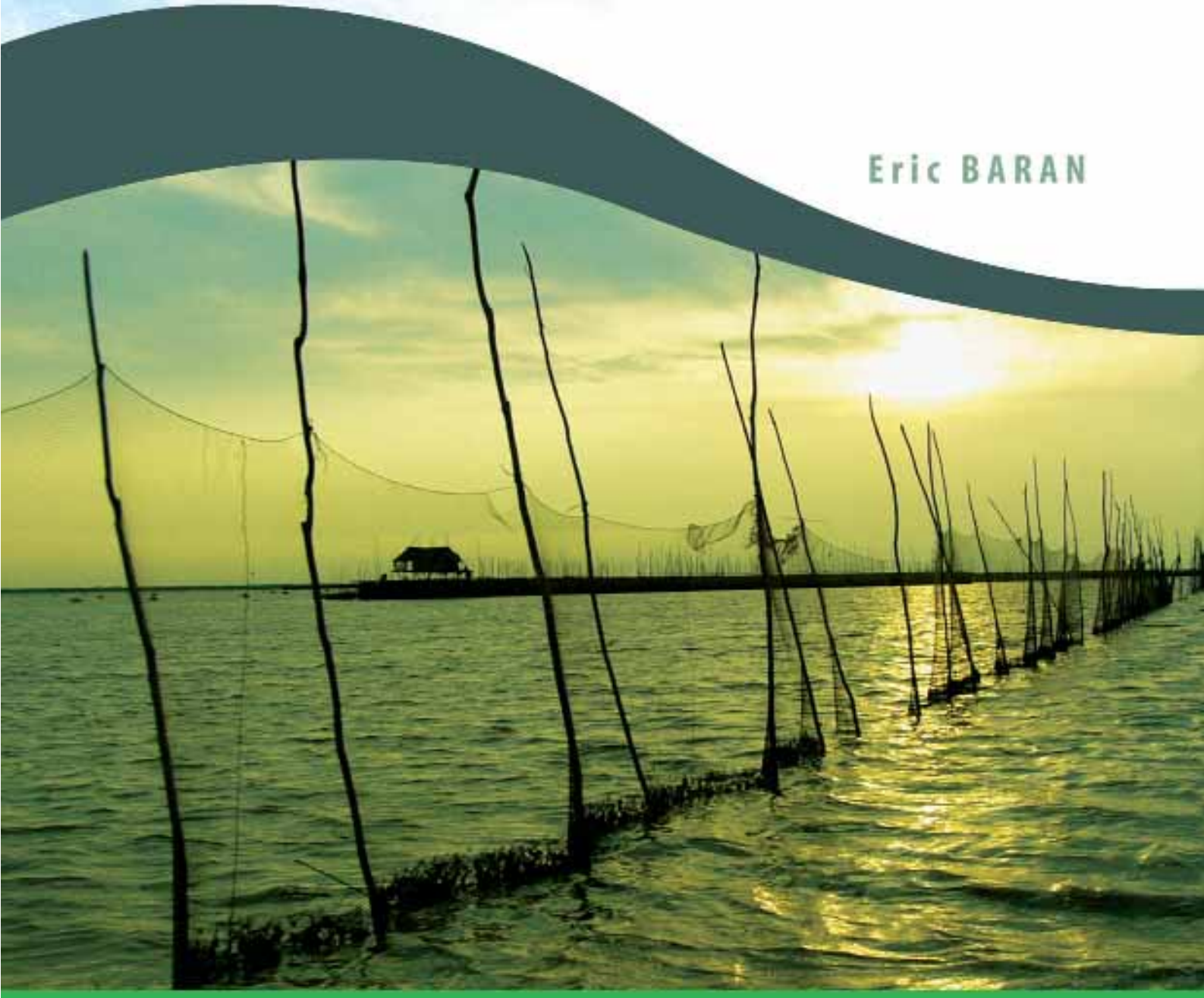
CAMBODIAN INLAND FISHERIES

FACTS, FIGURES AND CONTEXT

Eric BARAN



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ERIC BARAN

formerly known as "ICLARM - The World Fish Center"

Our Commitment:
to contribute to food security and poverty eradication in developing countries.

A Way to Achieve This:
through research, partnership, capacity building and policy support, we promote sustainable development and use of living aquatic resources based on environmentally sound management.

We believe this work will be most successful when undertaken in partnership with governments and nongovernment institutions and with the participation of the users of the research results.

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Eric Baran

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FOREWORD

Cambodian inland fisheries are the most intensive freshwater fisheries worldwide. This fact was recognized in the first half of the century, but has only been rediscovered in the last decade.

Despite progress in scientific knowledge, information about these fisheries remains scattered in a number of poorly accessible technical studies and in grey literature. The aim of this initiative was to synthesize the most relevant information, while highlighting the regional context, the sometimes contradictory figures, and the remaining knowledge gaps. This document is thus complementary to the "Introduction to Cambodia's inland fisheries" published by the Mekong River Commission in November 2004.

Our overall objective is to contribute to the sustainable management of a unique resource that feeds millions.

The Inland Fisheries Research and Development Institute (IFReDI), the Cambodian Department of Fisheries and the WorldFish Center would like to thank the Asian Development Bank for funding the project that led to this publication (T.A. T4025-CAM, 2003-2004).

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1 PHYSICAL FEATURES

1.MEKONG RIVER

Length:

- Length = 4 200 km, i.e. world's 12th longest river (MRCS[1] 1992); alternatively 4 400 km and 9th longest river (Milliman and Meade 1983), or 4 000 km and 16th longest river (Welcomme 1985). See also River systems of the world http://www.rev.net/people/aloe/river/

Discharge:

- Annual discharge = 475 million m^3 (Mekong committee 1987 in MRCS 1992); 14th average discharge in the world, and 3rd maximum discharge after the Amazon and the Brahmaputra (Welcomme 1985).
- Maximum mean discharge = 54 times the minimum mean discharge (after Welcomme 1985); or 30 fold according to MRC[2] statistics.

Area:

- Whole basin area of 795 000 km^2 and drainage area = 386 560 km^2 (Welcomme 1985).

Figure 1: Lower Mekong River.

[1] *Mekong River Commission Secretariat (MRCS)*
[2] *Mekong River Commission (MRC)*

- The lower basin area, covering approximately 609 000 km^2, contributes about 82% to the total annual flow volume.

Flows:

- 85-90% of the total annual discharge occurs during the flooding season between June and December.
- Its colossal high flows create large surfaces of wetlands in the rainy season.
- The contribution of each country to the average river flow is as follows: China 16%, Myanmar 2%, Lao PDR 35%, Thailand 17%, Cambodia 19%, and Viet Nam 11% (MRC 1998). Recent comments, pioneered by Hill & Hill (1994) have highlighted the variable contribution of each country to the flows of each season, with an emphasis of the role of dams on critical dry season flows.
- ”While only a fifth of the river's annual flow comes from China, the proportion normally reaches between 50 and 70% in the dry season” (New Scientist, 25 March 2004).

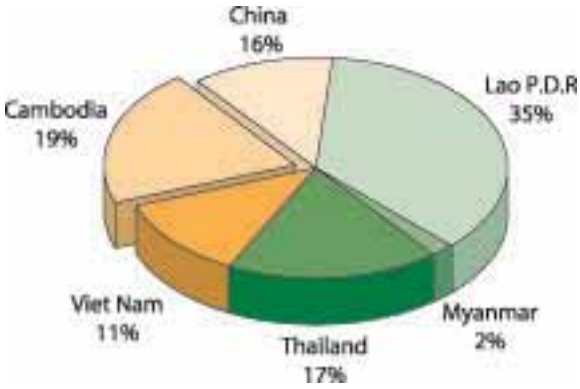

Figure 2: Contribution of each riparian country to annual river flows.

2. MEKONG WETLANDS

Due to the very high variation of water levels, the Mekong Basin is an area of extensive wetlands.

Definition of Mekong wetlands (Baird and Phylavanh 1999):

"Seasonally inundated riparian or riverine habitat = the area up to and including the littoral zone which is subject to sporadic flooding or inundation as a direct or indirect result of seasonal changes in the water levels of the Mekong River or its tributaries."

Surface of Mekong wetlands (Scott 1989, Lacoursiere *et al.* 1998):

- **Laos**
  9700 km² (edges of the river, along 1700 km; plus the Siphandone and Khone Falls areas)
- **Cambodia**
  Mekong edges: 2 000 000 ha = 20 000 km²
  Tonle Sap: 1 500 000 ha = 15 000 km²
  Total: 3 500 000 ha = 35 000 km² in Cambodia (19% of the country)
- **Vietnam**
  3 900 000 ha = 39 000 km² (more than the surface of Belgium)
- **Grand total**
  83 700 km² (i.e. the surface of Ireland, twice that of Switzerland).

Figure 3: Trees shaped by the flood, Khone Falls, Lao P.D.R.

3. TONLE SAP GREAT LAKE

Figure 4: Shallowness of the Tonle Sap Great Lake in the dry season.

