0	18.8	2.0	2.7	4.2	11.5	
	Two-thirds				One fifth	One fifth				

Table XXIV: Average annual household income by source type (Rab *et al.* 2005a, mimeo).

The socio-economic report by the Royal Government of Cambodia (RGC 2001) states: *"There is a strong correlation between sound Natural Resource Management and Poverty Reduction. The plight of poor can be improved by widening their access to forest, fisheries, water resources and other public goods, which is critical to improve the living standards of the people living in the Tonle Sap and riparian regions"*. However, if the productivity of the fishery declines, it will create immediate and tangible social problems for those who obtain part or all of their income from fish.

One of the most interesting attempts to determine the trade-offs inherent to three major national development goals (economic growth, poverty reduction and environmental sustainability) is the WUP-FIN policy model (Varis 2003, Varis and Keskinen 2005). This approach based on Bayesian networks allows an analysis of scenarios, with a quantification of the relative impacts of each development goal on 11 factors such as education, urban and rural development, agriculture, fisheries or conservation. This preliminary approach, that remains to be developed further, led to the following conclusions:

- an “economic growth scenario” contains the highest degree of uncertainties;
- a “conservation scenario” obviously ignores the villages and their development;
- a “poverty reduction scenario” gives relatively good results in all respects;
- the optimized trade-offs are achieved by an “integrated scenario” that also encompasses additional issues such as institutional development.

6.4 LIVELIHOOD ANALYSES

Several of the studies classified above under various headings have addressed livelihood issues. Fishing, fish culture, fish processing, fish selling and fishing gear making are all activities related to fisheries and livelihoods in Cambodia.

McKenny and Tola (2002) provided a summary of the role of fisheries in Cambodian rural livelihoods: fisheries diversify livelihood activities and thereby ‘insure’ against the risk of agricultural failures, provide easy access to income generating activities with very little capital investment and no land, and play a vital role in food security, maintaining and improving nutrition.

Among the studies that explicitly claim a livelihood approach that of Roudy (2002) detailed community structures and livelihood profiles; community development and resource utilization; natural resource uses, use values, and their unquantified values. Fisheries-based livelihoods are also discussed in a series of STREAM provincial workshops proceedings and localized studies (e.g. STREAM 2001). Israel *et al.* (2005) substantiated these discussions by showing on a large scale that in the three provinces studied, 89% of the households harvested aquatic resources for consumption, 76% of them sold fish and 61% of them processed fish. According to this study, aquatic resources are also playing a medicinal role for 10% of respondents (who do not have access to health services), and a social and recreational role for 74% of households (festivals, ceremonies, etc).

Another project focussing on fisheries-dependent livelihoods (Kaing *et al.* 2003) demonstrated that Cambodia’s fishing-dependent population form two distinct groups: those who combine fishing and farming or depend on fishing in the seasonally flooded areas, and those who can afford to buy fishing rights in the fishing lots and employ poor people as workers in industrial-style fishing operations.

The livelihood approach is at the heart of a portfolio of projects funded by the Asian Development Bank (ADB), focusing on the Tonle Sap system²¹. In a detailed study focussing on policy options for the Tonle Sap communities (Agrisystems/CamConsult/MRAG 2004), ADB consultants demonstrated that priorities were different among communities, those of the flooded areas being most concerned with renewable natural assets, while those in the transition zone focusing more on agriculture, irrigation and income diversification. In a similarly complex fashion, fishing lot operators are disliked by all villagers, although they offer many employment opportunities and some desired control over access to resources. The study underlines the fact that in this floodplain environment, it is not possible to address problems by focusing only on either land-based or fishery-based livelihood assets. Going one step further, Israel *et al.* (2005) conclude that the success or failure of efforts at improving resource management is dependent on addressing all the dimensions of vulnerability faced by rural households, in particular the lack of basic health services consistently cited as reasons turning families to illegal fishing or destructive resource harvesting.

²¹ See http://www.adb.org/Projects/Tonle_Sap/

6.5 IMPACT OF CHANGES ON FISHERIES IN CAMBODIA

6.5.1 CHANGES IN FLOW REGIME

Habitat and flow variability are widely accepted as major determining factors in the biodiversity of a system and fish populations may require years to recover from a single extreme habitat event (Hickey and Diaz 1999). According to Starr (2004), very low water levels in 2003 caused the fish catch to decrease by as much as 50%, also causing fish prices to double around the Tonle Sap Lake. Observations on the *Dai* fishery for migrating fish in the Tonle Sap River during 1995–2002 indicate that year-to-year variations in maximum Mekong river flood levels strongly affect the yield of this fishery (Van Zalinge *et al.* 2003, Hurtle *et al.* 2004b), which is dominated by about 40% of short-lived opportunistic species (Baran *et al.* 2001c, van Zalinge *et al.* 2004). Regional developments utilizing the Mekong water, such as irrigation schemes, may lead to lower downstream flood levels, and thereby have a negative effect on the fertility of the Tonle Sap system, which appears to depend on high flood levels.

The dramatic impact of dams on fisheries in Cambodia has been illustrated by the Yali dam located in Vietnam on a river flowing down to Cambodia. McKenney (2001) estimated that the erratic flow release of this dam resulted in over USD 2.5 million in lost income in 1999 for 3,434 households. On average, livelihood income per household decreased from about USD 109 per month to USD 46 per month (-57%). Non-quantified impacts of this dam include deaths and illnesses, livestock losses due to suspected water quality problems, and rarefaction of some natural resources. The Fisheries Office of Ratanakiri province (Fisheries Office 2000) as well as Baird *et al.* (2002) confirmed these impacts while emphasizing the losses in fish catches and water quality and the total disruption of local livelihoods.

6.5.2 HABITAT QUALITY LOSS

Although fish stocks are possibly over-exploited, a degree of protection is provided by keeping poachers out and preventing large-scale destruction of the flood forest. The designated fish sanctuaries around the Tonle Sap Lake might provide protection for the fish, even though monitoring of the sanctuaries is inadequate and the location of these sanctuaries probably sub-optimal. In non-guarded areas outside the fishing lots, flooded forest coverage is continuously being reduced by cutting, burning and conversion into rice fields and other crop lands (Jantunen 2004). This causes a loss in biodiversity and a decline in the economic value of these lands which are thought to be of marginal value for agriculture and crucially important for fish production (Van Zalinge 1998a).

Among threats to fisheries can be listed chemicals, that are widely used in and around the Tonle Sap Lake. Sixty-seven percent of the farmers surveyed used pesticides in 2000 (EJF 2002), with volumes as high as 72 l/ha/year for vegetables, and 1.3 million litres of pesticides were used in the Tonle Sap catchment area (Yang Saing Koma *et al.* 2001). Many of them are highly hazardous chemicals (including DDT and methyl-parathion) imported from neighbouring countries and used indiscriminately, for instance to harvest fish or to preserve dry fish (FACT 2001, Touch Seang Tana and Todd 2003). Although one study of organochlorine residue levels based on 48 freshwater fishes concluded that Cambodian fishes are among the less contaminated of the region (In Monirith *et al.* 1999), the possible consequences of chemical pollution for the population's health as well as on the environment, have never been quantified on a large scale in Cambodia. These possible consequences were detailed in EJF (2000). Considering the on-going large-scale development of irrigation around the lake, this issue needs to be urgently addressed.

Finally, the concentration of suspended solids has been recently highlighted as important to the productivity of the Mekong waters (Van Zalinge *et al.* 2003, Sarkkula *et al.* 2004, Kummur *et al.* 2005). This is fact that is often neglected but that may have a huge impact on the Tonle Sap's fisheries. As more than half of the Mekong's suspended solid load comes from China, this proportion will thus decrease significantly when China has finished building its dams on the Mekong mainstream.

6.5.3 CHANGES IN FISHING PATTERNS

Several commentators on the fisheries in the Tonle Sap believe that the amount of fish in the lake is dramatically decreasing (e.g. Mak Sithirith 2000; FACT 2001). However, there is also strong evidence that fish stocks have not declined overall but on the contrary that the overall catches at the moment are higher than any time in the past (Baran *et al.* 2001a, Van Zalinge *et al.* 2001). In fact, the population has increased much faster than the harvest. As a result, the catch per unit of effort or per fisher is falling, and medium and large-size species are becoming rarer while small opportunistic species (of low market price but high nutritional value) are becoming more abundant.

The causes for the perceived decline are believed to be widespread illegal fishing and over-fishing caused by an increasing number of fishermen, together with ineffective fishing management by the government. Fishermen themselves also state illegal fishing and over-exploitation are the main reason for the decrease (e.g. Keskinen *et al.* 2002).

Fishing lots provide an example of changes in fishing patterns and conflicting interests: large-scale fishing includes fishing lots that are auctioned for exclusive exploitation of fish resources (Van Zalinge *et al.* 1998b). In 1996, these fishing lots covered 80% of the Tonle Sap's shoreline (Gum 2000). Following social pressure, 56% of the total area of the private fishing lots was converted in 2000 into open access areas to allow the poor to benefit from the fisheries (Royal Government of Cambodia cited in Keskinen 2003). However fishing lots are also regarded by biologists as a good way to combine exploitation, environmental protection (Chheng Vibolrith 1999), and even biodiversity conservation (Coates *et al.* 2003). Hence, there is a dilemma between a management system "socially unjust" (as the fruits of the resource are captured by a few operators) that contributes somehow to conservation, and an open access system "socially more fair" but likely to result in unrestricted exploitation levels jeopardizing the resource.

7 SOCIALIST REPUBLIC OF VIETNAM

7.1 COUNTRY OVERVIEW

Vietnam is among the most densely populated countries in Southeast Asia, with the highest densities in the Mekong Delta, which is also the country's most important agricultural area. The Mekong Delta covers 369 million hectares, i.e. about 12% of the whole country.

Economic indicator	2000	2001	2002	2003
Agriculture (% of GDP)	24.53	23.24	22.99	
Industry (% of GDP)	36.73	38.13	38.55	
Services (% of GDP)	38.73	38.63	38.46	
GDP (billion US\$)	31.2	32.7	35.1	39.2
GDP growth (%)	6.79	6.89	7.04	7.24
Aid per capita (US\$)	21.42	18.25	15.88	
Population growth (%)	1.29	1.23	1.16	1.1
Population total (millions)	78.5	79.5	80.4	81.3

Table XXV: Selected economic indicators for Vietnam from 2000 to 2003 (World Bank web site).

There are still a high percentage of people (32% of the total population) living below the national poverty level according to World Bank estimates in 2002. The percentage of child malnutrition is 34% of all children under five years old. Although many are living close to water resources, only 56% of the total population have access to an improved domestic water system. The illiteracy rate is 6%. The percentages of rural population with access to clean water and electricity are as low as 17% and 48% respectively (Vo Tong Anh *et al.* 2003).