3.1. General features

- The Great Lake was formed some 5 000-6 000 years ago (Carbonnel 1963).
- It has a drainage area of about 67 000 km^2 (Nao Thuok *et al.* 1996).
- The Tonle Sap lake covers nearly 6% of Cambodia's total land area during the monsoon (Nao Thuok 1997).
- The lake drains through the Tonle Sap river towards the Mekong River in the dry season, contributing then about 16% of the Mekong discharge during this season. At the beginning of the rainy season the flow reverses as the Tonle Sap lake is then filled by the Mekong due to the fast water level rise in the mainstream. This results in an expansion of the Great Lake by four to six times (Van Zalinge *et al.* 2000).
- Recent studies of the Tonle Sap water balance by the MRCS/WUP-JICA & TSLV[1] project (2004) conclude that Mekong flow, Tonle Sap Basin runoff and overland flow (flowing from the Mekong through the bridges of the Kampong Cham road) represent 50%, 40% and 10% respectively of the Tonle Sap inflow.

3.2. Area

Dry season:

- 2 500 km^2 (Rainboth 1996);
- 3 000 km^2 with an average depth of 0.8-1m (Nao Thuok *et al.* 1996, Nao Thuok 1997);
- 160 km long, 35 km wide, depth 0.2-1.5 m (MRC Secretariat 1992).

Rainy season:

- 15 800 km^2 (Rainboth 1996), i.e. close to the area of Lake Ontario;
- More than 15 000 km^2 (Carbonnel and Guiscafré 1963);
- 300 km long, 100 km wide, depth 10-14m (MRC Secretariat 1992). This corresponds to about 25 times the area of Lake Geneva, twice that of Lake Titicaca).

[1] *Mekong River Commission Secretariat / Water Utilization Program- Japan International Cooperation Agency & Tonle Sap Lake and its Vicinities.*

3.3. Vegetation cover

In 1995 there were more than 600 000 ha of flooded forest, 80% being located around the Great Lake (Nao Thuok *et al.* 1996). Six different areas have been identified "according to topography and hydrology" (Table 1).

Table 1: Types of land and water resources which support freshwater capture fisheries in Cambodia (Ahmed *et al*. 1998, based on Cambodia Land Cover Atlas, Mekong Secretariat, Bangkok).

	Area (ha) 1985/1987	Area (ha) 1992/1993
Permanent water	567 100	411 100
Flooded forest	795 400	370 700
Flooded secondary forest	28 200	259 800
Flooded grassland	80 800	84 900
Receding and floating ricefields	17 500	29 300
Seasonally flooded crop fields	366 800	529 900
Swamp	12 200	1400
Total	1 868 100 ha 18 681 km^2	1 687 100 ha 16 871 km^2

"According to recent land use data estimates only 19,517 hectares of inundated forest remain around the Great Lake. The remaining non-agricultural land cover is more correctly described as inundated vegetation, grassland or bushland" (Gum 2000).

The JICA project in Phnom Penh updated data in 1999; they are detailed in Table 2.

Table 2: Distribution of selected land use classes in the Tonle Sap floodplain. (From Jantunen 2004, original data given in Keskinen and Huon 2002; hectares).

Water level (m)	1- 2	2- 3	3- 4	4- 5	5-6	6-7	7-8	8-9	9-10	10-road	Total	Percentage
Urban	23	0	0	0	0	0	0	23	436	1 476	1 958	0.1
Grass	24 118	24 782	34 755	40 504	47 248	77 780	108 100	125 105	98 110	147 730	728 574	49.1
Shrub	75 381	62 521	81 022	88 088	77 824	38 774	13 178	2 992	909	7 492	448 283	30.2
Forest	12 559	4 233	662	904	927	283	152	36	103	1 751	22 053	1.5
Water & soil	131 268	2 486	2 975	1 857	1 499	1 197	1 229	886	553	1 475	283 038	19.1
Total	243 349	94 022	119 414	131 353	127 498	118 034	122 659	129 042	100 111	159 924	1 483 906	100.0

From the figures of Tables 1 and 2, one can note a dramatic decline of the surface of flooded forest, mostly due to increased surface of rice cultivation (Figure 5).

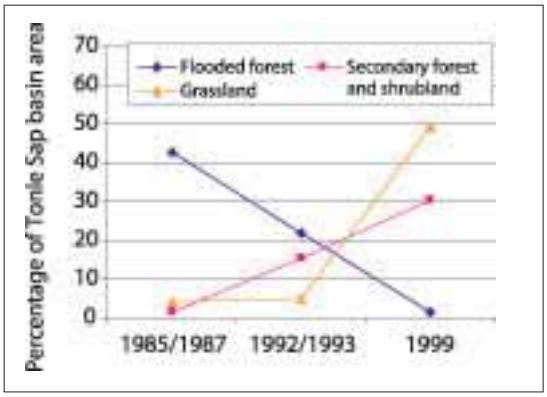

Figure 5: Trends in Tonle Sap vegetation cover.

3.4.Oxygen

The lake water is well oxygenated during the dry season because of the effective wind mixing. The oxygen conditions are however quite different in the inundated areas during the wet season. The flooded forests and wetlands are characterized by long periods of anoxia except near the surface. The reasons for anoxia (i.e., absence of oxygen in the water) are the decay of the organic material (vegetation rotting) and the calm physical conditions decreasing oxygen mixing and transport.

According to measurements, a characteristic feature of the floodplain is the temporary large scale anoxia (Koponen *et al.* 2003). This means that during several weeks every year a large proportion of the lake area is flooded, but with water whose oxygen content is quasi-nil and thus not accessible to most fish species. The implications of this large scale phenomenon, in particular on fish production, have never been studied.

3.5. Sedimentation

Figure 6: Sedimentation in some areas of the Great Lake (here Snoc Trou, at the mouth of the Tonle Sap River).

- **Fears about the Tonle Sap sedimentation**
  - Clearance of swamp forest around the Tonle Sap (for agriculture, firewood and fishponds) dramatically increases the siltation rate into this shallow lake (40 $mm.y^{-1}$ Csavas *et al.* 1994).
  - "Many people fear that the lake may eventually become two separate water bodies during the dry season" (Nao Thuok *et al.* 1996)
  - "The gradual siltation of the Lake and its mouth may cause serious problems in the near future if no management plan dealing with siltation and sedimentation is to be undertaken" (Nao Thuok 1997).

- **Recent reliable studies show that the sedimentation rate is actually very limited**
  - The best past estimates of sediment accumulation have been about 0.3 $mm.y^{-1}$ (Carbonnel and Guiscafré 1963). Recent studies have estimated the accumulation between 0.1 and 0.9 $mm.y^{-1}$. This would mean maximum 4 cm accumulation since the Certeza survey [in 1964] (Eloheimo *et al.* 2002, Kummu *et al.* 2005).
  - Consequently the center of the lake is not filling up with sediments. Net sedimentation in the lake proper has been about 0.1 mm over last 5 000 years and is presently practically zero. Settling and resuspension seem to be in balance as concluded by Carbonnel and Guiscafré (1963) and Tsukawaki (1997). However sedimentation can be relatively high at the mouth of the Lake's tributaries and at Snoc Trou (Koponen *et al.* 2003).

2 SOCIAL FEATURES

1. POPULATION

1.1. Population in the Lower Mekong countries[1]

- **Laos** Population: 5 922 000. Population growth rate: 2.45%. Birth rate: 36.9 births/1 000 population. Age structure: 0-14 years: 42.2%
- **Cambodia** Population: 13 125 000. Population growth rate: 1.8%. Birth rate: 27.3 births/1 000 population. Age structure: 0-14 years: 39.3%
- **Thailand** Population: 64 265 000. Population growth rate: 0.95%. Birth rate: 16.4 births/1 000 population. Age structure: 0-14 years: 24.2%
- **Vietnam** Population: 81 625,000. Population growth rate: 1.29% Birth rate: 19.6 births/1 000 population. Age structure: 0-14 years: 30.2% (July 1999 est.)
- Population in the Lower Mekong Basin in 2000: 56 million (Sverdrup-Jensen 2002); around 60 million in 2004 (MRC 2004). Fifty percent of this population is less than 15 years of age (Sverdrup-Jensen 2002).

1.2. Development in the Lower Mekong countries[2]

UNDP Human Development Index 2004:
n° 76/177 Thailand
n° 112/177 Viet Nam
n° 130/177 Cambodia
n° 135/177 Lao PDR

[1] *Source: The CIA World Fact Book 2003 [Jul. 2003 estimates] http://www.odci.gov/cia/publications/factbook/index.html*
[2] *Source: UNDP Human Development Index 2004*

1.3. Population around the Tonle Sap Great Lake

- Among 22 provinces 13 are considered as fishing provinces of which 6 border the Tonle Sap Great Lake (Nao Thuok 1997).
- "The six provinces that surround the lake have a population of nearly 3 million people (about 30% of the country's total population). About one third of this population lives on floating villages around the lake and within the inundated forests" (Nao Thuok *et al.* 1996).

Table 3: Number of fishing dependant communes and their population in the 6 provinces bordering the Lake (after Nao Thuok *et al.* 1996).

	Number of communes	Population
All communes	413	2 967 915
Fishing communes	170	1 086 686
Share of fishing communes	41.20%	36.60%

Ahmed *et al.* (1998) give detailed figures:

- Total population in the eight provinces around the Tonle Sap river and lake system: 5 650 094.
- Population of fishing districts of the Tonle Sap river and lake system: 4 191 649.

- Population of fishing communes: 58% of fishing districts, corresponding to 2.4 million inhabitants in fishing communes in 1995. Actually when Kandal and Kompong Cham provinces are removed from statistics as not being located around the Great Lake, 161 communes out of 307 are fishing communes (52%), and their population was made up of 1.2 million inhabitants in 1995.

Keskinen (2003) gives the latest and tightest estimate of the population living in the Tonle Sap flood-prone area (Table 4).

Table 4: Area and population in different zones (Keskinen 2003).

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	All zones
Altitude	0-6 m	6-8 m	8-10 m	10 m up to National Roads	Urban	
Area [km²]	8 531	2 407	2 292	1 574	73	14 876
Villages	88	82	313	554	121	1 158
Households	14 674	10 516	53 267	88 444	52 720	219 621
Population	84 742	56 690	283 104	470 196	291 460	1 186 192
Population density [persons/km²]	10	24	124	299	4 017	80
Average village size	963	691	904	849	2 409	1 024
Average household size	5.8	5.4	5.3	5.3	5.5	5.4

The total population around the lake is less than that identified in 1993; indeed a negative migration rate (-1% to -6%) has been identified in all the provinces bordering the Lake except Kampong Chhnang province (Haapala 2003). The reasons given are the decreasing fish catches, droughts and irregular rains/floods that impact rice yields, and increased sediment contents in rivers that degrades water quality.

Demography in fishing dependant communes:

- In 1995-96, nearly 58% of the population were below 21 years old, and 32% were below 10 years old (Ahmed *et al.* 1998).
- Recent detailed figures are found in Keskinen (2003).

Table 5: Basic social indicators in the Tonle Sap area (Keskinen 2003).

	All Tonle Sap zones
0 - 19 years	55.9%
20 - 39 years	25.8%
40 - 59 years	13.3%
60 - years	5.0%
Children 0 - 4 years	12.7%
Females	52.0%
Literacy rate	52.9%

Figure 7: The young generation of fishing lot nº 3, in Kompong Chhnang province.

2. DEPENDENCY ON FISH RESOURCES [1]

2.1. Dependency on fish resources in the Lower Mekong

- "In terms of volume, fish products far outweigh any one of the four main terrestrial commodity groups -beef, sheep, pig and poultry meat." (ADB 1997).
- 60% of fish in the basin are from open water capture fisheries (MRC Secretariat 1992).
- Annual consumption of fish and other aquatic animals is over 30 kg per person and per year (Sverdrup Jensen 2002).
- The harvest of aquatic animals as a source of protein is essential to the countries of the Mekong, amounting to one of the highest rates of fish consumption in the world (Figure 8).
- Aquaculture represents only 12% of these fish resources basinwide (Sverdrup Jensen 2002), which shows that the priority for the region should be to protect and optimise the exploitation of a huge natural capital rather than counting on the development of a meagre aquaculture sector as an alternative development option.

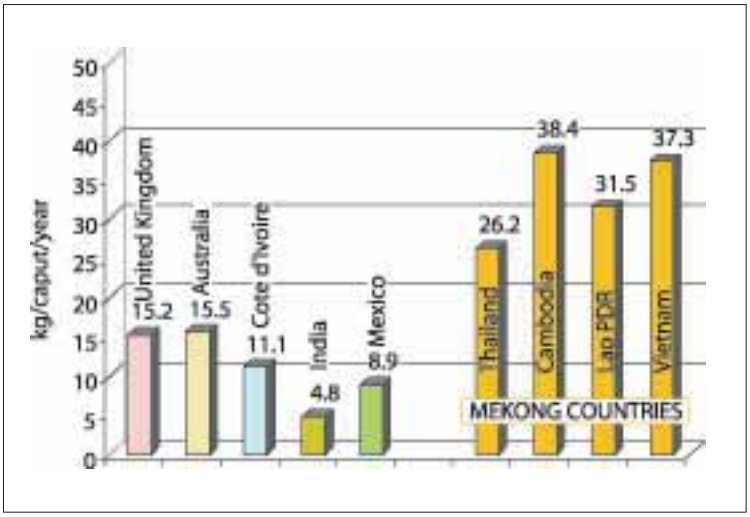

Figure 8: Fish consumption in a few countries worldwide (Baran and Baird 2003, based on FAO statistics and unpublished data).

[1] *A complementary source of information with a particular focus on social and management issues is the "Feast or Famine?" report produced by the Fisheries Action Coalition Team in Cambodia and the Environmental Justice Foundation. It is available on the Internet at: http://www.ejfoundation.org/pdfs/feast_or_famine.pdf*

Furthermore fingerlings used in aquaculture come almost exclusively from the wild (e.g., Ngor Pen Bun 1999), and the food that valuable carnivore cultured species are given consists of other wild species of lesser value.

2.2. Dependency on fish resources in Cambodia

- According to FAO statistics[1], in 2002 in Cambodia the freshwater fish production (373 933 metric tons) was double that of beef, pig and poultry (191 208 tons).
- About 88% of the inhabitants rely on natural fishing and fishing related activities (Nao Thuok *et al.* 1996).
- McKenney and Tola (2002) provide a good summary of the role of fisheries in rural livelihoods:
  - fisheries diversify livelihood activities and thereby 'insure' against the risk of agricultural failures;
  - fisheries provide easy access to income generating activities with very little capital investment and no land;
  - fisheries play a vital role in food security, maintaining and improving nutrition.

2.2.1. Fish as food source

- According to official statistics, fish and fish products comprise 40-60% of the animal protein dietary intake of rural Cambodians although some suggest the actual figure to be closer to 75% (Keskinen 2003).
- In fishing provinces of Cambodia, small scale fisheries can provide 65-75% of animal protein requirements of the households (Ahmed *et al.* 1998), whose value would be 40% that of the rice production (Guttman 1999).
- Even in a relatively less important fishing region, families living near water bodies catch on average 86 kg of fish per year (but those living away from these water bodies catch only 30 kg per year). Families that consider themselves as fishing families and that live near water bodies catch 123 kg per household per annum (families that consider themselves as fishing families and that live far from water bodies catch on average 56 kg per household per annum) (Ahmed *et al.* 1993).
- Including various forms of preserved fish raises fish consumption to an estimated 75.6 kg per capita per annum (Ahmed *et al.* 1998).
  - Average fresh fish consumption per capita (based on weekly consumption): 43.5 kg per annum.
  - Processed fish per capita per annum: 14 kg corresponding to 27.5 kg of fresh fish.
  - Total fish consumption per capita per annum: 75.6 kg.
  - Other animal proteins (chicken, pork, beef, duck,…): 8 kg per year per person.
- Using the annual per capita fish consumption for non fishing households (67 kg per capita per annum) as the basis, the total consumption of the entire population of 4.2 million living in the fishing districts in the provinces covered by the household survey is estimated to be about 290 000 tons. (Ahmed *et al.* 1998).
- 57% of the fishing households indicate that their supply of fish comes mainly from family fishing in rivers, lakes and in flooded ricefields (Ahmed *et al.* 1998)
- 10.5% of the households have fishing or a fishing related activity as the primary occupation while another 34.1% are engaged on a part-time basis. Thus, in these districts alone more than 1 million people are either fully or partly dependent on fisheries for their income (Ahmed e*t al.* 1998 in Van Zalinge *et al.* 2000).

[1] *http://www.fao.org/fi/statist/statist.asp*

2.2.2. Fishing as an occupation

- In 1995-96, 39% of households were involved in fishing and 77% of them were involved in farming as production and income-generating activities (Ahmed *et al*. 1998)
- As high as 90% of the households report that they have access to common property resources. Nearly 80% of the households use big rivers and lakes for fish and irrigation water (Ahmed *et al*. 1998).
- The 1998 Population Census pretends that 63.4% of persons living in the Tonle Sap flood plain are involved in agriculture, hunting and forestry, while 12.0% are involved in trade and 5.7% in fishing. This is a gross underestimation of the importance of fishing, as those who have witnessed the intensity of fishing can attest. As explained by Keskinen (2003), "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" (Keskinen 2003).
- The results of the Household Survey of Socio-Economic Assessment of Freshwater Capture Fisheries of Cambodia conducted in 1995-96 by the Department of Fisheries, DANIDA and the Mekong River Commission give more contrasted figures for the whole Tonle Sap flood-prone area, as detailed in Table 6.

Table 6: Proportions of primary and secondary occupations around the Tonle Sap Great Lake (after Keskinen 2003).