Agriculture contributed 23.6% to Vietnam's GDP (US \$32.7 billion) in 2001. From 1994 to 1997, the fisheries sector contributed about 3% to the national GDP (Vo Tong Anh *et al.* 2003). However, Thai Thanh Duong (2003) commented that the fisheries sector has developed rapidly and now contributes 7% of national GDP. Almost all freshwater body areas are heavily exploited for fisheries. Thus the number of fishers in the Mekong Delta has increased by 5.3% per year, i.e. four times more than the population growth and more than in the rest of the country (Table XXVI):

Region/Year	Number of Fishers		% increment per year over 8 years
	1990	1998	
Mekong Delta	314802	448564	5.3
Whole Country	1171130	1557921	4.1

Table XXVI: Number of fishers in Vietnam and in the Mekong delta in 1990 and 1998 (after Vo Tong Anh *et al.* 2003)

However, this analysis only focuses on professional fishers and does not reflect the importance of fishing as a part-time activity for a very large share of the population of the delta.

With a growing population, Vietnam's water resources are also facing potential shortages. At the moment, 90% of the water is used for agriculture, but industrial and domestic usages are increasing rapidly, while food production is at the same time expected to increase in order to meet the demands of the growing population. Vietnam has extensive water resource management structures, especially in the Vietnam Delta. According to statistics from the Water Resources and Hydraulic Works Department, 75 large and medium scale irrigation systems, 743 large and medium reservoirs, 1,017 dams and 4,712 sluices were recorded in 1996.



Figure 8: Map of South Vietnam

7.2 ECONOMIC VALUATION ANALYSES

7.2.1 DIRECT USE VALUES

7.2.1.1 Catch values

National statistics for the inland provinces of the Mekong Delta, where fisheries are exclusively freshwater and brackish, detail the catch and the labour force (Table XXVII):

Year	Catch Dong Thap (tons)	Catch An Giang (tons)	Effort Dong Thap (number of fishers)	Effort An Giang (number of fishers)	Tons/man Dong Thap	Tons/man An Giang
1995	16194	68047	4853	8518	3.34	7.99
1996	28292	72004	5109	8967	5.58	8.03
1997	26705	74300	5989	9023	4.46	8.23
1998	27118	76577	7092	8899	3.82	8.61

Table XXVII: Inland fish catch and labour force in two provinces of the freshwater area of the delta (General Statistical Office. 1999)

However, once again scientific estimates contradict official statistics. On the basis of household consumption surveys that remain controversial, the MRC estimated the total fish production for Tra Vinh province (Mekong Delta near the sea) alone to be roughly 87,559 tons/year of which 22,971 tons/year was from aquaculture and 64,587 tons/year from capture fisheries (AMFC 2002). In An Giang, near the Cambodian border, a study in 1999 estimated the annual production at 194,678 tons and consumption at 92,202 tons/year (Sjorslev 2001). Jensen (2000) set An Giang total annual production at 180,000 tons, and stated that there is reason to believe that the fish catches in the Vietnamese part of the Mekong Delta may be even higher than the total production in Cambodia. Indeed Phan Thanh Lam and Pham Mai Phuong (1999) amounted the catch in An Giang province at 190.7 kg/person/year (40% of the catch coming from rice fields and 53% from rivers and canals, with high variability depending upon profession and distance from water ways).

The productivity of Vietnamese inland waters is supplemented by that of reservoirs, acknowledging that most species originate from wild stocks. According to Nguyen Huu Nghi (1995, cited in Vo Tong Anh *et al.* 2003), the average fish productivity of the reservoirs amounts to 24.5 kg/ha/yr. The fish yields of reservoirs depend on nutrients, biomass, and the quality and quantity of stocked fingerlings. In Vietnam, the lowest yield (11.1 kg/ha) is found in large-size reservoirs (over 10,000 ha), middle yield (34.8–48.1 kg/ha) from medium-size reservoirs (about 2,000 ha and 1,000 ha) and the highest yield (83.0 kg/ha) from small-size reservoirs (Ngo Sy Van and Le Thanh Luu, 2001). Inland fresh- and brackish-water aquaculture ponds and tanks have 392,000 ha of production area in Vietnam. However most of the area is brackish water ponds. Van Zalinge *et al.* (2004) estimated the total production of Mekong Delta aquaculture at 171,600 tons in 1999.

7.2.1.2 Consumption values

On the official side, wild and cultured fish contribute about 40% of the total animal protein intake of the population, and the per capita availability of fish has increased from 11.8 kg in 1993 to 15.0 kg in 2000. During the 1994-1997 period, the contribution of the fisheries sector to national GDP was about 3% (Vo Tong Anh *et al.* 2003)

	Mekong delta
Per capita rice consumption (kg/month)	13.37
Per capita fish consumption (kg/month)	2.44
Per capita meat consumption (kg/month)	0.98
Malnutrition rate (%)	42.19

Table XXVIII: Consumption of rice, fish and meat in the Mekong Delta in 2000 (after Vo Tong Anh *et al.* 2003).

As mentioned above, scientific assessments at a more local level contradictiously estimate the overall fish consumption in the Vietnamese parts of the Lower Mekong Basin at 1,021,700 tons annually (Sjorslev 2001, Hortle and Bush 2003). The average annual consumption of fish in Tra Vinh province is 58.35 kg/person of which fresh fish account for 41.86 kg/person and fisheries products such as fish paste, dried fish and

fermented fish for 16.49 kg/person. An Giang province has very similar consumption figures, with 58 kg/person/year total, and Long An province slightly higher figures with 64 kg/person/year. In comparison, the average consumption of other animal products, such as pork, chicken and wildlife, was 35.58 kg/person/year in Tra Vinh.

7.3 SOCIO-ECONOMIC ANALYSES

As is the case with Cambodia, fisheries play much more important role in food security than in income generation in the Mekong Delta in Vietnam. This is proved by a fisheries household survey (AMFC 2002) which found that in Tra Vinh province in 2000 capture fisheries contributed 28% of food supply but only 4.5% of income, after rice farming, gardening and aquaculture. Similarly, in An Giang rice farming was the most important activity (52%), while fishing was ranked most important by 29% and second most important by 32% of the households.

Capture fisheries are of particular importance in the livelihoods of poorer people. The Vietnam Living Standard Study indicates that the poor spend more time on capture fisheries (in rivers, lakes and coastal areas) than on aquaculture in all regions of Vietnam except the South Central Coast (Vo Tong Anh *et al.* 2003). However, fish production in this region has fallen by 10-15% compared to 20 years ago (Sinh 1995; Sinh *et al.* 1997a and 2000). Poor knowledge of fishery technology and the use of harmful gears (electric fishing, chemicals, small mesh-size nets, harvesting of breeders, etc.) were among the reasons given for this decline.

7.4 LIVELIHOOD ANALYSES

Aquaculture is very developed with 407,000 tons reported as the national production in 1999. However, there is some indication that intensive aquaculture systems such as coastal shrimp farming have caused inequity (DFID 2000). Capture fisheries remain of considerable importance for rural people in the Mekong Delta, from poor to rich, and not only for full-time fishers, but also significantly for households in which fishing is a component of wider livelihood strategies. More specifically, Phan Thanh Lam and Pham Mai Phuong (1999) found that only 3% of the 1002 persons interviewed in An Giang province were professional fishers, but 37% of people were involved in fish-related activities. According to Sjorslev (2001) in the same province 7% of households are involved in professional fishing, 66% in part-time fishing and a further 5.7% in fish processing and trading. Carl Bro (1996) concluded from a survey of three regions (northern, central and southern) that the majority of surveyed households were involved in some form of fisheries or aquaculture activities. At the national level, Vo Tong Anh *et al.* (2003) concluded that capture fisheries form an important livelihood strategy for rural people in many parts of Vietnam, both for the poor and the rich and for full-time fisheries and other households.

Nho and Guttman (1999) reported from Tay Ninh Province that most households are involved in some form of capture fisheries but that the importance decreases from poor to rich households. Their study showed that 84% and 88% of 'low income' and 'very low income' households were involved in fishing respectively as compared to only 58% of 'medium income' and 44% of 'high income' households. The livelihood analysis conducted by the WorldFish project "Understanding Livelihoods Dependent on Fisheries" (Sultana *et al.* 2003b) identified through Participatory Rural Appraisals four categories of people who depend on fish for their livelihoods: full time fishers, part time fishers, landless subsistence fishers, and fish traders. These groups and their respective dependency upon fisheries resources were detailed, as well as their vulnerabilities, and capital assets. The study showed that inland capture fisheries remain of considerable importance to rural livelihoods in the Mekong Delta. The Government actively supports aquaculture development but has tended to ignore inland capture fisheries. In terms of poverty, the wild inland fishery is of greater importance than aquaculture and poor people have tended to become more reliant on wild aquatic resources as a result of growing indebtedness, landlessness and displacement. The study also highlighted the fact that the use of aquatic resources is unsustainable at the current exploitation rate. Capture fish production is declining due to over-fishing and use of damaging fishing methods; natural fish habitats and niches have been reduced in area due to rice farming expansion and intensification, and there is great concern about the direct discharge of effluents and pathogens from factories, hospitals and farms directly into canals and rivers in all these provinces.

7.5 IMPACT OF CHANGES ON FISHERIES IN VIETNAM

The major concern in Vietnam is the fact that reduced freshwater flows from the Mekong would allow a larger extension of the brackish water inland, the saline intrusion being incompatible with intensive rice production. However in this review focussing on fisheries we shall not detail the complex and much documented saline intrusion issue.

The changes in river basin management have impacts on fisheries similar to those detailed for Cambodia. These changes similarly consist of modifications (or obstruction) of the flow regime, loss of habitat and changes in fishing patterns (over-fishing). Hashimoto (2001) extensively reviewed the consequences of infrastructure development on the environment of the Mekong Delta. The main negative elements analysed in relation to inland fish production consist of segmentation and reduction of the aquatic habitat by dykes and levees and the reduction of the flushing effect of the flood. Flushing benefits the habitat and fish production by reducing the level of acidity and aluminium in the area, and by washing away pesticides and pollution accumulated in water ways during the dry season. However, the significant increase in suspended sediment during the flood is detrimental to fish aquaculture production, and the sudden and large fluctuation in physico-chemical parameters also sometimes causes mass mortalities among aquatic animals.

An element specific to Vietnam is the relationship between Mekong River discharge and the productivity of the coastal zone. This positive relationship is clearly demonstrated for most large rivers of the world, particularly in the Northern hemisphere, but has never been studied in the case of the Mekong and is surprisingly absent from discussions about the impact of reduced flows, though its importance has been highlighted several times in the scientific literature focussing on estuarine fisheries and also during the Second Large Rivers Symposium held in Phnom Penh in 2003.

8 CONCLUSIONS

The Greater Mekong inland fisheries are exceptionally important by global standards, with Cambodian fisheries the most intensively fished worldwide in terms of catch per person. These aquatic resources are crucial to the income, livelihood, and very subsistence of the population; they provide the last resort of security for the poorest people, but are also important to wealthier groups of the society. The importance of the fisheries in the Lower Mekong is not, however, reflected in the level of attention paid to it by the scientific community and governments. Aquatic resources suffer a shortfall in research initiatives, and this leads in turn to a lack of recognition of the importance of fisheries to food security and national economies.