	Primary occupation	Secondary occupation
Fishing	15.5%	20.0%
Fishing-related activities (fish selling, fish processing, fish culture, fishing gear making)	17.1%	28.5%

Thus fishing and fishing-related activities represent more than one-third of the Tonle Sap people's primary occupation, and half of their secondary occupation.

2.2.3. Access to aquatic resources

- "Because of the open access nature of fisheries resources, and because fishing typically does not require land ownership, it often becomes the employer of last resort, attracting people who have no other means of subsistence" (ADB 1997).
- 90% of the households still prefer a free and unlimited access rather than restrictions or regulations on the use of common property resources (Ahmed *et al*. 1998).

Table 7: Access to Tonle Sap common property resources 1995-96 (Ahmed *et al*. 1998).

Common resource	% of the population using it
Inundated forest	81
Big rivers / lakes	79.4
Flooded ricefields	61.1
Banks / beds of rivers / lakes	51.4
Irrigation canals / dikes / small rivers	38.1
Others	0.5

2.2.4. Trends in access to aquatic resources

- There is a trend in declining availability of products and benefits derived from common property resources (Table 8).

Table 8: Percentage of households reporting trends of availability and benefits from common resources (Ahmed *et al*. 1998).

Common resource	Trends in interviews
Inundated forest	Decreasing trend: 95.3%
Big rivers / lakes	Decreasing trend: 83.2%
Flooded rice fields	Decreasing trend: 40.0%
Banks / beds of rivers / lakes	Decreasing trend: 81.9%
Irrigation canals / dikes / small rivers	Decreasing trend: 62.3%

- The results of the Household Survey of Socio-Economic Assessment of Freshwater Capture Fisheries of Cambodia detailed in Keskinen (2003) give a recent detailed picture of trends, as expressed by the stakeholders themselves (Table 9).

Table 9: Trend of availability of products and benefits from…

Common resource	Trends and percentage
BIG RIVER / LAKE	
Decreasing	98.5%
INUNDATED FOREST	
Decreasing	97.5%
RIVER / LAKE BANKS	
Decreasing	59.6%
No answer	38.3%
FLOODED RICE FIELD	
Decreasing	36.4%
No answer	40.4%
IRRIGATION CANAL /	
DIKE / SMALL RIVER	
Decreasing	27.9%
No answer	51.0%

- "It is noted that in the past fishing season year 2003-04 the total fish catch dropped sharply to only 250 000 tons due to low level of Mekong flood, so that fish could not get into flooded forests for spawning, and due to destruction by other illegal fishing activities as well."
(Source: Minister of Agriculture, Forestry and Fisheries, 01 July 2004 [National Fish Day])

Figure 9: Sun-dried fish.

3 FISH & FISHERIES

1. BIODIVERSITY

- Considerable species richness of the fish fauna:
  - 1 200 fish species for the whole Mekong (Rainboth 1996, Rainboth and Jensen 1996) as compared to about 3 000 for the Amazon River;
  - 1 500 freshwater fish species according to MRC (2004);
  - 758 valid species according to FishBase 2004[1], including 700 native and 11 introduced species;
  - more fish families than any other river system (62 families according to FishBase).
- Extremely high diversity of mollusks (Rainboth 1996).
- High rate of endemic species: attested by many authors (Wallace, Taki, Welcomme, Rainboth, Kottelat, Roberts,...) above all in the upland areas. FishBase identifies 19 endemic species.
- Overall in terms of biodiversity the Mekong is among the top three rivers in the world, after the Amazon and the Zaïre (Dudgeon 2000).
- Particular ecological patterns: 85-95% of the freshwater fish populations in the Mekong basin follow the inundation patterns, undertaking migrations from the mainstream and tributaries to inundation zones to spawn and rear young between July and September (Pantulu 1986).

[1] *http://www.fishbase.org*

- Particular endemic and charismatic species, such as the giant catfish *Pangasionodon gigas* (also called *Pangasius gigas)*, that reaches a miximum length of 3m and a weight of 300kg. It migrates over thousand of kilometers from Cambodia to Yunnan province, in China. Once quite common, today disappearing (critically endangered according to CITES[1]; around 10 individuals are caught every year in Northern Thailand).

  Three dolphin species:

  - Irrawady dolphin (*Orcaella brevirostris*);
  - Chinese white dolphin *(Sotalia chinensis*, rare); and
  - Black finless porpoise (*Neophocaena phocanoïdes*).

- "*Mekongina erythrospila*, this [cyprinid] endemic fish species is the pride of the people and the symbol of Stung Treng province" (Chea Vannaren 1999). Its abundance has drastically declined over the past years.

- The main endangered large fish species are the Giant Mekong catfish (*Pangasionodon gigas*), the Giant Mekong carp (*Catlocarpio siamensis*) and the seven-line barb (*Probarbus jullieni*) (Nao Thuok 1997).

[1] *http://www.cites.org*

Figure 10: A giant catfish caught near Phnom Penh in 2002.

- Good overviews of Mekong fish biodiversity can be drawn from the MRC CD-ROM Mekong Fish Database and from FishBase (CD-ROM and online at www.fishbase.org; option information by Ecosystem/ Mekong).

  FishBase identifies in particular 18 species of high-level carnivores, 111 species of mid-level carnivores, and 240 species of omnivores, herbivores and detritivores (the trophic level or remaining species being unknown).

- In Cambodia alone, 847 species are recorded, including 477 freshwater fishes

  Among the 16 species classified as endangered, 10 are from the freshwater realm *(Balantiocheilos melanopterus, Botia sidthimunki, Chela caeruleostigmata, Dasyatis laosensis, Himantura chaophraya, Himantura oxyrhyncha, Pangasianodon gigas, Probarbus jullieni, Scleropages formosus* and *Tenualosa thibaudeaui)*.

2. MEKONG FISH ECOLOGY

- The fish fauna of the Mekong drainage is typically South Asian (Banarescu 1972).
- "The important commercial species are often broadly categorized (MRCS 1992) as:

  Black fish, species able to survive in swamps and plains year round with limited lateral migrations. These are mostly carnivorous and detritus feeders. This group includes: Channidae (Snakeheads), Clariidae, Bagridae (*Mystus sp.*) and Anabantidae.

  White fish, most species showing strong lateral and longitudinal migrations. This group includes many cyprinids, various *Pangasius sp.*, Siluridae and Notopteridae. Also included is the group of small, short-lived cyprinids, among which Trey Riel (*Henicorhynchus sp.*) is the most common" (Van Zalinge *et al.* 2000).

- Longitudinal migrants constitute about 63% of the total catch taken by fisheries in the Tonle Sap area (Van Zalinge *et al.* 2000).

- "These fish migrations seem to be largely confined to the Mekong and tributaries below the geological fault line at the Khone Falls in the Khong district of southern Lao P.D.R. on the border with Cambodia, although the extensive rapids and falls (10 -15 m) allow for the upstream passage of most species. [...] Quantitative information is lacking, although Baird *et al.* (1998) infer from interviews that annually some 4 000 tons are caught in Khong district (mostly above the falls), a large part of which consists of species having migrated up from Cambodia. The existence of a Dai fishery in the Vietnamese part of the Mekong suggests that there is also a dry season (November-March) movement downstream out of the Cambodian floodplains" (Van Zalinge *et al.* 2000).
- Detailed migration patterns based on traditional ecological knowledge have been described for about 60 species (Poulsen and Valbo-Jørgensen 2000; MRC 2001, 2003). These studies highlight in particular two main annual migration peaks in relation to water level changes, one around December and one around June (Figure 11).

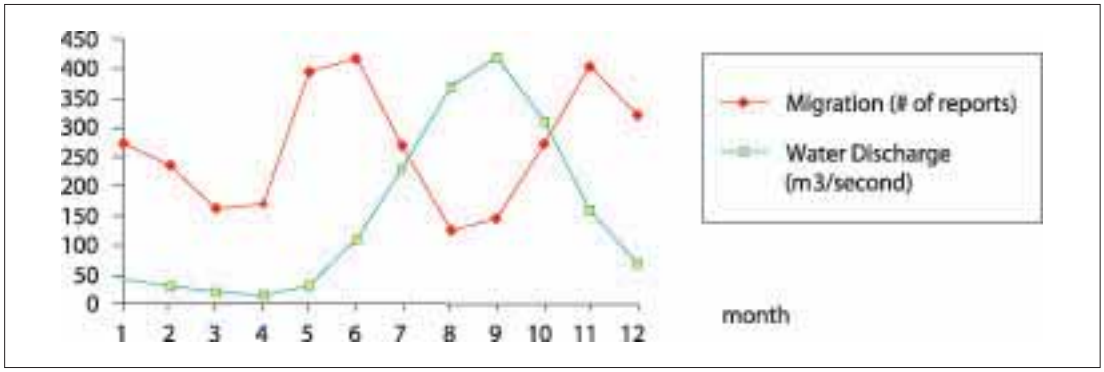

Figure 11: Major migration patterns in the Mekong mainstream, after Bao *et al.* (2001).

- "When the Mekong flood recedes, […] water levels on the submerged land start dropping, signaling to most fish species to migrate to deeper water in the lake or tributaries (lateral migration). Many species will then continue and undertake longer (longitudinal) migrations from the lake or tributary to the Mekong River" (Nao Thuok *et al.* 1999).
- "In July migratory fish move with the water current and invade inundated forest areas for feeding and reproduction. In November the water level gradually decreases and migratory fishes move back from the inundated areas to the Tonle Sap River and the Mekong. In December, January and February, the water current flows southwards very strongly from the Great Lake into the Mekong River; this induces long distance migratory fishes to move downstream" (Sam Chin Ho 1999).
- "Fish species with longitudinal migrations begin to spawn in the Mekong river at the beginning of the rainy season (May-July). Important spawning areas are located in the Mekong and tributaries in Kratie, Stung Treng and Ratanakiri provinces. Fish eggs and fry are carried by the currents and swept into the flood plain areas that are being inundated. Synchronization in the onset of the monsoon and the spawning process may be important. The filling up of reservoirs causes a delay in the patterns of flooding and weakens the flood pulse; it may disrupt this cycle" (Nao Thuok *et al.* 1999).
- The inundated forest is a breeding and feeding ground for most fishery resources of the Great Lake. This area is considered as the most productive freshwater zone in the world, together with one of the highest biodiversity (500 species) (Rainboth 1996). Around 280 fish species utilize the inundated forest for at least six months for breeding and feeding during the monsoon (Nao Thuok *et al.* 1996; Nao Thuok 1997).

3. MEKONG FISHERIES

A high diversity of fishing methods adapted to the environmental conditions is recorded (e.g., 102 fishing methods in Cambodia, more than forty in Southern Laos alone).

Estimates in 1976 :

The University of Michigan (Lagler, 1976) estimated production at 50-80 000 tons for the inundation zone, but this figure is questioned.

Estimates in 2000 :

Table 10 : Range of estimated capture fisheries production in the Lower Mekong Basin (Van Zalinge *et al*. 2000).

Countries	Annual catch range (tons)
Cambodia	289 000 - 431 000
Lao PDR	27 000
Thailand	303 000
Vietnam	190 000
TOTAL	**809 000 - 951 000**

Estimates in 2002 :

Table 11 : Production and value of fish, fish products and other aquatic animals in the LMB (Sverdrup-Jensen 2002).

Fish, fish products and other aquatic animals	Quantity (tons)	Price (USD per kg)	Value (USD millions)
Riverine capture fisheries	1 533 000	0.68	1 042
Aquaculture	260 000	1.05	273
Reservoirs	240 000	0.68	163
TOTAL	**2 033 000**		**1 478**

Estimates in 2004 (MRC 2004):

The yield of the capture fisheries is around 2.5 million tons.
The fish yield from reservoirs is around 250 000 tons.
The production from aquaculture is about 250 000 tons.
Extrapolation from average prices gives a first sale value for the fishery of about USD 1.4 billion, allowing for multiplier effects the fishery is worth several times that figure, and its replacement value is far higher.

- Actually the variation in estimates does not reflect interannual variability, but the growing knowledge about and the increasing acknowledgement of the importance of the Mekong fish resource.

- FAO statistics record 8 million tons of inland capture fish caught per year, including 563 000 tons from the four Lower Mekong countries (i.e., a contribution of 7%). If one acknowledges the underreporting of catches in FAO statistics, as highlighted in several documents (e.g., Coates 2002), and accepts the latest MRC figure (1.5 million tons), then the total catch from inland fisheries worldwide amounts to 9 million tons, and the Mekong Basin actually contributes 17% of this total.

Figure 12: Salted fish ready for transportation and trade.

4. CAMBODIAN INLAND FISHERIES

According to FishBase 2004, 847 species have been recorded in Cambodia, including 477 freshwater species. Information on growth is available for 8% of these freshwater species, diet is known for 6% of them, and information on reproduction is available for one fourth of these species only.

Alternatively, the MRC Mekong Fish Database lists 440 fish species in the Cambodian Mekong, including 363 freshwater species.

4.1. Cambodian inland fish production

There are several estimates of the inland fish production in Cambodia, depending upon the source considered. Presented below are all the available, and sometimes contradictory, statistics.

Table 12: Range of the annual inland fish catch in Cambodia from 1994 to 1997 (Van Zalinge *et al.* 2000).

Types of fisheries	Annual catch range (tons)
Large scale fisheries	
- Fishing Lots[1]	25 000 - 75 000
- Dais (bagnets)[2]	14 000 - 16 000
Middle scale fisheries[3]	85 000 - 100 000
Family fisheries[3]	115 000 - 140 000
Rice field fisheries[4]	50 000 - 100 000
Total	289 000 - 431 000

[1]Range reflects uncertainty in actual catch levels
[2]Range shows approx. minimum and maximum values in 1994-98
[3]Based on socio-economic survey data extrapolated to entire country
[4]Approx. 1.8 million ha x likely range of fish yields: 25 - 62 kg.ha^{-1}; source: Deap et al. *1998; Ahmed* et al. *1998.*

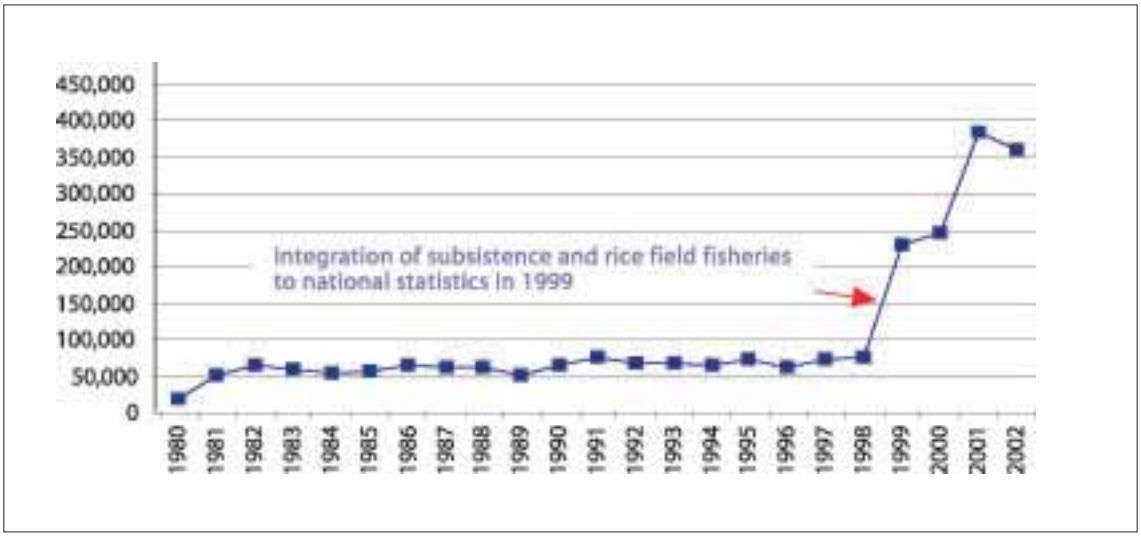

Figure 13: Cambodia inland fish catches (national statistics, Department of Fisheries).

Table 13: Cambodia inland fish catches (national statistics, Department of Fisheries).

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Tons	18 400	50 780	65 700	58 717	55 093	56 400	64 181	62 154	61 200	50 500
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tons	65 100	74 700	68 900	67 900	65 000	72 500	63 510	73 000	75 700	231 000
Year	2000	2001	2002							
Tons	245 600	385 000	360 300							

- Coates details the issues and challenges faced by the inland capture fishery statistics, in particular in Cambodia:

  "None of the countries reviewed derive their statistics based upon direct observations, report verification, sampling of catch or landings, or any other form of independent monitoring. This includes Cambodia, where the statistics have recently been substantially revised (i.e., corrected). This revision was made based upon new information produced by research, not through the introduction of an improved statistics collection system. Estimations are inherent in all of these country's systems and range from responsible attempts to estimate actual catches through to arbitrary supposition" (Coates 2002).

- With an annual production of 300 000-400 000 tons Cambodia's freshwater capture fisheries ranked fourth in the world in 1996 (FAO 1999 in Van Zalinge *et al.* 2000).
- The monetary value of the catch at the landing site ranges from US$ 100 to 200 million and increases in the marketing chain to between US$ 250 to 500 million (Van Zalinge *et al.* 2000).
- "According to the study by the Department of Fisheries, the annual total fish catch ranges from 300 000 to 450 000 tons with a value of US$150 to 225 millions" (Minister of Agriculture, Forestry and Fisheries, 01 July 2004 [National Fish Day]).

- Actually when the catch is divided by the popultion,i.e., the number of people who can realize the harvest, Cambodia is THE most intense inland fishery in the world.

(Baran 2004, Table 14 and Figure 14). This is based on official FAO statistics for 2000, which are quite conservative compared to scientific estimates for the same period.