Although development and investment opportunities might improve living conditions for the people of the Mekong basin, the majority of these people are still living in a rural subsistence economy and depend on the ecological system to supplement rice crops with fish, aquatic animals and plants. Among the multiple threats to Mekong fisheries is the uncontrolled modification of flows, particularly through dams that are coming back in regional energy strategies. Ill-advised flow modifications threaten to disrupt the livelihoods of those who depend on aquatic resources. Such disruption might involve the need to relocate and/or consider alternatives to fishing as a source of income, and none of these options can be achieved in the short-term. If the ecological system suffers from a development process rushed at the expense of the natural resources supply, most fishers or farmers will be unable to cope with a rapid change in their livelihood when they have neither the education nor the capital to shift to non-rural resource generating options. The most vulnerable would then be left worse off than they are now, with no other choice than migration to urban centers, at the expense of social peace and identity.

Although the value of inland capture fisheries is probably much better documented in the Mekong Basin than in Africa or in South America, the accuracy of the data and lack of up-to-date data remain a major gap that needs to be addressed in order to provide more reliable information and contribute to policy-making processes. Acknowledging the efforts and success of the MRC and other fisheries partners in increasing both knowledge and the political recognition of the importance of fisheries in the Mekong system, much remains to be done on i) accurately valuing the fisheries and ii) better communicating scientific and monitoring results so that fisheries are properly placed in regional planning and in weighting of development options.

In the face of these various threats to natural resources, what level of protection does aquaculture offer for the security of fish supply? As aquaculture fish only represents 12 per cent of the fish resources basin-wide and cannot grow quickly without extensive use of wild fish fry or the introduction of alien species, the priority for the region should be to protect and optimize the exploitation of a huge natural capital rather than counting on the development of a meagre aquaculture sector dependent on capture fisheries. In Cambodia for instance, without the supply of wild fish, aquaculture would produce only 15,000 tons – just four percent of the fish people consume.

That is not to say that aquaculture will not have a significant role in the future, but during the coming decade the emphasis should be on protecting the existing wild fish supply: slowing down rarefaction is crucial in order to avoid disruption of the natural food supply to the poor. More generally, sound management of aquatic resources requires a balanced 4-fold strategy: improved valuation of natural resources, protection and management of wild resources, aquaculture improvement, and better policies and governance. Without the development and effective implementation of such a strategy, the future of the most intense inland fisheries in the world will be uncertain.

9 REFERENCES

- ACO 2000. Lao agricultural census, 1998/1999 highlights. Steering committee for the agricultural census. Agricultural Census Office, Vientiane, Lao PDR. 62 pp.
- ADB 2000. Policies and strategies for sustainable development of the Lancang River Basin. Sector studies, TA No. 3139-PRC. Asian Development Bank. Landcare Research New Zealand Limited.
- ADB/UNEP 2004. Greater Mekong Subregion atlas of the environment. Asian Development Bank (Manila, Philippines) and United Nations Environment Program (Pathumthani, Thailand). 216 pp.
- Agrisystems/CamConsult/MRAG 2004. Final Report of the Tonle Sap Sustainable Livelihoods Project (Phase 1). Asian Development Bank, Manila, Philippines. 64 pp. + annexes
- Ahmed M., Hap Navy, Ly Vuthy, Tongco M. 1998 Socioeconomic assessment of freshwater capture fisheries in Cambodia: report on a household survey. Mekong River Commission, Phnom Penh, Cambodia. 186 pp.
- AMFC 2002. Tra Vinh fisheries survey. Report for the Component "Assessment of Mekong fisheries"; AMFC / RIA2 / DoF Tra Vinh / Department of Statistics Tra Vinh. Mekong River Commission, Phnom Penh, Cambodia. 69 pp.
- Amornsakchai S., Annez P., Vongvisessomjai S., Choowaew S., Kunurat P., Nippanon J., Schouten R., Sripapatprasite P., Vaddhanaphuti C., Vidthayanon C., Wirojanagud W. and Watana E. 2000. Pak Mun Dam, Mekong River Basin, Thailand. A WCD Case Study prepared as an input to the World Commission on Dams, Cape Town. [Online: www.dams.org]
- Arthington A.H., Lorenzen K., Pusey B.J., Abell R., Halls A.S., Winemiller K.O., Arrington D.A. and Baran E. 2004 River fisheries: ecological basis for management and conservation. Pp. 21-60 in R.L. Welcomme and T. Petr (eds) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, Volume 1. FAO, Bangkok. 356 pp.
- Baird I. G. 1996. Inland community fisheries in Southern Laos. Naga, the ICLARM quarterly, January 96. p. 13-15.
- Baird I. G., Inthaphaysi V., Phylavanh B., Kisouvannalath P. 1998. A rapid fishery survey in Khong District, Champasak Province, Southern Lao PDR. Technical report of the CESVI project for environmental protection and community development in the Siphandone Wetland, Champassak Province, Lao PDR. 31 pp.
- Baird I., Baird M., Chum Moni Cheath, Kim Sangha, Nuon Mekradee, Phat Sounith, Phouy Bun Nyok, Prom Sarim, Ros Savdee, Rushton H. and Sia Phen. 2002. A community-based study of the downstream impacts of the Yali Falls dam along the Se San, Sre Pok and Sekong Rivers in Stung Treng province, Northeast Cambodia. Report for the Se San Protection Network Project, Oxfam America, Phnom Penh, Cambodia. 78 pp.
- Baird I.G. and Beasley I.L. 2005. Irrawaddy dolphin *Orcaella brevirostris* in the Cambodian Mekong River: an initial survey. Oryx; 39; (3); 301–310
- Baird I.G. and Flaherty M.S. 2000. Local waters, international markets: a review of the sustainability of a Mekong river Probarbus fishery in southern Laos. Technical report of the CESVI project for environmental protection and community development in the Siphandone Wetland, Champassak Province, Lao PDR. 25 pp.
- Baird, I. G. 1994. Freshwater fisheries, with special reference to *Probarbus julleni* and *Probarbus labeamajor* in Southern Lao PDR and northeastern Cambodia, and the fish trade between northeastern Cambodia, southern Lao PDR, and Thailand. Lao community fisheries and dolphin protection project report, Pakse, Lao PDR. 30 pp.
- Baird, I. G. 2001. Aquatic biodiversity in the Siphandone wetlands. Pp. 61-74 in Daconto G. (ed.) Siphandone wetlands. CESVI (Cooperazione e sviluppo), Bergamo, Italy. 192 pp.
- Baird, I.G., V. Inthaphaisy, B. Phylavanh and P. Kisouvannalath 1998. A rapid fisheries survey in Khong District, Champasak Province, Southern Lao PDR. Technical report of the CESVI project for environmental protection and community development in the Siphandone Wetland, Champassak Province, Lao PDR.
- Bao T.Q., Bouakhamvongsa K., Chan S., Chhuon K.C., Phommavong T., Poulsen A.F., Rukawoma P., Suornratana U., Tien D. V., Tuan T.T., Tung N.T., Valbo-Jorgensen J., Viravong S. and Yoorong N. 2001. Local knowledge in the study of river fish biology: experiences from the Mekong, Mekong Development Series No. 1, Mekong River Commission, Phnom Penh.

- Baran E. 2005. Cambodian inland fisheries: facts, figures and context. WorldFish Center and Inland Fisheries Research and Development Institute, Phnom Penh, Cambodia. 49 pp.
- Baran E. and Baird I. G. 2003 Approaches and tools for sustainable management of fish resources in the Mekong River Basin. Pp. 78-87 in Cao M., Woods K., Hu H. and Li L. (eds.) Biodiversity management and sustainable development – Lancang-Mekong River in the new millennium. China Forestry Publishing House, Kunming, China. 246 pp.
- Baran E., Jantunen J., Chheng Phen *In press*. Developing a consultative Bayesian model for integrated management of aquatic resources: an inland coastal zone case study. In Tuong T. P., Hoanh C. T., Gowing J. W. and B. Hardy (eds) Effective land-water interface management for solving agriculture-fishery-aquaculture conflicts in coastal zones. CABI Publishing.
- Baran E., Van Zalinge N., Ngor Peng Bun 2001a. Floods, floodplains and fish production in the Mekong Basin: present and past trends. Pp. 920-932 in Ahyaudin Ali *et al.* (Eds.) Proceedings of the Second Asian Wetlands Symposium, 27-30 August 2001, Penang, Malaysia. Penerbit Universiti Sains Malaysia, Pulau Pinang, Malaysia. 1116 pp.
- Baran E., Van Zalinge N., Ngor Peng Bun 2001c Analysis of the Cambodian Bagnet ("dai") fishery data. ICLARM, Penang, Malaysia, Mekong River Commission Secretariat and Department of Fisheries, Phnom Penh, Cambodia. 62 pp.
- Baran E., Van Zalinge N., Ngor Peng Bun, Baird I.G., Coates D. 2001b. Fish resource and hydrobiological modelling approaches in the Mekong Basin. ICLARM, Penang, Malaysia and the Mekong River Commission Secretariat, Phnom Penh, Cambodia. 62 pp.
- Barlow, C. 2002. Size and value of the fishery in the LMB. Textbox p. 13-14 in Sverdrup-Jensen, S. (ed.). Fisheries in the Lower Mekong Basin: status and perspectives. MRC Technical Paper No. 6, Mekong River Commission, Phnom Penh. 103 pp.
- Batista V.S., Inhamuns A.J.F.C. and Freire-Brasil D. 1998. Characterisation of the fishery in river communities in the low-Solimões/high-Amazon region. Fisheries Management and Ecology; 5; 419-435.
- Béné C. and Neiland A.E. 2003. Contribution of inland fisheries to rural livelihoods in Africa: an overview from the Lake Chad Basin areas. Pp. 67-77 in R.L. Welcomme and T. Petr (eds) Proceedings of the second international symposium on the management of large rivers for fisheries, Volume 2. FAO, Bangkok. 310 pp.
- Bernacsek G. 1997a Reservoirs: a boon or a curse to fisheries? Catch and Culture, 2 (3). February 1997.
- Bernacsek G. M. 1997b Large dam fisheries of the Lower Mekong countries: review and assessment; main report. Project on Management of fisheries reservoirs in the Mekong basin. Mekong River Commission, Phnom Penh. Vol. I, August 1997." 118 p. + annexes
- Blaber S. J. 2002 Fish in hot water: the challenges facing fish and fisheries research in tropical estuaries. Journal of fish biology, 61; (1-A); 1-20.
- Bonheur N. 2001. Tonle Sap ecosystem and value. Technical Coordination Unit for the Tonle Sap, Ministry of Environment, Phnom Penh, Cambodia. 46 pp.
- Bonheur N. and Lane B. D. 2002. Natural resources management for human security in Cambodia's Tonle Sap Biosphere Reserve. Environmental Science & Policy; 5; 33-41.
- Buncha Apai 2003 Reconsidering creating a body of knowledge for sustainable socio-economic development in the Upper Mekong Basin. Pp. 160-167 in Cao M., Woods K., Hu H. and Li L. (eds.) Biodiversity management and sustainable development – Lancang-Mekong River in the new millennium. China Forestry Publishing House, Kunming, China. 246 pp.
- Bush S. 2002. Comparative advantage: changing market structures and food security in the Siphandone fishery, Lao PDR. Presentation at the International Symposium on sustaining food security and managing natural resources in Southeast Asia. January 8-11, Chiang Mai., Thailand
- Bush S. 2003a. "Give a man a fish..."; contextualising living aquatic resources development in the Lower Mekong Basin. Australian Mekong Resource Centre, Working Paper No. 8. University of Sydney, Australia. 38 pp.
- Bush S. 2003b Comparing what matters with what is done: fisheries and aquaculture in the Lao PDR Contribution to the Second international symposium on the management of large rivers for fisheries. Phnom Penh, 11-14 February 2003.
- Bush S. 2004a Needing the supply, or supplying the need? A political ecology of Mekong fishery statistics at different scales. Presentation at the Institute of Australian Geographers conference, April 2004, Glenelg, Australia. 32 pp.