Should disaggregated statistics about the Mekong delta in Viet Nam be available, they would probably show a similar fishing intensity.

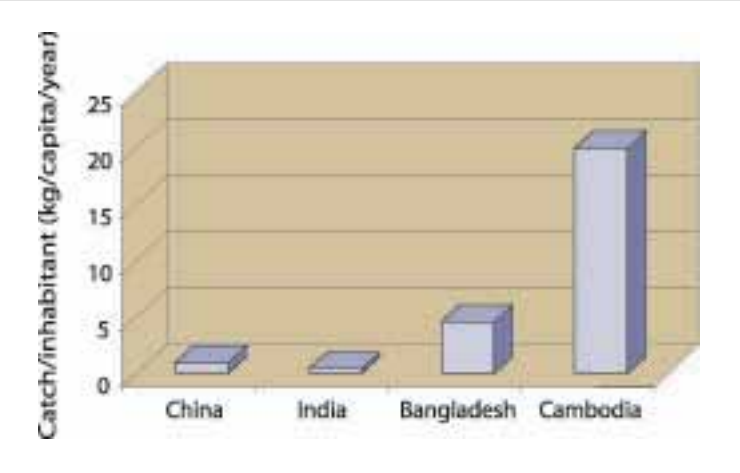

Figure 14: Fish catch per inhabitant in the four countries having the biggest inland fish catch.

Table 14: Fish catch and population of the four major countries worldwide.

Country	Fish catch 2000[1]	Population 2000[2]	Catch/inhabitant (kg.capita^{-1}.year^{-1})
China	1 222 955	1 265 830 000	0.97
India	416 490	1 014 003 817	0.41
Bangladesh	591 300	129 194 224	4.58
Cambodia	245 300	12 212 306	20.09

[1] *http://www.fao.org/fi/statist/statist.asp*
[2] *CIA World Fact Book - http://www.cia.gov/cia/publications/factbook/*

4.2. Tonle Sap fish production

The Great Lake Tonle Sap fisheries account for 60% of current annual commercial fisheries in government statistics (Ahmed *et al.* 1998).

Table 15: Global catch statistics in tons for the whole Tonle Sap system - lake and river - Siem Reap, Kampong Thom, Pursat, Kampong Chhnang, Battambang, Phnom Penh and Kandal provinces. (Department of Fisheries 1997, in Nao Thuok and Ly Sina 1998).

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Tons	44 612	57 240	48 738	47 806	46 365	53 745	52 355	50 004	42 355
Year	1990	1991	1992	1993	1994	1995	1996		
Tons	53 890	61 000	56 368	55 200	51 050	58 774	53 150		

When Phnom Penh and Kandal provinces are not included, the statistics are (Table 16):

Table 16: Global catches statistics in tons for the Tonle Sap Lake only—Siem Reap, Kampong Thom, Pursat, Kampong Chhnang and Battambang provinces (CNMC/Nedeco 1998).

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Tons	34 019	40 060	40 101	35 632	30 239	31 141	37 375	32 490	31 800
Year	1990	1991	1992	1993	1994	1995	1996		
Tons	36 050	41 000	40 408	39 200	38 280	39 077	36 700		

Alternative statistics are given in Table 17 and 18.

Table 17: Detailed fish catches in the Tonle Sap-Great Lake area (MRCS 1999).

Type of fishery	Catch in tons
Commercial fisheries (fishing lots and dais)	40 000 - 60 000
Commercial mobile fisheries (licensed)	30 000 - 40 000
Family mobile fisheries	50 000
TOTAL	**120 000 - 150 000**

Table 18: Range of annual inland fish production in the Tonle Sap Great Lake, 1994-1999 (Lieng and Van Zalinge, 2001).

Type of fishery	Annual catch range (tons)
Large-scale:	
- Fishing lot[1]	25 000-75 000
- Dai (bagnet) [2]	9 000-16 000
Medium-scale[3]	65 400
Small-scale[3]	73 600
Rice-fields	6 500-16 000
TOTAL:	**179 500-246 000**

[1]Range reflects uncertainty about actual catch level
[2]Range shows approx. minimum and maximum values in 1994-98
[3]Based on socio-economic survey data extrapolated to entire country.
[4]Yield is calculated based on the maximum water level of 9.36 m; the surface area of the Great Lake is approximatively 1 292 793 ha (Carbonnel and Guiscafre 1963; Mekong Secretariat 1993).

- When figures of Table 18 are related to those of Table 12, it appears that the Tonle Sap Great Lake contributes 57 to 62% of the Cambodian total inland fish production. This is consistent with figures given by CNMC/Nedeco (1998), i.e. 49-68%.
- The total revenue generated from the fisheries sector in 1999 amounted to USD2.4 million (Gum 2000).
- It should be noted that there are no scientific time series available to monitor the catch of the Tonle Sap fisheries over years.

Table 19 below (from Baran *et al*. 2001a) reviews available figures for each fishery during the 1994-2000 period. Figures for each fishery are detailed in section 4.5.

Table 19: Recent fish production (tons) of the Tonle Sap Great Lake and River fisheries, according to scientific surveys (Baran *et al*. 2001a).

Year	Dai	Mobile	Lots	Subsistence	Ricefields	TOTAL
1994 or 94-95			75,000			
1995 or 95-96	14 400	62,800	not updated	71,500	12,900	**242 200**
1996 or 96-97	16 800	not updated	not updated	not updated	not updated	**239 000**
1997 or 97-98	14 600	not updated	not updated	not updated	not updated	**236 800**
1998 or 98-99	8 900	not updated	not updated	not updated	not updated	**231 100**
1999 or 99-00	11 400	not updated	not updated	not updated	not updated	**233 600**

Figure 15: Capture chamber of a fishing lot.

4.3. Productivity of Cambodian floodplains

- The fish yield of the Tonle Sap area is 100-150 kg.ha^{-1}. This includes the catch of the dai fishery near Phnom Penh, which targets migratory fish coming out of this area, but not subsequent caches made by other gears in the Mekong River (Van Zalinge and Touch Seang Tana, 1996; Nao Thuok *et al*. 1999).

Table 20: Comparison of floodplain fish productivities from various countries (Lieng and Van Zalinge 2001).

Location	Fish yield (kg.ha^{-1}.year^{-1})	Source
Tonle Sap floodplain	139-190	Lieng and Van Zalinge (2001)
Tonle Sap floodplain	230	Baran *et al*. (2001)
Amazonian floodplain	24	Bayley and Van Zalinge (draft paper)
Nam Ngum Reservoir, Lao PDR	40-173	Mattson *et al*. (2001)
Bangladeshi natural floodplain	104-130	Hoggarth and Halls (1997)
Bangladeshi modified floodplain	51-81	Hoggarth and Halls (1997)
Indonesian floodplain	72-118	Hoggarth and Halls (1997)
Thai floodplain	25-52	MRAG (1994)

The exceptional productivity of Cambodian floodplains can be explained by three interconnected factors: high biodiversity, large accessible floodplains, and a very high exploitation rate by man over decades.

- The natural biodiversity allows the numerous species to make use of all kinds of resources, at different periods of the year (all trophic niches are occupied); in case of unfavourable conditions or habitat for a species, it also allows another species having close ecological requirements to take over (functional redundancy through a diversity of reproductive strategies).
- The accessibility of natural floodplains makes large areas available to fish for foraging and offers a diversity of niches and shelters (Junk 1976). The importance of the flood pulse in maximizing the energy made available to the riverine system has been largely demonstrated since Junk *et al.* (1989).
- The high (and until recently sustainable) exploitation rate attested since the beginning of the century in Cambodia (Petillot 1911, Chevey 1934) has probably resulted in a selection of now dominant fast-growing and short-life span species (mostly Cyprinids) which corresponds to a juvenile and very productive fish assemblage.

Thus the Tonle Sap combines high biodiversity, accessible floodplains, high exploitation rate and has the highest productivity worldwide, whereas the Amazon and Congo feature very high biodiversity and accessible floodplains but low exploitation rate, the Brahmaputra has high biodiversity, very high exploitation rate, but poorly accessible floodplains, and European big rivers combine low biodiversity and no longer accessible floodplains.

Figure 16: A view of the floodplain in the rainy season.

4.4 Detail of inland catches

Table 21: Species composition and value of the catch by type of fishery, in Cambodia, in 1995-96 (Van Zalinge *et al*. 2000).

Species name	Percentage of total catch	Percentage of total value %	Type of fish
1. Henicorhynchus sp.	21	9	Cyprinid
2. Channa micropeltes	9	19	Snakehead
3. Cyclocheilichthys enoplos	9	8	Cyprinid
4. Dangila sp.	6	2	Cyprinid
5. Osteochilus sp.	4	2	Cyprinid
6. Cirrhinus microlepis	3	4	Cyprinid
7. Pangasius sp.	3	3	Catfish
8. Barbodes gonionotus	3	2	Cyprinid
9. Paralaubuca typus	3	1	Cyprinid
10.Channa striata	2	6	Snakehead
Total of top 10 species	63	56	

National statistics are gathered in Khmer. Baran and Cheng (2004) showed, after a rigorous analysis of equivalences between Khmer and scientific names, that the top-ten commercial fish (Khmer names) actually correspond to 38-47 scientific species (Latin names). Subsequently:

- top 10 commercial fish species caught in Cambodia are still unknown to science (only genera are);
- the equivalence tables used so far to convert Khmer names into scientific species names are inaccurate;
- socio-economic statistics detailing species and based on these previous conversion tables are inaccurate (they might be accurate as long as the fish name is expressed in Khmer, but not when it becomes converted into a scientific name).

4.5 Some specific Cambodian inland fisheries

Categories of fisheries:

- **Large scale fishing,** also known as fishing lots, refers to highly commercial operations in designated water areas for which annual lease fees are collected by the government.
- **Middle scale fishing** refers to commercial operations in open areas in the rivers and lakes for which fishers are required to obtain licenses from the government.
- **Small-scale or family fishing** is a tax-free operation carried out solely for subsistence.

Both middle and large-scale fishing are subject to open and closed fishing seasons, whereas family-scale fishing is permitted throughout the year. The open fishing seasons are as follows (Nao Thuok and Ly Sina 1998 in Gum 2000):

- from 1st October to 31st of May for areas north of the Quatre Bras parallel (Chaktomuk junction)
- from 1st November to 30th June for areas south of the Quatre Bras parallel.

We focus below on statistics gathered by research projects, and scattered in the literature. They complement official statistics of the Department of Fisheries. See also Tables 17 and 18 for additional information.

4.5.1. Fishing lots

- From 1980 to 1988, 307 fishing lots were recorded, including 143 barrage lots, 96 Tonle Sap bagnets ("dais"), 13 shrimp lots and 55 sand beach lots. A reform took place in 1989, with seven small size bagnet lots ("Dai trey linh" in Kandal and Prey Veng provinces) and 31 catfish fry bagnets ("Dai kone trey pra") integrated, but a reduction of Tonle Sap river bagnets down to 76. The total number of lots remained almost stable until 1994, but that of Tonle Sap bagnets was reduced again to 63 in 1995. In 1999 the number of barrage lots was reduced to 135. The year 2000 was another year of reform, as the number of barrage lots dropped from 135 to 82, while the catfish fry bagnets were officially suppressed (total number of lots remaining: 164). The number of sand beach lots regularly decreased over years until total suppression in 2002. In 2003 the fishing lots amounted to 162, including 81 barrage lots, 60 Tonle Sap bagnets, 8 "Dai trey linh" lots and 13 shrimp lots (DoF 2003).
- "Nowadays there are 164 lots comprising lake, riverine and river beach lots and covering an area of 852 900 ha. In addition, there are 89 Dai (bagnet) fishing lots (see below) and 15 fish sanctuaries. Lots are allowed to operate under the general fishery law and some specific (burden book) regulations between October and June, but tend to start operations in the Great Lake in January" (Van Zalinge *et al.* 2000).
- The size of fishing lots around the lake ranges "from 20 to few hundreds of square kilometers. Lots use on average 20 to 40 km of bamboo fences and 40 000-80 000 pools to encircle the fish shoals each fishing season, from October to May" (Nao Thuok *et al.* 1996).
- In 1996 the Ministry of Environment estimated that fishing lots covered 80% of the Tonle Sap's shoreline (Gum 2000), although this proportion is after the restructuring of fishing lots, reduced significantly.

Figure 17: Construction of a fishing lot barrage in the Tonle Sap River.

- "In 2000 the government of Cambodia proclaimed radical changes in the management of fisheries by reducing the area of private fishing lots and allowing the lots to be managed by local communes instead" (Somony 2002). As a result, 56% of the total area of the private fishing lots i.e., 536 302 hectares was changed in 2001 to public fishing lots "to allow the poor to eke out their existence from fisheries" (Keskinen 2003).
- "Although the reform was a beneficial step, many regarded it to be too quick and radical as the communities were not ready for the responsibility of managing and supervising the areas handed over to them. After the temporary removal of fisheries officers in February 2001, illegal fishing methods ran out of control and anarchy replaced the corruption and inequality. Fishing lot owners were also reported to be refusing to release areas assigned for public fishing, often with the support of the military. This has lead to conflict between villagers and fishing lot owners, including governmental officers and the military (FACT 2001). However, there are signs that fishing disputes have slowly declined and the setting up of community fisheries is taking place throughout the Tonle Sap Area" (Keskinen 2003).
- Lot fishery catch statistics
  Estimates by Van Zalinge and Touch Seang Tana (1996), Deap Loeung *et al*. 1998 and Thor Sensereivorth *et al*. 1999 vary between 22 000 and 25 000 tons for years 1995 to 1998. However "given the lack of transparency of the lot fishery (CNMC/Nedeco 1998; Ly Vuthy *et al*. 2000; Degen and Nao Thuok 2000) and the very high productivity of these lots (Chevey and Le Poulain 1940; Fily and D'aubenton 1963), an arbitrary but conservative value of three times the reported catch (i.e., 75 000 tons per year) can be used" (Baran *et al*. 2001a).

4.5.2. Dai fishery

- In 2003 there were sixty Tonle Sap bagnets ("Dai") in the Tonle Sap river and eight "Dai trey linh" in Kandal and Prey Veng provinces.
- "Most of the auctionable Dai locations are in the Tonle Sap river, where in the 1997-99 biennium 68 operated from October through March. When the floods recede, fish leave the submerged lands toward the river and lake and eventually the Mekong. Particularly in a time window 6-1 days before full moon there is a peak in migratory activity. During the January peak period, 300-500 kg mainly of small cyprinids are taken every 15 minutes day and night during four to five days. More than half of the season's catch is taken in January. The bulk of the catch consists of the current year's crop of small 'white' fish species" (Van Zalinge *et al*. 2000).
- During the migration peak in the Tonle Sap River, an average of 34 tons of fish per hour (i.e., about 3 million fish per hour) are caught by the entire dai fishery (Baran *et al*. 2001a).
- A now illegal Dai fishery is specialised in fry, particularly *Pangasianodon hyphthalmus*. In 1998, more than 650 Dais were in operation. Only *Pangasianod* fry is kept alive, to be sold to cage culture enterprises, mainly in Viet Nam.

Table 22: Catch of the Dai fishery, based on scientific monitoring (after Baran *et al*. 2001a).

	1994 1995	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	Source
Catch of the dai fishery (tons)	18 400						Lieng *et al*. (1995); van Zalinge and Touch Seang Tana (1996); based on estimates
		20 000	16 800				Deap Loeung *et al*. (1998)
		14 400	15 500	14 700	8 900		Deap Loeung (1999)
		14 400	16 800	14 600	8 900	11 400	Baran *et al*. (2001a)

Figure 18: Catch of a Dai bagnet.

4.5.3. Middle-scale fisheries

Ahmed *et al.* (1998) provide estimates based on household surveys:

Table 23: Catches of the middle-scale fishery in 1995-1996 (Ahmed *et al.* 1998).

	Catch (tons)
Phnom Penh	22 600
Kompong Chhnang	7 000
Siem reap	3 000
Pursat	12 000
Battambang	4 500
Kompong Thom	13 700
Total (*without Kandal and Kompong Cham provinces*)	**62 800**

Table 24: Cambodian middle-scale fishery. Top 10 gears ranked by share in total catch (weight), 1995-1996 (Van Zalinge *et al.* 2000).

Type of gear	Share in percentage	Khmer name
1. Gillnets (all mesh sizes)	52	Mong
2. Encircling seine net	16	Uon Hum
3. Arrow-shaped trap	6	Lop Nor
4. Small river trawl	3	Neam
5. Encircling gillnet	3	Mong Hum
6. Hooks and lines	3	Santouch
7. Single bamboo trap	3	Lop
8. Beach seine	2	Uon
9. Castnet	2	Samnanh
10. Brush park[1]	2	Samrah
Share of Total Catch	92	

[1]*Probably grossly under-reported, as the fishing method is presently illegal.*

Figure 19: Brush park removal and fishing on the Tonle Sap.

4.5.4. Family fisheries

- Family fishing is generally synonym of "subsistence fishing" or "small-scale fishing".
- This fishing has been repeatedly claimed to be declining (Mouhot 1864, Sao-Leang and Dom-Saveun 1955; Blanc 1959).
- Family fishing is estimated to produce at least 115 000 tons annually in Cambodia (Van Zalinge *et al.* 2000).

Ahmed *et al.* (1998) actually provide detailed estimates based on household surveys (Table 25).

Table 25: Catches per province of the Family fishery in 1995-1996 (Ahmed *et al.*1998).