- Bush S. 2004b. Scales and sales: changing spatial and social fish trading networks in the Siiphandone fishery, Lao PDR Singapore Journal of Tropical Geography, 25; 1; 32-50
- Bush S. R. and Hirsch P. 2005 Framing fishery decline. Aquatic resources, culture and development; 1; (2), 79–90
- Campbell I.C. 2003 Invertebrates, biodiversity and the Upper Lancang-Mekong navigation project. Pp. 97-105 in Cao M., Woods K., Hu H. and Li L. (eds.) Biodiversity management and sustainable development – Lancang-Mekong River in the new millennium. China Forestry Publishing House, Kunming, China. 246 pp.
- Campbell I.C. 2005 Integrated water management for the Mekong River Basin. Pp. 250-266 in Biswas A.K., Varis O., Tortajada C. (eds) Integrated water resources management in South and Southeast Asia. Water resources management series, Oxford India Paperbacks. Oxford University Press, New Dehli, India. 353 pp.
- Carl Bro Management. 1996. Geographical, social and socioeconomic assessment of the fishery industry in Vietnam: Fisheries Master Plan Sub-Project II. Final Report Ministry of Fisheries and DANIDA, Copenhagen.
- Chainarong Sretthachau and Pianporn Deetes. 2004. Downstream impacts of hydropower and development of an international river: a case study of Lancang-Mekong. Presentation at the UN Symposium on Hydropower and Sustainable Development, Beijing, China, October 27-29, 2004. 4 pp.
- Chapman, E. C. and He Daming 2000. Downstream implications of China's dams on the Lancang Jiang (Upper Mekong) and their potential significance for greater regional cooperation basin-wide. 8 pp. Web-based article [Online: <http://asia.anu/mekong/dams.html>]
- Cherdsak Virapat and Mattson N. 2001. Inventory of reservoir fishery resources in Thailand. In: De Silva S. (ed). Reservoir and culture-based fisheries: biology and management. Proceedings of an International Workshop held in Bangkok, Thailand from 15–18 February 2000. ACIAR Proceedings No. 98. 384pp
- Cherdsak Virapat, Phimonbutra U., Chantarawaratid C. 1999. Fishery and fisheries management in Thai reservoirs: review and assessment. Report for the project "Management of the reservoir fisheries in the Mekong Basin". Phnom Penh, Cambodia, Mekong River Commission. 45 pp.
- Chevey P. 1933. The Great Lake of Cambodia: the underlying causes of its richness in fish. Pp. 3809-3816 in Proceedings of the fifth Pacific Science Congress, Vancouver, Canada.
- Chevey P. 1938. La pêche au Cambodge. Bulletin de la Société Centrale d'Aquiculture et de Pêche. Tome 45 (4-6) ; 35-44.
- Chevey P. and Le Poulain F. 1939. Rapport préliminaire sur la pêche dans les eaux douces cambodgiennes. Etudes scientifique, technique et économique. Extrait du Bulletin Economique de l'Indochine, fascicules 1 et 2. 124 pp.
- Chevey P. and Le Poulain F. 1940. La pêche dans les eaux douces du Cambodge. Travaux de l'Institut Océanographique de l'Indochine. 5^e mémoire. 195 pp. + 48pl. +7 cartes
- Chheng Vibolrith. 1999. Case study of fishing lot n° 3 in Siem Reap Province, Cambodia. Pp. 111-114 in Van Zalinge N., Nao Thuok, Deap Loeung (eds.) Proceedings of the annual meeting of the Department of Fisheries of the Ministry of Agriculture, Forestry and Fisheries, 19-21 January 1999. DoF/MRC/Danida project for management of the freshwater capture fisheries of Cambodia, Phnom Penh, Cambodia. 150 pp.
- Claridge G.F., Thanongsi Sorangkhou, Baird I.G. 1997 Community fisheries in Lao PDR: a survey of techniques and issues. IUCN, the World Conservation Union, Vientiane, Lao PDR. 69 pp.
- CNMC/Nedeco 1998. Sectoral studies: environment in the Tonle Sap area. Natural resources-based development strategy for the Tonle Sap area, Cambodia. Final report, volume 2, part A. Cambodian National Mekong Committee, MRC, UNDP. Phnom Penh, Cambodia.
- Coates D. 2003. An overview of inland capture fishery statistics of Southeast Asia. Pp. 40-44 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Coates D., Boivin T., Darwall W.R.T., Friend R., Hirsch P., Poulsen A.F., Quirós R., Visser T.A.M. and Wallace M. 2004. Information, knowledge and policy. Pp. 93-118 in R.L. Welcomme and T. Petr (eds) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, Volume 1. FAO, Bangkok. 356 pp.
- Coates D., Ouch Poeu, Ubolratana Suntornratana, N. Thanh Tung and Sinthavong Viravong. 2003. Biodiversity and fisheries in the Lower Mekong Basin. Mekong Development Series No. 2. Mekong River Commission, Phnom Penh.

- Coates, D. 2002. Inland capture fishery statistics of Southeast Asia: Current status and information needs. Asia-Pacific Fishery Commission, Bangkok, Thailand. RAP Publication No. 2002/11, 114 p.
- Cowx I., Almeida O., Béné C., Brummett R., Bush S., Darwall W., Pittock J. and van Brakel M. 2004. Value of river fisheries. Pp. 1-20 in R.L. Welcomme and T. Petr (eds) Proceedings of the second international symposium on the management of large rivers for fisheries, Volume 2. FAO, Bangkok.
- Daconto G. (Ed.) Siphandone wetlands. CESVI (Cooperazione e sviluppo), Bergamo, Italy. 192 pp.
- Davidson A., 1975. Fish and fish dishes of Laos. Imprimerie Nationale, Vientiane, Lao PDR. 202 p.
- Deap Loeung. 1999. The bagnet (Dai) fishery in the Tonle Sap River. Pp. 141-150 in Van Zalinge N., Nao Thuok and Deap Loeung (eds.) Proceedings of the annual meeting of the Department of Fisheries of the Ministry of Agriculture, Forestry and Fisheries, 19-21 January 1999. DoF/MRC/Danida project for management of the freshwater capture fisheries of Cambodia, Phnom Penh, Cambodia. 150 pp.
- Degen P. and Nao Thouk. 2000. Historical, cultural and legal perspectives on the fishing lot system in Cambodia. Pp. 49-60 in M. Ahmed and P. Hirsch (eds.) Common property in the Mekong: issues of sustainability and subsistence. ICLARM Studies and Reviews n° 26, 67 p.
- Degen P., Van Acker F., Van Zalinge N., Nao Thuok N. and Ly Vuthy 2000. Taken for granted: conflicts over Cambodia's freshwater fish resources. Presentation at the 8th IASCP Conference, 31 May 4 June 2000 Bloomington, Indiana, USA. 30 pp.
- DFID 2000. Poverty and aquatic resources in Vietnam: an assessment of the role and potential of aquatic resource management in poor people's livelihoods. DFID Bangkok, Thailand. 36 pp.
- Dixon P.-J., Sultana P., Thompson P., Ahmed M., Lorenzen K., Halls A.S. 2003 Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Synthesis report. WorldFish Center, Penang, Malaysia.
- DoF 2001a. Social and economic framework review. Agriculture productivity improvement project, Technical paper n° 8. Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia. 22 pp.
- DoF 2001b. Inland fisheries review. Agriculture productivity improvement project, Technical paper n° 2. Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia. 42 pp.
- DoF 2001c. Trade, marketing and processing of fisheries and fisheries product review. Agriculture productivity improvement project, Technical paper n° 6. Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia. 22 pp.
- Dubeau P., Ouch Poeu and Sjorslev J. 2001 Estimating fish and aquatic animal productivity/yield per area in Kampong Tralach: an integrated approach. Pp. 143-164 in Cambodia Fisheries Technical Paper Series, Volume III, Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Phnom Penh, Cambodia. 233 pp.
- Dudgeon D. 2000 Large-scale hydrological changes in tropical Asia: prospects for riverine biodiversity BioScience 50; 9; 793-806.
- Dudgeon D. 2003 The contribution of scientific information to the conservation and management of freshwater biodiversity in tropical Asia. Hydrobiologia 500; (1-3); 295-314
- Dugan P.J., E. Baran, R. Tharme, M. Prein, R. Ahmed, P. Amerasinghe, P. Bueno, C. Brown, M. Dey, G. Jayasinghe, M. Niasse, A. Nieland, V. Smakhtin, N. Tinh, K. Viswanathan and R. Welcomme. 2002. The contribution of aquatic ecosystems and fisheries to food security and livelihoods: a research agenda. Challenge Programme on Water and Food, Background Paper n° 3. 28 pp.
- EJF 2002. Death in small doses: Cambodia's pesticides problems and solutions. Environmental Justice Foundation, London, UK. 37 pp.
- Elvevoll E. O. and James D. G. 2004. Potential benefits of fish for maternal, foetal and neonatal nutrition: a review of the literature. Food, nutrition and agriculture, Vol. 27. [Online: www.fao.org/docrep/003/X8576M/x8576m05.htm]
- Emerton L. and Bos E. 2004 Values; counting ecosystem as an economic part of water. IUCN, Gland, Switzerland and Cambridge, UK. 88 pp.
- FACT 2001 Feast or famine? Solutions to Cambodia's fisheries conflicts. Fisheries Action Coalition Team in collaboration with Environmental Justice Foundation. 41 pp. [Online: www.ejfoundation.org/pdfs/feast_or_famine.pdf]

- FAO 1999. Fishery country profile: the Lao People's Democratic Republic. FAO Fisheries Department, FAO: Rome.
- FAO PADP. 1998. Small-scale rural aquaculture in Lao PDR. Field document n° 11, Provincial Aquaculture Development Project LAO/97/007, FAO/UNDP, Vientiane, 16 pp.
- FAO. 2003. Myanmar aquaculture and inland fisheries mission report. RAP publication 2003/18. Food and Agriculture organization, Bangkok, Thailand
- FEER 2004. The Mekong dammed- a great river at risk. Far Eastern Economic Review, 26 August 2004.
- Feng Yan, He Daming, Bao Haosheng. 2004 Analysis on equitable and reasonable allocation models of water resources in the Lancang-Mekong River Basin. Water International, 29; (1); 114–118.
- Fisheries Office. 2000. A study of the downstream impacts of the Yali Falls Dam in the Se San River Basin in Ratanakiri province, northeast Cambodia. Fisheries Office Ratanakiri Province and The Non-Timber Forest Products NGO. 43 pp.
- Fox C. 2004 Flood pulses, international watercourse law and common property resources: a case study of the Mekong Lowlands. Presentation at the Conference "Unlocking human potential: linking the informal and formal sectors". World Institute for Development Economics Research, 17-18 September 2004, Helsinki, Finland. 21 pp.
- Friend R. 2001. A people-centred fishery: socio-economic perspectives. Pp. 75-88 in Daconto G. (Ed.) Siphandone wetlands. CESVI (Cooperazione e sviluppo), Bergamo, Italy. 192 pp.
- Funge-Smith S. 2000. End of assignment report; provincial aquaculture development project LAO/97/007, FAO, Vientiane. 47 pp.
- Garaway C. 2005. Fish, fishing and the rural poor. A case study of the household importance of small-scale fisheries in the Lao PDR. Aquatic Resources, Culture and Development; 1; (2), 131-144
- Garaway C. J. 1999. Small waterbody fisheries and the potential for community-led enhancement: case studies in Lao PDR. PhD thesis, Imperial College of Science Technology and Medicine, London, UK. 414 pp.
- General Statistical Office. 1999. Statistical data of agriculture, forestry and fisheries 1990-1998 and forecast for year 2000. General statistical office, department of agriculture, forestry and fisheries. Statistical Publishing House, Hanoi, Vietnam. 380 pp.
- Gerrard, P. 2004. Integrating wetland ecosystem values into urban planning: the case of That Luang Marsh, Vientiane, Lao PDR IUCN – The World Conservation Union, Asia Regional Environmental Economics Programme and WWF Lao Country Office, Vientiane. 35 pp.
- Giteau M. and Martin M. 1995. Saveurs et cuisine à travers les âges au Cambodge. Pp. 205-235 in Blanchon F. (ed.) Asie - savourer, goûter. CREOPS, Presses de l'Université de la Sorbonne, Paris, France. 401 pp.
- Goh E. 2004. China in the Mekong River Basin: the regional security implications of resources development in the Lancang Jiang. Working paper n° 69. Institute of Defense and Strategic Studies, Singapore. 17 pp.
- Gourou P. 1984. Riz et civilisation. Fayard, Paris, France. 299 pp.
- Gum, W. 2000. Inland aquatic resources and livelihoods in Cambodia: a guide to the literature, legislation, institutional framework and recommendations. Consultancy report for Oxfam GB and NGO Forum on Cambodia. Oxfam, Phnom Penh. 122 pp.
- Guttman H., Funge-Smith S. 2000. The role of aquaculture in rural subsistence livelihoods in Lao PDR Provincial Aquaculture Development Project (LAO/97/007). STS Field Document 9. FAO Bangkok, 29 pp.
- Haapala U. 2003. Where do you go? Migration and urbanisation in Cambodia. WUP-FIN socio-economic studies on Tonle Sap n°9. MRCS/WUP-FIN, Phnom Penh, Cambodia. 43 pp.
- Halcrow 2004a. DSF user guides. Volume 2 of the final report of the Water Utilisation Project component A: Decision Support Framework. Halcrow Ltd. and Mekong River Commission. 15 pp.
- Halcrow 2004b. Impact analysis tools. Volume 13 of the final report of the Water Utilisation Project component A: Decision Support Framework. Halcrow Ltd. and Mekong River Commission, Phnom Penh, Cambodia.
- Halcrow 2004c. Knowledge base data catalogue. Volume 16 of the final report of the Water Utilisation Project component A: Decision Support Framework. Halcrow Ltd. and Mekong River Commission, Phnom Penh, Cambodia.

- Halcrow 2004d. DSF testing and evaluation. Volume 13 of the final report of the Water Utilisation Project component A: Decision Support Framework. Halcrow Ltd. and Mekong River Commission, Phnom Penh, Cambodia.
- Halwart M., D. Bartley D., Guttman H. (eds.). Traditional use and availability of aquatic biodiversity in rice-based ecosystems in Southeast Asia; a series of four studies in Cambodia, China, Laos and Vietnam. CD ROM. FAO, Rome, Italy.
- Hardner J., Somony Thay, and Heng Chhunhy. 2002. Living with the Mekong River flood: economic perspectives and local perceptions. WWF report prepared for the Living Mekong Initiative. World Wide Fund for Nature, Phnom Penh. 14 pp.
- Hashimoto T.R. 2001 Environmental issues and recent infrastructure development in the Mekong Delta: review, analysis and recommendations with particular reference to large scale water control projects and the development of coastal areas. Working Paper Series. Working paper No. 4. Australian Mekong Resource Centre, University of Sydney, Australia. 70 pp.
- He Daming and Chen Lihui 2002. The impact of hydropower cascade development in the Lancang-Mekong Basin, Yunnan. Mekong Update and Dialogue; 5; (3), 2-4. Australian Mekong Resource Centre.
- He Daming, Hsiang Te Kung 1997. Facilitating regional sustainable development through integrated multi - objective utilization, management of water resources in the Lancang- Mekong River Basin . Journal of Chinese Geography; 7; 4 , 9-21.
- Heinonen, J. and Vainio-Mattila, K. 1999. Biodiversity/ecotourism assessments in Yunnan, China. Report for the ADB project "Poverty reduction and environmental management in remote Greater Mekong Subregion watersheds. Asian Development Bank, Manila, Philippines. 25 pp.
- Hickey J. T. and Diaz G. E. 1999. From flow to fish to dollars: an integrated approach to water allocation. Journal of the American water resources association, Vol. 35, No. 5. American Water Resources Association.
- Hill M. T. and Hill S. A. 1994. Fisheries ecology and hydropower in the lower Mekong river: an evaluation of run-of-the-river projects. and Don Chapman Consultants Inc. and Mekong River Commission Secretariat, Bangkok, Thailand. 106 pp.
- Hirji R., Panella T. 2003 Evolving policy reforms and experiences for addressing downstream impacts in World Bank water resources projects. River Research and Applications, 19: 667–681
- Hirsch P. 2004 The politics of fisheries knowledge in the Mekong River Basin. Pp. 91-101 in R.L. Welcomme and T. Petr (eds) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, Volume 2. FAO, Bangkok. 310 pp.
- Hogan Z. S., Moyle P. B., May B., Vander Zanden M.J., Baird I. G. 2004. The imperiled giants of the Mekong. American Scientist, vol. 92 (3), 228-237.
- Hortle K.G. and Bush S.R. 2003. Consumption in the Lower Mekong Basin as a measure of fish yield. Pp. 76-82 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Hortle K.G., Lieng S., Valbo-Jorgensen J. 2004a An introduction to Cambodia's inland fisheries. Mekong Development Series n° 4. Mekong River Commission, Vientiane, Lao PDR. 41 pp.
- Hortle, K., Hgor Pengbun, Hem Rady and Lieng Sopha. 2004b. Trends in the Cambodian dai fishery: floods and fishing pressure. Mekong Fish Catch and culture, vol. 10, no. 1, April.
- In Monirith, Haruhiko Nakata, Shinsuke Tanabe, Touch Seang Tana 1999. Persistent organochlorine residues in marine and freshwater fish in Cambodia. Marine Pollution Bulletin; 38; 7, 604-612.
- IRN 1999. Power struggle: the impacts of hydro-development in Laos. International Rivers Network, Berkeley, USA. 68 pp.
- Israel D.C. , Ahmed M., Yeo Bee Hong, Hong Meen Chee 2005. Aquatic resources valuation and policies for poverty elimination in the Lower Mekong Basin. DFID and WorldFish Center, Penang, Malaysia. 189 pp. + annexes.
- Ivanoff J. 2003 Le partage des eaux en Asie du Sud-Est. Pp. 147-171 in Geistdoerfer A., Ivanoff J., Matras-Guin J. (eds.) La mer dévorée. Collection Kétos, CETMA, Muséum National d'Histoire Naturelle, Paris, France. 283 pp + annexes