Province	Family fishery 1995-1996
Phnom Penh	10 600
Kompong Chhnang	26 300
Siem reap	6 500
Pursat	6 400
Battambang	15 500
Kompong Thom	6 200
Total (without Kandal and Kompong Cham provinces)	71 500

4.5.5. Rice field fisheries

- Unlike many of its neighboring countries, Cambodia's ricefields and floodplains still produce a significant amount of aquatic products such as fish, shrimps, frogs, crabs, snails (Gregory *et al.* 1996).
- Wet season rain-fed lowland and deep-water rice-ecosystems covered about 1.8 million hectares in Cambodia in 1994/95 (Nesbitt 1997).

Rice field wild fish productivity

- Studies in Svay Rieng province estimate the productivity of rice field wild fish at over 80 $kg.ha^{-1}.year^{-1}$ (Guttman 1999); 25-96 $kg.ha^{-1}.year^{-1}$ (Guttman 1999); 125 $kg.ha^{-1}.year^{-1}$ (Gregory *et al.* 1996); 100 $kg.ha^{-1}.year^{-1}$ (Gregory 1997);
- Estimate for the Tonle Sap area: 150 $kg.ha^{-1}.year^{-1}$ (Guttman 1999);
- "Wild fish production of 50-100 $kg.ha^{-1}.year^{-1}$ in Southern Cambodia is possible" (Guttman 1999).

Rice field fish production and value

- Taking the lowest estimate of 25 $kg.ha^{-1}.year^{-1}$ as an average value for Cambodian lowland fisheries would suggest a total rice field catch of about 43 500 tons (Gregory 1997);
- In studied provinces, the value of fish caught in rice fields reaches 37-42% of that of the rice production (Guttman 1999).

According to the Mekong River Commission Secretariat (1999) there are 258 000 hectares of rice fields in the Tonle Sap area (below the 10m elevation contour line). When using for computation the value of 50 $kg.ha^{-1}.year^{-1}$ this represents an annual production of 12 900 tons of rice field wild fish for the Tonle Sap area.

4.6 Trends in Cambodian inland fisheries

- Baran *et al.* (2001b) have first shown that over the past 60 years due to increasing fishing pressure the total catch of the Tonle Sap area has almost doubled but the population has more than tripled, resulting in a sharp decline of the catch per fisherman (see Table 26 and Figure 20).

Table 26: Catch per fishing inhabitant over time in the Tonle Sap zone (Baran *et al.* 2001b).

Period	Great Lake fish production (tons)	Population in Cambodia (million pers.)	Fishing community (Tonle Sap area, million)	Catches of subsistence fisheries (tons)	Catches of rice field fisheries (tons)	Overall catches (tons)	Fish catch/ fishing commune inhabitant ($kg.person^{-1}.year^{-1}$)
1940's	100 000	3.2	0.36	21 500	3 900	125 000	347
1975's	85 000	6.3	0.71	42 300	7 700	135 000	190
1995's	145 600	10.7	1.2	71 500	12 900	230 000	192

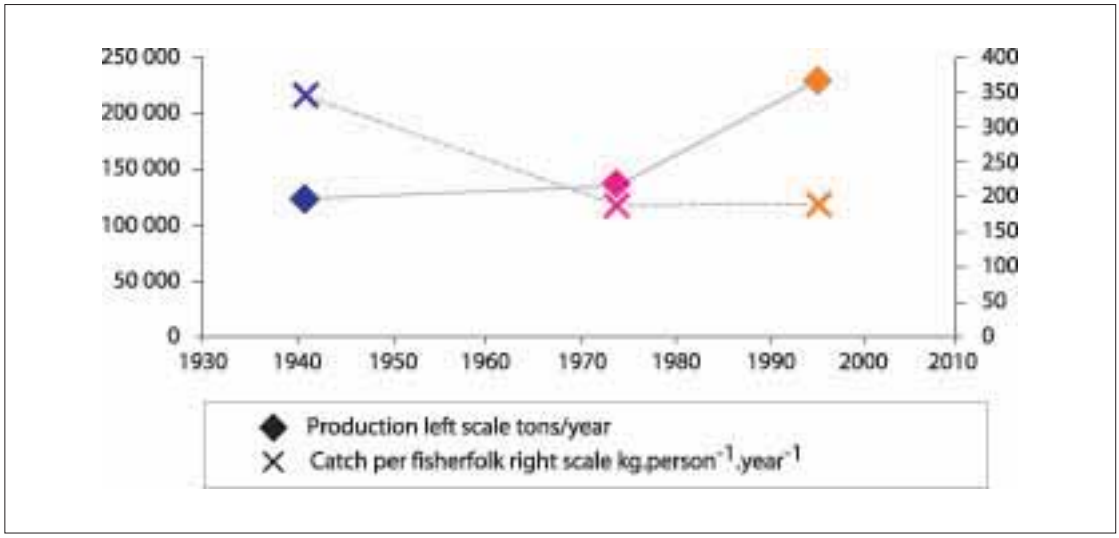

Figure 20: Trends in production and catch per fisher in the Tonle Sap area over 60 years (Baran *et al.* 2001b).

A recurrent hypothesis (since van Zalinge and Touch Seang Tana 1996) is that total catches are now close to a maximum, with:

- small fish increasing in catches;
- the catch of medium sized fishes showing a decrease; and
- a sharp decline of the catch of big fishes.

This hypothesis is consistent with observations and fishers' comments as well as with historical records in other freshwater fisheries (Welcomme 1995) but is impossible to test due to the lack of a large scale fish length monitoring program in the past years.

Figure 21: Kompong Luong, a floating city on the Southern bank of the Lake.

4 CONCLUSION

Both the Cambodian and the wider Mekong inland fisheries are exceptionally important by global standards, with Cambodian fisheries the most intensive worldwide in terms of catch per person. The aquatic resources are crucial to the income, livelihoods, and to the very subsistence of the population, fishing essentially providing the last resort of security for the poorest.

The threats to Cambodian fisheries are multiple. Among them is the uncontrolled modification of natural flows due to dykes, road network, small and large dams. For instance since the 1950's about 6 000 large and small multi-purpose dams with reservoirs and often extensive irrigation schemes have been built in the Mekong watershed (800 in Cambodia, 600 in Lao PDR and in Viet Nam respectively, 4 000 in Thailand; Van Zalinge *et al.* 2000). This has led to the fragmentation of aquatic habitats and the blocking-off of fish spawning areas. Flow modification—whether due to damming or to other activities—and broader development threaten to disrupt the livelihoods of those who depend on the aquatic resources. Such disruption might involve the need to relocate and/or consider alternatives to fishing as a source of income—neither of which can be achieved easily in the short-term.

A more pervasive threat is over-fishing, due both to the open access nature of the fishery and the lack of control over the resource. Over-fishing is partly attributable to a sharp population growth (22.8 million inhabitants expected by 2025[1]) that also results in habitat loss (loss of floodplains through water regulation) and habitat fragmentation (with clearance of wetlands along the river for agriculture, firewood and fishponds).

[1] *The population and Development Database, http://www.alsagerschool.co.uk/subjects/sub_content/geography/Gpop/HTMLENH/country/kh.htm*

Although the opening up of development and private investment opportunities holds out the promise of improved living conditions for the people living in the Mekong basin, the majority of these people, in particular in Cambodia, are still living in a rural subsistence economy and depend on the ecological system - supplementing rice crops by fishing, and foraging aquatic animals and plants from nearby wetlands. This ecological system is susceptible to suffer from a development process rushed at the expense of the natural resources supply, and most fishers or farmers will be unable to cope with a rapid change in their livelihood when they have neither the education nor the assets to shift to alternative non-rural resource generating opportunities. The most vulnerable would then be left out, even worse off than they are now.

In the face of these threats to Cambodian and regional fisheries, what level of protection does aquaculture offer for the security of fish supply? In the Mekong Basin aquaculture represents only 12% of the fish resources basin-wide (Sverdrup-Jensen 2002). Furthermore aquaculture amounts largely to capture fish grown in cages, and the food that valuable carnivore cultured species are given consists of other wild species of lesser value. Thus at the moment it is wild natural resources, rather than aquaculture, that provide food to millions in the region.

Without the supply of wild fish, Cambodia would be left with only 15 000 tons of aquaculture fishes whose cycle is mastered - just 4% of what people eat. It is clear that 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 meager capture fisheries-dependant aquaculture sector as an alternative option.

That is not to say that aquaculture will not have a significant role in the future; it is likely to be part of a successful strategy for sustainable access to aquatic resources. With 96% of aquatic resources in Cambodia being wild, however, it will take at least a decade before the situation turns in favor of aquaculture. In the meantime, the emphasis should be on protecting the wild fish supply. Slowing down decline is crucial in order to avoid disruption of the natural food supply to the poor. The situation, then, requires a balanced four-fold strategy:

- better integration of the value of natural and aquatic resources in policies;
- actual protection of wild resources and control of the fishing effort;
- promotion and development of an aquaculture sector independent from capture fish supply; and
- improved land and water management through institutional initiatives.

Such a strategy, effectively implemented, would go a long way to securing the future of the most intense fishery in the world and the food security needs of some of its poorest people.

Figure 22: Living on a floating house. A sustainable lifestyle?

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