- Jantunen T. 2004. Integration of hydrological, land use and water quality data to a model of the Tonle Sap fish resource. ADB/WorldFish Center project "Technical Assistance for capacity building of IFRDI"; WorldFish Center and Inland Fisheries Research and Development Institute, Department of Fisheries, Phnom Penh, Cambodia. 59 pp.
- Jensen J. 1996. 1,000,000 tonnes of fish from the Mekong? Mekong Fish Catch and Culture, Vol. 2, No. 1.
- Jensen J. 2000. Can this really be true? Rice, yes, and fish please! Mekong Fish Catch and Culture, Vol. 5, No. 3.
- Jensen J. 2001a. Managing fish, floodplains and food security in the Lower Mekong Basin. Water Science and Technology; 43; 9; 157-164.
- Jensen J. 2001b. Traditional fish productions: the milk of Southeast Asia. Mekong Fish Catch and Culture, Vol. 6, No. 4.
- Jensen J. 2001c. Fish passes in Australia – a national success; can it be copied in the Mekong? Mekong Fish Catch and Culture, Vol. 6, No. 3.
- Johnston R., Rowcroft P., Hortle K. G., McAllister C. 2003 Integrating environmental values into resource allocation - MRC's approach in the LMB. Presentation at Workshop on Integrating Environmental Impacts into Water Allocation Models of the Mekong River Basin, University of Economics, Ho Chi Minh City, 15 December 2003. 14 pp.
- Jones J. A. A. 1997. Global hydrology: processes, resources and environmental management. Longman, Harlow and New York, USA. 364pp.
- Kaing K., Thay S., Nao T., Ahmed M. 2003. Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Cambodia PRA report. WorldFish Center, Penang, Malaysia.
- Ker Naret, Sem Viryak, Don Griffiths 2001. Fish price monitoring in Kandal, Prey Veng and Takeo provinces of Cambodia. Pp. 165-175 in Cambodia Fisheries Technical Paper Series, Volume III, Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Phnom Penh, Cambodia. 233 pp.
- Keskinen M. 2003. The great diversity of livelihoods: Socio-economic survey of the Tonle Sap Lake. Water Utilization Program - Modelling of the Flow Regime and Water Quality of the Tonle Sap MRCS / WUP-FIN Project. MRC/Finnish Environment Institute, Phnom Penh. 126 pp.
- Keskinen M., Yim Sambo and Noy Pok 2002. Floating and fishing: field study in Kampong Preah village, Kampong Chhnang. WUP-FIN Socio-Economic Studies on Tonle Sap n° 1, Mekong River Commission and Finnish Environment Institute, Phnom Penh.
- Khin Sok (1993) Notes sur la pêche et la cueillette des plantes spontanées des réfugiés Cambodgiens en milieu semi-urbain. Pp. 249-261 in Krowolski N. (ed.) Autour du riz – le repas chez quelques populations d'Asie du Sud-Est. L'Harmattan, Paris. 261 pp.
- Kim Sour, Hav Viseth 2004 Fisheries and aquaculture in Cambodia's wetland environment. Pp. 1-13 in Torell, M. Salamanca, A. and Ratner, B. (eds.) Wetlands management in Cambodia: socioeconomic, ecological, and policy perspectives. WorldFish Center Technical Report 64, Penang. 45 pp.
- Kristensen J. 2000. Experience in international cooperation for planning and sustainable development of the Mekong River Basin. Paper prepared for the Fourth Regional Consultation of the World Commission on Dams. Hanoi, Vietnam 26-27 February 2000. 9 pp.
- Kristensen J. 2001. Food security and development in the Lower Mekong River Basin: a challenge for the Mekong River Commission. Presentation at the Asia and Pacific forum on poverty: reforming policies and institutions for poverty reduction. Asian Development Bank, Manila, 5-9 February 2001. 25 pp.
- Kummu M., Koponen J., Sarkkula J. 2005. Assessing impacts of the Mekong development in the Tonle Sap Lake. Presentation at the symposium "Role of water sciences in transboundary river basin management". Ubon Ratchathani, Thailand, March 2005. 10 pp.
- Kummu, M. 2003. The historical water management of Angkor, Cambodia. Presentation at the World Archaeological Congress 2003. 21-26 June 2003 Washington DC, USA. 27 pp.
- Lagler K. F. 1976. Fisheries and integrated Mekong river basin development. The University of Michigan, School of natural resources 363 pp.
- Le Poulain F. 1942 La coopérative des pêcheries d'eau douce du Cambodge. 39^e note de L'Institut Océanographique de l'Indochine. 20 pp.
- Levy-Ward A. 1993 Etes-vous capable de manger de la nourriture Isan ? Pp. 17-81 in Krowolski N. (ed.) Autour du riz – le repas chez quelques populations d'Asie du Sud-Est. L'Harmattan, Paris. 261 pp.

- Lieng Sopha, van Zalinge N. 2001. Fish yield estimation in the floodplains of the Tonle Sap Great Lake and River, Cambodia. Pp. 23-26 in IFReDI, 2001, Cambodia Fisheries Technical Paper Series, vol. III. MRC and Department of Fisheries, Phnom Penh. 233 pp.
- Little D.C. Pimjai Surintaraseree, Nick Ines-Taylor 1996 Fish culture in rainfed rice fields of northeast Thailand. *Aquaculture*, 140; 295-321.
- Lorenzen K., Nguyen Khoa, S., Garaway, C., Arthur, R., Kirkwood, G., Bounthanom Chamsingh, Douangchith Litdamlong, Innes-Taylor, N. and Siebert, D. 2000. Impacts of irrigation and aquaculture development on small-scale aquatic resources. Department of International Development, Environment Research Programme. Imperial College, London, UK. 59 pp.
- Lorenzen K., Xaypladeth Choulamany, Parvin Sultana P. 2003a Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Lao PDR country status report. WorldFish Center, Penang, Malaysia. 28 pp.
- Lorenzen K., Xaypladeth Choulamany, Parvin Sultana P. 2003b Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Lao PDR summary report. WorldFish Center, Penang, Malaysia. 15 pp.
- Mak Sithirith. 2000. Vulnerability of fisheries in Cambodia. Presentation to the Conference "Accounting for development: Australia and the Asian Development Bank in the Mekong Region". Sydney, Australia, 2000. [Online: www.ngoforum.org.kh]
- Makkonen K. 2005. Mekong cooperation - the linkages between poverty, environment and transboundary water management in southwest China's Yunnan Province. Presentation at the Seventh Biennial Nordic Conference on Chinese Studies, Helsinki, 7-9 June 2005. 13 pp.
- Maris B. 2005 *Antimanuel d'économie*. Breal, Rosny, France. 359 pp.
- Matics K.L. 2001 The role of networks in addressing research and development issues on women in fisheries: fisheries networks in the Mekong Basin. Pp. 45-56 in Williams M.J., Nandeesha M.C., Corral V.P., Tech E., Choo P.S. (eds.) International symposium on Women in fisheries. ICLARM, the WorldFish Center, Penang, Malaysia. 156 pp.
- Mattson, N. Balavong, V., Nilsson, H., Phounsavath, S., Hartmann, W. 2001. Changes in fisheries yield and catch composition at the Nam Ngum reservoir, Lao PDR In: De Silva, S. S. (ed). Reservoir and culture-based fisheries: biology and management. Proceedings of an International Workshop held in Bangkok, Thailand from 15 to 18 February 2000. ACIAR Proceedings No. 98. 384 pp.
- Mattson, N. S., Kongpheng Buakhamvongsa, Naruepon Sukumasavin, Nguyen Tuan, Ouk Vibol. 2002. Cambodia Mekong giant fish species: on their management and biology. MRC Technical Paper n° 3, Mekong River Commission, Phnom Penh, Cambodia. 29 pp..
- Mattson, N., Hartmann, W., Augustinus, T. 2002. Reservoir fisheries information: from statistics to management Pp. 83-88 in: FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- McDowall R.M. 2002. Evaluation of the report on environmental impact assessment of the navigation channel improvement project of the Lancang-Mekong River from China-Myanmar boundary marker 243 to Ban Houei Sai of Laos. The fisheries impacts reviewed. Report of the National Institute of Water and Atmospheric Research Ltd for the Mekong River Commission. 12 pp.
- McKenney, B. 2001. Economic valuation of livelihood income losses and other tangible downstream impacts from the Yali Falls dam to the Se San River Basin in Ratanakiri province, Cambodia. Oxfam America, Phnom Penh. 24 pp.
- McKenney, B. 2001. Valuation of flooded forests in Kandal province, Cambodia. Economy and environment program for Southeast Asia, Phnom Penh.
- McKenney, B. and Tola, P. 2002. Natural resources and rural livelihoods in Cambodia: A baseline assessment. Working Paper n° 23, Cambodia Development Resource Institute, Phnom Penh, Cambodia.
- McKenney, B. and Tola, P. 2004. Prahoc and food security: an assessment at the Dai fisheries. Cambodia Development Review vol. 8 (1). Cambodia Development Resource Institute, Phnom Penh, Cambodia.
- Meusch E., Yyoung-Aree J., Friend R., Funge-Smith S.J. 2003. The role and nutritional value of aquatic resources in the livelihoods of rural people – a participatory assessment in Attapeu Province, Lao PDR. FAO Regional Office Asia and the Pacific, Bangkok, Thailand, Publication No. 2003/11. 34 pp..
- MFD 2003. Mekong Fish Database: a taxonomic fish database for the Mekong Basin. CD-ROM, Mekong River Commission, Phnom Penh, Cambodia.

- Mogensen M.T. 2001 The importance of fish and other aquatic animals for food and nutrition security in the Lower Mekong Basin. M.Sc. thesis in human nutrition. Research department of human nutrition, the Royal Veterinary And Agricultural University, Denmark. 126 pp. + annexes.
- Molloy R., Chanthone Phothitay, Sonsai Kosy 2003. Seasonally flooded habitat and non-timber forest products: supporting biodiversity and local livelihoods in southern Lao PDR Contribution to the Proceedings of the MRC Sixth Technical Symposium on Mekong Fisheries, 26-28 November 2003. WWF Lao Programme and WWF Living Mekong Initiative. 28 pp.
- Mouhot H. 1868. Voyage dans les royaumes de Siam, de Cambodge, de Laos et autres parties centrales de l'Indo-Chine. Editions Olizane, Geneve, Switzerland, 1999. 315 pp.
- MRAG 2002. Community fisheries: lessons from Southern Lao PDR. Marine Resources Assessment Group, London, UK. 28 pp.
- MRC 1997. Greater Mekong Subregion state-of-the-environment report. Mekong River Commission and United Nations Environment Program. Bangkok, Thailand. 107 pp.
- MRC 2001. MRC Hydropower development strategy. Water Resources and Hydrology Programme, Mekong River Commission, Phnom Penh, Cambodia. 130 pp.
- MRC 2003a. Social atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh, Cambodia. 153 pp.
- MRC 2003b. State of the Basin Report: 2003. Executive summary. Mekong River Commission, Phnom Penh. 50 pp.
- MRC 2004a. Annual report of the MRC programme for fisheries management and development cooperation, April 2003 – March 2004. Mekong River Commission, Vientiane, Lao PDR.
- MRC 2004b. Mekong River Commission website, February 2005. [Online: www.mrcmekong.org]
- MRC 2005. Annual report of the MRC programme for fisheries management and development cooperation, April 2004 – March 2005. Mekong River Commission, Vientiane, Lao PDR.
- MRCS 1992. Fisheries in the Lower Mekong basin; review of the fishery sector in the Lower Mekong Basin. Mekong River Commission Secretariat, Bangkok, Thailand. 92 pp + annexes.
- NACA 2000. State of Asian aquaculture. Aquaculture Asia 5; 1; 4-24.
- Nam Sokleang. 2000. Mekong River flow data analysis. Pp. 23-29 in Van Zalinge N. Nao T. and Lieng S. (Eds.) Management aspects of Cambodia's freshwater fisheries. Mekong River Commission and Department of Fisheries, Phnom Penh, Cambodia. 170 pp.
- Nandeesha M.C. 2001 Help me to help myself: highlights of Phnom Penh seminar on women in fisheries in Indochina countries. Pp. 39-44 in Williams M.J., Nandeesha M.C., Corral V.P., Tech E., Choo P.S. (eds.) International symposium on Women in fisheries. ICLARM, the WorldFish Center, Penang, Malaysia. 156 pp.
- Ngo Sy Van and Le Thanh Luu 2001. Status of reservoir fisheries in Vietnam. In: De Silva S.S. (ed). Reservoir and culture-based fisheries: biology and management. Proceedings of an International Workshop held in Bangkok, Thailand from 15–18 February 2000. ACIAR Proceedings No. 98. 384 pp.
- Ngor Peng Bun. 1999. Catfish fry collection in the Mekong River of Kandal / Phnom Penh. Pp. 124-134 in Van Zalinge N., Nao Thouk, Deap Loeung (eds.) Present status of Cambodia's freshwater capture fisheries and management implication. Mekong River Commission and Department of Fisheries, Phnom Penh, Cambodia. 150 pp.
- Nguyen Khoa S., Lorenzen K., Garaway C.J., Chamsingh B. 2003. Impacts of irrigation development on capture fisheries in rice-based farming systems of Southern Laos. Contribution to the Second International Symposium on the Management of Large Rivers for Fisheries Phnom Penh, 11-14 February 2003.
- Nguyen Minh Quang 2003. Hydrologic impacts of China's upper mekong dams on the Lower Mekong River. Mekong River web site [Online: www.mekongriver.org/publish/qghydrochdam.htm]
- Nho, Pham Van and Guttman, H. 1999. Aquatic resources use assessment in Tay Ninh Province, Vietnam (results from 1997 survey). AIT Aqua Outreach Working paper No. SV-51. Asian Institute of Technology, Bangkok, Thailand.
- NORPLAN 2004. Cumulative impact analysis of Nam Theun II dam. Final Report. Asian Development Bank, Manila, Philippines.
- NSC 2002. Statistical yearbook 2001. National Statistical Center, Committee for Planning and Cooperation, Vientiane, Lao PDR. 99 pp.

NSF 1998 Chinese transboundary water issues. Pp 57-63 in: Working group summaries. China environment series n° 2. National Science Foundation, USA.

Ojendal J. and Torell E. 1998. National and sub-national consequences of a regional river basin agreement: the case of the Mekong River Agreement. Presentation at the seventh annual conference of the International association for the study of common property, Vancouver, Canada, 10-14 June 1998. [Online: www.indiana.edu/~iascp/iascp98.htm]

Osborne M. 2004 River at risk - the Mekong and the water politics of China and southeast Asia. Lowy Institute Paper n° 02. Lowy Institute for International Policy. 56 pp.

Ouch Poeu, Dubeau P. 2004 Value of floodplain fisheries in Kompong Traolach District, Kompong Chhnang Province. Pp. 32-26 in Torell, M. Salamanca, A. and Ratner, B. (eds.) Wetlands management in Cambodia: socioeconomic, ecological, and policy perspectives. WorldFish Center Technical Report 64, Penang. 55 pp.

Pawaputanon, O. 2003. Inland fisheries information in Thailand. Pp. 33-35 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.

Petersen. E. 2003. Valuing environmental water demands in the Mekong River Basin. Presentation at the International workshop on "Integrating Environmental Impacts into Water Allocation Models of the Mekong River Basin", 15 December 2003, Ho Chi Minh City, Vietnam. 27 pp.

Phan Thanh Lam, Pham Mai Phuong 1999 Preliminary results of the involvement in fisheries from the baseline survey in An Giang province, Vietnam. AMFP technical report, Mekong River Commission, Ho Chi Minh City, Vietnam. 12 pp. + annexes.

Phillips M. 2002. Freshwater aquaculture in the Lower Mekong Basin, MRC Technical Paper No. 7, Mekong River Commission, Phnom Penh, Cambodia. 62 pp.

Phonvisay A. 2001. Fish marketing study in Vientiane. LARReC Research Report n° 3, Living Aquatic Resources Research Center, Vientiane, Lao PDR. 89 pp.

Phonvisay A. and Bush S. 2001. Baseline study of the fish trade from the Siphandone fishery, Champasack Province. LARReC Research Report n° 4. Living Aquatic Resources Research Center, Vientiane, Lao PDR. 70 pp.

Plinston D. and He Daming 2000. Water resources and hydropower in the Lancang River Basin. Pp. 235-266 (chapter 4) in ADB 2000: Policies and Strategies for Sustainable Development of the Lancang River Basin. Landcare Research, New Zealand.

Podger G., Beecham R., Blackmore D., Perry C., Stein R. 2004 Modelled observations on development scenarios in the Lower Mekong Basin. Report of the Mekong Regional Water Resources Assistance Strategy. World Bank, Vientiane, Lao PDR. 122 pp.

Poulsen A.F., Ouch Poeu, Sintavong Viravong, Ubolratana Suntornratana, Nguyen Thanh Tung 2002. Fish migrations of the Lower Mekong River Basin: implications for development, planning and environmental management. MRC Technical Paper No. 8, Mekong River Commission, Phnom Penh. 62 pp.

Preeda Prapertchob 1999. A review of fish consumption in Thailand. Report for the project "Assessment of Mekong fisheries". Mekong River Commission, Vientiane, Lao PDR. 19 pp.

Preeda Prapertchob, Paitoon Kachamart, Jariya Wiratchakul, Ampon Hornak, Weera Pakuthai, Phanee Thirangkoon, Petcharin Kamsrakao 1989. Fish consumption studies in the Northeast. A research study prepared for the Department of Fisheries. Khon Khen University, Thailand. In Thai. (mimeo)

Rab M. A., Hap Navy, Ahmed M., Keang Seng, Viner K. 2005a Socioeconomics and values of resources in Great Lake-Tonle Sap and Mekong-Bassac area: results from a sample survey in Kampong Chhnang, Siem Reap and Kandal Provinces. WorldFish Center, Penang, Malaysia. 60 pp. + annexes.

Rab M. A., Hap Navy, Seng Leang, Ahmed M., Viner K. 2005b Marketing infrastructure, distribution channels and trade pattern of inland fisheries resources in Cambodia: an exploratory study. WorldFish Center, Penang, Malaysia. 42 pp. + annexes.

Rab M.A., Hap N., Ahmed M. 2004a. Socioeconomics and values of aquatic resources in Cambodia: results from a sample survey of Great Lake and Mekong Bassac Rivers. Presentation at the 7th Asian Fisheries Forum, 30 Nov.-4 Dec. 2004, Penang, Malaysia.

Rab. M.A., Hap Navy, Seng Leang, Keang Seng, Ahmed M. 2004b. Marketing infrastructure, distribution channels and trade pattern of inland fisheries resources in Cambodia: an exploratory study. Presentation at the 7th Asian Fisheries Forum, 30 Nov.-4 Dec. 2004, Penang, Malaysia.

- Ratner B.D, Dang Thanh Ha, Mam Kosal, Ayut Nissapa, Somphanh Chanphenxay 2004. Undervalued and overlooked: sustaining rural livelihoods through better governance of wetlands. WorldFish Center Studies and Reviews n° 28, 24 pp.
- Ratner B.D. 2003 The politics of regional governance in the Mekong River Basin. *Global change*; 15; 1; 59-76
- Revenga C., Brunner J., Henninger N., Kassem K., Payne R. 2000. Pilot analysis of global ecosystems: freshwater systems. World Resources Institute, Washington D.C., USA. 65 pp.
- RGC 2001. Socio-economic development requirements and proposals. Paper of the Royal Government of Cambodia for the 2001 Consultative Group Meeting for Cambodia, Tokyo, Japan 11-13 June 2001.
- Rigg J. and Jerndal R. 1996. Plenty in the context of scarcity: forest management in Laos. In Parnwell, M.J.G. and Bryant, R.L., (Eds.) 1996 Environmental change in South-East Asia: people, politics and sustainable development. Routledge, London, UK. 383 pp.
- Ringler C. 2001. Optimal water allocation in the Mekong River Basin. ZEF –Discussion Papers On Development Policy No. 38, Center for Development Research, Bonn, Germany. 50 pp.
- Ringler, C. 2000. Optimal allocation and use of water resources in the Mekong River Basin: multi-country and intersectoral analyses. PhD dissertation, Rheinischen Friedrich-Wilhelms Universität, Bonn, Germany.
- Roberts T. 1993 Just another dammed river? Negative impacts of Pak Mun Dam on fishes of the Mekong Basin. *Nat. Hist. Bull. Siam Soc.* 41; 105-133
- Roberts T. R. 2004 Fluvicide: an independent environmental assessment of Nam Theun 2 hydropower project in Laos, with particular reference to aquatic biology and fishes. NT2 project development group report, Bangkok. Unpublished paper.
- Roberts T. R., Baird I. G. 1995 Traditional fisheries and fish ecology on the Mekong River at Khone waterfalls in Southern Laos. *Nat. Hist. Bull. Siam Soc.* 43; 219-262.
- Roberts T. R., Baird I. G. 1995 Traditional fisheries and fish ecology on the Mekong River at Khone waterfalls in Southern Laos. *Nat. Hist. Bull. Siam Soc.*; 43; 219-262.
- Roberts T.R. 2001b. Downstream ecological implications of China's Lancang Hydropower and Mekong Navigation project. Web-based article [Online: www.irm.org]
- Roberts, T. R. 1995. Mekong mainstream hydropower dams: run-of-the-river or ruin-of-the-river? *Nat. Hist. Bull. Siam Soc.* 43 (1): 9-20.
- Roberts, T. R. 2001a. On the river of no returns: Thailand's Pak Mun Dam and its fish ladder. *Nat. Hist. Bull. Siam Soc.* 49: 189–230
- Roudy, G. 2002. Natural resource use and livelihood trends in the Tonle Sap floodplain, Cambodia: a socio-economic analysis of direct use values in Peam Ta Our floating village. M. Sc thesis, Imperial College of Science, Technology and Medicine, London, UK. [Online: www.mekonginfo.org]
- Sam Nouv, Lieng Sopha, Thor Sensereivorth 2003. Improving inland capture fisheries statistics in Cambodia. Pp. 14-19 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Sarkkula J., Baran E., Chheng P., Keskinen M., Koponen J., Kumm M. 2004. Tonle Sap pulsing system and fisheries productivity. Presentation at the 29th International Congress of Limnology (SIL 2004), Lahti, Finland, 8-14 August 2004. 5pp.
- Sarkkula J., Koponen J., Hellsten S., Keskinen M., Kiirikki M., Lauri H., Varis O., Virtanen M., Dubrovin T., Eloheimo K., Haapala U., Jozsa J., Järvenpää E., Kumm M., Chitt K., Noy P., Huon R., Heng R., Yim S., Yin S. 2003. Modelling Tonle Sap for environmental impact assessment and management support. WUP-FIN project "Modelling of the flow regime and water quality of the Tonle Sap". Draft final report. Mekong River Commission, Phnom Penh, Cambodia. 110 pp.
- Sarkkula J., Koponen J., Keskinen M., Kumm M., Lauri H., Varis O., Virtanen M. 2005. Hydrological, environmental and socio-economic modelling tools for the Lower Mekong Basin impact assessment. Inception report of the Phase II of the WUP-FIN project. Mekong River Commission, Vientiane, Lao PDR.
- Schouten R. 1998. Effects of dams on downstream reservoir fisheries, Case of Nam Ngum. *Fish Catch and Culture*; vol. 4; n° 2. 5pp.
- Scott D. A. 1989. A directory of Asian wetlands. UICN, Gland, Switzerland and Cambridge, U.K. 1181 pp.
- SEARIN 2004 The return of fish, river ecology and local livelihoods of the Mun River: a Thai Baan ("villagers") research. Southeast Asia Rivers Network (SEARIN), Chiang Mai, Thailand. 32 pp.

- Shoemaker B., Baird I.G., Baird M. 2001. The people and their river: a survey of river-based livelihoods in the Xe Bang Fai River Basin, in Central Lao PDR. Lao/Canada fund for local initiatives, Vientiane, Lao PDR. 79 pp.
- Siebert R. 2001. No chance for participation - dam building on the Mekong river. Development and cooperation ; 4; 14-16.
- Simon-Barouh I. 1993 L'alimentation quotidienne des Cambodgiens de Rennes. Pp. 199-248 in Krowolski N. (ed.) Autour du riz – le repas chez quelques populations d'Asie du Sud-Est. L'Harmattan, Paris. 261 pp.
- Singhanouvong D. and K. Phoutavong. 2002. Fisheries baseline survey in Champasack Province, Southern Lao PDR In: Poulsen, A. (ed.) Proceedings of the Fifth Technical Symposium on Mekong Fisheries, 11th - 12th December 2002. MRC Conference Series No. 4. Mekong River Commission, Phnom Penh. 364 pp.
- Sjorslev J. (Ed.) 2001. An Giang fisheries survey. Report for the Component "Assessment of Mekong fisheries"; AMFC / RIA2. Mekong River Commission, Phnom Penh, Cambodia.
- Sjorslev J.G. 2001. Assessment of consumption of fish and aquatic animals in the Lower Mekong Basin. Unpublished draft report for the MRC Technical Report Series. 35 pp.
- Sjorslev, J. G. (ed.) 2000. Luangprabang fisheries survey. LARReC research report n° 1 and AMFC project report, MRC, Vientiane, Lao PDR. 34 pp. + annexes
- Smith L.E.D., Lorenzen K. and Nguyen Khoa S. In press. Livelihood functions of inland fisheries: policy implications in developing countries. In press at Water Policy.
- Souvannaphanh B., Chanphendxay S., Choulamany X. 2003. Status of inland fisheries statistics in Lao PDR Pp. 27-32 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Starr P. 2003 Fisheries production in Cambodia. Catch and Culture; 9; 1, p. 6.
- Starr P. 2004. Low water blues. Catch and culture; 10; 1; 4-6
- STEA 2003 Lao PDR biodiversity: economic assessment. Science, Technology and Environment Agency, Vientiane, Lao. PDR (mimeo)
- STREAM 2001 Proceedings of a workshop on analysing livelihoods of fishers and farmers. 25-29 September 2001, Kompong Chhnang, Cambodia. STREAM Initiative and DFID, UK.
- Sultana P., Thompson P., Ahmed M. 2003a. Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Final technical report. WorldFish Center, Penang, Malaysia.
- Sultana P., Vo Tong Anh, Nguyen Huu Chiem 2003b Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Vietnam country summary report. WorldFish Center, Penang, Malaysia.
- Suntornratana U., Visser T. 2003. Women as a source of information on inland fisheries. Pp. 45-49 in: FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Sverdrup-Jensen, S. 2002. Fisheries in the Lower Mekong Basin: Status and Perspectives. MRC Technical Paper n° 6, Mekong River Commission, Phnom Penh, Cambodia. 84 pp
- TERRA 2003. Creating catastrophe: China and its dams on the Mekong. Watershed 8; 2; 42-48.
- Thai Thanh Duong 2003 Inland fisheries statistics in Vietnam. Pp. 36-39 in FAO (ed.) New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. FAO-RAP publication 2003/1. FAO, Bangkok, Thailand. 145 pp.
- Thay Somony 2002. The underestimated importance of freshwater shrimp fisheries and dried shrimp processing to families. A case study from Kompong Kleang commune, Siem reap, Cambodia. CBNRM Initiative, WWF, Phnom Penh, Cambodia. 13 pp.
- Torell, M. Salamanca, A. and Ahmed M. 2001. Management of wetland resources in the Lower Mekong Basin: issues and future directions. Naga, The ICLARM Quarterly 24; (3-4); 4-10
- Torell, M. Salamanca, A. and Ratner, B. (eds.) 2004. Wetlands management in Cambodia: socioeconomic, ecological, and policy perspectives. WorldFish Center Technical Report 64, Penang. 55 pp.
- Touch Seang Tana. and Todd B. H. 2003 The inland and marine trade of Cambodia. Oxfam America, Phnom Penh, Cambodia. 142 pp.
- UN. 2004. World population prospects. [Online: <http://esa.un.org/unpp>]
- UNDP. 2004. UNDP country office pages. [Online: <http://www.undp.org>]

- UNEP 2001. State of the environment 2001. NORAD and United Nations Environment Program, Bangkok, Thailand. 81 pp. + annexes.
- Van Zalinge N. 2002. Update on the status of the Cambodian inland capture fisheries sector with special reference to the Tonle Sap Great Lake. Mekong Fish Catch and culture, vol. 8, n° 2.
- Van Zalinge N. and Nao Thuok 1999. Present status of Cambodia's freshwater capture fisheries and management implications. Pp. 11-20 in Van Zalinge N., Nao Thuok, Deap Loeung (eds.): Present status of Cambodia's freshwater capture fisheries and management implications. Proceedings of the Annual meeting of the Department of Fisheries of the Ministry of Agriculture, Forestry and Fisheries, 19-21 January 1999. Mekong River Commission and Department of Fisheries, Phnom Penh, Cambodia. 150 pp.
- Van Zalinge N., Deap Loeung, Ngor Peng Bun, Sarkkula J. and Koponen J. 2003. Mekong flood levels and Tonle Sap fish catches. Presentation at the Second International Symposium on the Management of Large Rivers for Fisheries Phnom Penh, 11-14 February 2003. 13 pp.
- Van Zalinge N., Degen P., Pongsri Chumnarn, Sam Nuov, Jensen J., Nguyen V.H., Choulamany X. 2004. The Mekong River system. Pp. 333-355 in R.L. Welcomme and T. Petr (eds.) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, Volume 1. FAO, Bangkok. 356 pp.
- Van Zalinge N., Nao Thuok, Sam Nuov 2001. Status of the Cambodian inland capture fisheries with special reference to the Tonle Sap Great Lake. Pp. 10-16 in Cambodia Fisheries Technical Paper Series, Volume III, Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Phnom Penh, Cambodia.
- Van Zalinge N., Nao Thuok, Touch Seang Tana 1998a Where there is water, there is fish? Fisheries issues in the Lower Mekong Basin from a Cambodian perspective. Contribution to the Seventh Common Property Conference of the International Association for the Study of Common Property, Vancouver, Canada, 10 - 14 June 1998. 14 pp.
- Van Zalinge N., Nao Thuok, Touch Seang Tana, Deap Loeung. 2000. Where there is water, there is fish? Cambodian fisheries issues in a Mekong River Basin perspective. p. 37-48. In M. Ahmed and P. Hirsch (eds.) Common property in the Mekong: issues of sustainability and subsistence. ICLARM Studies and Reviews 26, 67 pp.
- Van Zalinge, N., Nao Thuok, Touch Seang Tana, Sam Nuov 1998b. It's big, unique, and important: fisheries in the Lower Mekong Basin, as seen from a Cambodian perspective, Mekong Fish Catch and Culture, vol. 4, n° 1
- Varis, O. 2003. WUP-FIN policy model; finding ways to economic growth, poverty reduction and sustainable environment. WUP-FIN Socio-economic Studies on Tonle Sap n°10, MRCS/WUP-FIN, Phnom Penh. 38 pp.
- Varis, O., Keskinen M. 2005. A Bayesian Network model for intersectoral policy analysis in the Tonle Sap area, Cambodia. Presentation at the International Conference on Simulation and Modeling (SimMod 2005), 17-19 January 2005, Bangkok, Thailand.
- Vidy G., Albaret J.-J., Baran E. 2000 Status of the freshwater/coastal/marine living resources with particular emphasis on threats and options in coastal areas". Proceedings of a UNEP International Workshop, 15-18 November 1999, Montpellier, France. UNEP Environment Information and Assessment Meeting Report n° 3. 95 pp.
- Vo Tong Anh, Nguyen Huu Chiem, Duong Toi Dung. 2003. Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. Vietnam country status report. WorldFish Center, Penang, Malaysia. 30 pp.
- Voeun Vuthy 2004 Description of bas-relief of fish at Angkor Wat and Bayon. Pp. 39-56 in Bulletin of the students of the department of archaeology; n° 3, July 2004. Royal University of Fine Arts, Phnom Penh, Cambodia. 131pp.
- Warren T. J., Mattson N.S. 2000. Can fish passes mitigate the impacts of water-related development on fish migrations in the Mekong Basin? Catch and Culture vol. 6 n° 2; 1-4
- WCD 2000. Dams and development: a new framework for decision-making. Report of the World Commission on Dams. Earthscan Publications. 404 pp.
- Wegner D.L. 1997 Review Comments on Nam Theun 2 hydroelectric project Environmental Assessment and Management Plan (EAMP). Web-based article [Online: <http://www.irn.org>].
- Welcomme R.L. 1985. River fisheries. FAO Fish. Tech. Pap., No. 262., Food and Agriculture Organization, Rome, Italy. 330 p.

- Welcomme R.L. 1995 Relationships between fisheries and the integrity of river systems. Regulated rivers: research and management; 11; 121-136
- White W. C. 2000. Infrastructure development in the Mekong Basin: risks and responses. Foresight Associates for Oxfam America. 19 pp.
- World Bank web site. Country statistics. [Online: www.worldbank.org].
- Xie S.Q., and Z.J. Li 2003. Inland fisheries statistics in China. Pp. 20-26 in "New approaches for the improvement of inland capture fishery statistics in the Mekong Basin". Ad-hoc expert consultation, Udon Thani, Thailand, 2-5 September 2002. FAO RAP publication 2003/01. FAO, Bangkok, Thailand. 145 pp.
- Yang Junxing 1996. The alien and indigenous fishes of Yunnan: a study on impact ways, degrees and relevant issues Pp. 157-168 in Peter J.A., Wang S., Xie Y. (eds): Conserving China's biodiversity (II). China Environmental Science Press. Beijing.
- Yang Saing Koma *et al.* 2001. The situation of pesticide use in the Tonle Sap catchment. CEDAC, Phnom Penh.
- Yim Chea, McKenney B. 2003 Domestic fish trade: case study of fish marketing from the Great Lake to Phnom Penh. Working paper n° 29. Cambodia Development Resource Institute, Phnom Penh, Cambodia. 24 pp.
- Yim Chea, McKenney B. 2003c. Great Lake fish exports: an analysis of the fee system. Cambodia development review, CDRI, vol. 7, issue 3.
- Yim Chea, McKenney, B. 2003b. Fish exports from the Great Lake to Thailand, Working Paper 27, Cambodia Development Resource Institute CDRI, Phnom Penh. 56 pp.
- Zurbrugg, A. 2004. Where there is water, there is fish: an analysis and critical assessment of Cambodia's Tonle Sap fisheries, ECON 5197 Project report and University of New South Wales. 58 pp.